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SUPPLEMENTAL COMMENT LETTER APPENDIX
SURFRIDER FOUNDATION
SAN DIEGO COASTKEEPER

The following documents form the basis for various themes and points made in the supplemental comment letter submitted by the Surfrider Foundation and San Diego Coastkeeper (Environmental Groups) dated April 6, 2009.

Exhibit A: An Evaluation of Compensatory Mitigation Projects Permitted Under Clean Water Act Section 401 by the California State Water Resources Control Board, 1991-1992. UCLA, 8/07.

Note: This comprehensive analysis of compensatory mitigation success does not support Poseidon's assertions that a 50% confidence interval for assessment of entrainment (or impingement) APF calculations is appropriate. The findings of the study show that in California, despite compensatory mitigation requirements regarding structure and function of restored or constructed wetland, rarely do such endeavors result in optimal wetland conditions. As such, the first step to developing an appropriate compensatory mitigation scheme is to ensure the impacts assessment is reflected in the restoration scaling. Where the APF calculations are allowed for lower level intervals, significantly higher mitigation ratios are required to ensure actual compensation for the APF experienced. Where, as here, the compensatory mitigation scheme is explained in terms of non-site-specific success criteria, the only option is to maximize impacts assessment confidence, <u>and</u> apply a duly protective compensation ratio. In the alternative, Poseidon should be required to conduct additional compensatory mitigation if either (a) real time impingement and/or entrainment losses are higher than predicted; or (b) the compensatory mitigation fails to achieve performance criteria within allotted time frames. Another alternative would be to shut down the CDP when mitigation criteria are not met, and require a substantial financial penalty to allow agency creation or restoration of additional, lesser functioning wetlands.

The report notes right up front, without caveat, that "Successful compensatory mitigation is technically complex, usually takes years to achieve, and can be expensive. Thus there is a real danger of failure, and a financial incentive for dischargers to avoid or minimize the necessary costs." (P.1) The report further recounts the findings of numerous studies which, while finding that mass acreage requirements have been achieved, also note that optimal wetland function is almost never achieved. In short, this report supports Environmental Groups' assertion that 95% confidence intervals should be applied to APF calculations, and site-specific mitigation conditions must be assessed prior to a determination of mitigation feasibility.

Exhibit B **A Case Study: Systemic Evaluation of Compensatory Mitigation Sites Within the Carlsbad Hydrological Unit. UCSD, 2005.**

Note: This study looked at the Carlsbad Hydrological Unit and assessed achievement of mitigation obligations and goals, including site specific bioassessment to ascertain wetland structure and function. This report is particularly relevant as it includes assessment of the watershed within which the CDP would be located, and validates various compensatory mitigation concerns expressed more theoretically in other documents in this Appendix.

The study confirms that sufficient mass wetland acreage creation often results from compensatory mitigation conditions, but that qualitative indicators of wetland function often do not support the "no net loss" of wetlands policy. Rather than a "hard science" look at mitigation success, the study, through a systemic approach, identified reasons why mitigation success is not as high as it could/should be. The conclusions of the report support Environmental Groups' assertion that the CDP compensatory mitigation scheme should include substantial funding for agency monitoring and reporting of compliance with performance criteria.

Exhibit C **Ecological Performance Standards for Wetland Mitigation: An Approach Based on Ecological Integrity Assessments. NatureServe, 2008.**

Note: This report, prepared for US EPA, initially discusses the "considerable controversy on the relative success of wetland mitigation," (P.2) and the desirability of mitigation within the same watershed as the impacts if true mitigation is ever to be achieved. (P.3) Where certain types of wetlands are difficult to be restored, impacts should be avoided, and if they cannot be, then extremely conservative assumptions and heightened mitigation ratios should be required. The so-called performance criteria in the MLMP depend upon comparison to reference wetland conditions. This study expressly states that such reference indicators of "ecological integrity" are challenging to (a) definitional difficulties inherent due to wetlands complexity, (b) costs, and (c) the need for extensive data to apply sufficient statistical rigor. The study generally supports the Environmental Groups assertion that site-specific conditions of the wetlands to be created or restored is critical to assessment of mitigation feasibility. This is particularly true with respect to development of the reference criteria, yet the MLMP does not take into account site specific functionality until a significantly later date in the approval process.

Exhibit D **Wetland Mitigation in Washington State. Part 1: Agency Policies and Guidance. Washington Dept. Of Ecology, US ACOE, EPA, 2006.**

Note: The Washington State guidance serves to spotlight failures in the development of the MLMP due to the ad-hoc disjointed multi-agency undertaking here. The inter-agency coordination took place extremely late in the regulatory process, and without pre-agreed upon structure and criteria for decision making. As a result, the MLMP has been thrust down agencies' throats based upon arguments that the 30 year old Southern California Edison SONGS compensatory mitigation scheme provides precedent for deferred site selection and performance criteria development. Among numerous other principles applicable to compensatory mitigation, this document supports Environmental Groups' assertions regarding the need to assess ecological function within the wetlands to be created or restored so that restoration scaling can be appropriately determined. The document also reflects the state of science with respect to compensatory mitigation, including assertion that "mitigation designs should be shifted from excessive engineering to designs that make ecological sense and are self-sustaining (i.e. long-term maintenance should not be required. (P.6) Because the actual mitigation plans for the CDP have not yet been created, there is no way to assess mitigation design and resulting impacts on feasibility at this point in time. The study also supports Environmental Groups' position that site-specific performance criteria are a critical component of mitigation success evaluation. (P.27, 55-59) Where, as with the CDP, only generic performance criteria are delineated, the mitigation plan is but a plan to create a plan.

Exhibit E **Success Standards for Wetland Mitigation Projects - a Guidance. Washington State Department of Transportation, 1999.**

Note: This guidance document states, point-blank "A critical element in the planning of any wetland mitigation project is the selection of objective and success standards." (P.1) The failure to identify site-specific wetland functionality success criteria, or to assess baseline conditions of prospective mitigation sites, renders any assessment of mitigation feasibility unduly speculative. The guidance document provides a number of performance criteria that should be defined for the specific mitigation site including (a) defined wetland hydrology, (b) size of wetland, (c) herbaceous cover both short and long term (species abundance), (d) species survival, (e) control of invasives, (f) desired species diversity, (g) slope, (h) aquatic invertebrate diversity, (i) aquatic invertebrate taxa presence, (j) area and depth of open water, (k) surface water depth and duration, (l) channelized water flow, (m) desired temperature. (P. 16-20). The MLMP fails to provide such site-specific performance criteria, and hence, the feasibility of compensatory mitigation proposed cannot be discerned. The guidance document also supports the Environmental Groups' request for contingency measures should restored or created wetlands fail to achieve stated objectives and goals. (P.22)

Exhibit F **Wetland mitigation in the United States: Assessing the success of mitigation policies. (Ambrose) Wetlands (Australia) 19: 1-27.**

Note: The study reflects the general failure of compensatory mitigation in Southern California to replace natural wetland functions. The study generally supports Environmental Groups' assessment that the CDP, when considered in its stand-alone condition, must first seek to avoid marine life impacts, then seek to minimize, and only once these conditions are applied would compensatory mitigation be an appropriate response. Because under the stand-alone condition, the CDP could be built at another location and with another design such that most marine life impacts would be avoided, any claims that the CDP as proposed qualifies for stand-alone approval are invalid. At the very least, the failure to assess alternative sites for ability to achieve avoidance and minimization are required. The study specifically describes failures of San Diego region salt marsh restoration attempts to achieve desired wetland functionality. The study generally supports Environmental Groups' demand for rigorous permit conditions linked to site-specific wetland functionality goals post remediation.

Exhibit G Evaluating the Success of the San Dieguito Lagoon Restoration Project through Independent Monitoring of Performance Standards.

Note: Specific to the San Onofre Nuclear Generating Station (SONGS) mitigation plan, which was the basis for the MLMP, the document reflects the value of developer-paid independent monitoring of performance criteria, as well as long term obligation of developer to achieve such standards. Monitoring is contemplated for 40 years, the full life of the SONGS project. The document also reflects that there are numerous performance criteria specific to the restoration/creation site that will be monitored (topography, tidal prism, habitat areas), whereas other criteria will be measured against reference wetlands (water quality, biological standards). While the SONGS mitigation project is heralded as a precedent for the CDP, it should be noted that the mitigation is being constructed decades late, and the full suite benefits will take even longer until the project matures.

Exhibit H Success in Wetland Mitigation Projects. National Wetlands Newsletter, 2008.

Note: The article references, as do many other documents, the National Research Council's 2001 article detailing failures of compensatory mitigation generally to achieve the national policy of no net loss of wetlands form a functional standpoint. The article generally confirms that ecological function is compromised even moreso than failure to meet administrative conditions in permits. The article concludes, "Although wetland mitigation accounts for a significant annual investment in habitat restoration and protection, it has not, to date, proven to be a reliable conservation tool. The article encourages site-specific permit conditions that include clearly defined performance with respect to community structure, soil, hydrology, amphibian communities, and vegetation. Herbaceous cover is described as a poor indicator of wetland success. The CDP's MLMP fails to specific performance standards specific to the mitigation sites, and therefore does not ensure mitigation can occur as speculated by Poseidon.

Exhibit I Salt Marsh Restoration Experience in San Francisco Bay. Journal of Coastal Research, 2001.

Note: The article reflects results of a study of tidally influenced coastal wetlands restoration projects in Northern California. The "Lessons Learned" from the survey of projects included opinions that (a) "The science of restoration is still experimental - we still do not fully understand what percentage of the original ecosystem function returns nor how long it takes," (b) "The key to successful restoration is insuring that physical processes are restored," (c) restoration project should have clear statements of measurable, achievable biological objectives, (d) stabilization of ecosystem function in a restored wetlands takes much longer than previously thought, (e) manipulated wetlands do not work well long term, so natural tidal rhythms should be sought. These concerns support Environmental Groups' assertion that identification of the actual sites for mitigation and site-specific criteria are required to ensure MLMP feasibility.

Exhibit J **Draft Regional Facilities Master Plan. San Diego County Water Authority, December, 2002.**

Submitted to the Regional Water Quality Control Board April 7, 2009.

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An Evaluation of Compensatory Mitigation Projects Permitted Under Clean Water Act Section 401 by the California State Water Resources Control Board, 1991-2002.

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Prepared for:
California State Water Resources Control Board

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An Evaluation of Compensatory Mitigation Projects Permitted Under Clean Water Act Section 401 by the California State Water Resources Control Board, 1991-2002.

Final Report

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Abstract

The purpose of this project, which was funded by the California State Water Resources Control Board (SWRCB), was to evaluate the compliance and wetland condition of compensatory wetland mitigation projects associated with Clean Water Act Section 401 Water Quality Certifications throughout California. This was done by selecting, reviewing and performing field evaluations for 143 permit files distributed across the 12 Water Board regions and sub-regions of the State. For each permit file we assessed the extent to which permittees complied with their mitigation conditions, including acreage requirements, whether the corresponding mitigation efforts resulted in optimal wetland condition, and if the habitat acreages gained through compensatory mitigation adequately replaced those lost through the permitted impacts. We found that permittees are largely following their permit conditions (although one-quarter to one-third of the time these are not met), but the resulting compensatory mitigation projects seldom result in wetlands with optimal condition.

Methods

Our goal was to evaluate the mitigation actions associated with at least 100 randomly chosen Section 401 permit files issued in California between 1991 and 2002. The permit files were selected using the SWRCB's permit tracking database, and reviewed through multiple visits to the SWRCB, each of the three Army Corps of Engineers district offices (Los Angeles, San Francisco, and Sacramento), and various Regional Boards. Ultimately, 143 permit files were assessed; mitigation projects from 129 permit files were visited for assessment of compliance with permit conditions (including acreage) and wetland condition, and 14 additional files were evaluated for compliance only.

Our determinations of Section 401 compliance included consideration of all mitigation conditions specifically outlined in the 401 permit letter, plus any additional conditions found in other agency permits when the 401 permit included explicit or implicit statements requiring that those documents be followed. In addition to the regulatory permits, the mitigation plan, if present, was carefully read to extract the essential compliance elements. Compliance with these conditions was scored using categorical scores, on a scale from 0% (no attempt to comply) to 100% (condition fully met).

To evaluate existing wetland condition, we performed the California Rapid Assessment Method (CRAM) at all assessable mitigation sites associated with our permit files. CRAM includes evaluations of the following attributes: buffer and landscape context, hydrology, physical structure and biotic structure. To provide a sound foundation for evaluating mitigation sites in this study, we established categories of wetland condition (optimal, sub-optimal, marginal and poor) based on the results from CRAM evaluations performed at 47 reference sites distributed throughout the state.

At each mitigation site we also mapped the border of the mitigation sites using GPS to evaluate acreages and determined the approximate proportions of jurisdictional

and non-jurisdictional habitat types that were present. These proportions, along with the overall site acreages, were used to calculate the component acreages of "waters of the U.S." versus non-"waters" habitats, wetlands versus non-wetland "waters," and subsets of these habitat types. These were compared to the impact acreage values in the permits to evaluate "no net loss" from the standpoint of habitat acreages.

Results

Of the 143 permit files assessed in this study, 129 had compensatory mitigation sites that could be assessed in the field (the mitigation requirements for the other 14 permit files could be assessed for compliance, such as fee payments to preservation or conservation banks, but there were no compensatory mitigation projects to assess). The mitigation sites were well distributed across the state, although some regions had issued relatively few 401 permits and, thus, had correspondingly few site evaluations (Figure AB-1). Many of these 129 permit files had multiple mitigation actions (e.g., wetland creation plus riparian enhancement) that needed to be evaluated separately; a total of 204 discrete mitigation sites were surveyed and evaluated. Of these 204 mitigation projects, 62% were onsite (i.e., within the greater boundaries of the permitted project area) and the rest were offsite. Seventy-five percent of these 204 sites involved permittee-responsible mitigation linked to specific permits files, while 25% involved third-party strategies (mitigation banks or in-lieu fee payments) or were part of larger mitigation projects used by permittees for multiple permits.

We looked at compliance in two ways. First, we assessed the degree of compliance with each condition, with the potential scores for each of these conditions ranging from 0 to 100%, and then we took the average of these compliance scores across all conditions; this is called the "average compliance score." For the 124 files with assessable 401 conditions, the average compliance score for 401 conditions was 84%. Second, we assessed compliance as the percentage of permit conditions that were met completely (100% score) for a particular file (hereafter, percent-met score). The average percent-met score was 73% (Table AB-1). Forty-six percent of the files fully complied with *all* permit conditions. The average compliance score based on mitigation plan requirements (a proxy for all agency requirements) was slightly lower than the 401 compliance scores (81% vs. 84%). Only 16% of the files fully complied with all mitigation plan conditions; however, 42% had scores of 90% or greater. Compliance with 401 permit conditions showed no trend over time, and there was no significant difference in 401 compliance or mitigation plan compliance among regions. We found high compliance for third-party mitigation requirements (mean score 99%) and relatively low compliance for monitoring and submission requirements (mean score 59%). The mean scores for other compliance categories ranged from 76-85% (Table AB-2). In general, most 401 permits contained relatively few compensatory mitigation-related permit conditions (often a single acreage-related requirement was specified); conditions regarding success and performance standards were notably infrequent, although these were more commonly included in other permits or the mitigation plan.

CRAM evaluations were conducted at each of the 204 discrete mitigation sites. Fifty three of these mitigation sites were sub-sampled because they were too large or complex for a single CRAM evaluation. Thus, a total of 321 separate CRAM evaluations were completed for this study.

Despite relatively high permit compliance, most mitigation sites were not optimally functioning wetlands based on the criteria we established from reference wetlands across the state. Mitigation sites had an overall mean score of only 59% (Figure AB-2). On average, sites scored better for biotic structure (e.g., plant community metrics) than for the hydrology attribute (Figure AB-3). Only 19% of the mitigation files were classified as optimal, with just over half sub-optimal and approximately one-quarter marginal to poor. There was some variation in CRAM scores among the SWRCB regions, with Region 2 exhibiting a slightly lower mean CRAM score than other regions (Figure AB-4). We did not assess function at impacted sites, nor did we assess function at the mitigation sites before the mitigation action was taken; therefore, it was not possible to compare directly the functions lost through permitted activities to those created through compensatory mitigation.

The 143 Section 401 permits that were evaluated authorized approximately 217 acres of impacts (including temporary impacts) and required that 445 acres of mitigation be provided. Our analyses indicate that 417 acres of actual mitigation acreage was obtained; 72% of files met or exceeded their acreage requirements, resulting in an overall mitigation ratio of 1.9**:**1. When considering permanent impacts (true losses) to creation and restoration mitigation (true gains), our results showed that “no net loss” *of acreage* is being achieved (1) overall, (2) for jurisdictional “waters of the U.S.” acreage, and (3) for wetlands themselves (Table AB-3). However, 39% of individual files resulted in net acreage losses overall, 47% resulted in a net loss of jurisdictional “waters” acreage, and 28% had net wetland losses (Table AB-4).

A simple reporting of overall acreage losses and gains does not provide the full picture of “no net loss” of wetland acreage (much less wetland function, discussed below). A simple accounting assumes no existing wetland acreage was present at the mitigation site prior to any mitigation activity (not always the case) and it does not address whether the habitat types mitigated were appropriate given the corresponding impacts. Within most regions, the habitat types mitigated were appropriate given the impacts (Figure AB-5); however, approximately 50% of the mitigation acreage within Regions 4 and 5S consisted of drier riparian and upland habitats that were outside jurisdictional “waters of the U.S.” Overall, 27% of mitigation acreage was non-jurisdictional. Vague regulatory language and a lack of clear accounting have contributed to this result; in the reporting of regulated impacts, the term “riparian” refers only to habitats within “waters of the U.S.” while in mitigation planning, a broader definition of riparian has often been applied that includes the entire zone of transition to fully terrestrial habitats, including non-jurisdictional habitat.

In comparing results from permit compliance, acreage requirements and wetland condition, we found little relationship between these different aspects of mitigation. For example, meeting acreage requirements was not related to overall permit compliance (r^2=0.002), nor was there any relationship between percent acreage met and CRAM score for wetland condition (r^2=0.015). General compliance with permit conditions was statistically correlated with CRAM scores; however, low r^2 values indicate the relationships between the variables were not very strong (mean 401 compliance score and CRAM score, r^2=0.126 (Figure AB-6); mean percent of 401 conditions met and CRAM score, r^2=0.207; and mitigation plan compliance and CRAM score, r^2=0.150).

Taken together, the findings of this study suggest that permittees are, for the most part, meeting their mitigation obligations, but the ecological condition of the resulting mitigation projects is not optimal (Figure AB-7). Given the low ecological condition of most mitigation wetlands, it seems likely that many mitigation projects did not replace the functions lost when wetlands were impacted, and hence that the goal of "no net loss" of wetland functions was not met, but this study cannot provide a definitive conclusion on this issue. To understand the net loss (or gain) in wetland function resulting from mitigation, functional assessments would be needed at the impact site before and after the impact occurred to determine the loss of functions, and at the mitigation site before and after the mitigation project was completed to determine the gain in functions. Linking gains to losses is difficult in a retrospective study such as this, and we have not attempted to do so. However, the low CRAM scores for most mitigation projects indicates that many of these projects are not functioning well as wetlands, and in the context of the likely condition of the original wetlands before they were impacted, it seems probable that a net loss of wetland function did occur for the wetlands included in this study.

The functional deficiencies of the mitigation projects and the likely failure of many projects to compensate for the loss of wetland functions are largely due to shortcomings in mitigation planning and in the development of the permit conditions. The root of these shortcomings lies with a lack of explicit consideration of the full suite of functions, values, and services that will be lost through proposed impacts and might be gained through proposed mitigation sites and activities. In short, this is at least partly due to regulatory agencies approving mitigation projects with conditions or criteria that are too heavily focused on the vegetation component of wetland function, with inadequate emphasis on hydrological and biogeochemical conditions and their associated functions and services (e.g., flood attenuation, water quality improvement).

Recommendations

The results of this study have informed a large number of recommendations (Table AB-5). The recommendations are separated into five main categories.

First, we present recommendations aimed at improving mitigation requirements. These recommendations mainly concern permit conditions, but also issues of the location of mitigation projects and how gains and losses associated with a project are tracked by habitat. The success of compensatory mitigation depends fundamentally on the mitigation requirements specified by the regulatory agencies. Our study found relatively high levels of compliance with mitigation permit conditions. In addition, there was no relationship between compliance with permit conditions and the condition of wetland mitigation sites. It appears that compliance with permit conditions yields no guarantee that a mitigation wetland will have high condition or function. Perhaps the most effective way to improve the success of compensatory mitigation would be to include permit conditions that lead to better mitigation projects.

Second, we present recommendations under the general heading of information management. Retrieving specific permit files was problematic during this study. Of the 429 files we sought, we could locate only 257 despite extensive efforts to do so. The difficulty in locating files had a variety of causes, ranging from limitations in the database to the physical management of hardcopy permit files. These recommendations concern improvements to the database (either the existing database, or a modified database), improvements to permit archiving, and improvements to tracking the progress of mitigation projects.

Third, we present recommendations to improve the clarity of permits. Permit conditions should be written as clearly assessable criteria, with individual conditions for each specific criterion to be evaluated. Permit conditions should be written with a clear and direct method of assessment in mind. Our results suggest that more clearly written conditions would improve the chance of compliance. Presently, some conditions are too vague or may be presented in a way that it is not possible to assess them.

Fourth, we recommend that the goal of "no net loss" be assessed in a more effective manner. Although we were able to assess whether there has been a net loss of wetland acreage, studies of the functions of wetlands before and after construction at both impact and mitigation sites are required to evaluate the net change in wetland functions.

Finally, we present recommendations concerning coordination with other agencies. Although the State Water Resources Control Board has responsibility for 401 permits, the entire process of regulating impacts to wetlands and "waters of the United States" is closely coordinated with other agencies, especially the U.S. Army Corps of Engineers and the California Department of Fish and Game. Improved information management might improve this coordination.

Compliance Monitoring

The results of this study clearly indicate the need to evaluate the compliance of mitigation projects with their permits. Thirteen of the 257 permits we located had to be excluded because of potential compliance issues. This indicates that up to 5% of the files we reviewed may have significant compliance problems (such as the impact occurring but no mitigation being undertaken). Our analysis of discrepancies between 401 permits and information in the permit files identified additional compliance issues. For example, 8% of the 143 files we evaluated had information indicating that the actual impacts were greater than authorized in the 401 permit; overall, there appeared to be compliance issues with **42%** of the files we evaluated. Compliance varied across condition categories with relatively high scores for third-party mitigation requirements and relatively low scores for monitoring and submission requirements. Moreover, many of the categories we assessed had a high fraction of permits for which the conditions could not be assessed; for example, we could not assess monitoring and submission conditions for more than half of the permits.

These results indicate a definite need for compliance monitoring. Without a significant compliance effort, permittees are failing to comply with a wide range of permit conditions without the Water Board staff knowing about it.

Our data allow us to identify some areas that seem most likely to have low compliance. However, in our view it does not provide a very sharp focus. Compliance issues are spread quite broadly across all aspects of the 401 program, so compliance monitoring will also need to be spread quite broadly. The areas identified as having lower compliance might warrant a particular emphasis during compliance monitoring, but compliance was not so high for most other areas (with the possible exception of third-party mitigation conditions) that it would be safe to assume high compliance with them.

Although monitoring requirements were regularly included as 401 permit conditions, and evaluated for compliance when appropriate, the relative scarcity of monitoring reports in the permit files we reviewed suggest that compliance with the monitoring requirement is checked infrequently (although some monitoring reports may have been submitted by permittees but not placed in permit files). Our compliance assessment indicated that conditions requiring mitigation monitoring were met only about 53% of the time; it was unclear whether any enforcement actions were undertaken in response to the absence of monitoring reports. While we were conducting a similar study for the Los Angeles Regional Water Quality Control Board (Ambrose and Lee 2004), that region was compiling lists of permit files without monitoring reports and contacting permittees to obtain the reports. This seems like a relatively cost-effective area on which to focus compliance monitoring efforts.

We make two specific recommendations concerning compliance monitoring. First, we recommend that mitigation monitoring reports should be streamlined and focused around demonstrating compliance with an established list of permit conditions. Second, we recommend that regulatory agencies establish a multi-agency cooperative to monitor compliance and track wetland losses and mitigation success across the State.

Table AB-1. Summary of compliance scores based on 401 and mitigation plan evaluations including average scores and scores for the percentage of conditions met to 100% satisfaction. The average compliance score was calculated by assessing the degree of compliance with each condition, with the potential scores for each condition ranging from 0 to 100%, and then averaging these compliance scores across all conditions. Successful included files with compliance scores greater than 75%, partially successful included files with scores between 25% and 75%, and failure included files with scores less than 25%. The average percent-met score was calculated based on the percentage of permit conditions for a particular file that were met completely (100% score). Compliance was assessed for conditions included in the 401 permit and for all conditions included in the corresponding mitigation plan.

	N	Score	Successful	Partially Successful	Failure
Average 401 compliance score	124	84.3%	76%	20%	4%
Average 401 percent-met score		73.3%	57%	30%	13%
Average mitigation plan compliance score	81	80.7%	68%	32%	0%
Average mitigation plan percent-met score		67.6%	48%	35%	6%

Table AB-2. Section 401 compliance for different compliance condition category (N=143 files). All conditions were grouped into general categories to look for patterns in compliance with different types of permit conditions. Condition scores that could not be determined were labeled ND (Not Determinable). N/A indicates not applicable.

Condition Code	Condition Category	401			
		Total # Conditions	Average # Conditions	Average # ND	Average Score
1	Third Party	58	1.5	0.1	99.3
2	Acreage	158	1.8	0.2	81.5
3	Site Implementation	411	6.0	2.7	84.8
4	Site Maintenance	49	1.6	0.8	76.0
5	Site Protection	66	1.5	0.6	81.3
6	Success & Performance Standards	199	3.9	1.5	76.4
7	Monitoring & Submission	254	3.6	2.0	59.5
8	Invocation of Other Agency Permits	126	1.7	1.1	N/A
9	Other	35	1.3	0.6	96.1
3 - 6	Site Implementation, Maintenance, Protection, Success/Performance Standards	725	3.2	1.4	79.6

Table AB-3. Permanent impacts and created mitigation acreage, including waters of U.S." and non "waters of U.S.," and wetland, non wetland "waters."

	Permanent Impact	Created Acreage	Proportion Obtained	Net Acreage Gain	Gained/Loss Ratio
Overall Acreage	165.8	270.9	NA	105.1	1.6
Waters of U.S.	162.7	223.1	82.4	60.4	1.4
Non Waters of U.S.	3	47.8	17.6	44.8	NA
Waters of U.S.:					
Wetlands	106.3	146.7	66.4	40.4	1.4
Non Wetland Waters	54.9	74.2	33.6	19.3	1.4

Table AB-4. Permanent impacts and created mitigation acreage, including "waters of U.S." and non "waters of U.S.," and wetland, non wetland "waters."

	% Files w/Gains	% Files Gained=Lost	% Files w/Loss
Overall Acreage	41	20	39
Waters of U.S.	36	17	47
Non Waters of U.S.	24	76	1
Waters of U.S.:			
Wetlands	40	32	28
Non Wetland Waters	17	37	46

Table AB-5. Summary of administrative and regulatory recommendations.

	Improving mitigation requirements	Information management	Improve permit clarity	Assessment of "no net loss"	Coordination with other agencies
Permit conditions should ensure complete compensation for the full suite of wetland functions and services lost	X				
Ensure that mitigation projects compensate for losses in water quality (pollution) improvement services	X				
There should be a better accounting of the habitat types lost and gained	X				
Mitigation projects should have appropriate landscape context	X				
Offsite mitigation should be within the same catchment, or at least the same watershed	X				
Improvements to Database		X			
Improve permit archiving		X			
Improve tracking the progress of mitigation projects		X			
Important permit information should be clearly delineated in tables			X		
Permit conditions should be written so that the extent of efforts must match the intent of the condition to be in compliance			X		
Every mitigation plan and permit should include a table of requirements upon which compliance will be judged			X		
Permits should be clear about the meaning of enhancement, restoration and creation			X		
Performance standards should be clear about the goal of invasive species control			X		
Proof of inundation or saturation appropriate for wetland development should be required for mitigation wetlands			X		
Pre- and post-construction functional assessments of impact and mitigation sites should be required				X	
Improve incorporation of final permit information into Water Board files					X
Consider developing an integrated permit					X

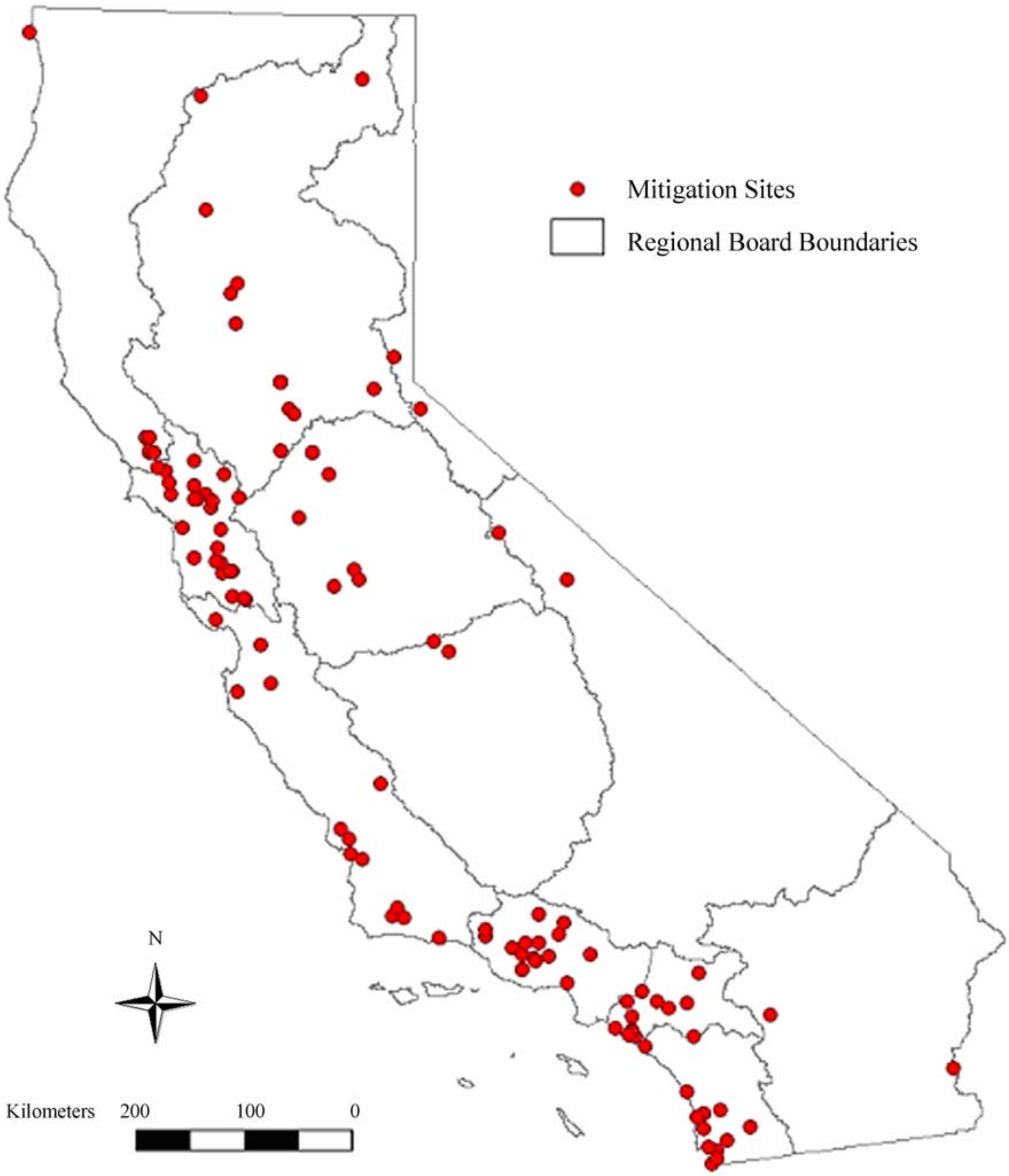


Figure AB-1. Statewide distribution of the assessed mitigation sites associated with the 143 permit files. Several of these sites, especially those in the central valley (Region 5) involved a collection of shared mitigation banks which resulted in fewer than 143 mitigation sites. Points represent each assessed mitigation site rather than multiple sites per file.

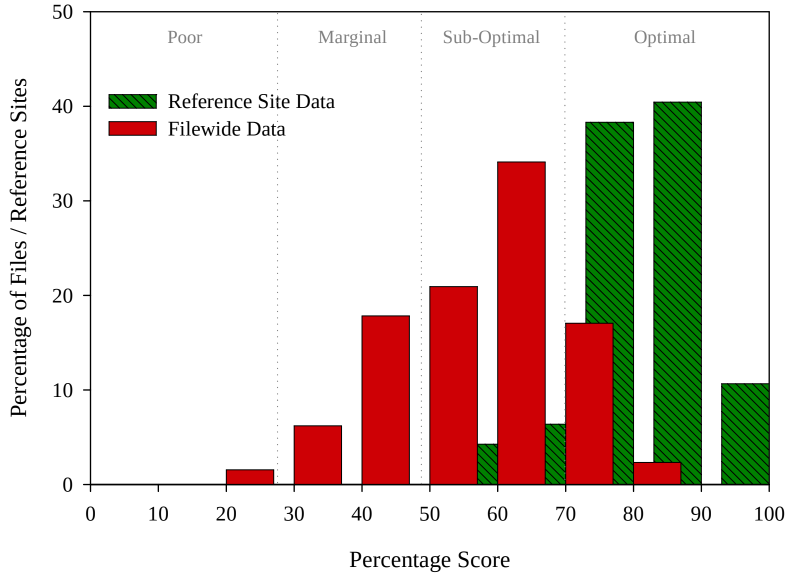


Figure AB-2. All CRAM data combined into a single overall wetland condition success score for each of the 129 files and 47 reference sites evaluated using CRAM.

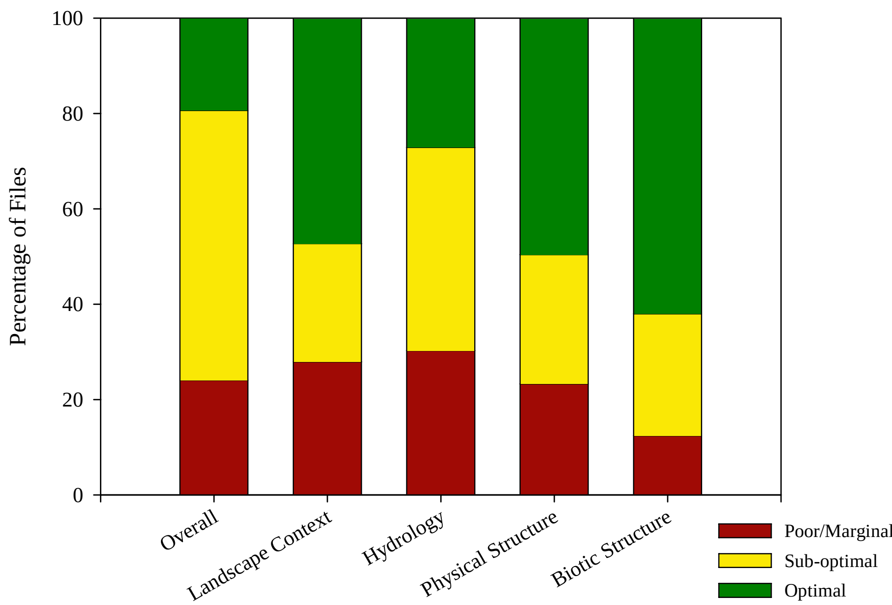


Figure AB-3. Percentage of files in CRAM success categories for overall CRAM scores and the four main attributes. For overall CRAM scores, optimal was considered 70 to 100 percent, sub-optimal was 49 to 70 percent (lower and upper bounds not inclusive), and marginal to poor was 49 percent and below. For buffer and landscape context, optimal was considered 74 to 100 percent, sub-optimal at 52 to 74 percent and marginal to poor 52 percent and below. For hydrology, optimal was considered 76 to 100 percent, sub-optimal at 53 to 76 percent and marginal to poor 53 percent and below. For physical structure, optimal was 53 to 100 percent, sub-optimal at 38 to 53 percent and marginal to poor 38 percent and below. For biotic structure, optimal was considered 47 to 100 percent, sub-optimal at 34 to 47 percent and marginal to poor 34 percent and below.

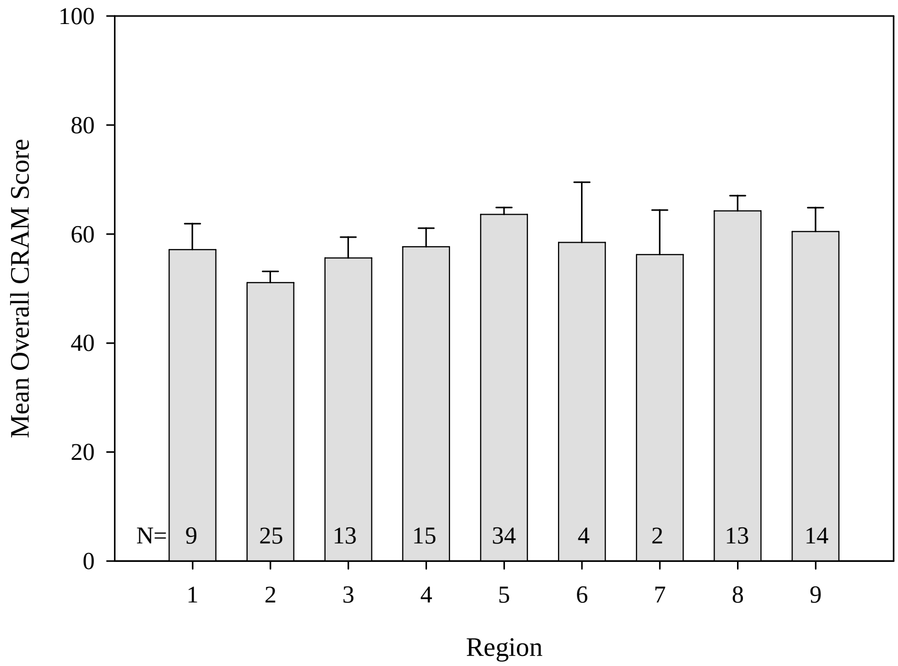


Figure AB-4. File-wide mean Total-CRAM percentage scores by State Board region (N=129 files).

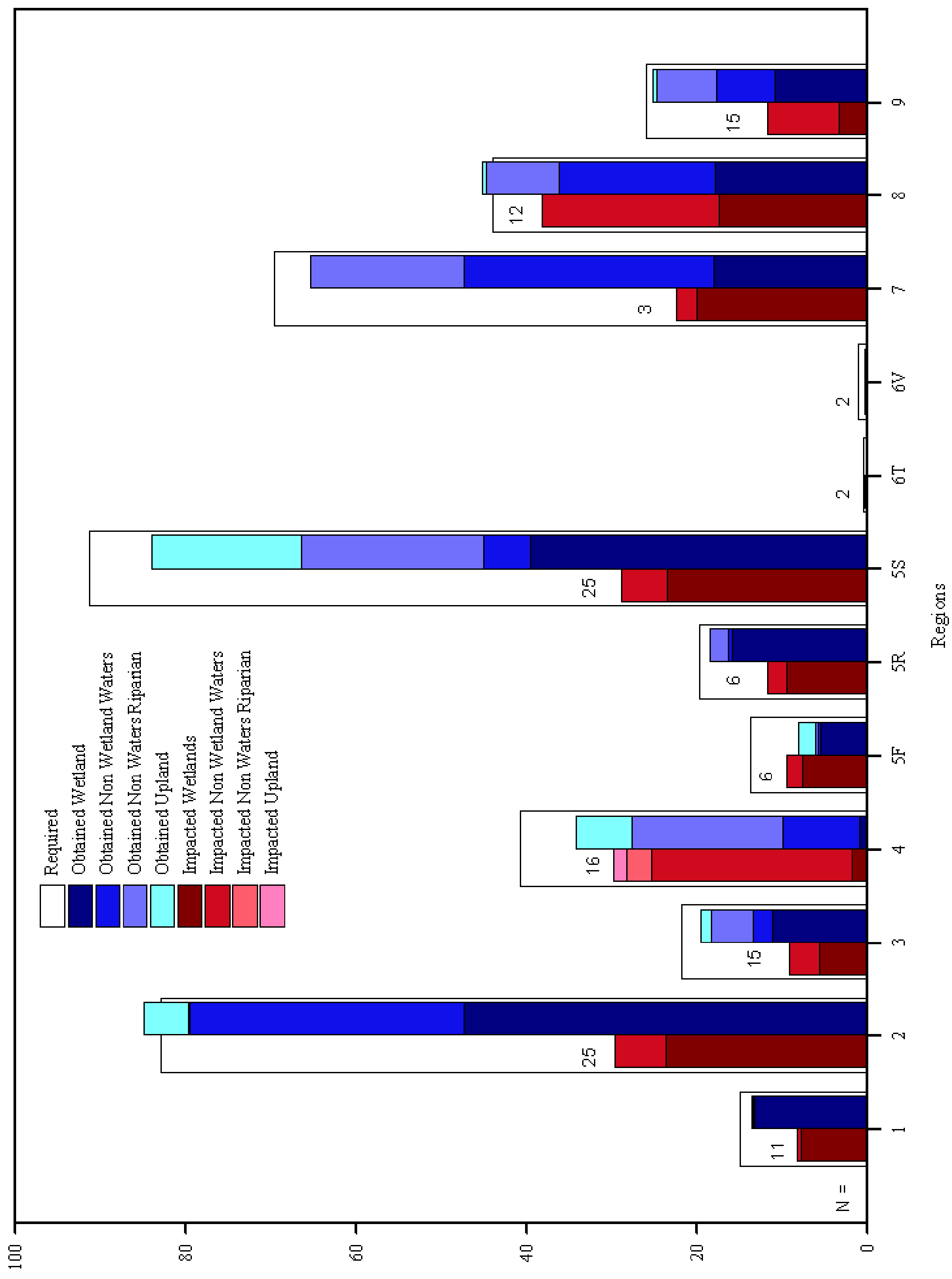
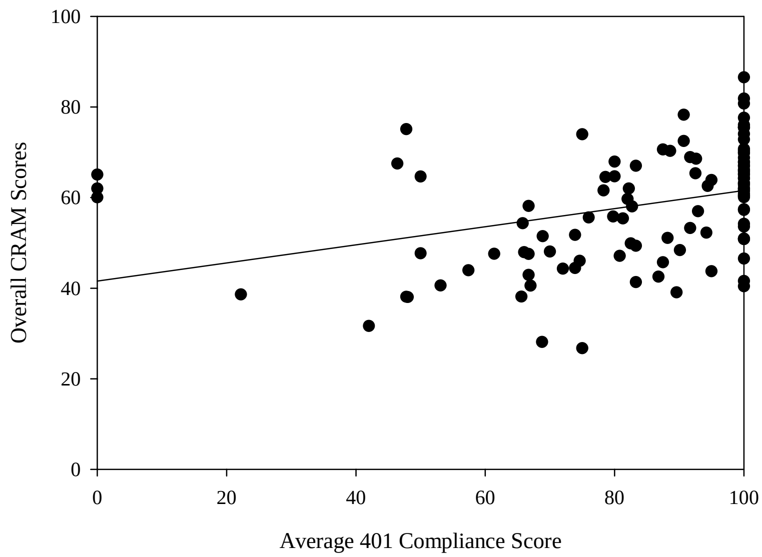


Figure AB-5. Total acreage impacted and obtained proportioned into jurisdictional wetland, and non-wetland “waters,” or riparian and upland habitats by State Board region. Total required acreage per region is also displayed. N displayed = number of files assessed per region for both impacted and obtained. Total N=138 files (there were five files for which wetland acreage was not specified for “waters of the U.S.”).



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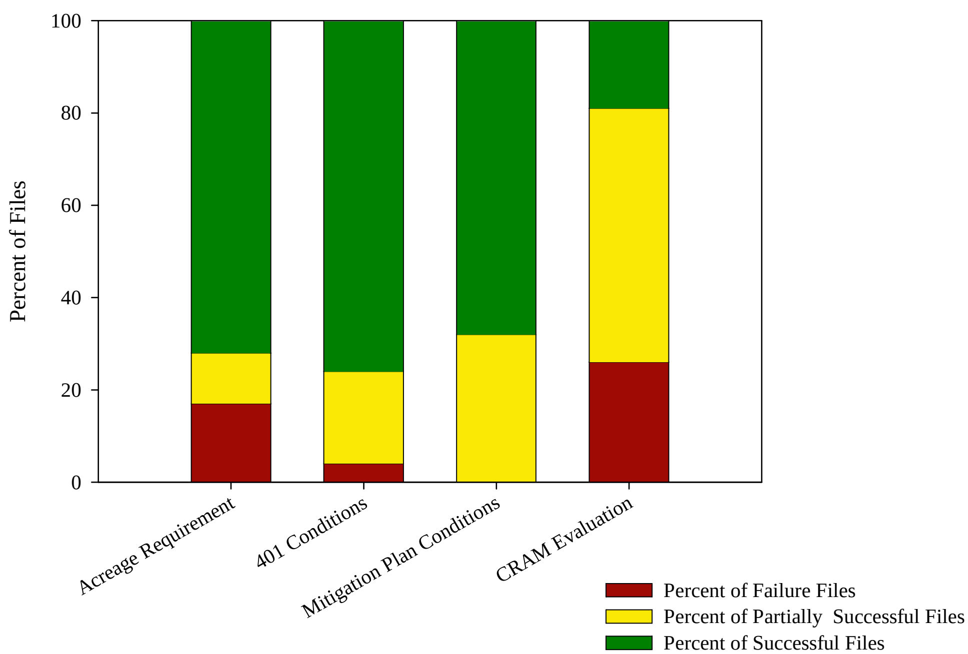

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1. Introduction

For about the last quarter century, the principle regulatory mechanism for the protection of wetland habitats has been Section 404 of the Clean Water Act (CWA). Every applicant for a 404 permit must also obtain state CWA Section 401 certification that the proposed discharge will not violate state water quality standards. In California the State Water Resources Control Board issues certifications for multi-Regional projects, and Regional Water Quality Control Boards issue certifications for projects entirely within their administrative regions. In addition, if the work will involve impacts to a streambed, a Streambed Alteration Agreement must be obtained from the State Department of Fish and Game (DFG), and if there are threatened or endangered species issues, the U.S. Fish and Wildlife Service and /or DFG may issue permits under the federal or State endangered species acts. Since about 1990, these regulatory agencies have pursued a State and National goal of “no net loss” of wetland acreage and function. Given this goal, any wetland losses that do occur must be offset through compensatory mitigation actions.[1] Within the regulatory framework, a strong emphasis has been placed on the avoidance and minimization of proposed impacts. However, the majority of CWA Section 404 proposals are ultimately approved (NRC 2001), making mitigation for permitted wetland impacts essential for the protection of wetland function.

1.1. Scope and Objectives

Recognizing the importance of compensatory mitigation in achieving “no net loss” and, more generally to assure compliance with regulatory mandates, the SWRCB contracted with the University of California, Los Angeles to conduct this study. The scope and objectives of the contract were:

> Beneficial uses of wetlands and riparian areas in California have been heavily impacted by a variety of projects, with more than 90% of California’s wetlands and riparian areas lost. California’s *Wetland Conservation Policy* establishes a “no net loss – long term gain” goal for wetland quantity, quality, and permanence (Executive Order W-59-93). The main tool used by the State Water Resources Control (State Board) and the Regional Water Quality Control Boards (Regional Boards) to protect wetlands and riparian areas is the Clean Water Act (CWA) §401 Water Quality Certification (WQC) Program. Section 401 WQC is associated with CWA §404 permits issued by the U.S. Army Corps of Engineers (USACE). A principal means to achieve the “no net loss” goal is the requirement for compensatory mitigation when unavoidable impacts to wetlands and riparian areas occur.
>
> Successful compensatory mitigation is technically complex, usually takes years to achieve, and can be expensive. Thus there is a real danger of failure, and a financial incentive for dischargers to avoid or minimize the necessary costs. These considerations argue for an effective compliance

[1] Compensatory mitigation is the creation, restoration, enhancement, or occasionally, preservation of wetland resources either onsite or offsite to offset permitted losses in wetland acreage and/or function.

mitigation program for compensatory mitigation projects. However, due to staffing constraints, the Regional Boards perform little or no such compliance monitoring. A second concern is that regulatory conditions, even if complied with, may not assure reestablishment of beneficial use quality or permanence. The National Academy of Sciences, in a 2001comprehensive review of wetland compensatory mitigation in the U.S. found that the national "no net loss" goal is not being met because (1) there is little monitoring of permit compliance, and (2) the permit conditions commonly used to establish mitigation success do not assure the establishment of wetland functions. The San Francisco Estuarine Institute and the Southern California Coastal Water, working with other concerned State and federal agencies, have developed a California Rapid Assessment Method (CRAM) for assessment of wetland condition to address this concern. A third concern is that, because we have not integrated compliance monitoring into our routine regulatory practice, the State and Regional Board's administrative and regulatory procedures may not adequately support effective and efficient compliance monitoring of compensation sites.

The objectives of this project are to: (1) determine project-specific and regional compliance with regulatory requirements, (2) assess wetland function and condition at the compensatory mitigation sites, (3) improve administrative and regulatory practice for establishing and monitoring conditions to regulate compensatory mitigation, and (4) determine the need for ongoing compliance monitoring.

Compensation sites in the North Coast, San Francisco Bay, Central Coast, Los Angeles, Central Valley, Lahontan, Santa Ana, Colorado Basin, and San Diego Regional Board jurisdictions were considered for the study.

The purpose of this project was to evaluate the compliance and wetland condition of compensatory wetland mitigation projects associated with §401 Water Quality Certifications throughout California. This was done by selecting, reviewing and performing field evaluations for nearly 150 permit files distributed across the 12 Water Board regions and sub-regions of the State. For each permit file we assessed the extent to which permittees complied with their mitigation conditions, including acreage requirements, whether the corresponding mitigation efforts resulted in optimal wetland condition, and if the habitat acreages gained through compensatory mitigation adequately replaced those which were lost through the permitted impacts.

The Water Boards' 401 Program was established in 1990. During the period from which permits were evaluated (1991-2002) and continuing to the present, the 401 Program has evolved. A major change was the adoption of new Program regulations, which became effective on June 24, 2000. The new regulations specified the information to be included in an application for certification, eliminated the possibility of waiving certification, identified standard conditions to be included in all certifications, and generally systematized the processing of applications. In addition, regulatory practice has evolved as field staffs have acquired experience with the Program. This study presents analysis of data representing historical practice over the study period.

1.2. Previous Studies

Wetland mitigation has been the focus of many critical studies (see Race 1985, Zentner 1988, Kentula *et al.* 1992, Holland and Kentula 1992, DeWeese and Gould 1994, Miller 1995, Mitsch and Wilson 1996, Zedler 1996, Race and Fonseca 1996, Gilman 1998, Breaux and Serefiddin 1999, Gwin *et al*. 1999, Ambrose 2000, Brown and Veneman 2001, Kelly 2001). In 2001, a panel convened by the National Academy of Sciences completed a comprehensive review of compensatory wetland mitigation in the U.S. (NRC 2001).

The work reported here follows from a number of previous studies focusing on Section 404 permits. Mary Kentula and her colleagues have conducted a series of studies exploring the effectiveness of Section 404 permitting in the United States (Kentula et al. 1992, Holland and Kentula 1992, Sifneos et al. 1992a, 1992b), including California. These studies relied solely on office reviews of permit files. In general, these studies have reported that Section 404 permits have not prevented the continued loss of wetland habitat in the U.S. However, office reviews of permit files are necessarily limited to the intent rather than actual implementation of mitigation. To remedy this limitation, a number of studies have assessed actual compliance with permit conditions in the field (see NRC 2001). In California, for example, DeWeese and Gould (1994) found 50% of the projects evaluated achieved at least 75% compliance with stated permit conditions, while Allen and Feddema (1996) identified a compliance rate of 67% in Southern California. Several studies have suggested that increased enforcement of mitigation permits would improve compliance with permit conditions (Holland and Kentula 1992, Sifneos et al. 1992a, DeWeese and Gould 1994).

A few studies have gone beyond compliance assessment to evaluate ecological condition or functions of mitigation sites. The NRC report summarizes 11 of these studies. The most relevant for our work was conducted by Mark Sudol in southern California (Sudol 1996, Sudol and Ambrose 2002). Sudol reviewed Section 404 and Section 10 permits for Orange County and conducted field assessments of each mitigation site to evaluate its compliance with permit conditions as well as how well the wetland performed certain functions (as indicated by the Hydrogeomorphic Assessment Methodology (Brinson 1993)). Sudol found 18% of the mitigation sites complied fully with their permit conditions, but that none of the sites had appropriate levels of wetland function. One of the strengths of Sudol's work was the combination of an office review of permits with field assessments of permit compliance and wetland function/condition (Sudol and Ambrose 2002), and this approach was adopted for this study.

Most of these previous studies have focused on mitigation success solely with respect to the Section 404 permit conditions, without considering the contributions of other agencies involved in the greater regulatory process. In particular, few have investigated the successes and failures of mitigation projects with respect to the permit conditions of the Section 401 Water Quality Certification orders. Breaux et al. (2005) studied mitigation success for 20 projects near San Francisco Bay which had been regulated under the 401 and 404 programs by the local Regional Water Quality Control Board and Corps district, respectively. They found that most projects were in compliance with their permit conditions and were realizing their intended habitat functions. They reported increased habitat functional success at larger sites and argued that regulators should favor regionally integrated mitigation banks because of their improved benefits to wildlife. In a similar study commissioned by the Los Angeles Regional Water Quality Control Board, Ambrose and Lee (2004) investigated this issue within the Los Angeles/Ventura area by evaluating the mitigation projects associated with approximately 55 Section 401 permits issued by that Regional Water Board. For those projects, they found that the assessable 401 permit conditions were mostly being complied with, yet very few mitigation projects could be considered optimally functioning wetlands. About half of the total mitigation acreage consisted of drier riparian and upland habitats that were outside of jurisdictional "waters of the United States;" about two-thirds of the projects did not fully replace the functions lost, and, thus, "no net loss" was not being achieved. The present study would help determine if the findings of Ambrose and Lee (2004) are unique to the Los Angeles/Ventura Region, or if they reflect mitigation success statewide.

2. Background

2.1. Definitions and Characteristics

Definitions of wetlands and riparian areas vary widely among different groups and for different purposes. A recent NRC panel defined a wetland as below, based not on regulatory requirements but a consensus of wetland scientists; this definition provides context for the important benefits that wetland ecosystems provide:

> An ecosystem that depends on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate, and the presence of physical, chemical, and biological features reflective of that regime, such as hydric soils and hydrophytic vegetation (adapted from NRC 1995).

In general, wetlands are characterized by the presence of biophysical gradients between aquatic and terrestrial habitats and include freshwater marshes, tidal salt marshes, riverine floodplains, riparian wetlands, mangroves, and several types of depressional wetlands. These can be grouped into estuarine (tidal salt marshes), riverine (floodplains and riparian areas), lacustrine (lake affiliated), or palustrine (freshwater marshes and bogs) wetlands. The biological communities present at the various wetlands can take many forms, but one of their predominant characteristics is the presence of hydrophilic (water-loving) vegetation.

While the preceding characterization of wetlands reflects an ecological perspective, more restrictive definitions are used for regulatory purposes, with the specific definition depending on the regulatory agency. Of most relevance for this study, wetlands as defined by the U.S. Army Corps of Engineers (USACE) must generally meet a three-parameter test, having appropriate hydrology, hydric soils, and wetland vegetation. According to the USACE, wetlands are defined as:

> Wetlands are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

In addition to wetlands themselves, Section 401 and 404 permits also cover impacts to aquatic and riparian habitats falling within federally jurisdictional "waters of the U.S." and, in California, wetlands and riparian areas falling outside "waters of the U.S." may be regulated under other State laws and mandates (more discussion of jurisdictional habitats under the Clean Water Act is given later; see page 26).

Riparian habitats are defined in a non-regulatory sense as those areas that are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota (NRC 2002). They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands (NRC 2002). Riparian areas include those areas that are adjacent to perennial, intermittent, and ephemeral streams, lakes, or estuarine-marine shorelines. These habitats often line the margins or banks of streams and lakes and are characterized by the presence of low-growing hydrophytic herbs, shrubs, and tall woody trees. Much of the difference in the regulatory versus ecological definitions of wetlands that we have encountered in this study relates to variations in the definition of riparian areas.

2.2. Functions and Services

Human activities have encroached on wetlands and river systems. Vast, low-lying riverine floodplains and coastal wetlands have been key targets for human development because of the relative ease of reclamation and because of their associated fertile soils. These complex drainage systems have often been reduced to straightened channels with tall constructed banks or levees, designed to contain high flood waters. In addition, isolated wetlands have commonly been drained and filled, or converted to livestock watering areas. The result of these impacts has been the diminishment of the beneficial services that these wetland habitats provide (NRC 1995; NRC 2001; NRC 2002; Leibowitz 2003), and humans are now beginning to recognize the consequences of their loss. As a result, much of the focus of concern about the loss of wetland habitats revolves around the loss of functions and services they provide.

The functions and services[2] that wetlands and riparian areas provide fall into three broad categories: hydrology and sediment dynamics, biogeochemistry and nutrient cycling, and habitat and food web support. Each wetland type performs characteristic functions; no particular wetland performs all possible functions. A brief description of wetland functions and services follows; this is a simple overview and not a detailed catalog of all functions and services performed by wetlands.

[2] "Functions" refers to natural processes occurring in wetlands; "services" refers to processes or attributes of wetlands that are useful to humans.

2.2.1. Hydrologic Functions

Water flowing along the surface of the earth naturally flows downhill towards lower areas of the terrain and begins to accumulate in rills, rivulets, streams, and ultimately river channels as it makes its way to the ocean. Water infiltrating into the earth will also flow down-gradient through the interstitial spaces in the soil or rock, eventually emerging back at the surface in topographically lower areas. These areas where the ground water table emerges are commonly adjacent to or within stream channels. The hydraulic connectivity between precipitation source areas and re-emergence areas results in increased groundwater contributions to streams following storm events, though there is usually a modest time lag and great modulation of flow. The combined flow from overland runoff and emerging groundwater following a storm event results in a pulsed stream discharge pattern with peak flood levels occurring some time after the point of maximum precipitation. Sediment is also a significant proportion of storm runoff as soil eroded from adjacent hillsides enters the stream along with the storm water (Knighton 1998). The destructive force of the storm flow reaches the maximum at the peak of discharge, and these peak flows are what human management strategies have tried to accommodate through the construction of tall levees and often-straight concrete channels. The general philosophy has been to move the water to the ocean as fast as possible, to minimize flooding during peak flows.

But the natural geomorphology of river channels develops to accommodate these peak flows with appropriately wide floodplains and adjacent wetlands, which serve to modulate high water flow through the short term storage of water and sediment (Knighton 1998). During high flow events, water flows over the banks of the natural channel and spreads out over floodplains, where the velocity is reduced and the sediment settles out. Water percolates into soils and sediments within floodplains and riparian areas, where it is stored until the flow recedes. Then the water slowly flows back out during periods of low flow, helping to maintain baseflow conditions during the dry season[3]. Isolated depressional wetlands collect some of the water that would otherwise flow directly to the stream, thus contributing to the moderation of storm flow and the recharge of ground water. In addition, the vegetation that occurs on floodplains and in riparian zones provides mechanical flow reduction and energy dissipation of high flow, and riparian trees, shrubs, and grasses contribute to the stabilization of the stream banks. Often, the absence of riparian vegetation on the banks can lead the destabilization of the banks and their subsequent erosion and incision, though the presence of riparian trees may contribute to bank erosion in other circumstances (Lyons et al. 2000).

2.2.2. Biogeochemical Functions

Biogeochemical functions in wetlands and riparian areas include the retention and removal of substances from the water, sediment accumulation, and nutrient cycling, among others. All of these result in the overall maintenance of water quality. For example, a riparian buffer zone located between an agricultural area and a stream channel

[3] These processes are more common in low gradient streams. High gradient streams, which exhibit different hydrological functions, tend to have shallower or exposed bedrock with limited to absent floodplains and minimal surface to subsurface hydrological connections.

can absorb much of the nutrients leaching from a nearby agricultural field through either surface flow or through the groundwater (NRC 2002). These nutrients can be transformed and removed from soils (e.g., denitrification of nitrogen), adsorbed to soil particles (e.g., phosphorous),or assimilated by riparian vegetation, thus minimizing their transport to the stream. In many agricultural areas, the absence of a riparian buffer may result in direct inputs of nutrients to the stream, in which case instream wetland conditions become very important with respect to improving water quality. Many biogeochemical reactions are redox dependent. That is, certain reactions occur in the presence of oxygen while others require the absence of oxygen. Many of the beneficial reactions that contribute to the improvement of water quality, such as denitrification or the transformation of contaminants, require the absence of oxygen (Casey et al. 1986, Reddy and D'Angelo 1997).

2.2.3. Ecological Functions

Wetlands are extremely important habitats for migratory birds, which use them for resting and feeding areas as they travel from place to place or for breeding. Wetlands and riparian areas are also important to many other species of plants and animals, including threatened and endangered species, and can be areas of notably high biodiversity. For example, riparian habitats in the Santa Monica Mountains cover less than 1% of the land area yet are the primary habitat for 20% of the higher plant species (Rundel 2002). In today’s heavily fragmented landscape, riparian areas can be extremely important corridors for the movement of animals. Many isolated wetlands that become dry during part of the year cannot support fish species, making them important habitats for reptiles and amphibians that would otherwise be preyed upon by fish (Gibbons 2003). Further, riparian trees and other vegetation perform important shading functions, providing significant thermal regulation for the community by keeping water and air temperatures cool during warm dry periods.

2.3. The Protection of Wetlands

When Europeans first arrived in North America, the vast amount of dense woodland and wetland habitat constituted substantial impediments to the settlement of the land (Hawke 1989). Throughout most of our nation’s history, the federal government actively encouraged the conversion of wetlands for useful purposes and for disease abatement, as evidenced by legislation such as the Federal Swamp Land Act of 1850, which promoted their conversion to agricultural land (NRC 1995). The notion that wetlands perform functions or services that can be beneficial to the greater human society has only taken root within the last several decades. Among the suite of landmark environmental laws passed in late 1960’s and early 1970’s was the Clean Water Act, which had the ambitious goal “to protect the physical, chemical and biological integrity of the nation’s waters” (NRC 2001).

While the main focus of the Clean Water Act was to prevent water pollution, some aspects of this law extended protection to wetlands, and these remain the most important federal protections for wetlands today. Wetland protections came primarily under Section 404 of the CWA, in which the U.S. Army Corps of Engineers was made responsible for regulating the discharge of dredged or fill material into “waters of the

United States," including wetlands, under the general oversight of the EPA. Under CWA Section 404, restoration and creation practices were to be employed to compensate for impacts to wetlands. Wetlands are often located wholly or partially on privately owned land. This aspect of wetland regulations have made them some of the most contentious elements of environmental law to date (NRC 1995), and the resulting protection of wetland habitat has fallen short of the goals set forth in the Clean Water Act (NRC 2001).

By the mid 1980's, wetland declines had resulted in the loss of approximately 117 million acres of wetlands nationwide, about half the original amount (NRC 1995). In California, declines were much more severe with losses estimated to be about 90%.(Dahl 1990) Recognizing this problem, and given the refined understanding of the importance of wetland functions, the EPA called for a National Wetlands Policy Forum in 1987 and asked the participants to make national policy suggestions for the future of wetland protection. The central recommendation of the panel was to create a policy of "no net loss" of remaining wetlands which would be emphasized in the Corps' Section 404 permitting program. In 1990, the first Bush administration adopted this policy of "no net loss." Later that year the Corps and EPA produced a guidance document that instructed regulatory personnel how to implement compensatory mitigation requirements (see below) within their 404 permit program such that "no net loss" would be achieved (NRC 2001). The implementation of this policy goal, along with a stronger emphasis on compensatory mitigation practices to offset wetland losses, took effect in 1991.

2.4. Clean Water Act Sections 404 and 401

Section 404 of the Clean Water Act prohibits the discharge of dredged or fill material such as sand or soil into "waters of the United States," unless a permit is issued under the regulatory authority of the U.S. Army Corps of Engineers. The great majority of permit applications are ultimately approved (NRC 2001). While some projects must be evaluated and permitted on an individual basis, others may fall into more general categories, such as bank stabilization or the maintenance of bridge over-crossings. Numerous regional or nationwide permit categories are available for such projects, which can help to streamline the approval process. With the exception of some nationwide permits, Corps personnel must follow a standard three-step sequence in their decision making process. They must first determine if different strategies could be employed in which all or some of the proposed impacts might be avoided or minimized. Given the national goal of "no net loss," any remaining impacts must be compensated for by creating, restoring, or preserving wetlands or waters in another location (NRC 2001). This is termed *compensatory mitigation*.

With respect to compensatory mitigation, agency guidance documents and regulatory personnel have traditionally preferred nearby, in-kind mitigation to offset losses. However, recognizing the shortcomings of some permittee-responsible mitigation, federal and state agencies have developed policies for the use of alternative third-party strategies such as *mitigation banks* and *in-lieu fee programs* where mitigation is likely to be off-site (NRC 2001).

Mitigation banks are sites where a large restoration, creation, or enhancement project, is undertaken to provide compensatory mitigation in advance of projects that will create wetland losses.[4] Credits from these projects can be used to offset losses (debits) permitted under Section 404 on an acreage basis. Mitigation banks may be established by entities that anticipate having large numbers of future permit applications, or by third parties that wish to sell their credits for a profit. Although there is a formal process for establishing mitigation banks, some of the mitigation banks used by permittees with a large number of permits are only informal banks, having never been established through the formal process but nonetheless being used by the permittee and regulatory agencies as a bank. In-lieu fees are payments made to natural resource management entities for implementation of either specific or general wetland development projects.[5] Mitigation banks have the benefit of avoiding temporal losses of wetland habitat that occur between the time the actual loss occurs at the impact site and the point where complete function is restored at the mitigation site. In-lieu fee programs may or may not avoid temporal losses. Both of these third-party approaches have the potential to restore large areas of relatively high quality contiguous wetland habitat that may be better situated in a landscape context than individual mitigation projects, being placed in proximity to existing functional wetland habitat. However, banks and in-lieu fees often result in off-site mitigation, with potential negative effects due to spatial shifts in habitat distributions and loss of wetlands within some regions. In addition, the values wetlands provide often are dependent upon their location in the landscape, such as their position relative to one another, to adjacent waters, and to the human population that would benefit from the services provided (Brown and Lant 1999).

Most often, the amount of mitigation required is not a simple one-acre mitigated for one-acre lost ratio (NRC 2001). The additional acreage is intended to account for temporal losses and incomplete replacement of function. Therefore, mitigation ratios of 2:1, 3:1, or greater are sometimes required.

Every applicant for a 404 permit must also obtain a *state water quality certification* required under CWA Section 401, which, in California, is administered by the State Water Resources Control Board and its nine Regional Water Boards[6]. This document certifies that the project will not adversely impact water quality, or if it does, those impacts will be mitigated. In addition, if there will be impacts to river or stream courses, the applicant must enter into a *streambed alteration agreement* with the California Department of Fish and Game (DFG), and if impacts to threatened or endangered species may occur, a biological opinion will be issued from the United States Fish and Wildlife service; these regulations ensure that the project does not adversely impact the local fish and wildlife, or if it does, those impacts are mitigated. Other state or federal regulatory agencies may play a role as well. While each agency treats their mitigation requirements as separate and distinct, the applicant usually blends all agency requirements together into a single mitigation project.

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[4] Of course, there are many variations on this general description, a common variant being allowing credits from a mitigation bank before it is completed and demonstrated to be successful.

[5] In the past, in-lieu fees were not necessarily restricted to natural resource management, and as a result became a controversial form of mitigation. For example, in-lieu fees used for general administrative expenses at an agency do nothing to replace lost natural resources.

[6] The administration and implementation of CWA Section 401 varies from state to state; California is among those states with more developed 401 programs.

Some wetlands and riparian habitats are considered non-jurisdictional by the Corps and therefore are not regulated under CWA Sections 404 and 401. In California these habitats may be considered “waters of the State” and be regulated under the Porter-Cologne Act and other State laws, policies and regulations. In recent years the jurisdictional authority of the Corps has been reduced by several Supreme Court decisions; as a result, “waters of the State” determinations have become a more critical part of comprehensive wetland protection, with compensatory mitigation required for any regulated impacts to these state-regulated resources.

Aside from CWA Section 401, there are a number of means by which the State and Regional Boards regulate impacts to wetlands and other aquatic resources. Examples are the National Pollution Discharge Elimination System (NPDES) permits, which regulate point source discharges, Waste Discharge Requirement (WDR) permits, which can regulate both point source and non-point source pollutant discharges, and the best management practices (BMPs) required under their Storm Water permitting program. Storm water BMPs can include large detention basins and treatment wetlands that can provide substantial compensation for hydrological and biogeochemical impacts, but these are treated separately from other compensatory mitigation requirements associated with Section 401 permits. Waste Discharge Requirements, however, are often combined with the Section 401 requirements into a single joint permit. Through CWA Section 401, these other regulatory programs, and, more generally, through a series of Water Quality Control Plans (Basin Plans), the state and regional boards attempt to ensure that water quality standards (beneficial uses, water quality criteria, antidegradation policies) will be met.

2.5. Assessing mitigation success

After a permit is issued, monitoring of the mitigation site is almost always required; however, there is generally little regulatory follow up evaluating what happened at either the impact site or the mitigation site. This is, in part, because there are so few regulatory staff and so many permit applications (NRC 2001). Mitigation reports typically are required to be submitted by the permittee throughout the certification period, but it is not clear how often this is done or how often regulatory staff review them. In addition, record keeping has been identified as an impediment to assessing mitigation practices, with incomplete files and inadequate database tracking systems being a common regulatory problem (NRC 2001, Ambrose and Lee 2004).

Few determinations of the regulatory success of compensatory mitigation projects occurred during the first decade of their existence (NRC 2001). Determining mitigation compliance can be difficult. Assessing permit compliance entails an initial permit review and site visit to determine if the project was undertaken, if the actual acreage matched what was proposed, and if the specified performance standards were met. In planning and executing a compensatory mitigation project, the permittee’s focus usually is to satisfy permit conditions. As long as the permittee can demonstrate that the performance standards set forth in the permit have been met, their obligations have been fulfilled. As yet, aspects of wetland function have not been adequately incorporated in performance standards (NRC 2001, Ambrose and Lee 2004), in part because of the legal difficulties in assigning specific targets for function (NRC 2001). Some performance standards that have been developed are intended to be proxies for function, but given the challenges of measuring functions directly, assessments of hydrological, biogeochemical, and ecological function have remained elusive.

Data reported by the Army Corps of Engineers indicate that the goal of "no net loss," as measured by acreage shifts, is not only being met but is being exceeded. According to the Corps, from 1993 through 2000, approximately 24,000 acres of wetland losses were permitted, while 42,000 acres were created through compensatory mitigation (NRC 2001). Thus an average mitigation ratio of 1.8:1 was achieved. However, these statements of mitigation success and the achievement of "no net loss" were based solely on the acreage of mitigation *required in the permits*, not on field evaluations of wetland acreage or function present at mitigation sites. In addition, they may have not included existing acreage of wetlands at mitigation sites. Furthermore, they have not addressed functions provided at mitigation sites. One recent study that employed functional assessment methods to evaluate the success of the Section 404 permitting program, conservatively estimated that only 55% of mitigation sites met permit conditions, while only 16% of the sites could be considered successful in terms of function (Sudol and Ambrose 2002). Another study, Ambrose and Lee (2004), found that the majority of mitigation projects met their mitigation acreage requirements and most were in compliance with permit requirements overall, yet few (4%) resulted in optimally functioning wetlands and, with respect to a structured qualitative assessment of the beneficial services lost versus those gained through the mitigation project, 66% failed to achieve "no net loss." These data suggest that the success of the Clean Water Act and the "no net loss" policy has not succeeded in preserving our nation's remaining wetlands. It is impossible, however, to determine the extent of wetland losses that would have occurred in the absence of the Section 404 program.

3. Methods

3.1. Project Management

This statewide study was conducted by two research groups: a University of California, Los Angeles (UCLA) research group consisting of Dr. Richard Ambrose (principal investigator), two full-time research technicians, three shorter-term technicians, and one graduate student/project coordinator (Steven Lee), and a University of San Francisco (USF) research group consisting of Dr. John Callaway (principle investigator), three graduate student researchers working full-time and one shorter term technician.

The Principal Investigators maintained oversight over the entire project, including project conception and design and completing the final report. UCLA had primary responsibility for contract administration and project management, project coordination and management, the initial SWRCB database review, regional apportionment and selection of permit files for review, Freedom of Information Act (FOIA) coordination, and progress report generation. The permit review and field efforts for this project were roughly equally divided between the USF and UCLA groups, with USF responsible for the northern half of the state and UCLA the southern half. Considerable effort was spent ensuring consistency between USF and UCLA data collection procedures. Members of the UCLA group participated in the initial file review for the north-central portion of the

State and joined the USF group for a number of their field reconnaissance visits and site evaluations, and a member of the USF group participated in some site evaluations conducted by UCLA. After the fieldwork was completed, UCLA was responsible for data management, data analysis and presentation, and producing the initial draft of the final report. UCLA carried out most of the QA/QC procedures and, after finding a range of data and consistency problems, helped the USF group resolve these issues. The USF group incorporated the site GPS coordinates into GIS base maps to create regional and statewide maps showing the distribution of our mitigation site assessments. In addition, the USF group completed an analysis of mitigation banks (see Appendix 9) and a supplemental assessment of wetland condition (the Wetland Ecological Assessment, or WEA) at a subset of their sites and carried out all analyses and reporting of those data (see Appendix 10).

3.2. Permit File Selection and Review

For this study, our goal was to evaluate the mitigation actions associated with at least 100 Section 401 permit files issued in California between 1991 and 2002. The projects were to be distributed across the 12 regions and sub-regions of the State Water Resources Control Board (SWRCB) in proportion to the total number of 401 permit actions issued within each region (Figure 1). For instance, if a particular region had issued 10% of the total statewide 401 permits in this timeframe, then 10% of our evaluations occurred in that region. The regional targets were exceeded for all regions except for Redding (5R) and Lake Tahoe (6T), for which we met the targets exactly. For those regions with small proportional targets (Region 7 and sub-Regions 5F, 6T, and 6V), we attempted to add more files to increase the sample sizes, but this only was achieved for sub-Region 5F.

Files were selected using the SWRCB's permit tracking database. We used the version dated October, 2004, obtained directly from the State Board. To ensure statistically reliable information, projects were chosen randomly from this database. Initially, we expected to select all projects based on the database fields that indicated compensatory mitigation was required. However, we discovered that the database did not reliably indicate a compensatory mitigation requirement for permits issued before 1998; for these files, a physical inspection of a large number of files at the State Board office was necessary in order to find the appropriate number of projects requiring mitigation. To account for the difference in information in the database as well as ensure an equal distribution between older and more recent permits, half of the projects were from 1991-1998 and half were from 1998-2002. The permit projects included in our study included 401 permits with explicit mitigation conditions as well as permits without conditions but with implicit or explicit requirements that the mitigation conditions of other regulatory agencies be followed. The permit projects were reviewed through multiple visits to the SWRCB, each of the three Army Corps of Engineers district offices (Los Angeles, San Francisco, and Sacramento), and various Regional Boards. There were many complications that had to be resolved in selecting files for this study; a full accounting of the selection process is provided in Appendix 1.

3.3. Office Review and Assessment

After the initial permit review at the Corps and/or Regional Board offices, the relevant file materials were photocopied and retained for further review and for reference during field visits. Prior to the field visit, each file was subjected to an extensive office review to verify that the project occurred, to gain a general understanding of both the project impact and the expected mitigation activities, and to extract all relevant permit conditions for the ensuing compliance evaluation. To this end, all available documentation was consulted, including any pre-project planning information, the 401 order, 404 permit, streambed alteration agreement, mitigation plan, monitoring reports, and any other information reflecting changes in the planned actions since the permits were issued. Often, correspondence with regulatory personnel, the permittee, the permittee's consultant, or the in-lieu fee recipient was necessary to resolve site access issues, to determine if the impact or mitigation projects were undertaken, or to verify fee payments.

Office evaluations were a significant element of the condition assessment methodology (discussed below); the information gained from this evaluation improved the understanding of the landscape context of the site, including the surrounding land uses and the stressors associated with those land uses and helped to identify the boundaries of the assessment area. One important component of the office review was the acquisition of web based aerial photographs (http://terraserver.microsoft.com/), which provided landscape context and aided in the location of project sites.

As we performed the office reviews, some files were deemed un-assessable and were excluded from further study. Reasons for such exclusion varied but included confirmation that the impact and/or mitigation project never happened and denial of access to the project site.

3.4. Site Visits

Given the broad geographic scope of this statewide study, combined with the time limitation imposed by the contract and the protracted permit review process, logistics and efficiency were critical aspects of the field phase of the project. Early site visits and methodological refinements occurred close to the home bases of the two research groups; more distant sites were assessed later. Once the assessment procedures were established and the initial list of permit files was obtained, the project locations were marked on state and regional maps and organized into local or multi-day research trips based on the proximity and clustering of the sites. Substantial effort was put into planning field work to maximize efficient use of time in the field. Seasonal and other factors were considered, and the trip clusters were prioritized and scheduled. In advance of a trip, the relevant files were reviewed, the permit conditions extracted, data forms were generated, access issues were anticipated and pursued, and other logistical arrangements were made.

Upon arrival at the general project area or the mitigation site location, we looked for evidence of mitigation activities such as plantings, irrigation systems or disturbed earth to confirm the presence of mitigation activities. The permit paperwork and aerial photographs were helpful in establishing the presence of the mitigation site and determining its boundaries. For each of the fully assessed files, a considerable amount of time was spent onsite deciphering the language of the permit file paperwork to understand the nature of the impacts, to identify all discrete mitigation projects involved, to identify and map the boundaries of those discrete projects. Following regulatory conventions, a site was considered onsite if it was on the same property as the impact, and this determination was relative to the scale of the greater project area. For a large development project, two mitigation actions located a kilometer or more apart could both be considered onsite, while the mitigation site for a small utility crossing might be considered offsite even if separated by just 100m.

Occasionally, we found that the impact project was currently under construction and the mitigation activities had not yet been initiated, or there was no evidence that the impact or mitigation project occurred. It was also common, especially with the newer permits, that the impact project had occurred, but the construction of the mitigation site was still under way. There were a few instances where the impact project had been completed, but we found no evidence that the required mitigation had occurred. In each of these cases, the file was excluded from further consideration in this study. A list of all such files with the reasons for exclusion has been provided separately to the SWRCB. In addition to these excluded permit files, there were 14 files for which compliance evaluations could be made, but where wetland condition evaluations were not performed either because of ambiguities inherent in the mitigation banking and/or in-lieu fee process or for logistical reasons. These files, provided in Appendix 2, are included in our compliance results but not the results of our condition evaluations. We refer to these 14 files as "compliance only" files, while files that were evaluated for permit compliance, acreage, and wetland condition (CRAM) are referred to as "fully assessed" files.

3.5. Acreage Determinations using GPS

The acreages of mitigation sites were determined by mapping the perimeter of each site. After initial site reconnaissance, we walked the site perimeter using a mapping grade GPS to establish the outline of the site. GPS data were collected with a Trimble Pro XR GPS receiver and a TSCE handheld interface. Many permits (70 of the 129 permit files we assessed) involved multiple mitigation sites. In these cases, we surveyed and evaluated the discrete mitigation sites separately.

Although simple in concept, the actual acreage determinations were complex. The reasons for this are varied. In many permits, there were ambiguities in the identification of mitigation habitat types and no site positioning information. The boundary between mitigation wetlands and adjacent existing wetlands was often not easily discerned. Many mitigation project sites blended together several different habitat types (e.g., wetlands, alluvial scrub, riparian areas, etc.). In addition, multiple mitigation strategies were often used (e.g., creation, restoration, enhancement, and preservation) and were difficult to distinguish. Even where site boundaries could be determined, they were usually not clearly delineated as they transitioned into the surrounding landscape. GPS coordinates of mitigation sites were almost never available in the permit files, and stakes, flags or other survey markers were seldom present. We attempted to be as accurate as possible in our surveys of site perimeters, but we erred toward overestimation rather than underestimation of site area. That is, we walked the widest boundary possible as determined by disturbed earth, irrigation systems or obvious vegetation plantings to provide a "best case" acreage estimate.

We were sometimes unable to determine even the approximate boundaries of a mitigation site. (See Section 6.2.1.7 for a recommendation to address this problem.) This was common for older sites and for re-vegetation projects in active channels or floodplains. When the evidence of mitigation activities was scant or absent, and when these activities blended into the surrounding landscape, it was not possible to delineate the perimeter of the project site. We attempted to confirm the general location of the mitigation site from evidence of mitigation activities at the expected site location and/or through information gleaned from the permit files. If it was possible to confirm a general location for the mitigation site, a single GPS point was taken to identify the approximate location of the site and our corresponding evaluations.

After field mapping, GPS data were downloaded to office computers and managed using Trimble's Pathfinder Office Version 3.0 software. GPS data were differentially corrected (yielding sub-meter accuracy) using data collected from the base station provider nearest to the mitigation site, as determined by an automated internet search. The acreage values were obtained from the corrected files within Pathfinder Office. Occasionally small perimeter adjustments were made to these files or polygon fragments were added or subtracted using the measuring tool function in that program. Acreage values were recorded and compared to the permit requirements to determine acreage compliance. There may have been a number of discrete mitigation sites associated with a file, and these were mapped separately. However, permit requirements generally included only a single acreage requirement per file (or per habitat type), so we combined the acreages of separate mitigation sites to determine compliance.

In situations where the site perimeters were clear and unambiguous, we always reported our survey values as the obtained acreage. However, where the site perimeters were less clear, and especially where single GPS points were taken, a judgment had to be made to determine whether there was compliance with acreage requirements. In such cases, we considered all available information, including visible features of the site and information from the permit file such as acreage values reported in mitigation plans and monitoring reports, to judge whether the acreage requirement was met. Ultimately, a decision regarding acreage compliance was made for all files with acreage requirements. It should be noted that the target acreage outlined in the mitigation plan is intended to compensate for all agency requirements (including the Army Corps, and CA Dept. of Fish and Game), and often exceeds that required by the 401 permit alone.

For every file, a single representative GPS coordinate was selected and recorded in Pathfinder as the best description of the location of the mitigation sites (Appendix 4). Also included in this appendix is a compact disc containing all GPS-related computer files associated with this project.

3.6. Compliance Evaluations

In theory, permit compliance would be determined by considering each of the specific and general conditions listed in an agency's permit, assessing whether each condition had been met or not met, and then assigning an overall compliance score based on the percentage of conditions met. In practice, a third party assessment of permit compliance, especially one that attempts to follow the standard conventions of scientific rigor, is complicated by the idiosyncratic nature of regulatory permits in which each project is unique and there is little standardization in the wording of permit conditions.

Most of the conditions listed in 401 orders were administrative in nature or involved impact avoidance measures to be implemented during the construction phase of the impact and mitigation projects. This was especially true of the standard conditions that are often attached to the 401 order, but many of the special conditions fell into this category as well. Most of these conditions were impossible to assess in an after-the-fact review, such as the present study, because one would need to be present during the construction phase or have detailed post-construction compliance reports documenting how each condition had been satisfied. While compliance monitoring reports were often required, they were infrequently available.

Since the focus of this study was on the success of compensatory mitigation projects, the conditions we considered in our compliance evaluation were limited to those dictating the mitigation actions to be taken, any performance standards meant to ensure the success of the mitigation project, and any submission requirements for mitigation-related documents. The 401 permits we reviewed included relatively few conditions in these categories. The most commonly encountered were descriptions of the proposed mitigation actions and acreages, submission requirements, references to the mitigation plan or specific phraseology that the plan be followed, and conditions invoking the permit requirements of other regulatory agencies (e.g., the 404 permit issued by the U.S. Army Corps of Engineers, the Streambed Alteration Agreement issued by the California Department of Fish and Game (DFG), and occasionally, other agency requirements such as those specified in the U.S. Fish and Wildlife Service (FWS) Biological Opinion).

Our determinations of 401compliance included all mitigation conditions specifically outlined in the 401 permit order, plus any additional compliance goals or conditions found in the mitigation plan and other agency permits when the 401 permit included explicit statements requiring that those documents be followed. With respect to the mitigation plan, if the 401 permit contained a submission requirement or included language indicating that the plan had already been obtained and reviewed by the Regional Board prior to permit issuance, we considered it to be implied and enforceable that the plan be followed as a condition of the permit. We did not consider other agency requirements as implied and enforceable conditions of the 401 permit unless there was specific language mandating that those permits be followed. At the same time, we recognized that during the mitigation planning process, the permittee must consider all agency requirements (not just the 401), and that the mitigation plan represents a blending together of these conditions into a single project. Therefore, we completed a second compliance evaluation that considered how well the assessable goals and performance standards of the mitigation plan were met. In addition, in the field we assessed compliance with all agency conditions contained in the file, even for permits not explicitly invoked by the 401 order. Due to time limitations and the fact that these latter analyses were beyond the contractual scope of this project, they are not included in this report.

As part of our general office assessment, each permit file was subjected to a thorough review during which all appropriate mitigation requirements were extracted from the available paperwork. Beginning with the 401 order, each regulatory permit was carefully read to allow for a full understanding of the project requirements and to distinguish mitigation-related conditions from the other conditions of the permit. All relevant conditions were entered into a Microsoft Access database and tracked according to the source permit. Many of these conditions were entered verbatim, but it was often necessary to paraphrase or dissect the permit text because the permit requirements were written in an ambiguous fashion or not amenable to a direct assessment of compliance. (See Sections 6.3.2 and 6.3.3 for recommendations the deal with this issue.) For example, a single line-item condition including two or more discrete requirements that could not easily be assessed or scored together would be separated into assessable conditions. In other cases, long passages were condensed down to the essential compliance elements. All relevant mitigation-related conditions were entered, even conditions that would likely be un-assessable.

In addition to the regulatory permits, the mitigation plan, if present, was carefully read to extract the essential compliance elements. Though it may implicitly or explicitly be mandated that the mitigation plan be followed as a condition of the permit, there is no simple prescription for assessing mitigation plan compliance. Mitigation plans must be prepared and submitted by applicants in a format that has been dictated by the RWQCB and the Corps; however, they are highly variable in their presentation. Mitigation plans are not written as lists of assessable conditions; both permit-mandated and permittee-initiated objectives, actions, and success criteria are blended together and presented diffusely throughout the pages of the mitigation plan. (See Section 6.3.3 for a recommendation addressing this issue.) This complication required that we establish criteria for extracting discrete compliance elements from the mitigation plans. A full accounting of these conventions and lists of typical conditions extracted are presented in Appendix 6. All relevant objectives, actions, and success criteria taken from the mitigation plans were entered into our Access database and recorded as coming from the mitigation plan.

Prior to the field visit, lists of conditions by source were printed as data sheets and permit conditions were assessed for compliance through a combination of field and office assessments. There are at least two equally justifiable methods of assessing permit compliance. The first is to score each condition as either met or not met, and to calculate an overall compliance score as the percentage of conditions met. This approach is consistent with the regulatory perspective and has been used in other studies of mitigation compliance (e.g., Sudol 1996). The approach employed in this study departed from this met-not met perspective because we recognized that permittees may attempt to meet a particular condition even if they fall short of the success criterion needed to meet that condition to 100% satisfaction. In other words, a *not met* score does not allow the distinction between a permittee who obtained 95% of the required mitigation acreage and a permittee who made no mitigation attempts at all. Since our goal was to understand the critical factors influencing compliance success, we were interested in incorporating this distinction. Thus, we scored each condition as a percentage on a scale from 0% (no attempt to comply) to 100% (condition fully met).

In most cases, compliance was assessed within five scoring categories: 100%, 75%, 50%, 25%, and 0%. A 100% score was assigned if the condition had been clearly met or exceeded. The 75% scoring category was applied if the condition fell short of being fully met, but had been mostly met. If the condition was about half, or partially met, it received a 50% score. The 25% category was used if some level of compliance effort had been made, but the outcome fell far short of expectations, and the condition was mostly not met. Finally, a 0% score was assigned if there was clear evidence that the permittee made no effort to comply with the condition. These broad categories were used to distinguish different degrees of compliance with a particular condition but avoid difficulties that could arise from trying to distinguish between fine-scale categories (e.g., 85% versus 90% compliance).

For some conditions, the score could readily be calculated as a percentage relative to the desired outcome. For instance, if the target mitigation acreage was 0.75 acres but our surveys revealed that only 0.50 acres had been obtained, then the compliance score would be 67% (0.50/0.75). Acreage compliance was almost always calculated in this way. This approach was used for other variables that were continuous in nature (such as survivorship or percent cover), but only when our assessments could be made with a high degree of certainty. Otherwise, the condition was assessed using the above scoring categories. Some sites that we evaluated were only recently restored, and it would not be appropriate to evaluate these using final criteria in permits or mitigation plans. In these cases, we evaluated sites according to interim success standards that were identified in mitigation plans (e.g., 50% cover by year 3, 75% cover by year 5, etc.).

In scoring compliance, we were careful to distinguish between compliance with the explicit verbiage of the condition and the ecological outcome that the condition was directed towards. For example, if a condition required that “non-natives be removed prior to planting,” then as long as we found evidence that this task was done, the condition would be assigned a high score, even if the site was currently dominated by non-natives. However, if the condition required that “non-natives be eradicated from the site,” then a site dominated by non-natives would yield a low score.

A large number of mitigation conditions could not be assessed because there was not enough evidence to confirm or deny that a required action had been taken. In such cases, we had no choice but to score the condition as “not determinable.” These conditions were not included in our analyses of overall compliance score. Many of these conditions could not be assessed because one would have had to be present during project implementation or have access to detailed information verifying compliance. For example, it is commonly required that any non-native species be removed prior to restoration, stripped or exposed areas be hydroseeded with native grasses, and mulch applied around plantings. Sites rarely contain evidence of such activities a few years after construction, so without photo-documentation or written verification, none of these conditions can be assessed in an after-the-fact review such as the present study. A full accounting of the compliance issues we experienced, along with our resolutions and scoring conventions, is provided in Appendix 6.

3.7. Evaluations of Wetland Condition

3.7.1. California Rapid Assessment Method (CRAM)

Permit compliance alone may not guarantee that mitigation actions result in ecologically functional wetlands or riparian habitats. To evaluate existing wetland condition, we performed the California Rapid Assessment Method (CRAM; Collins et al. 2005) at all assessable compensatory mitigation sites associated with our permit files. CRAM is a semi-quantitative method for the rapid assessment of wetland and riparian condition. The following excerpts from the CRAM 3.0 manual (Collins et al. 2005), with some paraphrasing, provides the basic conceptual framework of this methodology:

> The objectives of CRAM development are to provide a rapid, scientifically defensible, and repeatable [assessment of wetland condition] that can be used routinely in wetland monitoring and assessment programs, [notably in the] evaluation of wetland restoration project performance under the Coastal Zone Management Act, Section 1600-1607 of the California Fish and Game Code, Sections 401 and 404 of the Clean Water Act, and local government wetland regulations, [and in the] assessment of restoration or mitigation progress relative to ambient conditions, reference conditions, and expected ecological trajectories.
>
> The CRAM methodology consists of scoring wetlands of any of several different classes based on four attributes: hydrology, biotic structure, physical structure, and buffer/landscape context. Within each of these attributes are a number of metrics that address more specific aspects of wetland condition. Each of the metrics is assigned a score based on either narrative or schematic descriptions of condition, or thresholds across continuous, numerical values. Scores assigned are aggregated up to the level of attributes as well as into a single, overall score. In addition to assessing wetland condition, CRAM provides the practitioner with guidelines for determining the types of stressors that may be affecting a given wetland, and may therefore help explain low condition scores.

To clarify terminology that is used throughout the report, we have adopted the use of the two key terms from CRAM methodology: *attributes* represent the four major areas that are evaluated in CRAM (hydrology, biotic structure, physical structure, and buffer/landscape context), whereas, *metrics* are the specific parameters that are scored in the field within a particular attribute. There may be anywhere from two to six metrics per attribute.

During our previous study of mitigation success (Ambrose and Lee 2004), we used an earlier version of CRAM (CRAM Version 2.0; Collins et al. 2004) to evaluate wetland condition at mitigation sites in SWRCB Region 4 (Los Angeles/Ventura). At the time of that study, CRAM was in an intermediate stage of development and some aspects of the method had not been resolved. We made a number of modifications to that version of CRAM to improve its utility for evaluating mitigation wetland sites, many of which were subsequently incorporated into CRAM. By the beginning of the present study, a new draft version of CRAM was available and ready for field calibration. Early in the project, the UCLA and USF research groups participated in a calibration meeting that included several field tests of the revised method. Issues identified during that calibration meeting were incorporated into the new version (Version 3.0, Collins et al. 2005), which was distributed to the CRAM calibration teams for further field testing. As we entered the fieldwork phase of this study, we began using CRAM 3.0 in our site evaluations. During the course of this study, a few additional modifications were proposed by members of the CRAM development team and an unofficial revision of CRAM (termed Version 3.5) was implemented. We adopted the proposed modifications and incorporated them into our remaining site evaluations; we also rescored all previous evaluations to ensure consistency among all mitigation site assessments. Subsequently, CRAM has continued to evolve with newer versions (see www.cramwetlands.org for more information on CRAM).

Despite changes to CRAM incorporated after our study for Regional Board 4, the delineation of the assessment area still required modification or adaptation. CRAM was designed to evaluate complete wetland systems, including larger estuarine or depressional wetland complexes or for riverine sites, the entire riparian zone consisting of the stream channel and the vegetation along both banks. However, mitigation sites are rarely complete wetland systems. For example, it was very common for riparian mitigation projects to occur outside the active channel and to involve plantings along only a single bank, or within an area above the bank that previously was upland habitat. While CRAM has rules for establishing the limits of the assessment area (including the appropriate reach length and the lateral limits of the riparian zone), our assessment areas had to conform to the boundaries of the mitigation sites. Thus, if the mitigation efforts occurred on a single bank, most of our ecological evaluations (such as plant cover) would be limited to that bank area alone. However, several aspects of the riverine CRAM evaluation were dependent upon the characteristics of the main stream channel. Specifically, the assessment criteria for all three hydrology metrics (water source, hydroperiod, and upland connection), two of the abiotic structure metrics (abiotic patch richness and topographic complexity), and two of the biotic structure metrics (biotic patch richness, and interspersion and zonation) were focused on channel and floodplain characteristics. If CRAM was applied strictly, assessment areas that did not include the stream channel would always score poorly for those metrics. However, we adopted the convention to consider the channel as part of the assessment area for these metrics, provided that the mitigation site was in direct proximity to, and hydrologically connected with, the stream channel. As a result of this approach, riparian mitigation sites or portions of sites that occurred high on channel banks, and were clearly not wetlands, received relatively higher scores for these metrics than they would have with a more strict application of the CRAM assessment area. While this may have inflated the CRAM scores for some mitigation sites, we adopted this convention to allow mitigation sites adjacent to a stream channel to be assessed as part of the entire riverine system, even if the mitigation action did not alter the channel. Furthermore, this was consistent with the approach used earlier by Ambrose and Lee (2004). Mitigation sites that were not directly associated with a channel, such as "riparian" plantings in upland areas above and beyond the banks, were scored using the standard definition of CRAM assessment areas since there was no clear connection to a channel; such sites received the lowest scores for channel-dependent metrics. Aside from this convention for including channel characteristics in the evaluation of riparian sites, all other aspects of CRAM related solely to the actual site of the mitigation actions.

For every file, we determined whether the permit requirements resulted in one or more mitigation projects that could be assessed appropriately using CRAM through our permit review, site reconnaissance, and compliance investigations. Restoration, creation, and enhancement projects that were post-construction and for which the initial vegetation efforts had been made were evaluated using CRAM. As a convention, we did not perform CRAM at any wetland preservation or conservation sites because there was no mitigation *action* to assess. Such files were evaluated for compliance only (e.g., payment of fees).

When a permit file contained a single discrete mitigation site, a single CRAM evaluation was made. Many files, however, included two or more distinct sites involving fundamentally different habitats or mitigation strategies. For example, the mitigation requirements of a given file might include a depressional wetland creation project and a riparian restoration project, or the file might include two separate "riparian" sites, one of which involved the reconfiguration and planting of a stream bank while the other involved "riparian" plantings in a separate location that was beyond the stream banks in an upland area. As another example, a file might involve mitigation bank payments for both tidal wetland and seasonal wetland credits. Separate CRAM evaluations were done for each of these distinct mitigation sites.

When an individual mitigation site was small and homogeneous, we assessed the entire site with a single CRAM evaluation. If the site was larger and more complex but a central location appeared to be representative of the entire site, we performed a single CRAM evaluation in the central location. However, there were many mitigation sites that were so large and/or complex that we needed to perform two or more CRAM evaluations in different locations in order to characterize the entire site. Decisions about how to subsample were dictated by the physical and biological features of the sites. For example, if a site consisted of a series of excavated wetland depressions occurring diffusely throughout the site or in groupings across the general mitigation project area, we would assign numbers to each of the depressions and randomly select two or more individual sites to evaluate. Alternatively, we would break the site into like groupings and randomly subsample one depression per grouping. As another example, for a long and complex stream/riparian system that was too extensive to integrate into a single CRAM evaluation, we might perform three separate evaluations, one at each end and one in the middle of the reach. Often, up to five or more evaluations were performed for a single mitigation site. In all cases where multiple CRAM assessments were made for a single mitigation site, the CRAM scores were averaged to arrive at a single CRAM per site.

One change that occurred between the earlier version of CRAM used in Ambrose and Lee (2004) and CRAM 3.0 was an increased emphasis on assessing the vegetation community at the site. The greater level of detail required for the identification of individual plant species and the determination of the relative percent cover for each species added considerable time to the field evaluations, demanded increased expertise regarding the statewide flora, and created complications in the assessment of the percent invasive plant species and native plant species richness metrics. The consistent identification of plants to a given taxonomic level was problematic for such a large study. We attempted to identify all plants to the species level; however, for some specimens, we were only able to reach the genus or family level. For specimens that could not be identified in our field visits across the state, we photographed or collected plant samples that could be later identified in the lab or with the assistance of local experts. Cover estimates for unidentified species were made in the field and placeholder names were replaced when samples were identified. Grasses were particularly challenging for identification, especially those that had senesced early in the year. Despite these challenges, we are confident that with respect to the relevant CRAM metrics, dominant species were correctly categorized as native or non-native.

We also had to adapt CRAM guidelines for the timing and seasonality of assessments. CRAM was designed to be performed during the growing season, which for different wetland types in different locations might occur at different times of the year. However, the timing of this project required that our field evaluations be made during the summer and early fall of 2005, when many annual plants had already senesced for the season. To reduce the effect of this off-season sampling, we departed from the written CRAM methodology and included senesced annual plants in our cover estimates. Such individuals were identified to species where possible, any unidentified individuals were combined into larger unidentified categories according to our best judgment of native/non-native status, and cover estimates were made. Although we tried to identify all species that would have been included if the site had been assessed during the growing season, some herbaceous plants undoubtedly had decomposed or were unrecognizable at the time of our site evaluations.

Ambrose and Lee (2004) had modified the previous version of CRAM by superimposing a numerical scale over the CRAM letter grades and developing algorithms for combining metric scores into scores for each of the four attributes plus a Total-CRAM score for the entire file. For CRAM 3.0, the CRAM development team opted against the 1-12 scoring scale used by Ambrose and Lee (2004) and adopted a modified system of letter grading instead. This system allowed for the application of “+” and “–“ designations to add refinement to the existing letter grades. For most metrics, which are scored on an A-D scale, this system is analogous to the 1-12 scale. However, a few of the CRAM metrics are limited to an A-C scale and one has been expanded to an A-E scale. The CRAM developers intend that these letter grades be combined into a single CRAM score, but a convention for doing so has not yet been developed. For our site evaluations, we followed the new protocol and scored the CRAM metrics as letter grades, adding + or – designations as appropriate. Once all CRAM data were finalized, entered and checked for quality control, we converted these letter grades to numerical scores for analysis. The majority of the metrics, which were on a D- through A+ range, were converted using a corresponding 1-12 scale. Metrics with a C- through A+ scale were converted using a 1-9 scale, and E- through A+ metrics were converted using a 1-15 scale. Details regarding our conversion conventions are provided in Appendix 7. To normalize these scores so they could be combined, the scores were converted to percentages (e.g., 9/12 = 75%) so that all metric scores would be on the consistent 0-100% scale.

CRAM scores were combined in three stages. First, a single score was determined for each metric. For mitigation sites with a single CRAM, no further adjustments were needed. For CRAM evaluations that were subsamples for a large or complex mitigation site, a mean metric score was calculated by averaging each of the separate metric scores. For example, if three depressional wetlands were randomly selected and assessed within a larger complex of depressions, then these would be averaged together at the metric level in order to arrive at a single set of CRAM scores for that mitigation site.

Next, the individual metric scores were combined by attribute (e.g., buffer/landscape context and hydrology) and then into a single CRAM score fore each mitigation site. For the hydrology and physical structure attributes, the metric scores were treated as equal and independent, so they were simply averaged. The buffer/landscape context and biotic structure metrics were more complicated and were treated differently. For biotic structure, the two plant community metrics (percent invasive plant species and native plant species richness) were clearly related to one another (high non-natives usually meant low natives). Therefore, before averaging with the rest of the biotic structure metrics, a geometric mean was calculated for these two scores. Within the landscape context category, the percent of the assessment area with buffer and the average width of buffer metrics jointly determined the general buffer extent, and these in combination with buffer condition, reflected the overall buffer quality. To clarify this point, it is possible to have a very high quality buffer that is adjacent to just a small portion of a site. Conversely, most of a site may have extensive buffer areas that are of very low quality. To account for the complex relationship among these three metrics, we first took the geometric mean of the percent of assessment area with buffer and the average width of buffer metrics to determine general buffer extent, then took the geometric mean of this result and buffer condition. Once we determined this overall buffer score, it was averaged with the remaining landscape context metric, connectivity, to determine the landscape context category score. The four attribute scores were averaged to obtain an overall Total-CRAM score.

Finally, a single CRAM score was calculated for each permit file. For files with a single mitigation site, the final CRAM score for the file was the same as the score for the site. For files with multiple mitigation sites, a final CRAM score was calculated using a weighted average of the scores for the individual mitigation sites. The individual CRAM scores were weighted by the area of the mitigation site. Weighting the CRAM scores by acreage prevented a small mitigation site from having a disproportionate effect on the score for the file. For example, if a file had a very small wetland creation site that received a high CRAM score and a very large wetland restoration site that received a marginal CRAM score, a simple average of these two CRAM scores would not reflect the combined wetland condition because of scale differences between the component sites. To account for this, we multiplied the individual CRAM scores by the proportional acreage of each mitigation site.

Determining the acreages for each mitigation site required a careful review of the permit files, which we accomplished after all sites had been assessed. There was no simple procedure for making the acreage determinations since the permit files are complex and each poses a unique set of circumstances concerning the component site acreages. In some cases these acreages were taken from our GPS data, sometimes they were obtained from the permit file paperwork, and sometimes both sources of information were used. As an example, suppose a file involved 1.0 acre of onsite riparian enhancement and a payment for 0.25 acres of vernal pool creation credits at a 10-acre mitigation bank. We might have used the GPS to delineate the boundaries of the riparian site and measured an area of 0.95 acres. We considered how confident we were in our GPS surveys before deciding whether to apply the expected or the measured acreage. If there was a very clear perimeter to the site and we had good satellite coverage, we would use the measured value; otherwise, we would use the expected value from the permit paperwork. For the mitigation bank, even if we had done a series of CRAM evaluations at the mitigation bank to represent the 10 acre site, and these were later combined for a single score for that site, we would still use only the 0.25 acres of credit for our acreage proportions because that was the fraction of the entire site that related to the permit file. Had we applied the expected riparian acreage from the permit file, then the total file acreage would be 1.25 acres, which would yield acreage proportions of 0.8 and 0.2 to be multiplied by the respective riparian and vernal pool CRAM scores. Using a similar procedure, we established the acreages associated with every mitigation site, which were then used to weight the CRAM scores for each mitigation site in order to calculate a single CRAM value for each permit file.

3.7.2. Reference Sites

As part of CRAM development, CRAM was to be calibrated through extensive sampling of a range of wetlands within each wetland class, including high quality reference sites. Without some calibration of wetlands in optimal condition, the appropriate target for judging mitigation sites was not clear. Performing CRAM at reference sites and viewing the resulting distribution of scores would help define the appropriate target range for mitigation success. To provide a sound foundation for evaluating mitigation sites in this study, we performed CRAM at a series of reference sites distributed throughout the state.

Before field sampling began, we carefully considered how reference wetlands would be used. It would have been useful to sample reference sites that were paired with impacts sites and could represent the condition of wetlands at impacted sites. Unfortunately, it was not possible to match impacted wetlands in this study. Instead, the reference sites are used to provide a context for the condition of the mitigation sites, rather than as a direct comparison to the condition of mitigation sites. We were aware of the problem of setting the bar very high for mitigation by choosing only pristine wetlands for our reference sites, and we explicitly did not search out the best possible wetland sites in the state as references. Instead we tried to identify reference sites of comparable condition to natural wetlands in the area**.** Our reference sites were relatively unimpacted by human activities compared to other wetlands in a region, but were not pristine. We generally avoided wetlands with distinct development (such as houses) in the watershed, but some reference sites certainly had been influenced by human activities. For example, in the southern Central Valley, there is essentially no portion of the lower valley floor that has not been modified in some way by human activities, yet this is where most of the permitted impacts occur and where most mitigation sites are located. These reference wetlands may be of slightly higher condition than wetland sites that were impacted, but that is not necessarily the case.

We needed to sample reference sites because CRAM had not yet been fully calibrated, so it was not clear what any particular value of CRAM meant compared to the condition of natural wetlands. The main use of the reference sites was to establish the cut-off between optimal and sub-optimal condition, which was set to include about 89% of the reference sites. This cut-off varied for the total CRAM score and the scores for each attribute and could not have been calculated with data from reference sites. Because our reference sites were **not** chosen to be the best available sites, these data do not necessarily represent optimally functioning wetlands; however, they do give an indication of ambient conditions of wetlands in the state. They also serve as a reasonable target for mitigation. In evaluating mitigation results we have been careful to identify that our comparisons are to reference wetlands and that the condition of these may be slightly different than the condition of wetlands that were impacted.

In general, we took an opportunistic approach to finding reference sites in the field, sampling reference sites that were close to mitigation sites as time allowed. Discussion with local agency staff, environmental consultants, or private citizens were helpful in identifying potential reference sites, but we also consulted maps or aerial photographs and conducted internet searches to identify wetland sites in preserves or other open space areas of limited human influence. The UCLA group sampled 22 reference sites throughout the state, including (see Collins et al. (2005) for definitions): 5 high gradient riverine, 11 low gradient riverine, 2 lacustrine, 2 vernal pool, 1 depressional, and 1 seep/spring wetland (Table 1). Three of these sites were in northern California, but most occurred in the southern half of the State. The USF group planned to sample a similar number of reference sites in the northern half of the State, but they were unable to do so because of time limitations. To provide data for reference sites in the northern half of the state, we used data from the CRAM calibration teams, who had completed much of their calibration field work by the end of the field season. Their calibration trials involved just two wetland classes: estuarine and riverine. The CRAM calibration evaluations were done for a wide range of wetland conditions, from high quality sites to lower quality sites. To select appropriate reference sites from this data set, we used the qualitative assessments of overall wetland condition made by the calibration teams to select sites that were relatively unimpacted by human activities. The CRAM calibration teams provided us with data for 7 estuarine sites and 18 riverine sites (Table 1), resulting in a total sample of 47 reference CRAM evaluations (Figure 2). All reference CRAM data were incorporated into our Access database, subjected to standard QA/QC procedures, and analyzed for comparison with our mitigation site data.

3.7.3. Wetland Ecological Assessment

In our previous mitigation study for SWRCB Region 4, Ambrose and Lee (2004) performed an alternative condition assessment methodology called the Wetland Ecological Assessment (WEA), developed by Breaux and Martindale (2003) to assess mitigation sites in Region 2. We performed a separate WEA assessment for every mitigation site evaluated in Region 4 to compare to the CRAM assessments. We found a strong correlation between the WEA scores and the corresponding CRAM scores, with WEA yielding slightly higher condition scores. In the present study, we decided not to repeat a WEA/CRAM comparison for the southern California sites, but the USF group performed WEA at their sites in northern California. The WEA evaluation is presented in Appendix 10.

3.8. Mitigation Habitats Analysis

Evaluating wetland condition at compensatory mitigation sites through CRAM provides some measure of mitigation success. However, taken alone, these assessments do not indicate whether the mitigation actions resulted in “no net loss” of wetland acreage and function. In order to understand “no net loss” of wetland functions, one would need to perform an assessment at the mitigation site before and after the mitigation actions were made to understand the true functional *gains*, and before/after evaluations of the impact site would be necessary to understand any functional *losses*. Indeed while some mitigation projects convert upland habitats to wetlands, most mitigation actions are undertaken at locations that already include some wetland acreage and exhibit some degree of wetland function. Clearly, before/after evaluations of wetland function are not possible in a study like this because the projects have already occurred.

In our previous study of mitigation success, Ambrose and Lee (2004) investigated this “no net loss” question by performing qualitative assessments of the beneficial wetland services gained through mitigation activities compared to what was lost through project impacts. We were unable to perform similar assessment in the present study. However, we were able to expand another aspect of the Ambrose and Lee (2004) study, the jurisdictional habitats evaluation, which allowed us to investigate “no net loss” with respect to acreage of individual types of wetland habitat.

3.8.1. Jurisdictional Habitat Assessment

While wetland delineations at proposed impact sites are a required step in the permit process, there is seldom a requirement that similar wetland delineations be performed at mitigation sites to ensure that adequate acreage of jurisdictional habitat is created, restored, or enhanced. (For a definition of these terms, see Section 6.3.4.) At each mitigation site we made a general assessment of the approximate proportions of jurisdictional and non-jurisdictional habitat types that would have been recorded had such wetland delineations been made. These general assessments were not intended to represent full legal wetland delineations at mitigations sites, which would have been much too time-consuming and were beyond the scope of this contract; rather, these assessments were meant to provide a rough estimate of the extent of different habitat types present. In these assessments, the first distinction we made was between the portion of the site that was within the ordinary high water mark of the water body, including adjacent wetlands (federal "waters"), and the remaining portion of the site. The non-"waters" area was apportioned into riparian habitats and upland habitats. The "waters of the U.S." area was apportioned into wetland habitats and non-wetland "waters." These jurisdictional habitat categories are listed in a hierarchical fashion in (Table 2).

Our wetland estimates did not conform to the three parameter test (hydrology, hydric soils, and hydrophytic vegetation) because we did not measure soil characteristics. For younger sites, we factored in the potential for future development of soils and plants, provided that the hydrology was appropriate. Therefore, our data likely represent a slight to moderate overestimate of jurisdictional wetland habitat, since some of these sites might not develop hydric soils. In most cases, the established site vegetation was used to delineate wetland perimeters. However, for sites with sparse vegetation, site topography and hydrological indicators aided our boundary determinations.

In both 401 and 404 permits, non-wetland "waters" are often, but inconsistently, described in more specific categorizations such as "streambed," "open water streambed," "unvegetated streambed" and "vegetated streambed" habitats, but are sometimes simply referred to by some other description such as "riparian waters." We followed this same approach in subdividing the non-wetland "waters" category, but in a hierarchical way that would enable grouping in an unambiguous way. Non-wetland "waters" categorized as "other" were almost exclusively those riparian "waters" habitats that were within the ordinary high water mark of the water body, but beyond the channel or adjacent wetlands. The clearest definition of "riparian" specifies those areas "…adjacent to perennial, intermittent, and ephemeral streams, lakes, and estuarine-marine shorelines" (NRC 2002). But in regular use, and in the permit files, there is substantial ambiguity in the application of "riparian," with reported impacts to "riparian waters" that may or may not include the channel itself. This ambiguity makes it difficult for us to compare our riparian "waters" category to those from the permit files.

3.8.2. Habitat Acreage Analysis

Many of the 401 permits that we analyzed were issued early in the regulatory process, before aspects of impact and mitigation planning were finalized. As we carried out the early phases of this project, we noticed that the impact acreage and mitigation requirements reflected in the 401 orders frequently did not agree with the impact, required, and obtained acreage that ultimately occurred through project implementation. This lack of agreement would be manifested in the SWRCB database as well, since those data are derived from the information in the 401 orders. To determine the extent of this difference between the 401 order and actual implementation, we conducted a formal comparison.

After all the fieldwork was completed, we performed another review of all "fully assessed" and "compliance only" files to extract the most accurate information available regarding acreage losses and gains. We considered all relevant information, including all regulatory permits, the mitigation plan, monitoring reports, correspondence reflecting planning adjustments, and the dates of all such documents. The final acreages for project impacts, permit requirements, and the “obtained” acreage values determined through our study were recorded. For the impact acreage data, permanent versus temporary impacts were distinguished. In addition, acreage data were further categorized into their respective jurisdictional habitat categories (see Table 2) to analyze the individual habitat types lost versus gained. As with the more general information mentioned above, the impact and required data were obtained through our acreage analysis permit review, and the values for each habitat type were classified as permanent or temporary impacts. The “obtained” acreage data for the site were either taken from the permit files or from our GPS surveys, depending upon which values were deemed the most accurate. As mentioned earlier, when the site perimeters were clear and unambiguous, the data from our GPS surveys would be used, but when the exact perimeter of the site could not be delineated, judgments were necessary to decide whether to accept the acreage value reported in the permit files. Once the appropriate mitigation site acreage value was determined, it was sub-divided into its component habitats multiplying it by the jurisdictional habitat proportion values from our jurisdictional habitat assessment. These data were further divided into created versus enhanced acreage to distinguish acreage *gains* from habitat enhancements. These steps provided us with a clear analysis of acreage losses and gains and facilitated a separate analysis comparing these data to the corresponding acreage data reported in 401 permits and in the SWRCB permit tracking database.

3.9. Digital Photographs

Digital photographs were taken at all of the mitigation sites. Our objective in taking these photos was to capture the essential features of the site at the time of our site visit. In many cases, only a few photos were necessary to accomplish this, while many photos were needed at other sites. It was difficult to cover some sites adequately because of the sheer size or complexity of the site. In addition to the general site photos, close up pictures of individual plants were taken for the purposes of subsequent identification, or for other reasons. The digital images were organized within computer folders labeled with the appropriate file identification number. All digital images are provided in Appendix 13 of this report, on DVD media.

3.10. Data Management and Analysis

All permit review, compliance, CRAM, and supplemental data were entered into a series of Microsoft Access databases developed for this project. The UCLA and USF groups maintained separate databases for their respective files, and these were later combined into a single version. The CRAM data were entered into a database obtained from the CRAM developers to ensure that the results of this study could feed back into the ongoing CRAM development process. As indicated earlier, CRAM version 3.0 was used, but with certain interim modifications implemented by the CRAM development team (unofficially termed version 3.5). Data extracted from queries of the Access databases were typically imported into Microsoft Excel for processing, graphed using SigmaPlot v.9.0, and statistical analyses performed in Systat v.11.

Most of the data analysis procedures have already been discussed in earlier portions of this Methods section. In general, the data in this report are organized and analyzed in two distinct ways: (1) by file, and (2) by individual mitigation site. As stated earlier, a number of permit files consisted of two or more discrete mitigation sites that could not appropriately be combined into a single evaluation. Thus, separate functional evaluations and habitat analyses were made for each of these sites to yield a total sample of 204 individual mitigation site evaluations for the 129 assessable permit files included in our study. Individual CRAM scores were combined into a single overall Total-CRAM score by factoring the proportional acreage of each respective mitigation site. The permit requirements transcended these individual mitigation actions, and thus, a single compliance evaluation was performed per file. Where necessary, the CRAM and "habitat" results are presented by mitigation site with a sample size of n=204. In other cases, such as comparisons between CRAM and compliance, they are given by file with a sample size of n=129. In other analyses, the compliance data from these 129 permit files are combined with the "compliance only" files (where no CRAM evaluation could be conducted but compliance could be assessed) resulting in a larger sample size of n=143.

3.11. Quality Assurance/Quality Control

The quality assurance and quality control (QA/QC) measures required for this project were uniquely complex. This was mainly due to the interface between our needs regarding scientific rigor and objectivity and the inherently non-scientific regulatory practices we are studying. While several previous studies have investigated wetland mitigation success, the geographic scope and multi-agency aspects of this study were without precedent, and much of our methodology had to be developed and adaptively managed as the project progressed. Timing limitations were a factor here since we had just a single field season to implement what was originally conceived as a three year study. Given the extensive decisions and interpretations that were required in this study, splitting the effort between the UCLA and USF research groups compounded the QA/QC challenges. For many ecological studies, the QA/QC procedures simply involve checking for mathematical and data entry mistakes by reviewing 10% or so of the data sheets and calculations. For this project, the QA/QC procedures spanned the entire effort, from the earliest aspects of our permit review to data analysis. Many of these procedures have already been discussed in the above portions of this Methods section, but several more specific aspects of our QA/QC are provided here.

Throughout the permit file selection process, we developed and refined a series of rules and conventions for determining which files to pursue and which to consider outside the scope of this mitigation study. After our list of prospective files was generated, we went back through the original source list to ensure consistency. After all files were reviewed and categorized, we made sure that our conventions for excluding files were consistent. Several files ended up being excluded because of an incorrect interpretation of the permit file paperwork.

The task of extracting the relevant mitigation compliance requirements from a permit file was exceedingly complex and difficult to standardize. While the permits usually follow a standard format, most permit conditions are not clearly delineated but are mentioned diffusely throughout the text of the permits, mitigation plans and other documents. Our rules and conventions for extracting these requirements evolved considerably throughout the course of the study. After the initial lists of conditions were developed and entered into the database, they were modified repeatedly as each permit file was subjected to subsequent reviews. In some cases, conditions that had been included were removed when we determined they were really procedural in nature or had to do with minimizing impacts during project implementation. In other cases, relevant conditions were added after they were missed in an earlier review, sometimes because they were in obscure portions of the file paperwork. Many permit conditions that were extracted verbatim were later divided when we determined they involved two or more distinct assessable conditions. The rules for scoring the permit conditions were also developed and refined throughout the course of this study and many site evaluations had been completed before the methods were finalized. Later in the project, after all data were collected, every condition of every file was reconsidered to ensure a consistent scoring approach.

Despite attempts in CRAM development to reduce decision-making in the field and to improve scientific defensibility, there remained instances where differences in interpretation could lead to differences in data collection. Our previous experience with CRAM (Ambrose and Lee 2004) helped reduce these interpretation and decision-making issues substantially, as did the early field trials with members of the CRAM development team. After all the CRAM data were collected, we went back through all of the data sheets for every file to ensure that we had followed a consistent approach in all the evaluations. Numerous changes were made through this process, most in relation to the vegetation data and for the physical and biotic patch types. The plant community data are particularly noteworthy, as many species identification and consolidation issues were resolved through this process. For example, it was mentioned earlier that grasses and senesced annual plants presented unique challenges in our CRAM assessments. Through our QA/QC of the CRAM data, we discovered that the UCLA and USF groups diverged in their approaches to these issues and in their level of taxonomic resolution. The UCLA group had taken a more general approach to grass identification and had not included senesced annual plants in their evaluation. To maintain consistency, they went back through their data sheets and used site photos and other information to increase their resolution regarding grasses and senesced annual plants. The current version of CRAM included a provision that + or - modifiers be added to each of the letter grades; however, no rules for this procedure had been developed. After all other CRAM issues were resolved, we revisited our scoring decisions for every metric of every file to ensure that these grade modifiers were applied consistently.

The outcome of the CRAM evaluation was profoundly influenced by the correct interpretation of the assessment area. As discussed earlier, the CRAM methodology was designed to assess complete wetland systems, and conventions had to be established regarding the application of CRAM for the evaluation of discrete mitigation sites. A considerable amount of time was spent ensuring that our project researchers understood these conventions. After the field season, the habitat acreage analysis forced us to go back through every file to carefully consider the actual acreage losses and gains that occurred through project implementation. One objective of this analysis was to assign a proportional acreage value to each CRAM evaluation within a particular file. During this procedure, numerous inconsistencies were discovered in the way our established CRAM conventions were applied. For example, a particular mitigation action might have involved restorative plantings on or above the stream banks, yet the channel itself was included in the assessment area. Alternatively, the CRAM evaluation for this project may have involved the correct mitigation site assessment area, but a second CRAM evaluation was done just for the channel. As we reconsidered these issues for every permit file, several changes were made, ranging from simple data adjustments to entire permit files being moved from the "fully assessed" category to the "compliance only" category or being excluded altogether.

Measures were also taken to ensure that the data for our habitats analysis were consistent throughout. Understanding how to apportion a particular mitigation site into its component habitat types required careful consideration of regulatory jurisdictions and wetland delineation. At least one member from each research group had received formal wetland delineation training. In order to ensure consistency in our evaluations, we had intensive internal discussions regarding the jurisdictional issues. Yet during the habitat acreage analysis that we performed after the field season, several inconsistencies were discovered in the jurisdictional habitat data. While some of these errors were related to the apportioning of individual habitat elements, most were caused by the same misinterpretations of assessment area that beset our CRAM evaluations. One consistent misinterpretation of particular relevance to this habitat assessment was the restricting of the assessment area to the *wetland* portion of the site. As a hypothetical example, if the permit requirements and mitigation planning documents indicated that a 1-acre wetland site would be created, then our assessments should include the mapped boundaries of that 1-acre creation site, even if only one half of that area was actually wetland. While the purpose of the jurisdictional habitat assessment was to address this specific issue, many sites had been erroneously delineated as 100% wetland, even though the entire 1-acre site had been mapped. As we went back through every file to review the CRAM assessment area issues, we also resolved these jurisdictional habitat inconsistencies and then carried out the remaining portions of the habitat acreage analyses.

After the field data collection phase was complete, the paper data sheets were scrutinized by the field team to ensure that all information was filled in correctly, consistently and legibly. Any calculated values (e.g., acreage or percentage calculations) were double-checked with a calculator, and then the data were entered. In order to reduce human error during data entry, the CRAM Access database was designed to only allow data entry in the appropriate format specific to that data table. For example, one electronic CRAM data form only allows the entry of letter grades A, B, C, D, etc. when entering data into this form. Each research group entered the data for their respective field evaluations.

Once all data were entered, all computer files were double-checked against the paper data sheets to ensure that no errors occurred. Initially, 10% of the files were randomly selected and all data from those files were reviewed for completeness and accuracy in data entry. Through this process, enough errors were detected to warrant checking 100% of the files. This involved checking the data in our Access database both visually and using queries to ensure that there were no duplicate entries, blanks, or improper values (e.g., data that were out of the allowed range), and that data were completely entered into all relevant tables. These QA/QC procedures extended beyond our Access database and included a thorough review of all data relating to our GPS surveys. The GPS data were treated separately from the remainder of the field data and were not included in the Access database. The QA/QC measures taken with respect to the GPS data include ensuring adequate satellite geometry, maintaining a PDOP value around 2.00, differentially correcting the data using the nearest base station provider, and keeping a record of all base stations used in the differential correction of all files. In the end, every datum from every field form was double-checked against the databases, and all mistakes discovered were corrected. We are confident that the resulting dataset is free from significant data management errors.

As mentioned above, ensuring consistency between the UCLA and USF research groups was challenging. Early in this project, both teams participated in a CRAM calibration meeting that involved field testing of the method to ensure user consistency. Then, to ensure that both groups were employing a consistent approach, a member of the USF team joined the UCLA group for the first round of mitigation site field visits, and the project coordinator from UCLA later joined the USF group for two separate weeks of field work at northern California sites. Extensive phone and email correspondence also helped in this regard. After the field season, both groups were responsible for the QA/QC of their respective permit files. Then, after the majority of the QA/QC procedures were completed, members of the UCLA group traveled to USF to help them finalize their remaining data tasks. During that visit, enough data errors and inconsistencies in approach were discovered to warrant a second round of QA/QC procedures between groups. Through this process, every USF file was subjected to a thorough re-review, which involved rechecking all aspects of the data for consistency, including the permit review, permit compliance, CRAM, habitat acreage analysis, and GPS data. Once all data modifications were complete, they were re-entered into the computer databases and all relevant files were checked one last time to make sure that every datum was correct.

4. Results

This section presents results for the four principal components of the study: (1) permit review, (2) permit compliance evaluation, (3) evaluation of wetland condition, and (4) habitat acreage analysis. A final section combines elements from the individual sections to provide a synthesis of some of the study's results.

4.1. Permit Review

As noted in the Methods section, we experienced numerous difficulties in selecting, identifying, and locating an adequate number of permit files distributed by region and year. The details of these complications are provided separately in Appendix 1.

Between 1991 and 2002, a total of 9,924 CWA Section 401 permit orders were generated by the 12 SWRCB regions and sub-regions. The greatest numbers of 401 permits were issued in Region 2 and sub-Region 5S, followed by Regions 4, 9, 3, 8, and 1 (Figure 1). Our initial goal was to assess at least 100 permit files across the state, apportioned by region according to the percentage of the total state 401 orders that each region had issued. The percentage values displayed in Figure 1 reflect the proportions of files issued within each region; these regional proportions were used to calculate the target number of files to be assessed by region, given our initial goal of 100 assessed files. In the end, we assessed 143 permit files (Table 3). Narrative descriptions of each assessed project are provided in Appendix 12. Of these, 129 were fully assessed for compliance, habitat acreage and condition, while 14 were assessed for compliance only (e.g., fees paid). In addition, we identified 13 permit files with either clear compliance shortcomings (i.e., impacts occurred but mitigation project was never undertaken), or expected shortcomings suggested by denials of site access. A list of these files has been provided to the State Board.

Of the 429 permit files randomly selected and pursued at either the Corps or Regional Board offices, a large percentage (40%) could not be positively identified in the agency databases or located in the file archives (Table 3). Many files that *were* located (104 files) were excluded after further review because they did not have assessable mitigation projects. We had difficulties finding assessable files in all regions, but particularly in Region 9, Region 7, and the two sub-regions of Region 6 (the reasons for this are discussed in Appendix 1). Files that were potentially assessable but were not assessed for lack of time are included in this table for completeness, as are two multi-regional files that had been issued directly by the State Board.[7]

Mitigation sites were more heavily concentrated in portions of the state with greater development pressure over the past 10-15 years (Figure 3), particularly the San Francisco Bay area, north of Los Angeles, Orange County, and San Diego. Several sites, especially those in the Central Valley (Region 5) involved a collection of shared mitigation banks, so there are fewer than 129 mitigation points on the map. Most regions had some "compliance only" files (Figure 4), with no particular pattern among regions except Region 4 having a somewhat larger number than the other regions. Surprisingly, the projects regulated by the various Regional Board offices (see regional tallies in Table 3) did not always fall within the boundaries of those regions. For example several of the 401 permits located in the southern portion of sub-Region 5R were issued by the Sacramento office (5S); two in the southern portion of sub-Region 5S were issued by the Fresno (5F) office and the San Francisco office (Region 2) permitted some of the projects within areas designated as Region 1. Alternatively, the perimeters of the regions and sub-regions, as indicated by the SWRCB GIS base maps, might not reflect their true jurisdictional boundaries. For the purposes of this study and our respective analyses, such permit files remained associated with the issuing regional office.

The 143 assessed permit files involved 204 distinct mitigation sites or actions (Table 4). Of these, 62% (127 sites) were within or immediately adjacent to the greater project boundaries (onsite), while the remaining 38% (77 sites) were offsite. There was no obvious geographic pattern to the offsite mitigation sites (Figure 5). While the majority of permit files involved permittee-responsible mitigation linked to specific permits files (hereafter termed file-specific mitigation), others involved third-party

[7] These two files were obtained inadvertently since multi-regional projects were not part of our file selection/regional apportioning methodology. Even though the files were potentially assessable, the files were excluded from our study because they were not selected in accordance with our selection protocol.

mitigation strategies such as mitigation banks or in-lieu fee payments, or informal, permittee-controlled mitigation banks which were used by those permittees for multiple permit actions. Some mitigation projects included both onsite file-specific mitigation and offsite payments for mitigation bank credits. In total, about 75% of the mitigation actions were file-specific, while the remaining 25% purchased or applied acreage credits at some larger restoration, creation, or preservation site. Of these latter actions, 30% involved the application of acreage credits within informal permittee-controlled mitigation banks. For the remaining 70%, a third-party approach was employed that included credit purchases at formal mitigation banks or in-lieu fee programs. Payments for acreage at formal mitigation banks recognized by the Corps and/or FWS made up the majority of these credit purchases, while three mitigation actions involved in-lieu fee payments to invasive species eradication programs. While several regions applied such strategies, the use of mitigation banks was especially prevalent in Region 5 (Figure 5). Of the 24 fully assessed files in Region 5S, 17 involved credit purchases at five mitigation banks. One of these mitigation banks was used by 13 files. Further details on mitigation bank projects are given in Appendix 9.

The files we assessed included both older and newer mitigation projects (Figure 6). The number of 401 orders issued by the SWRCB gradually increased from 1991 to 1998, declined through 2000, and then increased again through 2002. We had initially selected a roughly even distribution of files throughout the years, except for the early years prior to 1995 for which fewer 401 orders were issued. The distribution of assessed files roughly followed the distribution of certifications, but with disproportionately more 1996-1998 and 2000 files, and disproportionately fewer 1992 through 1995 and 2002 files. We did not assess any files with 401 orders issued in 1991, which is not unexpected given the low number of files available from that year. As is discussed in Appendix 1, we had a difficult time obtaining assessable files from the earlier years (1991-1994) due to the prevalence of unconditioned waivers issued during that period. For these 401 actions, the compensatory mitigation requirements of other regulatory agencies were often explicitly or implicitly invoked by the Regional Boards, but such requirements were not clearly indicated in the 401 certification orders, or in the SWRCB database. It is not clear why our sample included so many 1997 and 2000 permit files; for some unexplained reason, files from these years were more easily located and more frequently contained assessable mitigation projects. The reason that proportionally few 2002 files were included might be because many mitigation projects had not yet been undertaken.

Nearly half (46%) of the 143 files we assessed represented permits given to developers (Figure 7). Municipal permits comprised almost a quarter of the files (24%). The California Department of Transportation (Caltrans), industry, private, and state/federal agencies each comprised 6-9% of the total number of files. Caltrans was distinguished from other state and federal permittees because of the large number of permits they received and the uniformity in the types of projects involved (mostly bridge crossings).

In the following paragraphs we provide an analysis of assessed files by habitat type, impact type (permanent or temporary), and several aspects of the impact and required mitigation acreage. The data used in this analysis are not simple extractions of 401 permit information taken directly from the SWRCB database or the 401 permits. Instead, they were derived from detailed reviews of all project-related information found in the permit files, including the 401 permit, the 404 permit and other agency permits, all mitigation planning documentation, and post-construction monitoring reports. Taken together, this information provided us with the most complete picture possible of the “as built” impacts and mitigations that occurred under the 401 program. During our permit reviews we discovered that the information obtained in this way frequently differed from the corresponding information taken directly from the 401 permits or the SWRCB’s permit tracking database. Through a specific analysis performed to understand the nature of these discrepancies, we found that the source of the differences ranged from simple data management issues to more substantive issues of potential regulatory concern. The results of that analysis are presented below, near the end this section.

Wetlands were the habitat type impacted by the most files (Figure 8), although there were substantial impacts to habitats classified as “riparian” and “streambed,” as well as combinations of these three. A few files had impacts to non-streambed open “waters,” such as, lake and ocean habitats. Some files reported impacts to a single habitat type while others impacted multiple habitat types. For several files, the impacts were not well specified. Some of these listed impacts to unspecified “waters of the U.S.” while others did not provide any specificity for the impacts.

For the overall acreage impacted and required, data from the files were consolidated and displayed by logarithmic size categories as appropriate for the wide range of acreages involved (Figure 9). These figures show that most files involved impact and/or required acreage values in either the 0.1 to 1 acre range or in the 1-10 acre range. However, a substantial number of files had acreages in the 0.01 to 0.1 acre range and, overall, the acreages involved ranged from 0.002 to 60 acres. The total acreage impacted and required for these 143 projects, as determined by our detailed file review, were 216.8 and 445.2 acres, respectively. Permanent impacts, totaling 166 acres, far outweighed the 51 acres of temporary impacts (Figure 10).

In most years, more acres were required for mitigation than were allowed to be impacted (Figure 11). Ten percent of the projects (14) had fewer acres required for mitigation than were allowed to be impacted. The overall mitigation ratios were particularly large in 1996, 2000, and 2002. When the required mitigation ratios were calculated on an individual project basis and averaged by year, there also was no consistent temporal pattern in mitigation ratios through the years (Figure 12). The higher mean mitigation ratio in 1994, 2000, and 2002 were largely due to single files in each of these years with relatively large ratios (23:1, 70:1, and 123:1, respectively).

The Regions differed in the amount of impacts and mitigation included in the permits we reviewed. Among the well represented regions (those with greater numbers of file assessments), the combined acreages of impact were relatively high in Regions 2, 4, 5S and 8 (Figure 13). Among the well represented regions, Regions 2, 5S, and 8 required the highest cumulative mitigation acreage (summed across all project files); Region 7 also required a relatively large amount of cumulative mitigation acreage, though it was represented by few permits. Among these regions with relatively high cumulative mitigation acreage, Regions 2, 5S and 7 had relatively low cumulative acreage of impacts. In addition to cumulative acreage summed across all project files, we examined the average impact and mitigation acreage per file. The mean mitigation ratios required for these projects also varied across regions (Figure 14). Regions 2 and 4 had the highest mean ratios, but the large standard errors for these regions reflect a great deal of variability amongst projects in these regions.

The results for Region 7 (Figure 13) are notable in that the disproportionately high amount of impact and mitigation acreage occurred through just three permit files. This was primarily due to a large restoration project initiated by the United States Fish and Wildlife Service, wherein twenty acres of wetlands adjacent to the Colorado River were to be dredged to form a deepwater lake. The mitigation for this project was to include 40 acres restoration (invasive removal and riparian plantings around the lake), plus the lake conversion itself (20 acres). Although it was discussed in the 401 permit, the wetland acreage lost was not specified as impacts by the Regional Board and was thus not included in the SWRCB database. Even though there was no impact acreage listed, the permit (and database) included the 20-acre lake conversion as compensatory mitigation. The 40 acres of required restoration were not recorded as compensatory mitigation in the permit or database.

4.1.1. Discrepancies between file information and SWRCB database

As indicated above, we discovered numerous discrepancies between the information obtained through our detailed file reviews and the corresponding information found in the 401 permits and the SWRCB database. Two examples illustrate such discrepancies: (1) for approximately 25 files, the database indicated wetland or streambed impacts that either did not occur or occurred in combination with other habitat impacts that were not recorded in the database; (2) according to the database, the selected files involved a little over 2 acres of temporary impacts, while we determined that, in fact, there were over 50 acres temporarily impacted. In addition, there were approximately 34 fewer acres of permanent impacts than reflected in the database. Data entry errors at least partially influenced these results. In the SWRCB database, there are data entry fields for habitat impacts (e.g., “Wetland,” “Riparian,” etc.), and temporary impacts (e.g., “WTEMP,” RTEMP,” etc.). According to the written conventions of the SWRCB, the former data fields are to be analogous to “total impacts,” and the latter fields are supposed to include the subset of the total impacts that are temporary. In practice, the ambiguity that is inherent in these data entry labels has led to substantial inconsistency in data entry. While we did not do a file by file analysis of this issue, our file information reviews identified numerous examples where the permanent and temporary acreage data were entered separately such that the sum of these data fields would equal the total impact acreage.

There were considerable differences between the impact and required acreage values reflected in the database and the corresponding acreages that were ultimately involved. According to the SWRCB database the total acreage impacted and required for these 143 permit files was 198.9 and 241.0 acres respectively, while the corresponding values reported above were 216.8 and 445.2. Several files for which zero impacts were indicated did involve clear impacts. To understand how these differences varied among the files, we subtracted both impacted and required acreage values obtained through our detailed file review from the corresponding database values and plotted the resulting distributions (Figure 15). Of the 143 projects, approximately 48% (68 projects) had impact acreage differences between our file review and database. Twenty-one percent had fewer impacts indicated in the files than the database and 27% had greater impacts. The differences for most projects were below 1 acre, but the differences exceeded 1 acre for 10 projects. For required acreage, 63% (90 projects) had differences between the file review and database. For 53% percent of the projects (76 projects), information in the file indicated that more mitigation acreage was required than was indicated in the SWRCB database, while less acreage was required for 10% of the projects. For most of the projects, the discrepancy in acreage requirements was less than 1 acre. The discrepancies exceeded 1 acre for 31 projects.

In order to understand the nature and source of these variations, a comprehensive acreage discrepancy analysis was performed. Every file for which our reported impact and/or required mitigation acreage differed from the database values was thoroughly reviewed. Impact and mitigation acreage data were extracted from each document in the file, including the 401 permit, 404 permit, streambed alteration agreement, biological opinion, and mitigation plan, plus monitoring reports and correspondence. The relevant dates were noted and the text of each document was read, in detail, for context. Based on the review, the final impact and mitigation acreage values were confirmed (our reported values), and a brief narrative was written for each file to explain the source of the discrepancy. Then the files were categorized according to the type of discrepancy. Files commonly contained two or more discrepancy categories.

The complete results of this acreage discrepancy analysis, including narratives, are provided in Appendix 3. The main findings are summarized in Table 5. Among the 143 randomly selected 401 permit files, discrepancies between our reported values and the SWRCB database values occurred in 101 files (71%). For 9 files (6.2%), the discrepancies were due to simple rounding issues and were inconsequential. For 26 files (18.2%), the discrepancies were caused by data entry or interpretation errors when the 401 permit information was entered into the SWRCB database. Data interpretation errors were usually the result of unclear permit language and the lack of unambiguous acreage fields; other data entry errors included inputted values that were incorrect by a factor of 10 (e.g., 0.07 acres instead of 0.7 acres). While database entry issues are troublesome, it is the content of the 401 orders that the Regional Boards rely on for compliance considerations. In comparing our results to the information extracted directly from the 401 orders, discrepancies were still found for 60% of the files (86 files). For 19 files (13.4%), another regulatory agency simply required more mitigation acreage than the Regional Board, and we reported this greater acreage; these discrepancies are not errors, but simply reflect differences among agencies. These above categories amount to relatively minor quality assurance and quality control (QA/QC) issues.

For 27 files (18.9%), the discrepancy was due to an accounting difference. For example, the Regional Board may have only considered wetland or permanent impacts while the project included impacts to non-wetland “waters” and temporary impacts, respectively. For 24 files (16.8%), the information in the 401 orders contained transcription, typographical, or interpretation errors indicating impact or mitigation acreage values that were clearly different from the planning documents available prior to 401 issuance. Both of these categories reflect inconsistencies in the writing of 401 permits and indicate that under the 401 program, the SWRCB may not always be regulating the full suite of jurisdictional impacts that are occurring. The extent to which these inconsistencies are understood and intentional is not known.

Legally, it is the 401 permit, as written, that defines the requirements of the SWRCB and the permittee must comply with the terms of that permit. In practice, changes regularly occur following the issuance of the 401 permit, and we observed that the 401 permits did not always reflect the most current information regarding the project impacts and mitigation. Substantive changes in project planning or implementation that occurred after the 401 was issued resulted in discrepancies in 40 (30%) of the files. For 12 of these files (8.4% overall), the impacts were not altered but there were changes in the context or acreage of the mitigation project. For five of these files, another agency approved modifications that resulted in greater mitigation acreage, but for the other seven, the approved changes resulted in lower acreage or a fundamentally different mitigation strategy (e.g., offsite purchase vs. onsite creation; riparian enhancement vs. wetland creation). Reductions in the amount of mitigation required or substantive changes in the mitigation approach would seem of regulatory concern to the SWRCB. The other 28 files involved changes in impact acreage. For three of these files (2.1%), the project impacts were reduced after the 401 was issued but the mitigation stayed the same. For another 13 files (9.1%), lower impacts were accompanied by a change in mitigation required by other agencies. Of these latter files, most had lower mitigation acreage than required in the 401 permit as a result of decreased impacts. However, at least two files contained a fundamentally different mitigation strategy. If the mitigation acreage undertaken was lower than that specified in the 401 permit, then this could be of concern to the SWRCB, but if the lower mitigation was the result of impact avoidance understood and approved by other regulatory agencies, then such departures from the written 401 requirements might be judged less important. For the remaining 12 files (8.4%) out of the 28 files involving changes in impact acreage, changes during project planning or implementation resulted in greater impacts than reflected in the 401 permits and SWRCB database. An increase in the area of impact would seem of regulatory concern to the SWRCB.

In all cases where the 401 permit information did not reflect later impact and/or mitigation adjustments, the planning modifications were approved by another regulatory agency (i.e., Corps, Fish and Game, or Fish and Wildlife Service). For most projects, we could find no evidence that the Regional Board was consulted or copied on the modifications; while one or more of the other agencies were regularly addressed on correspondence, listed on the documents as responsible parties, or included in copy-to lists, the Regional Board seemed to be largely omitted from the decision-making process after the initial 401 review. Note that our review was often based on files from the Corps rather than Regional Board files, so we might not have seen some correspondence. However, the Regional Board should nonetheless have been named on copy-to lists and other documents. These examples indicate that communication between the Regional

Board and the permittees, consultants and other agency staffs involved in ongoing project planning and implementation occurring after 401 issuance could be improved.

Of the 40 files which had substantive changes after the 401 was issued, the Regional Board *was* copied on the changes for only a few. However, these notifications did not result in modified 401 orders. When modified 401 orders are created, they supersede the original order, and the SWRCB database is to be updated with the revised impact and mitigation acreage information (also, the term "CERTMOD" is to be included in the notes field). We have found that this database updating is regularly done correctly. However, through the acreage discrepancy analysis, we found that for 7 of the 143 randomly chosen permit files (5%, or 17.5% of the 40 files we reviewed that had changes after the initial 401 certification), the information from these revised certification orders (dates, acreages, etc.) was erroneously recorded redundantly in the database as separate records.

The sources of the acreage discrepancies we found fall into three broad categories: (1) data management and QA/QC issues; (2) inconsistencies in the writing of 401 permits; and (3) deficiencies in communication and follow-up after 401 issuance. Discrepancies falling into the first group, while notable, do not raise substantive regulatory/compliance concerns, while those from the other groupings may or may not raise regulatory concerns. To understand the extent of the regulatory/compliance issues indicated by the discrepancies, we performed a specific analysis considering the context and nature of the discrepancies for every file, judging whether they represented a substantive regulatory/compliance concern for the RWQCB/SWRCB. If the source of the discrepancy was limited to (1) a minor rounding error, (2) a database entry error, (3) another agency requiring greater mitigation acreage, or (4) reduced impacts with either no change in mitigation acreage or increased mitigation, then the discrepancy was not deemed a regulatory/compliance concern. However, if the source of the discrepancy fell within any of the other categories of Table 5, then the project was deemed of regulatory/compliance concern. The guiding principle that we employed here was whether the 401 order would have differed if the 401 manager had (1) seen, correctly interpreted, and correctly transcribed all the impact and mitigation information we found through our file review, and (2) employed an approach consistent to that of other managers regarding the accounting of temporary versus permanent impacts and wetland versus non-wetland "waters" impacts. Through this analysis, we judged that there *was* a regulatory issue for 60 files (42%). While some of these files involved transcription, interpretation, or accounting issues involving information available prior to 401 issuance, the discrepancies for 38 files were caused by 401 permits that did not reflect planning and/or implementation changes that occurred after 401 issuance. This highlights an important fact: because the Corps requires proof of 401 certification (or waiver) prior to issuing the 404 permit, permittees seek their 401 certification early in the regulatory process before some avoidance and minimization of wetland impacts occurred and before the mitigation planning is finalized. In such cases, communication and follow-up between the Regional Board and permittees, consultants and other agency staffs is essential if the project changes, and our results indicate that it often was insufficient. When the 401 order is issued based on preliminary planning information, the order (and the corresponding database information) could become outdated unless the Regional

Board maintains an active role in the remaining aspects of regulatory planning and modifies the 401 certification if necessary. Our definition of “regulatory/compliance concern” assumes that the SWRCB would wish to regulate and track all wetland and riparian impacts (permanent and temporary) that occur within its jurisdiction. The permit files we documented with impacts exceeding those approved by the 401 permit would surely be of concern to the SWRCB; some of the other cases may be less important because, ultimately, it is the text of the 401 permit that the permittee must comply with in order to remain in compliance with the terms of the permit.

4.2. Status of Regulatory Compliance of Compensatory Mitigation Sites

Thirteen of the 257 permits we located had to be excluded because of potential compliance issues. This indicates that up to 5% of the files we reviewed may have significant compliance problems (such as the impact occurring but no mitigation being undertaken).

For the files we were able to evaluate, the majority met most of their permit requirements (Figure 16), although fewer met all conditions to 100% satisfaction. Of the 143 assessed permit files, 19 did not have any assessable 401 conditions (the 401 permit could not be located for 13 of these, although enough information was available from the Corps to locate and assess the site; whether these would have had assessable conditions is not known). For the remaining 124 files, the average 401 compliance score was 84% (Table 6). As described in detail in the methods, the average 401 compliance score (hereafter, average 401 score) was calculated as the mean of the compliance scores for all of the permit conditions; the potential scores for each of these conditions ranged from 0 to 100%. Almost half (46%) of the files achieved perfect (100%) average 401 scores, indicating that they were in full compliance with all 401conditions; 57% had an overall score of 90% or greater, and 77% had average 401 scores of 75% or more. Three files received average 401 scores of zero.

Compliance was also assessed by determining the percentage of permit conditions that were met completely (100% score) for a particular file (hereafter, average 401 percent-met score). This approach to measuring compliance is more consistent with regulatory evaluations, even though it is a more stringent standard, with no credit for partially meeting permit conditions. According to this approach, on average 73% of a file’s 401 permit conditions were fully complied with (Table 6). Forty-eight percent of the files fully met more than 90% of their conditions, and 57% completely complied with at least 75% of their conditions (Figure 16). Seven files did not meet any of their conditions to 100% satisfaction.

Characterizing these files in terms of success or failure for compliance is not straightforward. For some files, the 401 requirements may have involved a single mitigation condition, such as an acreage requirement. Other files might have multiple conditions, including highly specific planting requirements and performance standards if the 401 permit had included a condition to follow the mitigation plan. There is no simple prescription for determining which aspects of the mitigation plan to include as assessable conditions; these documents are not organized in a way that makes this tractable. The “conditions” extracted from these plans were often difficult to assess. Moreover, the complexity of some conditions meant that 100% compliance might not be realistic. Nonetheless, we did use the 100% criterion as the standard against which files should be judged and concluded files were in full compliance only if all conditions were completely met. We placed near-misses in the 75% (mostly met) scoring category; therefore, we defined the lower limit of this category as the cutoff for “success.” Likewise the cutoff for “failure” was defined by the upper limit of our 25% (mostly not met) scoring category. Given this convention, 76% of the permit files were considered successful according to the average 401 score and 4% were considered failures (Table 6). The remaining 20% were partially successful. According to the average 401 percent-met score, 57% were successful, 30% were partially successful, and 13% were failures. Although a simple success/failure evaluation is not as informative as the numeric evaluations given in the previous paragraphs, we made success determinations to facilitate a simple summary of the compliance results.

Although compliance with mitigation plans was included in the 401 compliance assessment if the mitigation plan was invoked (directly or indirectly) by the 401 permit, we also conducted a separate compliance evaluation for mitigation plans, since they can be viewed as a proxy for all agency requirements for file-specific mitigation projects. The majority of projects (57%, or 81 of the 143 permit files) contained mitigation plans. Mitigation plans were not included in the remaining files for a variety of reasons. For some files, plans were not required (e.g., mitigation bank credits purchased); for others, the plan was not in the agency’s file, presumably because it was misplaced or never submitted. Of the mitigation plans that were reviewed, some were relatively simple documents that described the general mitigation strategies; 16% of the 81 files had fewer than five conditions. The majority (84%) of the mitigation plans were detailed documents containing implementation plans and mitigation goals from which we extracted more than five conditions. The mitigation plan conditions for most (63%) files (44 of the 70 files for which we had conditions from both 401 permits and mitigations plans) had been invoked by the 401 permit and were included in the above 401 compliance evaluation. The mitigation plan conditions for the remaining 37 files are unique to this analysis.

The average mitigation plan scores for these 81 files was 81% (Table 6, Figure 17) compared to 84% for the 401 compliance scores for the total sample of 124 files (Figure 16). However, only 16% of the files had perfect scores (all conditions 100% met) and only 22% had scores of 90% or higher for the mitigation plans compared to 46% perfect scores and 42% with scores of 90% or greater for the 401 permits. Of the 81 files with mitigation plans, 68% were considered successful for mitigation plan compliance based on their compliance scores, 32% were partially successful, and none were considered failures (Table 6). Using the percent-met scores, on average 68% of a file’s mitigation plan requirements were fully complied with. Forty-eight percent of the files were successful based on their percent-met scores, 35% were partially successful, and 6% were failures (Table 6).

Files scored significantly lower for mitigation plan compliance than for 401 compliance both for the average scores (Kolmogorov-Smirnov 2 sample test, $p<0.001$) and for average percent-met scores ($p<0.001$). It would seem that mitigation plan conditions are more difficult to fully comply with than 401 permit conditions. However, this conclusion could be due to the large percentage of the 401 permits with just one or two permit conditions (e.g., acreage requirements or credit purchases) with which compliance was relatively easy, whereas mitigation plans typically have many more conditions that the 401 permits. Seventy of the files for which we had mitigation plan scores also had 401 scores, so we could compare scores directly. The average mitigation plan scores for these 70 files were significantly lower than the average 401 scores (Wilcoxon signed-rank test, p=0.030), but the average percent-met scores were not significantly different (p=0.252). Thus, there is some evidence that compliance with mitigation plan conditions was lower than compliance with 401 conditions, but it appears that projects were as likely to comply fully with their mitigation plans as with their 401 permits.

For the 124 files evaluated for 401 compliance, on average 30% of the permit conditions were not determinable (Figure 18). All permit conditions could be determined for 40 files (32%). Eighty-four files had at least some conditions that could not be determined, with an average of 45% non-determinable conditions per file. When mitigation plan compliance was considered separately, 30% of mitigation plan conditions were non-determinable (similar to the 401 compliance result). All conditions could be assessed for only 12 out of 81 (15%) files (Figure 19). Sixty-nine files had at least some mitigation plan conditions that could not be determined, with an average of 35% non-determinable conditions per file. The results from these two figures are indicative of the differences between the types of conditions listed in the 401 orders versus typical mitigation plan conditions. Aside from invocation conditions (those requiring that the mitigation plan or other agency permits be followed), the mitigation conditions specified in the 401 permit often consist of a single acreage requirement. Those containing more mitigation conditions often include a range of other requirements that, like acreage, tend to be addressed in a yes/no fashion or are not determinable (e.g., revegetation requirements, and monitoring and submission requirements). Mitigation plans include many more specific “conditions,” such as requirements for site preparation, implementation, and performance standards. While such conditions are less frequently complied with at the level of 100% satisfaction, they are also more frequently assessable in an after-the-fact assessment, such as the present study.

One might expect compliance with 401 permit conditions to have increased through the years as the regulatory practices evolved; however, we did not find this to be the case (Figure 20; r^2=0.000, p=0.845). There was no significant difference in 401 permit compliance by year (ANOVA, p=0.959). Mitigation plan compliance was more variable through the years (Figure 21), and the correlation between compliance and year also was not significant (r^2=0.030, p=0.119). As with 401 permit compliance, there was no significant difference by year (ANOVA, p=0.357). Nor was there a significant difference between the early files (1992-1997) and the more recent files (1998-2002) in 401 compliance (Mean±SE= 84.9±2.9 for 92-97 and 84.0±2.7 for 98-02; t=0.223, P=0.824) or mitigation plan compliance (78.6±2.9 for 92-97 and 82.4±2.7 for 98-02; t= -0.944, P=0.348).

Overall, there was no significant difference in 401 compliance among regions (Figure 22; ANOVA, p=0.882). Similarly, there were no significant differences among regions for mitigation plan compliance (Figure 23; ANOVA, p=0.198).

Average 401 permit compliance did not differ significantly by 401 certification type (Figure 24; ANOVA, p=0.159). Section 401 orders fell into four general categories: certifications, certifications with conditions, waivers, and conditional waivers. Regulatory practice evolved over the study period, and after June 24, 2000, issuance of waivers was no longer authorized by the State Board. Some of the regulatory orders also comprised waste discharge requirements (WDRs), either standard WDRs, conditional WDRs, WDR waivers, or conditional WDR waivers. We treated these as equivalent to the corresponding 401 certification categories and grouped them accordingly. In terms of a Regional Board's level of involvement in the mitigation planning, one would expect certifications to include more involvement than waivers, and conditional orders more than standard orders. In practice, we found that the number of conditions from the various order types varied widely. From this study, it is unclear which certification category represents greater involvement by Regional Board staff.

There were notable differences in the frequency of use of the various categories of permit conditions (Table 7). In general, the majority of mitigation requirements dictated the actual tasks to be completed during the preparation and construction of the mitigation site (i.e., site implementation tasks). For 401 compliance, site implementation tasks comprised the most conditions (30%), followed by monitoring & submission requirements (19%), success & performance standards (15%), and acreage requirements (12%). While acreage requirements comprised 12% of the conditions, only one or two such conditions were necessary for any particular file. Of the 143 permit files, 89 (61%) included at least one acreage requirement. For other condition categories, a given permit file may have had 10 or more conditions per category, especially when the mitigation plan was invoked by the 401 order. Fifty percent of the 401 orders invoked the requirements of other regulatory agencies or required that the mitigation plan be followed. Conditions involving mitigation site maintenance and the protection of the site from degrading influences, plus third party requirements (mostly credit purchases), made up a relatively low percentage of the conditions. For mitigation plan compliance, most of the "conditions" involved site implementation (39%), success & performance standards (21%), monitoring & submission requirements (16%), and acreage requirements (9%). Excluding the miscellaneous "other" category, the average number of conditions per category ranged from 1.5 to 6.0 for 401 compliance, and 1.6 to 7.9 for mitigation plan compliance (Table 7).

Compliance across the condition categories was variable. Third party requirements were almost always complied with fully (Figure 25). Monitoring and submission requirements had considerably lower compliance (about 60%), although this could be due to the fact that some monitoring documents were submitted but were not located in our review. The other categories had compliance scores of 75-85%. Except for third-party requirements, the percent-met scores were considerably lower than the 401 scores. Acreage and credit purchasing conditions could usually be determined, while the conditions for other categories more frequently could not. Relatively few of the conditions in the success and performance standards category were non-determinable. Monitoring and submission requirements were more frequently non-determinable than other conditions, which is interesting since this category also had the lowest compliance scores when we could assess it. The patterns of compliance and non-determinability were similar for compliance with mitigation plan, although for mitigation plans, there was somewhat less variability among the categories (Figure 26).

Because many of the permit, and even mitigation plan, conditions include purely administrative requirements (such as submitting reports) or actions that are only peripherally connected to the ecological functioning of a mitigation site, we analyzed compliance for a combination of condition categories deemed most relevant to the success of the actual mitigation project. These categories, shown in the last line of Table 7, include the Site Implementation, Maintenance, Protection, and Success/Performance Standards categories. For this grouped category, the mean compliance scores were about 80% for both 401 and mitigation plan compliance. The mean percent-met score was considerably lower, 63% for 401 compliance and 66% for mitigation plan compliance.

All of the above 401 compliance results included the conditions found in mitigation plans and other agency permits that had been explicitly or implicitly invoked as a requirement of the 401 permit. In order to understand the contributions of the Regional Boards *per se* to the outcome of mitigation projects, we considered only those conditions specifically required by the 401 permits. A single mitigation-related permit condition was required for 27% of 401 permits (Figure 27). Another 18% percent of the permits contained two mitigation conditions, and 15% had three conditions. Ten permits (8%) specified 7-12 conditions, while eleven permits (8%) did not contain any mitigation-related permit conditions. These data do not include the eleven permit files for which no 401 permit was obtained. Among the 12 Regional Boards, Regions 6T and 6V required the most mitigation requirements per 401 order (Figure 28), but there were just two permits for each of these sub-regions. Of the regions with larger sample sizes, Regions 2 and 4 included relatively more mitigation conditions per file while Regions 5S and 8 included relatively few.

Of the mitigation conditions included in 401 permits, the majority involved acreage and third party acreage credit requirements, site maintenance requirements, and monitoring and submission requirements (Figure 29). Relatively few conditions specified the actual mitigation tasks to be implemented, protective measures, or success and performance standards. These data represent the conditions found in all 132 permit orders combined. When mitigation conditions from a given category were included in the permit order, there was, on average, between one and two conditions of that category per order (Figure 30). When present, there were close to two site maintenance and two monitoring and submission conditions on average per order, close to 1 site maintenance condition per file, and for acreage requirements, third party acreage credit requirements, and success and performance standards, there were approximately 1.5 conditions each per order.

As indicated above, most 401 permit orders included 1 to 3 mitigation-related conditions. When just a single mitigation-related condition was included, it involved a simple acreage or acreage credit requirement almost 90 percent of the time (Figure 31;

black and red bars, combined). Three single-condition orders contained site maintenance requirements and one contained a monitoring and submission requirement. Similar breakdowns are provided in Figure 31, for 401 orders with up to four mitigation-related permit conditions. As the number of conditions increased, the proportion of maintenance and monitoring/submission conditions increased. Site protection, site implementation, and success and performance requirements were always a minor proportion of the conditions. These data demonstrate that most 401 permit orders included in this study contained relatively few permit conditions dictating the actions to be taken at the mitigation sites, or the success criteria upon which those sites would be judged. Instead, most permits specified the mitigation acreage requirements, included some site maintenance requirements, and mandated that mitigation and monitoring related documents be submitted.

As we reviewed the files, extracted the relevant permit conditions, and consolidated the various agency conditions for our compliance analyses, we noted substantial overlap between the 401 conditions and the conditions required by other regulatory agencies. We performed a separate analysis to understand the extent of these redundancies. The conditions extracted from each relevant agency's permit were aligned with those extracted from the 401 permit orders. Each 401 condition was scrutinized for equivalency with the other permit conditions. Some were verbatim copies of other agency conditions, while others were different in verbiage but equivalent in context. In all cases, our test was whether the greater mitigation responsibilities would have differed had a particular condition not been included in the 401 order. Overall, 62% of 401 conditions were either redundant or invoking (Figure 32). Thirty-eight percent of the 401 conditions were unique to the 401 permit. Those conditions unique to the 401 permit included all 401 conditions involving monitoring and submission requirements, which were 25% all 401 conditions. Excluding these since other agencies had their own submission requirements as well, about 13% of all 401 conditions were unique requirements of the 401 program. A breakdown of redundant and invoked conditions by region is given in Figure 33. Regions 6T, 6V, and 7 had the lowest percentage of redundant and invoked conditions, but these regions had very small sample sizes. Among the other regions with larger sample sizes, Region 2 included a relatively greater percentage of unique conditions in their 401 orders. Region 8 was unique among these latter files as having a relatively low percentage of invoking conditions.

Considering the full set of conditions explicitly specified in the 401 orders, the mean permit compliance score was 84% (Figure 34). This score is identical to the overall mean compliance score given earlier (including invoked conditions from other permits). In addition, the distribution of scores is essentially the same as the earlier distribution. Because of these similarities, no further analyses were performed on these 401-specific conditions.

4.3. Function and Condition of Compensatory Mitigation Sites

CRAM evaluations were completed for 129 of the 143 permit files (14 files included in the above compliance evaluations did not contain assessable mitigation projects). These 129 files had 204 discrete mitigation sites due to multiple mitigation actions (e.g., depressional wetland creation plus riparian enhancement) that needed to be evaluated separately (Figure 3). Fifty three of these mitigation sites were sub-sampled because they were too large or complex for a single CRAM evaluation. These resulted in a total of 321 separate CRAM evaluations for this study. In addition, we performed CRAM evaluations for 22 reference sites across the State and added 25 more reference sites from the CRAM development team for a total of 47 reference site evaluations (Figure 2). CRAM results are presented below in two ways: one is by mitigation site with a sample size of 204, and the other is by file with a sample size of 129; for the latter, the scores of multiple mitigation sites were combined into a single overall score per permit file. Additional CRAM results that were too detailed for inclusion in the main report are provided in Appendix 7.

The 204 mitigation sites were largely represented by low gradient riverine (46%) and depressional (36%) wetland classes (Figure 35). The remaining 18% of assessed mitigation sites, in decreasing order of occurrence, were vernal pool, estuarine, lacustrine, seep and spring, high gradient riverine, and lagoon wetland classes. Although mitigation sites were distributed throughout the state, the occurrences of each wetland class vary by region (Figure 36), with vernal pool and seep and spring mitigation sites only present in central to northern portions of the State. Similarly, estuarine sites were primarily in the north, though two estuarine sites were located on the south coast of California. While depressional and low gradient riverine sites were common throughout the state, depressional sites were more prevalent in the north, and low gradient riverine sites dominated in the South.

4.3.1. Total-CRAM Scores

The total-CRAM scores for the 129 permit files assessed had a mean±SE of 59%±1.1, with a median of 61% (Figure 37; Table 8). Very few mitigation sites scored above 80%, while nearly 30% of the mitigation sites scored below 50%.

As mentioned previously, we collected data for 47 reference sites in order to put the mitigation CRAM scores in context. The total CRAM scores for the reference sites had a mean±SE of 79%±1.4, with a median of 82%. We used the distribution of reference site CRAM scores to establish categories of wetland condition. Nearly 90% of the reference sites had total CRAM scores of 70% or greater. For this reason, we established a 70% score as the cutoff for “optimal” wetland condition. We evenly distributed the remaining attainable CRAM scores into the three remaining categories. Thus, we defined the “sub-optimal” cutoff at 49%, and distinguished “marginal” from “poor” categories at 28%; in most cases, we have combined these categories and refer to them collectively as “marginal to poor.”

Using these criteria, *only 19% of the mitigation files were optimal*, just over half were sub-optimal, and approximately one-quarter were marginal to poor (Table 8). Files with optimal and sub-optimal scores were distributed throughout the state, though there was a prevalence of marginal to poor files in northern California around the greater Bay Area (Figure 38) [see Appendix 5 for detailed mapping of mitigation and impact locations by region]. In our previous study of mitigation success in SWRCB Region 4, we found that just 2% of the files assessed had optimal wetland condition (Ambrose and Lee 2004). However, in that study, optimal condition was defined as an 80% or above

CRAM score. We established that criterion based on the quartiles of the 1-12 scoring scale, since reference site evaluations were not available for that study. The reference site evaluations included here suggest that the 80% criterion used in that study may have been too high; more of the permit files included in that study would have been considered optimal had a standard of 70% been applied.

There was no relationship between CRAM score and certification year (Figure 39; r^2=0.005, p=0.415). Given evolving regulatory practices, one might expect more recent permit files to have mitigation sites with higher CRAM scores if more recent regulatory practices resulted in more successful mitigation projects. Alternatively, older sites have had more time to develop, so higher scores might be expected of these sites. Neither of these expected trends can be discerned for the actual relationship, with one possible exception. The CRAM scores for 2002 do not range as high as earlier years, which could be because these younger sites did not have enough time to develop sufficiently to score highly on CRAM.

There were significant differences in Total-CRAM scores by region (ANOVA: $F = 2.642$; $p = 0.005$) with relatively low median scores in Regions 1, 2, and 6V, and relatively high scores in Regions 8, 9, and sub-Regions 5F, 5S, and 6T (Figure 40; Table 9). Sub-Regions 6T and 6V had the highest (74%) and lowest (43%) median scores, respectively; however, these sub-regions had only two permit files each. When combined, the overall Region 6 score was comparable to the other regions (64%). A Tukey post hoc analysis revealed the differences between the low scores in Region 2 and the relatively high scores in sub-Region 5S ($p = 0.006$) to be responsible for the overall differences among regions. Region 2 had the highest percentage of marginal to poor files (52%), while Region 9 and sub-Region 6T had the highest percentage of optimal files (sub-Region 6T had only two permit files, both of which had optimal condition) (Figure 41). Neither Region 7 nor sub-Region 6V had any optimal files, but they had very few files. Sub-Region 5R did not have any marginal to poor files, and the percentage for sub-Region 5S was low, even with a large number of files. However, the majority of files for these sub-regions had sub-optimal rather than optimal condition. The results for sub-Region 5S are notable due to the high percentage of those files that used formal mitigation banks. The standard error of scores from this sub-Region was low (Table 9) and this likely influenced the significance region effect. However, 17 of the 24 fully assessed permit files from this sub-region used 5 mitigation banks (13 files used a single bank; see Figure 5), and so the CRAM scores of those banks were repeated across these files.[8] A more in-depth analysis and discussion of mitigation banks is provided in Appendix 9.

4.3.2. CRAM Attribute Scores

As with the Total CRAM score, we used the reference site data to provide context for the scores from the mitigation sites. We determined “optimal” cutoffs for each of the four CRAM attributes with the same criterion used to establish the overall “optimal”

[8] Rather than report the score for a particular mitigation bank site just once, the score was assigned to all files that purchased credits from that bank since the functional losses from those projects were to be offset by mitigation bank site function.

cutoff. Because the overall "optimal" cutoff contained 89% of reference sites above that score, we set each of the four attribute "optimal" cutoffs to the score with approximately 89 percent of reference sites above that score. For each attribute, we established the three remaining categories by evenly dividing the remaining attainable CRAM scores by three. Thus, for buffer and landscape context we established an "optimal" cutoff at 74%, "sub-optimal" at 52% and distinguished "marginal" to "poor" at 30%. We established a hydrology "optimal" cutoff at 76%, "sub-optimal" at 53% and distinguished "marginal" to "poor" at 30%. Physical and biotic structure attribute cutoffs were markedly lower than the overall CRAM cutoffs. Physical structure had an "optimal" cutoff at 53%, "sub-optimal" at 38% and distinguished "marginal" to "poor" at 23%, while biotic structure had an "optimal" cutoff at 47%, "sub-optimal" at 34% and distinguished "marginal" to "poor" at 21%.

4.3.2.1. Buffer and Landscape Context

The median landscape context score for the 129 files was 72% (mean 66%) with a distribution that was skewed towards higher scores (Figure 42, Table 8). Approximately half the files had optimal scores, while roughly a quarter of files each were in the sub-optimal and marginal to poor categories. Region 7 and sub-regions 5S and 6T scored particularly well in the landscape context attribute while files for Region 1 and sub-Region 6V scored lower (Table 10). Overall, five of the regions had the majority of their files with optimal scores, and four regions (Region 7 and sub-Regions 5R, 5S, and 6T) did not have any files scoring in the marginal to poor category for landscape context. Despite criticism that mitigation projects are too often placed in proximity to development, these results indicate that the mitigation projects we assessed have been undertaken at sites that were reasonably well positioned in a landscape context.

4.3.2.2. Hydrology

Hydrology attribute scores for the mitigation sites had a mean and median score of 63% (Figure 43, Table 8). Many (43%) permit files had sub-optimal scores, while 27% had optimal, and 30% had marginal to poor scores. The Total-CRAM scores for sub-Regions 6T and 6V were reflected in their hydrology scores with the highest (81%) and lowest (36%) scores of all regions (Table 11), but these two regions had only two files each so these extreme values are likely a consequence of the small sample size. Two sub-regions of Region 5 (5F and 5R) also had higher scores, but when these were combined with large number of files from sub-Region 5S, the overall Region 5 hydrology mean was similar to other files. Regions 3 and 4 had the lowest hydrology scores, as Region 3 had the majority of files being sub-optimal and no optimal files, while 80% of Region 4 files were evenly split between sub-optimal and marginal to poor for hydrology.

Improper hydrology has often been cited as the major shortcoming of mitigation project design (NRC 2001). The mitigation sites sampled during this project had lower hydrology scores than the reference sites, yet when compared to other CRAM attributes the site hydrology scores were not disproportionately poor. However, approximately 50% of the assessed mitigation projects were classified and evaluated as riverine wetlands, and our conventions for employing CRAM were quite liberal with respect to stream-associated mitigation. Many of the riverine/riparian projects we evaluated did not include the channel itself. Instead, they occurred along the sloping banks of stream channels, frequently extending some distance away from the top of the banks. Others began at the top of the banks and extended outward from there, with even less connection to the channel. If the site was in direct proximity and seemingly hydrologically "connected" to the stream channel, the channel-dependent aspects of CRAM were scored as if the channel was part of the assessment area. Hence, many riverine sites that largely lacked wetland hydrology on the site were given more favorable scores for hydrology than the restoration site alone would have warranted. If we had taken a more narrow scope in defining the CRAM assessment area, hydrology scores would have been much lower. This is an important point regarding the utility of CRAM in evaluating mitigation sites, and it will be necessary to establish a standard approach for identifying assessment areas for future riverine mitigation reviews.

4.3.2.3. Physical and Biotic Structure

The reference sites scored relatively low for physical and biotic structure and had wide variability in their scores (Figure 44 and Figure 45). Low scores at the reference sites are likely a result of CRAM calibration (more recent versions of CRAM have rectified this issue); however, since our classification of individual mitigation sites was based on their score *relative* to reference scores, this issue does not affect our evaluation . For reference sites, the median physical structure score was 79% (mean 76%) and the median biotic structure score was 68% (mean 67%). The overall low physical structure scores were mainly driven by low scores in the physical patch richness metric, while vertical biotic structure and biotic patch richness scores lowered the overall biotic structure attribute.

CRAM scores for mitigation sites were low scores for both the physical structure and biotic structure attributes, with mean and median scores just above 50% (Table 8). However, since the reference sites also had low scores for these attributes, the cut-off for optimal/sub-optimal was low. Most mitigation files scored optimally in physical structure, with approximately a quarter of files in the sub-optimal and marginal to poor categories. The majority of files were optimal for biotic structure, about one quarter were sub-optimal, and only 12% were marginal to poor. As with hydrology, certain aspects of the physical and biotic structure attributes were channel-dependent. That is, the metrics were designed around physical and biological aspects of the stream channel. In cases where a hydrological link between mitigation site and channel existed, the channel was treated as part of the assessment area for those metrics, even if the mitigation project did not enhance the channel area.

Region 2 had the lowest median score for physical structure (40%), with 48% of its files considered marginal to poor (Table 12). Similarly, only 25% of sub-Region 5F files were optimal, while neither of the Region 7 files was optimal. In contrast, Region 8 had the highest mean score for physical structure (67%) and this region was joined by Regions 3, 4, 9, and sub-Region 5S in having a larger percentage of optimally scoring files.

Regions 2, 3, 4, 7, and sub-Regions 5R and 6V all had a median biotic structure scores lower than 50%, with the two Region 7 files having particularly low scores (Table

13). Region 2 and 4 had only 40% of files score in the optimal category, while 9 of the remaining 10 regions and sub-regions had the majority of their files score optimally. Similar to physical structure, Region 8 scored comparatively high for biotic structure, with a median score 65% with the vast majority of its files scoring optimally.

With respect to physical structure, these results are not surprising. Most mitigation sites do not emphasize topographic complexity and physical patch types as design elements. However, the results for biotic structure are interesting given that most mitigation activities seem to focus on habitat improvement, namely the enhancement, creation, restoration, or preservation of plant communities. The focus of the biotic structure metrics was on these plant communities, requiring time intensive investigations into the diversity and cover of native and non-native plant species. The poor results from the reference sites for biotic structure suggest that CRAM is poorly calibrated to for this attribute. (CRAM calibration efforts were being conducted at the same time we were assessing mitigation sites; the results of those efforts could not be incorporated into our analyses.) However, even lower scores at mitigation sites indicate that the mitigation projects are not producing sites with optimal biological condition.

The following sections highlight the main findings with respect to each of the 15 individual CRAM metrics.

4.3.3. Individual CRAM Metrics

The distribution of scores for individual CRAM metrics scores varied widely. For example, the percent of assessment area with buffer metric had a median score of 92%, while physical patch richness, biotic patch richness, vertical biotic structure, and native plant species richness had a median of only 42% (Table 14). In general, the majority of metrics had mean scores between 60 and 70%.

The mitigation sites scored lower than the reference sites for all 15 individual CRAM metrics (Figure 46). Differences were most pronounced for the average width of buffer, buffer condition, water source, hydroperiod, hydrologic connectivity, and physical patch richness metrics. There was less difference between mitigation and reference sites for the six biotic structure metrics, percent of assessment area with buffer, and organic matter. However, the reference sites scored relatively low for the six biotic structure metrics and physical patch richness. This indicates a problem with CRAM calibration for those metrics, which will likely be resolved after CRAM is recalibrated. In the meantime, the relatively small difference between mitigation and reference sites for the biotic structure metrics could be either because the mitigation sites are doing relatively well in these areas or that the CRAM metrics are not sensitive to differences in condition that may be present at mitigation sites (perhaps because the reduced range of reference scores). We cannot distinguish between these two possibilities from the data.

The 15 individual CRAM metrics scores varied by SWRCB region (Figure 47). Region 7 shows a particularly distinct pattern, perhaps due to the low sample size (only two files). Although it scored high (similar to the reference sites) for connectivity, percent of assessment area with buffer, and average width of buffer, it scored low on all biotic structure metrics. Region 2 scored particularly low in topographic complexity

(46%) compared to the eight other regions, which averaged between 63 and 71%. Although Region 9 did not score especially high in the overall biotic attribute, it did remarkably well in the two plant metrics, exceeding the reference sites scores.

4.3.4. Wetland Class

The overall Total-CRAM scores varied widely within most wetland classes (Figure 48). Although CRAM was developed for use in a variety of wetland classes, it has not yet been calibrated for all wetland classes. Even the recent calibration effort focused on only two wetland classes, riverine and estuarine. Thus, it is not clear whether differences observed among wetland classes reflect variations in mitigation success, or unresolved issues in the CRAM methodology. Since CRAM has been tested most extensively for riverine wetlands, we expect wetland condition to be most accurately reflected for this class. Appendix 8 discusses differences in CRAM scores for different wetland classes in more detail.

4.4. Habitat Acreage Analysis

The 143 Section 401 orders authorized approximately 217 acres of impacts and required that 445 acres of mitigation be provided; our analyses indicate that 417 acres of actual mitigation acreage was obtained (Figure 49). Overall, 94% of the required mitigation acreage was met. For the individual files, 72% met or exceeded their acreage requirements. Twenty percent (28 files) of the files exceeded their acreage requirements. For 52% of the files (73 files), we determined that the acreage requirements had been met exactly. Twenty-eight percent (40 permit files) of the files did not meet their acreage requirements. As noted in the methods, the obtained acreage values were based on GPS survey of sites where possible, review of files for mitigation bank purchases and other evidence of acreage met, and a combination of field visits and file review where GPS survey of sites was not possible. Roughly one third of acreage determinations were based on each of these approaches.

There was no clear temporal pattern in how well the required acreage was met. The cumulative acreage requirements were shy of being met in most years with the exception of 1992, 1993, and 2001 (Figure 50). In 2001, the acreage requirements were exceeded by 3%, and the acreage requirements were met for the few 1992 and1993 files. These data are comparing total acreage obtained to total acreage required. When the average required mitigation ratios were compared to the average obtained ratios (gain/loss) by year, the results were more variable (Figure 51). The data in this figure represent the averages of individual project mitigation ratios, by year, whereas the previous figure shows the mitigation ratios based on the overall sum of acreages by year. For about half the years the average gains exceeded the requirements, while for the other half they did not. There were two years (1992 and 1993) that met the requirements exactly. Although there were some differences from year to year, there was no general trend, such as earlier years achieving less than the required ratio or later years exceeding it, nor was there ever a very large difference between required and obtained mitigation ratio.

Regions 2 and 8 exceeded their acreage requirements by 2 and 3%, respectively (Figure 52). All other regions fell slightly short of their acreage requirements, meeting from 38% (Region 6V) to 97% (Region 9). The regions that met the lowest percentage of their acreage requirements were Regions 6T and 6V which each had only two files—the lowest sample sizes of all the regions.

While the mitigation acreage fell short of meeting the permit requirements, the regulatory process nonetheless yielded an apparent "gain" of 200 acres on 217 acres of impacts, which is an overall mitigation ratio of 1.92:1 (Table 15). However, this simple ratio is based on the assumption that mitigation sites included no existing wetland acreage before the mitigation project was undertaken. In fact, many mitigation actions consist of site preservation or simple vegetative enhancement to existing habitats without any changes in site hydrology; these types of mitigation actions cannot be considered acreage "gains" because there is no increase in wetland area. Since the simple mitigation ratio includes mitigation actions that do not actually increase wetland area, the ratio overestimates the contribution of compensatory mitigation towards achieving a goal of "no net loss" of wetland area. Details regarding acreage gained versus lost for particular projects are provided in Appendix 11. Also provided in this appendix are the raw habitat proportion data collected for each individual mitigation site.

4.4.1. Riparian Jurisdictional Issues

In addition to the problem of including mitigation actions that did not increase wetland area as a wetland "gain," losses in certain habitat types were often compensated for by "gains" in other habitat types, and it was not always clear that the difference was an intended regulatory outcome. In this section, we separate the acreage losses and gains by their component jurisdictional and non-jurisdictional habitats, and attempt to distinguish true losses and gains in area from simple alterations of habitat.

A substantial issue in evaluating acreage shifts is the consideration of riparian habitats that may not necessarily be jurisdictional wetland habitats. While essentially all impacts considered in the wetland regulatory process were to jurisdictional "waters of the United States" (two projects contained mitigation requirements for a combined total of 4.40 acres of upland habitat), 27% of mitigation acreage consisted of drier "riparian" and upland habitats that were outside jurisdictional "waters" (Figure 53). Our "obtained" acreage assessments focused on mitigation habitats and did not include obvious buffer acreage or large conservation tracts that were built into the mitigation requirements. For individual files, part of this non-jurisdictional mitigation acreage may have been unanticipated by regulatory personnel (i.e., site location or mitigation action was different than proposed). However, the majority of this acreage involved site locations and actions that were proposed and subsequently approved. Of the acreage required to compensate for jurisdictional losses directly (buffers excluded), only 64% clearly involved jurisdictional mitigation acreage. Of the remaining acreage, 14% was to include creation, restoration, enhancement, or preservation of upland habitats and the other 22% was ambiguously listed as "riparian" mitigation without distinguishing whether jurisdictional or non-jurisdictional habitat was intended.

In some cases, the mitigation of impacts to jurisdictional habitat by creation of non-jurisdictional habitat may have been intended to deal with particular project circumstances. For example, requiring riparian habitat on a stream bank might be implemented for mitigating wetland impacts in a flood control channels, where affected wetlands are often choked by monotypic stands of cattails/bulrush or non-native invasive species such as peppergrass; in these cases, the agencies might determine that greater environmental benefit could be reached by improving the riparian habitat instead of replacing the lost wetland in kind. Rarely is the reasoning described in the permit files in these cases, however, and even more rarely is a careful analysis of functions lost vs. gained given. In many cases, the emphasis on habitat rather than functions means that wetland losses compensated through non-jurisdictional riparian mitigation result in corresponding shifts in hydrological and biogeochemical functioning.

In some cases, the inclusion of non-jurisdictional habitat as mitigation for impacts to jurisdictional habitat may be due to differences in interpretation of what constitutes "riparian" habitat. "Riparian" habitat can be defined from an ecological or regulatory perspective. In determining riparian *impacts*, a regulatory definition is employed that considers only those riparian habitats within the ordinary high water mark (OHWM) defining "waters of the U.S." (Though the Regional Boards may regulate wider areas under the Porter-Cologne Act and while DFG regulates stream impacts to the "bed, bank, and channel" under Section 1600 of the Fish and Game code, the extent of riverine habitats regulated through streambed alteration agreements is commonly extended to the outer drip line of riparian vegetation; see CDFG 1994). However, in considering riparian mitigation, permittees and their consultants often use an ecological definition of riparian, which includes the entire zone of transition to fully terrestrial habitats. The lateral limits of "riparian" under this definition are vague and can include extensive areas that are beyond jurisdictional "waters." When the mitigation requirements include the ambiguous term "riparian," it is unclear whether the habitats mitigated were intended to be jurisdictional or non-jurisdictional riparian habitat. It should also be mentioned that impacts listed as "riparian" usually involved the entire riverine zone, including the channel itself and the portion of the floodplain and banks deemed within the OHWM. This usage does not conform to the most widely accepted definition of "riparian," defined as the area between fully aquatic and fully terrestrial habitats and not including the actual riverine channel. Additionally, the term *riparian wetland* has been applied loosely and has often referred to both three-parameter wetlands and/or non-wetland "waters" habitats within the OHWM. Our determinations of riparian "waters" were limited to those *non-wetland* portions of the banks and floodplains between the channel and the OHWM.

Aside from the non-jurisdictional acreage found in our site evaluations, the remaining mitigation acreage yielded a net "gain" of jurisdictional acreage with an overall gain/loss ratio of 1.43:1 (Table 15). Given the breakdown of habitat types, the mitigation associated with these 143 permit files resulted in overall net "gains" in both wetland and non-wetland "waters" acreage (Figure 54). There were 181 acres of wetland mitigation compared to 121 acres of wetlands impact, resulting in a net "gain" of 60 wetland acres and a gain/loss ratio of 1.50:1. There were 75 acres of non-wetland "waters" impacted and 105 mitigation acres mitigated for a total gain of 30 acres (mitigation ratio of 1.40:1). The replacement ratio for non-wetland "waters" acreage was slightly lower than that of wetland acreage, but this might be expected given that the "no net loss" goal is focused on *wetland* habitats. Of the non-jurisdictional mitigation acreage, 70% was identified as non-"waters" riparian habitat and the remaining 30% was upland. While the acreage associated with these latter habitat types seems inconsistent with "no net loss" goals, the overall acreage of non-jurisdictional habitats was over and above net "gains" in jurisdictional wetland and non-wetland "waters" habitat. It is possible that some amount of this additional habitat was due to the increased jurisdictional requirements of the DFG; too few *streambed alteration agreements* were present in the permit files to test this. However, mitigation ratios are often proposed as a buffer, a way to account for uncertainty in the success of wetland creation or restoration, or to accommodate temporary losses occurring between impact and the completion of the mitigation project, and other sources of uncertainty. The inclusion of non-jurisdictional habitat in acreage considerations obscures the amount of buffer being incorporated into mitigation requirements.

4.4.2. True wetland acreage losses and gains

In evaluating wetland acreage losses, especially with respect to the goal of "no net loss," it is useful to distinguish between temporary losses and permanent losses, and permit analyses typically make this distinction. Temporary losses can result in important impacts to wetland resources and services (and thus should be mitigated), but they do not result in the permanent loss of wetland acreage.

Similarly, not all mitigation projects result in true wetland acreage gains. As mentioned above, mitigation consisting of habitat preservation does not increase the extent of wetlands. Habitat enhancement also does not increase wetland acreage, even though it may increase the functions and services performed by an existing wetland. On the other hand, habitat creation clearly results in increased wetland acreage. We also consider wetland restoration to result in increased wetland acreage. This increase is a matter of perspective, since restoration by definition occurs in areas that once supported wetland habitat. However, since there was no wetland at the site immediately before the restoration project, we consider this to be a gain in wetland acreage.

To provide an assessment of true losses and gains of wetland acreage, we compared the acres of permanent impacts (true losses) to the acres of creation and restoration mitigation (true gains). In total, 76% of the impact acreage was permanent and 24% was temporary. In contrast, 65% of the total mitigation acreage consisted of creation or restoration mitigation while 24% involved habitat enhancement and 11% was preservation (Figure 55). We did not include any large upland conservation/preservation areas associated with these permit files since these were usually required by FWS for impacts to endangered species and were tangential to the wetland impact/mitigation requirements. Comparing these true losses with true gains, there was a net gain in overall acreage (Table 16).

Most (82%) creation and restoration projects involved jurisdictional acreage. The jurisdictional acreage proportion was lower for enhancement projects (58%) and preservation areas (48%). For jurisdictional "waters," there was a net gain in overall acreage (Table 16), with an overall gain/loss ratio of 1.37**:**1. Both wetlands and non-wetland "waters" habitats experienced gains of acreage (Figure 56). The overall replacement ratio for wetland impacts was 1.38:1 while the ratio for non-wetland waters was 1.35:1.

These results suggest that at least for overall acreage, mitigation required by the SWRCB and other regulatory agencies appears to be resulting in net gains of wetland acreage across the State. However, there are at least two reasons was may have overestimates acreage gains. First, many sites categorized as "creations" were in fact enlargements of existing wetlands, with both the created and pre-existing "waters" included in the reported mitigation acreage. Second, our GPS surveys yielded best-case acreage estimates since we erred on the side of overestimation rather than underestimation when delineating site perimeters.

The above findings for cumulative mitigation acreage do not indicate how well "no net loss" of acreage is being achieved by individual mitigation projects, or if large gains from certain projects are compensating for net losses in others. In fact, while 64% of permits resulted in acreage gains, 20% of the permits resulted in net acreage losses (Table 17). Thirty-three percent of the projects had net acreage losses in jurisdictional "waters," while 22% had losses for wetlands. Comparing permanent impacts to creation and restoration mitigation, only 41% of the projects yielded acreage gains while 39% resulted in net losses of acreage (Table 18). Almost half of the projects indicated net losses of jurisdictional "waters" habitats, and over one quarter of the projects (28%) resulted in net losses of wetlands.

To determine if the projects with disproportionately large acreage gains or losses were skewing the results, we removed the five projects with the biggest acreage gains and the five with the biggest acreage losses from the analysis. Following this step, net acreage gains were still found with an overall gain/loss ratio of 1.7:1 (compared to 1.9:1 for all projects). For jurisdictional "waters," the gain/loss ratio was the same as before (1.4:1), but for wetlands it was higher, at 1.7:1 (compared to 1.5:1 for all projects). While there were substantial deficiencies in habitat acreage for 20% of the projects, the large mitigation ratios required by the regulatory agencies have been successful in achieving overall net gains in wetland acreage within California.

4.4.3. Regional Comparisons

In our previous study within SWRCB Region 4, Ambrose and Lee (2004) found that net gains in overall acreage and in wetland acreage had been obtained within SWRCB Region 4. The results from this project indicate that these findings were consistent across the State. However, in that Region 4 study, Ambrose and Lee found an overall net loss in jurisdictional acreage, with roughly 50% of the mitigation acreage consisting of drier riparian and upland habitats that were outside "waters of the U.S." This finding was not consistent across the State. When separated by the 12 Regions and sub-Regions of the SWRCB, our habitat acreage data show that most regions yielded net gains in both overall and jurisdictional acreage (Figure 57). Consistent with Ambrose and Lee (2004), Region 4 experienced a net loss of jurisdictional "waters of the U.S.," with over half (53%) of the mitigation acreage consisting of non-jurisdictional habitat. Sub-Region 5F and the two sub-regions of Region 6 also had net losses in jurisdictional acreage, though Region 6 included just four files, and the loss for six projects of sub-Region 5F would not be apparent if all three sub-regions of Region 5 were combined. Sub-Region 5S was similar to Region 4 in that approximately 50% of the mitigation acreage (46%) was non-jurisdictional. However, unlike Region 4, Regional 5S had a net gain in jurisdictional acreage. For Region 7, 28% of the mitigation acreage was non-jurisdictional; however, like sub-Region 5S, this was in addition to net jurisdictional gains. Region 2, for which we assessed more permits than any other region, experienced the greatest "gain" in jurisdictional acreage. Sub-Region 5S had almost the same number of assessments as Region 2, and nearly as many impact acres. However compared to Region 2, sub-Region 5S had relatively low jurisdictional gains. This region also has the largest number of mitigation bank projects, and had a mean required mitigation ratio lower than Region 2 (Figure 14). Regions 5S and 7 achieved the highest cumulative gain/loss ratio of all the regions (2.91**:**1 and 2.90:1, respectively). Region 4 was also unique in requiring mitigation for impacts to non-"waters" habitat (coastal sage scrub and alluvial fan scrub uplands).

For three of the southern California regions, wetland acreage made up a relatively low percentage of the regulated impacts and mitigated "gains" (Figure 58). The impacts in Region 4 were mostly to non-wetland "waters" habitat (79%). In Regions 8 and 9, wetlands comprised just 45% and 29% of impacts, respectively. On the other hand, wetland habitats comprised 9%, 49% and 61% of the respective jurisdictional "gains" in Regions 4, 8, and 9. Nearly all impacts in Region 1 were to jurisdictional wetlands, and these were compensated almost entirely through comparable wetland mitigation. Region 9 had the highest overall gain/loss ratio (3.20**:**1), while Regions 4 and 7 and sub-Regions 5F, 6T, and 6V all experienced net losses of wetland acreage. While all Regions except 7, 5R, and 6T had some amount of upland mitigation acreage, Regions 2, 4, and sub-Region 5S were notable in this regard.

4.5. Combined Acreage, Compliance and CRAM Results

Throughout the preceding sections, we have condensed our results into simple summaries of success, partial success, and failure. Although these summaries do not reflect the richness of the full results, they simplify comparisons across different aspects of the project. Most (72-76%) of the assessed permit files were successful in meeting their acreage requirements and other responsibilities related to permit compliance, but few (19%) were considered optimal in terms of wetland condition (Table 19). Thus, permittees are largely following their permits (although one-quarter to one-third of the time these are not met), but the permit conditions that are being met are not resulting in compensatory mitigation projects that are similar to natural wetlands.

Since acreage and overall permit compliance are normally used as the primary indicators of regulatory mitigation success (i.e., post-mitigation functional evaluations are rarely performed), it is important to explicitly evaluate the relationship between these indicators and the condition of the mitigated wetland. Simply meeting acreage requirements did not ensure overall permit compliance (Figure 59; p=0.612, r^2=0.002); not only was there no overall trend, there was a wide range of compliance values for projects meeting 100% of their acreage requirement. Similarly, there was no relationship between percent acreage met and CRAM score for wetland condition (Figure 60;

p=0.169, r^2=0.015). The range of CRAM conditions for projects with 100% acreage met was even broader than for compliance. Clearly, including sufficient acreage in a project, which is relatively easy to accomplish, had little influence on whether the project would be accomplished as required or if it would produce a high-quality wetland.

Although compliance with the acreage requirement was not correlated with CRAM score, general compliance with permit conditions was. Mean 401 compliance score (Figure 61; p=0.000, r^2=0.126), mean percent of 401 conditions met (Figure 62; p<0.001; r^2=0.207), and mitigation plan compliance (Figure 63; p=0.001, r^2=0.150) were all significantly correlated with wetland condition. However, the low r^2 values indicate the relationships between the variables were not very strong, with the compliance data explaining only 13-21% of the variance in the overall CRAM scores. Clearly, other factors influence the condition of mitigation wetlands, but compliance with permit conditions appears to have some influence.

Since some permit conditions are more administrative in nature while others are directly focused on mitigation site performance, it is possible that certain categories of permit conditions might have a stronger relationship to wetland condition than others. Separate regression analyses were performed to compare the four condition categories deemed the most relevant to the CRAM outcome (Figure 64). No significant relationships were found between the overall Total-CRAM scores and the mean scores for the site implementation (p=0.219, r^2=0.027), site maintenance (p=0.297, r^2=0.068), site protection (p=0.743, r^2=0.005), or success & performance standards (p=0.052, r^2=0.091) condition categories. Most of the "conditions" included in these categories came from mitigation plans, rather than the regulatory permits themselves. When additional regressions were performed just for the set of conditions found in the mitigation plans, the relationship with the Total-CRAM score became significant for success & performance standards (p=0.024, r^2=0.086). However, as with the other significant compliance relationships, the r^2 value was very low. This suggests that while compliance with performance standards is somewhat correlated with a positive CRAM outcome, the relationship is not very strong. Given the recent emphasis on success and performance standards in permitting and mitigation requirements, this latter result might seem surprising. However, the lack of a relationship highlights the fact that CRAM condition success means achieving the appropriate hydrological, physical, and ecological conditions at the site, while most performance standards are focused primarily on vegetation success. As a final test, we investigated the relationship between performance standard compliance and the CRAM biotic structure attribute scores: this is the portion of CRAM most closely focused on vegetation success. No significant results were found (p=0.196, r^2= 0.042, for average 401 compliance; p=0.639, r^2= 0.006, for average 401 percent-met). Thus, it seems safe to conclude that while compliance was weakly correlated with CRAM, adequately meeting the permit conditions, even those performance-based standards, does not guarantee the mitigation site will be a well functioning wetland. This implies the need for on-going development of more appropriate standards which will ensure a stronger connection between permit conditions and overall functional development of mitigation wetlands.

An analysis of these 143 files by permittee type (developer, industry, Caltrans, municipal, private, and state/federal) revealed some clear differences in both mitigation requirements and outcomes (Table 20). As was mentioned earlier, Caltrans was distinguished from other state and federal permittees because of the large number of permits they receive and the uniformity in the types of projects involved (mostly bridge crossings). In general, state/federal permittees had the highest mean impact acreage, were assigned among the lowest mitigation ratios, had the lowest obtained mitigation ratios, and had the lowest 401 compliance scores, though they had slightly better scores for mitigation plan compliance. Despite having lower permit requirements and compliance, state/federal permittees achieved the highest Total-CRAM scores. On the other hand, developers and industry-related permittees had relatively low mean impact acreages but were assigned the highest mitigation ratios, scored in the middle for permit compliance, and had the lowest Total-CRAM scores, although the difference between lowest and highest Total-CRAM scores was not great. Municipal and private entities had lower mean impacts (private had the lowest of all permittee types), while their mitigation requirements and mitigation outcomes were near the middle of the range. Caltrans projects had impact acreages near the middle of the range, but like other state/federal agencies had low required mitigation ratios, lower obtained ratios, and higher CRAM scores.

It is not clear if the regulatory agencies assign mitigation requirements differently depending on the type of applicant, or if these mitigation ratios reflect the different types of impact or mitigation projects. For Caltrans, most permitted impacts involved bridge installation and repair projects. Due to the prevalence of temporary impacts for such projects, the mitigation required was often a 1:1 ratio and involved mere vegetation plantings in the associated channel. The CRAM scores for such mitigation projects are often high because of the pre-existing conditions in the channel. Other state or federal permittees might blend their mitigation responsibilities into larger restoration objectives and their actions are not as constrained by the typical concerns of “for profit” entities.

Industry permittees stand out in Table 20 as having exceptionally high mitigation ratio requirements, up to an order of magnitude higher than some other permittee types. This was due primarily to two files. The first involved the complete relocation of a stream channel from one side of a landfill site to the other. Only the loss of the channel itself was considered impacts (2.9 acre narrow strip of “waters” with no accounting of floodplain impacts), while the mitigation requirement included the new channel plus a wide non-“waters” floodplain and the banks of the stream, for a total of 44.0 required acres (required ratio of 15.2:1). The other involved 0.035acres of impacts and 4.3 acres of mitigation, a required mitigation ratio of 122.9:1. Had these two outliers been eliminated from this analysis (and Table 20), the required mitigation ratio for industry permittees would have been 2.0:1 and the obtained ratio would have been 2.9:1. Overall, industry, municipal, and private permittees exceeded their mitigation acreage responsibilities, while developer, Caltrans, and state/federal permittees fell short.

We include in Table 20 a summary statistic calculated by multiplying each file’s obtained acreage value by its respective Total-CRAM score (“Average CRAM-Adjusted Acreage” in the last row of the table). The purpose of this calculation was to adjust the mitigation acreage according to the condition of the site. For example, if a one-acre mitigation site had a 100% CRAM score, it would get "credit" for one acre. On the other hand, if the CRAM score was 50%, the site would get "credit" for only one-half acre, since its condition was not optimal. This is a simple, albeit relatively crude, method for adjusting raw acreages to account for the condition of the habitats produced. A similar approach has been suggested for the Hydrogeomorphic (HGM) assessment method (Brinson and Rheinhardt 1996, Hauer and Smith 1998).

Because CRAM scores were less than 100%, the Average CRAM-Adjusted Acreage was substantially lower than the simple acreage gain estimate. We reported earlier that these 143 permit files impacted a total of 217 acres of impacts and obtained 417 of mitigation acreage. Adjusting acreages by CRAM scores, the resulting mitigation acreage dropped to 225 acres (Figure 65). Although the mitigation acreage is substantially lower, it still indicates more adjusted acreage obtained as compensatory mitigation than acres lost.

5. Conclusions

Impacts to wetlands in California are regulated by a variety of different agencies and regulations. Although the principle objective of this study was to investigate statewide mitigation success under the CWA Section 401 Water Quality Certification program, it is not possible to evaluate the success of the State's 401 Program in isolation from the actions of other agencies, particularly the U.S. Army Corps of Engineers and the California Department of Fish and Game. This is particularly true because most 401 permits "invoke" the mitigation plan for the project, which encompasses requirements from the suite of agencies regulating the project. To a large degree, then, the findings of this study relate to the general compensatory wetland mitigation process in California.

We have organized this discussion into a series of major issues. We start with the two major components of the 401 Program that we evaluated, permit compliance and wetland condition. Included in the section on wetland condition is a discussion of how permit conditions could influence the success of wetland mitigation. Next, we discuss how mitigation resulted in the replacement of different habitat types and differences in results among the Regional Boards. We then discuss issues related to mitigation banks. The final section considers the question of whether "no net loss" of wetland acreage and functions is being achieved in California.

5.1. Permit Compliance

Overall, compliance with 401 permit conditions relating to compensatory mitigation was reasonably high, though by no means perfect. Using a strict interpretation of compliance as having to meet each condition to 100% satisfaction, 46% of the files with 401 conditions met 100% of those conditions, with another 50% at least partially in compliance. On average, 73% of a project's 401 permit conditions were complied with in full. Although this percentage is fairly high, it is worth noting that the legal standard would be 100% compliance with all conditions, so fewer than half of all mitigation projects were in full compliance.

The comparable figures for mitigation plan compliance were lower, with only 16% of the files with mitigation plan conditions meeting all their permit conditions, and a mean by-file score of 68% of conditions met. Ambrose and Lee (2004) found that about 2/3 of files for the LARWQCB met 100% of their permit conditions. This value is not directly comparable to the current study, however, because the compliance evaluations of the two studies differed substantially[9]. In the current study, fully meeting all conditions is a fairly high standard, particularly considering the fact that some conditions were extracted from the mitigation plan. In reviewing the mitigation plan, we had to judge what was a "condition" rather than having the conditions described explicitly. In addition, in many cases there were more than 20 or 30 conditions, ranging from straightforward implementation conditions to complex performance standards. Even a relatively minor shortcoming in one standard would prevent a project from achieving perfect compliance.

A more flexible way to judge permit compliance is to evaluate how well condition were met on a graded scale rather than using a yes/no criterion, thereby allowing for a fractional score (e.g., a particular condition was 75% completed). The average 401 compliance scores, according to this definition of compliance, were slightly higher than the corresponding "percent-met" scores, with a mean score of 84% across all files. For mitigation plan compliance, which includes the requirements of all regulatory agencies, the overall average compliance score was 81%. Regardless of which aspect of compliance was used (average scores or percent-met scores, 401 permit or mitigation plan) most projects largely met their permit requirements.

When separated by compliance category, most of the average 401 compliance scores ranged from about 76% to 85%. Conditions relating to third-party mitigation requirements (mostly acreage or credit requirements) had a high average score (around 99%) while monitoring and submission requirements yielded a lower average score (about 59%). Acreage requirements were usually assessable, but for the other condition categories, a significant number of the conditions (regularly between 25% and 50%) could not be determined. Many of the permit conditions did not directly relate to mitigation actions that promote proper site functioning. When those categories of permit conditions were removed from the analysis (i.e., only those conditions relating to site implementation, site maintenance, site protection, and performance/success standards were included), both 401 and mitigation plan compliance scores averaged about 80%.

With compliance scores averaging about 80%, it appears that permit compliance has not been a substantial impediment to the success of compensatory wetland mitigation required by 401 certifications. We encountered a few files with significant compliance shortcomings, and 13 such files were excluded from our study because the mitigation projects were never undertaken, despite project impacts. However, most mitigation projects met most of their permit conditions, or at least met the permit conditions that were assessable.

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[9] In the Ambrose and Lee study, conditions from the 401 permits that were not related to mitigation were included in the assessment and the evaluation did not include any "invoked" conditions from other permits. We altered our methods for assessing compliance in the current study to provide more focus on compensatory mitigation, at the same time examining the entire set of mitigation requirements.

5.2. Wetland condition

Understanding how wetland mitigation sites function is a key component of assessing whether the goal of "no net loss" of wetland acreage and functions has been met. In this project, we used the California Rapid Assessment Method (CRAM) to assess the condition of mitigation wetlands (as well as reference wetlands). Although CRAM is specifically designed to assess wetland condition rather than function, since it is based on a one-time "snapshot" of the assessment wetland, we view it as a reasonable indicator of wetland function.

Only about 19% of the permit files we assessed were considered successful with respect to overall wetland condition, based on overall CRAM score greater than 70% (i.e., "optimal" category based on the overall CRAM scores of relatively undisturbed reference wetlands). These results indicate that the vast majority of wetland mitigation projects did not result in wetlands with optimal condition. While 19% is a low success rate, it is somewhat higher than that found in previous studies (although the variation is likely due to differences in the identification of success criteria). Sudol (1996), using a different assessment method (the HGM assessment method), reported 0% success in wetland mitigation projects in Orange County, California. Ambrose and Lee (2004) reported a success rate of 2% for the Los Angeles/Ventura region using a previous version of CRAM. Although it is possible that the statewide success rate is somewhat higher than reported by Ambrose and Lee, the difference is more likely due to Ambrose and Lee's use of a different cut-off for optimal condition (80% rather than 70%), suggesting that their results for LA/Ventura are comparable to the current results for the entire state. CRAM is still under development, and future refinements will undoubtedly occur. It may be difficult to compare directly the earlier applications of CRAM. Nonetheless, it is clear that few mitigation wetlands have the same conditions as relatively undisturbed natural wetlands.

Mitigation sites tended to have relatively high CRAM scores for the "buffer and landscape context" attribute but lower scores for hydrology, physical structure, and biotic structure. As discussed above, some of this variation may be due to differences in the relative effectiveness of CRAM for each of these attributes, but when compared with reference site scores, median mitigation scores were substantially different across the attributes. For example, for buffer and landscape context, the median mitigation score was 80% of the reference. For hydrology, the median mitigation score was 69% of the reference. For physical structure, the median mitigation score was 67% of the reference. For biotic structure, the median mitigation score was 76% of the reference. Mitigation sites appear to do worst in this comparison for hydrology and physical structure. As CRAM is calibrated and refined, more detailed comparisons among attributes will be possible.

As has been found in other studies (Craft et al. 1999, 2002, 2003, Gray et al. 2002, Kentula et al. 1992, Simenstad and Thom 1996, Warren et al. 2002, Zedler and Callaway 1999), we expected to see some increase in the condition of restored wetlands over time. We lacked data on wetland age or the specific date of implementation; however, we evaluated the effect of age on the condition of mitigation wetlands using the "year of certification", under the assumption that projects were likely to be implemented shortly after certification and that this was a reasonable surrogate for the age of a mitigation site. There was no relationship between year of certification and total-CRAM score. At least two factors might be expected to influence this relationship, and they probably work in opposite directions. On the one hand, regulatory practice has evolved since 401 certifications (or waivers) were first issued, and one might expect CRAM scores to improve over time. That is, as regulators changed the way they reviewed projects (e.g., adding permit conditions in order to improve mitigation), these improvements should have led to higher CRAM scores over time. On the other hand, one might expect older mitigation projects to score higher because they have had more time to mature and develop optimal wetland conditions. Other studies (e.g., Craft et al. 2003) have demonstrated that wetland structure and functions increase over time since restoration. In addition, some workers have argued that monitoring should be required for at least ten years to give the mitigation wetland time to develop so that any deficiencies would be more apparent. There was a slight suggestion that the youngest mitigation sites (certification date of 2002) did not achieve as high a CRAM score as older sites; however, no other pattern was apparent. Because there was no trend in CRAM scores over time, it was not clear if either – or both – of these factors were acting. However, any improvements in wetland condition that might have been caused by improved regulatory practice clearly were swamped by other factors.

5.2.1. Permit conditions

Permit conditions guide mitigation projects to produce the types of wetlands needed to compensate for losses due to impacts. The conditions set the parameters of the mitigation project and, in theory, as long as these conditions are complied with, the mitigation project should provide appropriate compensation. In practice, compliance with permit conditions was not correlated with CRAM score, even when we considered only the permit conditions most directly related to mitigation performance, or when compliance with performance standards was compared to CRAM biotic structure. In other words, high rates of permit compliance did not guarantee optimal, or even high, wetland condition.

Does this mean that permit conditions do not influence the success of wetland mitigation? Probably not. However, it does appear that the conditions typically included in 401 permits and mitigation plans do not ensure that the mitigation wetlands have optimal condition, even when there is compliance with the permit requirements. Although a more detailed examination of the relationship between compliance and wetland condition might provide some additional insight into this relationship, the general conclusion is likely to remain: a permittee can do everything required by a 401 permit and mitigation plan yet still produce a mitigation wetland lacking important characteristics.

There are three areas of permit conditions that we suggest could be improved. First, permit conditions need to focus on broader set of wetland characteristics. Currently, permits and mitigation plans focus largely on the vegetation component of wetlands, in particular the percent cover and survivorship of native plant species. Extensive planning goes into determining appropriate species to plant, developing planting configurations, maximizing plant survival and growth, and preventing non-native plant species. All of these are important. However, wetland ecosystems incorporate many aspects beyond plant cover, and the production of a well-functioning, sustainable wetland requires broader considerations (Ambrose 1995). Permit conditions should focus on the full suite of wetland functions and services (see Section 6.1.1).

In general, the metrics used in CRAM could serve as an initial guide to the types of wetland characteristics that could be incorporated into 401 permits. These metrics were selected by an experienced group of wetland experts to identify key aspects of wetland condition. While CRAM metrics do not include all aspects of a wetland that should be considered in permit conditions, they identify aspects to consider for future permits.

Second, permit conditions should support closer tracking of jurisdictional losses and gains. In previous work in Region 4 (Ambrose and Lee 2004), we found that jurisdictional habitat (those within jurisdictional "waters of the United States") was being replaced with non-jurisdictional habitat, with the net effect of a loss of jurisdictional habitat. The current study confirmed that result for Region 4 but did not find an overall net loss of jurisdictional habitat statewide. Nonetheless, 401 certifications are rarely clear and precise about the types of habitats being impacted and replaced through mitigation. If a simple habitat classification scheme (e.g., Table 2) was used consistently in 401certifications, file documents, and the agency database, the accounting between habitat types lossed versus those gained through mitigation (i.e., created, restored, enhanced, or preserved) would be much clearer. This would help ensure that permit conditions require compensation appropriate to permitted impacts.

Finally, wetland mitigation might be improved if permits and mitigation plans included more conditions specifying success criteria/performance standards. Remarkably few permits included these types of permit conditions, and even when they were included in a permit, there were not many separate conditions specified. The lack of performance standards in the permits leaves more opportunity for a permittee to interpret the intent of a permit in ways that may not originally have been intended.

5.3. Changes in habitat types and acreage

In previous assessments of the success of wetland mitigation projects, there has been little consideration of the fact that the habitats under consideration vary in their regulatory status. To address this problem, in Ambrose and Lee (2004) we distinguished between different types of habitats, and especially between jurisdictional and non-jurisdictional habitats, which allowed us to investigate "no net loss" with respect to acreage and individual types of wetland habitat. In the present study, we again evaluated impacts and mitigation according to the different types of habitats affected.

Our jurisdictional habitat evaluations demonstrated that, while essentially 100% of the regulated acreage losses were to jurisdictional "waters of the United States" (including wetlands, jurisdictional riparian habitats and other non-wetland "waters"), almost 30% of the mitigation "gains" involved riparian and upland habitats that were not jurisdictional "waters." After isolating the jurisdictional "waters" portion of the mitigation acreage, the resulting overall gain (permanent losses versus creation gains) still gave an overall mitigation ratio of 1.4:1. However, when individual files were considered, only 36% had net acreage gains, 17% replaced their acreage exactly, and 47% of the files resulted in net acreage losses. This issue appears to be particularly important for riparian habitats, where there are wide-ranging definitions of wetland/upland boundaries used across agencies and in a regulatory versus ecological context.

For wetlands specifically, more acres were created than impacted. Forty percent of individual files resulted in net acreage gains (permanent losses/creation mitigation), and 28% resulted in net losses of wetland acreage. Our estimates of wetland habitat at mitigation sites represent the best-case scenario because we assumed no existing wetland acreage at the mitigation sites, and we did not apply a strict three-parameter wetland delineation test. More acres of non-wetland “waters” were also created than impacted. Seventeen percent of individual files resulted in net acreage gains, and 46% resulted in net losses. Thus, for both jurisdictional wetlands and non-wetland “waters,” our results indicate that there has been a net gain in acreage overall. However, a quarter to a half of all individual files still failed to replace the acreage impacted.

This study confirms the findings of Ambrose and Lee (2004) that overall, the cumulative acreage of compensatory mitigation projects exceed the cumulative impacts. However, within the Los Angeles/Ventura Region, our previous study found that over half the mitigation acreage consisted of drier riparian and upland habitats that were outside jurisdictional “waters of the U.S.” In this study, we found that, while there was substantial non-“waters” mitigation acreage, this was over and above the net gains of jurisdictional acreage that were obtained.

Although acreage is an important component of the goal to have “no net loss” of wetlands, the goal also encompasses wetland functions. The achievement of “no net loss” of wetlands is discussed further in Section 5.6.

5.4. Differences among regions

We found no significant differences in permit compliance among SWRCB Regions. There was a hint in the data that Regions 8 and 9 might have slightly higher average 401 compliance scores, and Regions 2 and 3 slightly lower, but these differences were not significant.

We discovered that some Regional Boards (e.g., Regions 4 and 9) considered shading for bridge/crossing projects to be a permanent impact, while others (e.g., Region 5) considered only the actual bridge footings as permanent impacts with no mitigation required for shading except for bridges that were very low relative to the stream/floodplain elevation.

With respect to wetland condition of mitigation sites, some regional differences were apparent. There was little difference in Total CRAM scores among the regions with large sample sizes, except that Region 2 had a slightly lower mean score than some of the other regions. Differences in proportions of mitigation files in optimal, suboptimal, or marginal/poor condition were more distinct. The underlying cause(s) of the regional differences in mitigation wetland conditions are not clear. There was a slight (non-significant) indication that Regions 2 and 3 had lower permit compliance scores. However, this seems unlikely to explain the differences since Region 3 was typical in its distribution of wetland conditions, and there was no relationship between compliance and wetland condition in the overall study. Differences in the geographic distribution of different wetland types might explain at least part of this trend. Region 2 had more depressional and estuarine wetlands, which had the lowest mean CRAM scores, than other regions. In addition, Region 2 includes a major urban area, which seems likely to constrain many of its mitigation projects. However, Region 4 also includes a major urban area. Although its proportion of optimal sites was higher than Region 2's and its proportion of marginal/poor sites was lower, Region 4 did have more marginal/poor sites than some of the other regions. In contrast to the slightly lower scores we found, previous work by Breaux et al. (2005) for 20 mitigation sites in Region 2 found relatively high condition scores using the WEA method. Differences in the two studies could be due to differences in the sites sampled or methodology (e.g., WEA appears to result in consistently higher scores than CRAM). In particular, scores for estuarine sites appeared to be different with the two methodologies.

There were regional patterns in mitigation acreage requirements. While most regions experienced net gains in acreage, sub-Regions 5F and 6T had net losses, though both of these had relatively few permit file evaluations. The acreage for just two regions (Regions 2 and 8) exceeded the cumulative mitigation requirements, while the remaining regions fell short of their respective requirements. Compared to other regions, Regions 7 and 8 stood out as having relatively high cumulative impact acreages given the number of permits involved. Region 7 had one file involving particularly large impacts. This result for Region 8 is especially noteworthy since that Regional Board had required the lowest cumulative mitigation ratio (1.15:1). Regions 2, 5S, and 7 had required the greatest cumulative mitigation ratios.

Interestingly, the results for Region 4 were consistent with the Ambrose and Lee (2004) study, in that over half that region's mitigation acreage (53%) consisted of non-jurisdictional riparian and upland habitats. While Region 4 had a small net gain in acreage overall, there was a net loss in jurisdictional acreage (14.6 acres lost, or 40% of the acreage not replaced). Region 8 and Sub-Regions 5F, 6T and 6V also experienced net losses of jurisdictional acreage. Sub-Region 5S was similar to Region 4 in that approximately 50% of the gains were non-jurisdictional, though in this case, it was over and above a net gain in jurisdictional acreage. For Region 3 and sub-Region 6V, the proportion of non-jurisdictional habitat was approximately 31% and 38%, respectively, of the total obtained mitigation acreage, and for all other Regions and sub-Regions the non-jurisdictional acreage was 30% or less.

5.5. Mitigation banks

Our results indicate that compensation at mitigation banks yielded slightly higher average CRAM scores (though non-significant) than project-specific mitigation (see Appendix 9). The lack of statistical significance could be due to differences in sample size between mitigation types (formal banks, informal banks, and project-specific mitigation) and the wide range of habitat types which increased variation within each mitigation type, as well as any natural variation in these responses. For CRAM, the largest differences between banks and project-specific mitigation projects were in the hydrology and buffer/landscape context attributes. There were no differences in physical and biotic structure attributes between banks and project-specific mitigation. Given the importance of hydrology for mitigation wetlands, as noted above, our results indicate that banks should continue to be evaluated as a potential improvement to the mitigation process. There are a number of likely benefits associated with the consolidation of habitats in mitigation banks, and while our results do not show a strong or significant difference in CRAM scores, the trends are informative.

Ideally, a more focused evaluation of banks should be designed to compare a similar number of bank and file-specific projects of similar habitat classes within a particular region. This would reduce outside variation in CRAM scores, or other measures of condition or function, and provide a more definitive comparison of the relative effectiveness of mitigation banks. However, given the actual distribution of mitigation bank projects within the state this could be difficult. We found that most banks were clustered in the Central Valley, with a small number of banks being developed in the Santa Rosa area, and others found sporadically across the state. A focused study within the Central Valley is most likely to yield high sample sizes. Similarly, banks vary in terms of habitat types, with most focusing on depressional, vernal pool, and riparian wetlands. There has not been clear distinction in some banks to differentiate vernal pool mitigation from other depressional wetlands. More consistent classification in this regard would be useful for future assessments of banks and other mitigation projects.

Although CRAM scores include aspects of biogeochemical functions, suggesting that mitigation banks are performing these functions adequately, this does not consider the geographic distribution of these functions. Mitigation policy has traditionally prioritized on-site mitigation over off-site mitigation, but many agencies have adopted policies allowing for off-site banks because of their potential benefits. However, some wetland functions may not be replaced on a regional basis as effectively as others. In particular, water quality improvement, such as nutrient recycling or pollutant removal, provide an important service to a local watershed, and the creation of a similar function in a distant watershed does not provide the same spatial distribution of benefits. This may be especially relevant for mitigation banks in relatively undeveloped areas. In these cases, there will be relatively little gain in water quality improvement because water quality will already be good in these undeveloped areas. In contrast, the loss of services related to water quality at the impact site could be substantial from some permitted impacts (such as a residential development). When focusing on this particular service, other mitigation strategies in the same watershed as the impact, such as removal of concrete lining from a channelized stream, might provide a better balance to the loss of water quality improvement services while maintaining geographic proximity to the impact (see Recommendations 6.1.2 and 6.1.5). It is also possible that Best Management Practices (BMPs) required by the Regional Boards for stormwater permits might provide adequate replacement for these services. Because we focused on mitigation associated with 401 permits, our analyses cannot be used to evaluate the effectiveness of BMPs in this context. However, if stormwater BMPs are to be used to compensate for lost wetland functions, there should be specific analyses supporting their use in the 401 permits; in particular, there should be a discussion about how the stormwater BMPs would be used to replace lost functions.

5.6. Evaluating "no net loss"

California state and federal policies have established goals of "no net loss" of wetland area or function. Our results indicate that, statewide, the overall acreage of compensatory mitigation projects has exceeded the impacted acreage of wetland and other jurisdictional habitats (see Section 5.3). Although the overall mitigation acreage exceeded the overall impacted acreage, a substantial portion of the files resulted in net acreage losses. In addition, wetter jurisdictional areas that were lost were frequently replaced by drier riparian and upland habitats.

In addition, achieving the goal of "no net loss" of wetland acreage does not ensure that wetland functions were protected. Despite the obvious importance of assessing compensatory mitigation in terms of wetland functions, there have been remarkably few functional assessments in a regulatory context. In part, this may be due to the lack of a standard method for functional assessments. There is a long history of wetland evaluation methods being developed for regulatory purposes, but most methods have had severe limitations. The Hydrogeomorphic (HGM) Assessment Method was developed specifically to address many of these limitations, and it is well suited for functional assessments in a regulatory context. In fact, Sudol (1996) used an early version of the HGM approach to evaluate Section 404 mitigation sites in Orange County. However, HGM requires regional models for each wetland type, and many compensatory mitigation projects in California would not have had an appropriate model available for assessment. The California Rapid Assessment Method (CRAM) is being developed to fill the need for a simple method to assess wetland condition (as a proxy for function) at a wide range of wetland types in California. In this study, we used CRAM as an indication of the function of wetland mitigation sites, based on the assumption that a wetland in good condition should also function well.

A more fundamental problem with assessing "no net loss" of wetland function is the study designs available for use. Assessments of wetland condition conducted at a mitigation site years after the mitigation was completed, such as we had to do, cannot indicate whether the policy of "no net loss" of wetland function has been achieved. Determining the change in function requires measuring function at the impact site before and after impact to assess loss of functions, and at the mitigation site before and after mitigation to assess gain. Such an approach is not possible in an after-the-fact assessment such as the present study; in fact, we know of no large-scale survey that has been able to adopt this approach.

Although our assessments of the current condition of the mitigation sites indicate whether the ultimate outcome of mitigation actions resulted in a high quality/functioning wetland, our data cannot address how much of the quality/function was *caused by* the mitigation action. It is likely that all current "function" is not attributable to the mitigation activities completed at a site; in many cases, this is certainly the case. For example, many mitigation actions consisted of simple vegetative enhancements to pre-existing stream habitats, and other "creation" projects involved slight enlargements of existing wetlands. Had comparative CRAM evaluations been done at these mitigation sites *prior* to the mitigation actions, many of the resulting pre-mitigation scores might have been no different than our post-mitigation assessments. This would be especially true for hydrological and biogeochemical function, since most mitigation efforts focused on improving vegetation. In addition, we decided to give a mitigation site credit for an existing channel at sites that were adjacent to existing streams but did not include any actual stream habitat. Although these sites were physically and hydrologically connected to the channel, in no way did they "create" the functions that were identified based on CRAM scores. Despite the many cases where it was clear the mitigation actions did not create all of the wetland functions at the site, we could not assess how much gain in function might have occurred due to the mitigation actions because we had no comparable data on the pre-existing functions at each mitigation site. Similarly, we had no information on the loss in function caused by the impact site. Lacking an assessment of both gains and losses, a rigorous evaluation of "no net loss" of wetland function was not possible.

In our study of mitigation success for the Los Angeles/Ventura region, we tried to evaluate "no net loss" of wetland function directly by assessing the beneficial wetland services lost due to project impacts and gained through mitigation actions (Ambrose and Lee 2004). Through site visits and careful review of files, we gained insights as to the nature of the functional losses and gains. Through our resulting structured qualitative assessment, we determined that over half of the mitigation projects (66%) failed to compensate adequately for the full suite of beneficial services lost through the project impacts. Unfortunately, time constraints prevented us from performing a similar assessment in the present study. However, our anecdotal observations suggest that the results would have been similar if we had performed the same qualitative assessment.

Although a rigorous assessment of net change in wetland function was not possible in this study, the relatively low CRAM scores for condition suggest similar levels of function at the mitigation sites. As noted in the methods, reference sites were not chosen to be indicative of pristine conditions but were representative of typical wetlands found in their region. The lower scores at mitigation sites suggests that the mitigation actions may not be fully compensating for the functions lost at the impact sites. However, this conclusion remains unconfirmed pending a study using the proper study design.

6. Recommended Administrative and Regulatory Changes

The recommendations from our study are separated into five main categories (Table 21). First, we present recommendations aimed at improving mitigation requirements. These recommendations concern mainly permit conditions, but also issues of the location of mitigation projects and the tracking of habitat gains and losses for a project. Second, we present recommendations under the general heading of "Information Management." These recommendations concern improvements to the State Board's permit tracking database (either the existing database, or a modified database), improvements to permit archiving, and improvements to tracking the progress of mitigation projects. Third, we present recommendations to improve the clarity of permits. Fourth, we recommend that the goal of "no net loss" be assessed in a more effective manner. Finally, we present recommendations concerning coordination with other agencies.

To the extent possible, we have tried to ensure that the recommendations included in this section stem directly from the work done under contract to the SWRCB[10]. However, our previous study for the Los Angeles Regional Water Quality Control Board (Ambrose and Lee 2004) had a similar goal, and we produced an extensive series of recommendations in a Guidance Document to the LA Board (Ambrose and Lee 2004b); there are inevitably many similarities between those recommendations and the recommendations presented here. In addition, we acknowledge the influence of many other studies of mitigation effectiveness (e.g., Kentula et al. 1992, DeWeese and Gould 1994, Race 1985, Breaux et al. 2005, Allen and Feddema 1996, Sudol 1996, Zedler 1996, Breaux and Serefiddin 1999, Breaux and Martindale 2003), as well as comments by State and Regional Board staff.

Although the recommendations presented below are based on work done during this project, early results and recommendations were discussed with State Board staff. In addition, there are other ongoing efforts to improve processes associated with the 401 Program. Thus, a number of these recommendations are already being implemented or are planned for implementation in the near future. For example, two database efforts, the California Integrated Water Quality System Project (CIWQS) and Wetland Tracker, would incorporate some of the issues identified in these recommendations.

6.1. Improving Mitigation Requirements

The success of compensatory mitigation depends fundamentally on the mitigation requirements specified by the regulatory agencies. Our study found relatively high levels of compliance with mitigation permit conditions. In addition, there was no relationship between compliance with permit conditions and the condition of wetland mitigation sites. It appears that compliance with permit conditions is no guarantee that a mitigation wetland will have high condition or function. Perhaps the most effective way to improve the success of compensatory mitigation would be to include permit conditions that are more likely to lead to mitigation projects with higher levels of wetland condition and function.

6.1.1. Permit conditions should ensure complete compensation for the **full suite** *of wetland functions and services lost*

Wetland functions include a broad range of physical and biological processes. Many of these functions, such as flood water attenuation, groundwater recharge, water quality improvement (i.e., pollutant removal), and support of wildlife, provide valuable services for humans. To ensure that compensatory mitigation provides full compensation

[10] Thus, this is not an exhaustive list of how we think mitigation practice could be improved, but rather represents recommendations addressing issues we encountered during the present study.

for lost wetland functions and services (also called values), discussion of project impacts and mitigation should be framed in terms of functions and services.

Note: in this section, "wetland" is used in the broad, non-regulatory sense as a shortcut to the regulatory terms "waters of the United States and adjacent wetlands."

6.1.1.1. Permit conditions should place more emphasis on performance standards

401 permits include conditions addressing various aspects of compensatory mitigation projects, one of which concerns the performance of the mitigation project. We found that the number of success and performance standard conditions included in most 401 permits was relatively limited; only 15% of all permit conditions that were related to mitigation addressed success or performance standards. Thus, the basis for determining whether the mitigation project is successful is not specified in most 401 permits; instead, performance standards are contained in other permits (e.g., 404 or 1600 permits) or the mitigation plan.

In many cases, other permits or, especially, the mitigation plan may be an appropriate location for performance standards. For example, the details about a particular mitigation project are often not known until the mitigation plan is produced. However, the absence of particular success criteria or performance standards in the 401 permit leaves the Regional Boards with less explicit input into the nature of the mitigation project. If the Regional Boards want to emphasize particular elements of the mitigation project (for example, see Recommendation 6.1.2), the 401 permit is the most effective place to require these.

6.1.1.2. Performance standards should include hydrological and biogeochemical conditions as well as vegetation

When performance standards are included in 401 permits, they often focus on aspects of vegetation or invasive plants. We do not recommend that fewer performance standards be required concerning native vegetation or invasive plants. In fact, the current attention on vegetation and invasive plants is well-founded on scientific studies of mitigation success. However, some vegetation issues need clarification. In particular, adoption of a specific and consistent definition of invasive species would be a substantial improvement in permit planning and monitoring.

Despite the importance of vegetation and invasive plants, there are other important wetland functions that should be included as performance standards (see Section 2.2). General summaries of wetland functions, as well as functional assessments such as the HGM assessments, include hydrology, biogeochemistry[11], and ecological functions. Permit conditions, however, rarely focus on hydrology or biogeochemistry. Since hydrological and biogeochemical standards have not been widely used to date,

[11] Wetland biogeochemical functions include processes that transport or transform different materials (see Section 2.2.2 for more detail). The breakdown of organic material and nitrogen cycling are two common biogeochemical functions. These functions support important services such as removal of nutrients or contaminants from water.

there are few examples of standards that would be appropriate, and this is an area that would benefit from work to develop standardized conditions. Performance standards for hydrological conditions could include ensuring proper hydrology through saturation/water level monitoring, mitigation site delineations, and so forth. Biogeochemistry conditions could be structured around soil measurements (bulk density, salinity, pH, redox, etc.) Water quality measurements, including parameters such as nutrients and total suspended solids, could also be made upstream and downstream of the impact site to determine water quality impairment and upstream and downstream of the mitigation site to determine water quality improvement. Compared to other wetland functions, the potential for mitigation site to exhibit proper biogeochemical and water quality functioning depends heavily on the proper landscape positioning of the site.

In addition, performance standards should include conditions that cover different ecological scales, such as population, community, and ecosystem conditions (Ambrose 1995). For example, at the population level, performance standards could require successful reproduction for key species (especially habitat-forming species such as trees) to ensure sustainable populations.

Although we found that, in general, hydrological and biogeochemical functions of wetlands were not addressed as completely as they should be in permit conditions, the necessary focus depends on the specific circumstances. In some cases, vegetation standards may need greater emphasis. Some trends were apparent for different wetland types. For example, riparian mitigation tended to be focused too heavily on vegetative plantings without appropriate hydrological improvements, while some seasonal/depressional mitigation tended to involve excavation and seeding without enough plantings.

6.1.2. Ensure that mitigation projects compensate for losses in water quality (pollution) improvement services

Wetlands can remove pollutants, including excess nutrients, metals and bacteria, from water flowing through the wetland. This service is frequently cited as a key benefit of wetlands. Given the focus of Section 401 of the Clean Water Act on water quality, the pollutant removal capabilities of wetlands should be considered explicitly in 401 permits. This may best be achieved by including a separate analysis for impacts to water quality, as well as the identification of how these impacts would be mitigated. (We use “water quality” here in the general sense relating to pollutants in water, rather than in the broader regulatory sense.)

Water quality services provided by natural wetlands may be replaced incidentally by the compensatory mitigation projects that are typically required by 404 and 401 permits. However, without a specific consideration of these services, it is impossible to evaluate if these services are replaced fully. Systematic consideration of the effects of different mitigation alternatives on water quality may lead to a shift in priorities for mitigation for the Regional Boards. For example, treatment wetlands are often discouraged as a form of mitigation because ostensibly pristine wetlands could be replaced by urbanized wetlands with high pollutant loads. This may be a valid point from the perspective of ecological function, and a high-quality wetland may be required to mitigate impacts to ecological functions. But from the perspective of pollutant removal, treatment wetlands may be ideal for compensating for impacts to water quality.

We discuss three examples where water quality services are especially likely to be overlooked.

First, the compensatory mitigation projects we studied focused largely on the provision of habitat, and the upper, drier riparian habitat that is commonly a part of compensatory mitigation projects (see Section 4.4.1, Figure 54) provide relatively little water quality benefit. While such habitats may replace many of the lost functions in the broader regulatory sense of "water quality," they may not replace the functions that remove pollutants. To ensure the replacement of lost water quality functions, it may be necessary to add elements to mitigation projects in addition to the normal conditions focusing on habitat replacement. For example, a portion of the mitigation wetland near the water inflow point(s) might incorporate design features used in treatment wetlands, or treatment wetlands might be required outside the boundaries of the wetland used for general mitigation. It may be appropriate for the Water Board to require treatment wetlands for all large development projects to ensure that the permitted projects do not result in water quality impairment (i.e., pollution).

Second, a specific analysis of water quality aspects might alter the mitigation required for some projects concerning "low quality habitat." The term "low quality habitat" may be appropriate when considering the value of a habitat for plants or animals. However, from the perspective of water quality, such habitats may have significant water quality functions. For example, channels surrounded by development can have high potential for water quality remediation. Mitigation for impacts to "low quality habitat" tends to be limited because of the focus on habitat, but such mitigation may not adequately replace the water quality improvement functions performed by the original habitat. The Water Board should be careful to ensure that all functions performed by "low quality habitats," especially water quality improvement functions, are fully replaced.

Third, mitigation banks may be effective tools for replacing lost habitat functions, but, as currently designed, they may not provide adequate compensation for water quality impacts, particularly for services such as floodwater attenuation and pollutant removal. For many wetland functions, maintaining the function in the same region may be appropriate. The loss of water quality improvement functions or floodwater attenuation in a local reach may have far-reaching local consequences which would not be compensated by a mitigation bank in a different location (see Section 6.1.5).

6.1.2.1. Projects involving channelization, the installation of concrete linings, and cut and fill operations resulting in large scale drainage modification/culvert installation should be discouraged

When a stream segment is channelized, lined, or culverted, the hydrological, biogeochemical, and ecological functions and services lost are very difficult to mitigate. While this has been widely recognized and stream "improvements" are now discouraged, such projects are still occurring, often because the surrounding area is already urbanized and the stream is considered degraded and consisting of “low value habitat.” This may be an accurate assessment with respect to habitat-related functions and services, but such streams can be extremely beneficial with respect to water quality improvement (notably water pollution remediation). Large scale development projects with drainage modification can have particularly high net water quality impacts because the loss of water quality function is coupled with increased runoff and pollution input.

6.1.2.2. Promote channel daylighting and complete channel restoration projects (concrete removal) as compensation for biogeochemical impacts

One reason that losses of stream function are difficult to mitigate is that one cannot easily create stream systems in existing upland habitats. Most projects that we evaluated which called for riparian creation were, in fact, riparian vegetation projects within upland areas with little or no alteration of site hydrology. Some mitigation projects have attempted to create stream function by widening existing streams, or by creating side channels in upland areas that are fed by water diversions. Such projects can result in limited functional gains. Yet the purpose of Section 401, along with other aspects of the SWRCB and RWQCB regulatory mandates, is to protect beneficial uses in general and water quality in particular. Where possible, adding performance standards that relate directly to biogeochemistry and water quality functioning is important, but reconsidering overall mitigation strategies may lead to more successful compensation for such impacts.

In our previous study (Ambrose and Lee 2004), and again in the present study, we found that projects involving the complete restoration or relocation of channel segments or cross-sections, particularly those involving the removal of concrete linings, can result in significant gains in hydrological, biogeochemical, and ecological functions and services. In urban setting (where concrete-lined channels often occur), habitat values can be limited due to landscape context. Nonetheless, channel relocation/restoration projects can still provide substantial ecological functions and services, as well as providing mitigation opportunities in a setting where such opportunities can be limited.

Although channel daylighting or complete channel restoration could open up new opportunities for replacing lost stream functions, such projects could be quite expensive and thus might not be feasible for all permittees. Large developers might be able to undertake projects such as these on an individual basis. In addition, mitigation banks could be developed to enable the benefits of channel daylighting or complete channel restoration to be realized even for relatively small individual projects. Mitigation banks have many advantages over permit-specific mitigation, but most existing bank projects have been focused on ecological functions and services, including habitat for threatened and endangered species. Because the benefits they can impart to water quality improvement, and "no net loss" in general, the SWRCB should promote the development of mitigation banks involving full channel restoration (including daylighting and the removal of concrete linings). Channel daylighting and complete channel restoration might have relatively limited benefit if conducted in only small areas; mitigation banks would provide a mechanism for pooling efforts to achieve a more meaningful project.

6.1.3. Improve accounting of the habitat types lost and gained

Permit documents should use a standardized habitat classification. Currently, the SWRCB's Section 401 internal guidance document indicates that five different waterbody types should be used in the Project Information Sheet: wetland, riparian, streambed, lake, and ocean. (For each waterbody type, the guidance document indicates that acres of permanent and temporary impacts should be recorded.) Although these are all generally recognized waterbody types, our review of impact and mitigation projects suggests that a somewhat different classification could make it easier to track mitigation of impacts to jurisdictional habitats, which is an important step towards determining whether the goal of "no net loss" of wetland area and function is being achieved.

"Riparian" is a particularly problematic term. Impacts and mitigation concerning riparian habitats need to be more clearly defined to ensure that non-jurisdictional areas are not used to mitigate for jurisdictional impacts. The SWRCB's Section 401 internal guidance document defines riparian as "stream or lakeside jurisdictional water (below line of normal high water), vegetated, but not jurisdictional wetland (may be either wet or dry most of the time)." This definition seems to clearly restrict the use of "riparian" to jurisdictional "waters," as is appropriate for regulatory use with respect to 401 and 404 permits. Impacts are generally delineated according to this definition, although occasionally we found that the entire jurisdictional area, including the stream itself, was termed "riparian." However, mitigation planners have regularly applied a broader definition of "riparian" that includes both jurisdictional and non-jurisdictional habitat. Permits and mitigation plans seldom distinguish between these two habitat types. Thus, a non-regulatory definition of "riparian" is often being used in a regulatory situation. As a result, impacts to jurisdictional riparian habitat have often been compensated for by mitigation within non-jurisdictional riparian or even upland areas, resulting in a net loss of jurisdictional riparian acreage and values.

A more useful terminology would clearly distinguish between areas classified as "waters of the United States" versus areas that are not "waters of the United States" (for example, see Table 22). These main categories are distinguished based on regulatory considerations. Within each of these main categories, appropriate general habitat classifications are identified. These categories are based on those currently presented in the SWRCB's Section 401 internal guidance document (and, in fact, those exact categories could be used if desired). The categories presented in Table 22 reflect the types of habitats frequently named in wetland permit documentation, as well as general types of wetlands recognized by wetland scientists.

Besides standardizing the way habitats are described in wetland permits, Table 22 provides a structure for tracking the areas of losses due to permitted impacts and gains from mitigation. The losses and gains (in acres and/or linear feet) should be recorded for wetland/riparian creation, restoration, enhancement, preservation for each of the habitat types, including transitional habitat and upland buffer areas.

6.1.4. Mitigation projects should have appropriate landscape context

One of the clearest differences between the CRAM evaluations of compensatory mitigation wetlands sampled in this study and their reference wetlands was their landscape context. In CRAM, landscape context contains four metrics, one for connectivity and three related to the amount and quality of the buffer around the wetland. The CRAM manual defines these concepts as:

> The **connectivity** of a wetland refers to its potential to interact with other areas of aquatic resources, such as other wetlands, lakes, streams, lagoons, etc., and their surrounding environs at the watershed or embayment scale, and to the likely relative importance of the wetland in the landscape context. Wetlands within a watershed or in the same embayment are often functionally connected by the flow of water, such that they have an additive influence on the timing and extent of flooding, filtration of pesticides and other contaminants, and the movement of wildlife.
>
> For the purpose of CRAM, a **buffer** is a zone of transition between the immediate margin of a wetland and its larger environment that is likely to help protect the wetland from anthropogenic stress. Areas adjoining wetlands that probably do not provide protection are not considered buffers. Buffers can protect wetlands by filtering pollutants, providing refuge for wetland wildlife during times of high water levels, acting as barriers to the disruptive incursions by people and pets into wetlands, and moderating predation by ground-dwelling terrestrial predators. Buffers can also reduce the risk of invasion by non-native plants and animals, by either obstructing terrestrial corridors of invasion or by helping to maintain the integrity and therefore the resistance of wetland communities to invasions.

Mitigation wetlands frequently had poorer buffers and/or connectivity to adjacent wetlands (especially for riparian habitats). Because buffers and connectivity relate to conditions outside mitigation project boundaries, they may not typically be considered carefully in mitigation planning. However, poor buffers or low connectivity will adversely affect the functioning of a mitigation wetland. Mitigation projects should be planned with adequate buffers and functions.

While adequate buffers and adjacent open space are extremely important for wildlife and other ecological functions and services, they may be less important when the purpose of the mitigation site is focused on flood control and water pollution remediation.

6.1.5. Offsite mitigation should be within the same catchment, or at least the same watershed

While some functions can be replaced in another watershed, other functions (such as water quality improvement, floodwater retention, habitat connectivity) cannot. When mitigation occurs outside the catchment in which the impact occurs, some functionality in that system is lost. In some cases, mitigating those losses in a nearby catchment in the same watershed would provide adequate compensation for downstream impacts. For example, if impacts to a wetland reduces its ability to attenuate floods, then mitigation in the same catchment would provide the most appropriate compensation, but mitigation somewhere else in the same watershed would at least provide similar protection against downstream flooding.

The problem of mitigation occurring outside of the catchment or watershed in which the impact occurred is especially prevalent with third-party mitigation. As discussed earlier (Section 5.5), mitigation outside the watershed, as occurs with many mitigation banks, may be especially problematic because the mitigation may occur in relatively undisturbed watersheds where these services may be less important.

6.2. Information Management Recommendations

In this section, we discuss recommendations to improve the management of information associated with 401 permits. The performance of this study revealed the difficulty of retrieving specific permit files. Of the 429 files we sought, we could locate only 257. The difficulty in locating files had a variety of causes, ranging from limitations in the database to the physical management of hardcopy permit files. This section also includes recommendations designed to improve the ability to track the progress of mitigation projects.

6.2.1. Improvements to Database

Our review of mitigation projects depended on information from the SWRCB database for project identification. We used the database to select projects indicating compensatory mitigation requirements, and using the project information contained therein, attempted to identify and locate the physical permit files at either the Regional Boards, or Corps district offices. During the course of our extensive work with the database, we identified a number of areas that could be improved.

Note: Recommendations 6.2.1.1to 6.2.1.4 can be implemented with the existing database. Although the existing database contains fields for the most important information concerning 401 permits, we have identified some areas that could be improved. These improvements would require that the database be modified, as reflected in Recommendations 6.2.1.5 to 6.2.1.11.

Also note that, as an early action response to the preliminary findings of this study, the SWRCB began documenting ACOE file numbers in the database (Recommendation 6.2.1.2) in May 2005. To enhance data quality, file numbers are being entered, discrepant field values are rechecked (Recommendation 6.2.1.4), and full project titles are being entered (Recommendation 6.2.1.1). In addition, we recommend a number of additional fields be added to the database. Many of the fields recommended are included in the California Integrated Water Quality System (CIWQS), an agency-wide data management system now being deployed that will store all water board data, and in "Wetland Tracker," which Region 2 hopes to begin requiring soon as a permit condition in a pilot program.

6.2.1.1. Full project titles should be entered into the database

The location of permit files was much more arduous than expected because the information in the State Board database was not sufficient to identify a unique project in the Regional Board's or Corps of Engineers' respective databases. Generally, the project title was abbreviated, and therefore, lacked many relevant key words that would have facilitated cross referencing with other databases.

6.2.1.2. Additional critical information should be included within the "notes" field

Much additional information is available in the 401 permit that would have been useful in the cross-referencing and identification of files using the Regional Board's or Corps's respective databases. Information such as the Regional Board's permit ID number, the Corps' 404 permit number, other agency permit numbers, and the county should be entered in the "notes" field of the database.

Note: if the database is modified as recommended, it would include this information as database fields; see Recommendation 6.2.1.6. However, there is no reason to wait until the database is modified to begin entering this information. The SWRCB's Section 401 internal guidance document indicates this information can optionally be included in the "notes" field.

6.2.1.3. Each permit should be assigned a unique numeric or alpha-numeric identifier to be used by both the Regional Board and the State Board

While most Regional Boards assign each project a project identification number, their numbering formats are not compatible with centralized use by the State Board. Hence, these identification numbers have not been included in the State Board's database. A consistent statewide format should be implemented and the State Board's database should include a field for these primary identification numbers.

Note: if a centralized database is developed as recommended (see Recommendation 6.2.1.5), a single permit identifier would naturally be assigned because both the Regional and State Boards would use the same database. However, there is no reason to wait until a centralized database is developed to assign a unique identifier.

6.2.1.4. Database records should be entered using a quality assurance protocol

As would be expected in any extensive data entry project, there were a number of mistakes in the State Board database entries. A quality assurance protocol should be established to double-check entries. This would included, at a minimum: (1) checking whether the permit represented a modified or re-issued certification to avoid redundant data entry, (2) ensuring that all permanent and temporary impact to wetlands and non-wetland "waters" are included and that these are inputted into the correct fields per the established protocol (see Recommendation 6.2.1.8), and (3) checking entries for typographical errors. In many quality assurance programs, a certain percent of the entries (e.g., 10%) are checked independently for accuracy. This protocol would have to be integrated into any future changes to data entry methods.

Although pure entry errors occurred, some database entry errors were due to misinterpretations of the permit information caused by ambiguous wording or the difficulty of having to extract important information that was embedded in the text of the permit (see Recommendation 6.2.2).

6.2.1.5. A central database should be developed for use by both RWQCB and SWRCB to avoid redundant data entry

Currently, the State Board maintains a database for information from all 401 certifications, and some Regional Boards maintain their own independent databases. There is a lack of correspondence between the fields in the Regional Boards and State Board databases. In addition, since much of the information required by the State Board is the same as required by the Regional Boards, there is unnecessary duplication of effort to maintain a series of independent databases.

6.2.1.6. Database records should include fields for all critical information from a permit, and those fields should be adequately populated for every permit

Within the State Board database, project descriptors were often abridged versions of the full titles found in the certification letters, and the county and other agency permit numbers were usually absent. With such limited information, it was difficult to identify and locate the physical permit files at either the Regional Board or Corps offices using their respective databases. The SWRCB's Section 401 internal guidance document specifies "to facilitate cross-referencing, include the U.S. Army Corps of Engineers' (Corps) file number if it is available (Optional)." In practice, we found few files with the corresponding Corps number included. The database should include fields for the 404 permit number and the numbers of other agency permits including the Department of Fish and Game's 1600 permit and the Fish and Wildlife Service's Biological Opinion. In addition, a field should be included for the county and the permittee's consultant (if relevant). In the SWRCB's Section 401 internal guidance document, information such as this is identified as optional additional information that may be added at the Region's discretion; we feel that critical administrative details, such as county and other agency permits, should be required fields in the database.

Additional fields could also be useful in the database. For example, information fields for file attachments for permits, pre- and post- mitigation photos, and so forth would provide a broader view of the project. This information would be useful for later compliance evaluations, and might be entered by the permittee if electronic form submission is adopted (Recommendation 6.2.1.10).

Having full project titles, county of project, and other agency permit numbers would greatly simplify any future efforts to evaluate the 401 program. Perhaps more importantly, though, it would ensure that each project is unambiguously identifiable. Clear identification of projects would be important for any action that needed to check project characteristics, including enforcement actions and (when the database has such capabilities) tracking mitigation monitoring or other compliance activities (such as paying in-lieu fees).

6.2.1.7. Include GPS locations for the impact and mitigation sites in the SWRCB database

The SWRCB's Section 401 internal guidance document indicates that latitude and longitude information would be useful for GIS analysis of impact (discharge) locations; this information is listed as optional. With the ready availability of inexpensive GPS instruments, latitude and longitude should be required for all permits, for both the impact and the mitigation sites. As a minimum requirement, a single point location could be recorded for impact and mitigation site (or each of the mitigation sites, if more than one).

Ideally, a survey-grade GPS would be used to determine the boundaries of impact and mitigation sites. Recent technological advances have made survey grade GPS units relatively affordable, and it would be reasonable to expect all future projects to provide an electronic GIS shape file with the specific boundaries of the mitigation project. This information could be submitted for GIS mapping and analysis by Regional or State Board staff. It would simplify the assessment of compliance with acreage permit conditions.

6.2.1.8. Eliminate ambiguities between permanent and temporary impacts by including fields for "total impacts," "permanent impacts," and "temporary impacts"

Currently, the fields for total impacts and the subset of the total impacts that are temporary are not consistently being applied appropriately. As an example, the fields for wetland impacts include "wetlands" and "wtemp." According to the database entry instructions, the total wetland impacts are to be recorded in the "wetlands" field and the subset of the impacts that were temporary are to be recorded in the "wtemp" field. In practice, permanent impacts were often entered into the "wetland" field and the temporary impacts were entered into the "wtemp" field. Data entry staff should be adequately trained to ensure that these fields are used appropriately. Alternatively, the confusion could be eliminated by having one field for total impacts, one for permanent impact, and one for temporary impacts.

6.2.1.9. Permit conditions should be entered into the database

Tracking the compliance of a compensatory mitigation project would be simpler if the permit conditions upon which compliance will be judged was recorded in the permit tracking database. Having permit conditions in the database would simplify independent studies of compliance. When the database has capabilities for tracking project compliance, having the permit conditions specified in the database would reduce the amount of time needed to understand the crucial permit requirements and determine if they had been met.

Currently, it would be difficult to extract the appropriate permit conditions from the permit file. However, Recommendation 6.3.1 recommends that permit conditions should be clearly delineated in the permit.

6.2.1.10. Have permittees submit permit information in electronic form

Clearly, one of the difficulties of maintaining a database is the time required to enter the appropriate data. If the information needed for the database could be submitted by the permittee in electronic form, staff time needed to enter information would be minimized. Having an electronic form for permittees to fill out would also minimize database entries. Instead of having to enter all information (multiple times when separate databases are maintained by the State Board and each regional board), the basic information would need only to be checked, although additional information (such as permit conditions; see Recommendation 6.2.1.9) might have to be entered by Water Board staff. The form and database could be designed so the information from the form would flow simply into the database.

6.2.1.11. The database should contain information to improve management after a permit is issued

Information management for 401 permits currently seems focused almost exclusively on activities leading up to the issuance of a permit. However, post-permit activities are also critical for a successful 401 program. Better information about the project after the permit is issued would allow Regional Board staff to track the progress of projects and assist compliance and evaluation efforts.

Post-issuance information that could be useful includes:

- The database should track document submissions
- The database should incorporate flags for overdue documents.
- In concert with the fields for specific permit conditions, there should be fields for recording satisfactory compliance with conditions.
- The database should track any enforcement actions undertaken on the permit.

This type of information is included in CIWQS and is being proposed for the Wetland Tracker.

6.2.2. Improve permit archiving

During our previous study of permits at the Los Angeles Regional Board (Ambrose and Lee 2004), we discovered a number of issues associated with the archival of office hardcopy file management. Informal surveys of other Regions suggested that file organization and archiving at the Regional Boards did not support efficient file retrieval, making it necessary to perform our file reviews at the Corps district offices. Issues with hardcopy file management were also apparent in this project when we tried to locate specific files and either had difficulty locating them through the issuing Regional Board or the Regional Board was never able to provide us with a copy of the files.

File archival is obviously important for a retrospective program evaluation such as this study, but it is also essential for tracking permit compliance, including compliance with submissions of monitoring reports. Obviously, it is difficult to establish compliance with a permit if the file cannot be located. Therefore, we recommend that permit archiving systems for each Regional Board be evaluated and improved if necessary.

One particular addition to the database that could help with office hardcopy file management would be a chain of custody field for recording the location of physical permit file folder. This could minimize the possibility of misplacing permit files as they are transferred between staff workstations and short- or long-term filing systems.

6.2.3. Improve tracking the progress of mitigation projects

Various changes to the database could improve its ability to track the progress of mitigation projects after a permit has been issued (e.g., Recommendation 6.2.1.11). However, there are additional activities the Water Boards could undertake to improve project tracking.

6.2.3.1. Track the submission of monitoring reports

Monitoring reports provide a potentially simple and efficient method for assessing the progress, and potentially the compliance, of a mitigation project (see Recommendation 7.3.1). However, our review suggests that this tool is not being used effectively. Monitoring and submission requirements had among the lowest compliance rates of all categories we evaluated. Through a tracking field in the database or other means, monitoring reports (and other submission requirements) should be routinely reviewed.

6.2.3.2. Keep better track of credit purchases

Currently, files for projects requiring mitigation bank or in-lieu fees often lack information about the payment of the required fees. In our assessments we found several examples where the evidence of fee purchases was submitted to one agency but not other agencies (see Recommendation 6.4).

6.2.3.3. Track in-lieu fee payments

We found some examples of in-lieu fee projects in which the money was paid, but not used (yet) for actual mitigation activities. For instance, several payments to the Center for Natural Lands Management were not applied to a mitigation site because no approved site was available at the time of fee payment. Several years had gone by in the interim and those projects appeared to have been forgotten about; at the very least, there was an extended period of temporal resource loss. It would be useful if a record could be made, either in the revised database (see Section 6.2.1.8) or elsewhere, when the payment was made <u>and</u> when the money was applied to mitigation.

6.3. Improve permit clarity

Permit conditions should be written as clearly assessable criteria, with individual conditions for each specific criterion to be evaluated. Permit conditions should be written with a clear and direct method of assessment in mind. Our results suggest that more clearly written conditions would improve the chance of compliance. Presently, some conditions are too vague or may be presented in a way that it is not possible to assess them.

Permit clarity could be improved if a standardized list of permit conditions were developed. A standardized list could incorporate the main characteristics found useful for each type of permit condition. It could be a living document that was revised to incorporate improved knowledge about what permit language did or did not achieve the desired results. It would improve consistency since all permit writers would be working from the same list; we found many examples of permit conditions that covered the same general topic but were worded in different ways. It would improve predictability for permittees and their consultants, since different projects would use the same wording to describe conditions to achieve the same goals. It would also provide permit writers with an overall structure for the types of conditions that might be required, so permit conditions might be more comprehensive. Obviously, standard conditions would often need to be modified to meet the particular demands of a specific project, and not all appropriate conditions could be anticipated. Nonetheless, a standardized list of permit conditions could help clarify the intent of permit conditions.

Creating a standardized list of permit conditions would be possible with moderate effort, but it was beyond the scope of this project. We recommend that a specific effort be made to establish a standardized list of permit conditions, and that this effort include all regulatory agencies responsible for wetland permits.

6.3.1. Important permit information, including impact and mitigation acreage and permit conditions, should be clearly delineated in tables and not buried within the permit text

After comparing the information in the 401 permits and database to the other regulatory permits, we found many cases where the database errors were the result of ambiguous language in the 401 permit. For example, the language of a permit may not have been clear whether two or more distinct impacts were additive or inclusive. Although these were considered database errors, it was clear that the cause was the difficulty in understanding the intent of the permit. The likelihood of such errors is higher when information for the database must be extracted from the text of the permit. Misinterpretations would be less likely if the key mitigation requirements were listed in tables.

6.3.2. Permit conditions should be written so that efforts made in a small portion of the site cannot satisfy the verbatim text of the condition when the intention of the condition was that the efforts would be made throughout the site

In our compliance assessments, we frequently encountered situations where ambiguous phraseology in the permit requirements required that we assign a high compliance score to a mitigation project even though only partial mitigation efforts had been made. As an example, in assessing compliance with a condition that read “must remove invasive plants prior to planting,” we had to assign a high score even if we found evidence that invasive plants were removed from only a small portion of the site. When the intention of a particular condition is that the action or success standard would apply to the entire site, the condition should include such specifications (“…throughout the entire site”).

6.3.3. Final Mitigation plans (and perhaps all permits) should include a table listing the requirements upon which compliance will be judged

Prior to the approval of the final mitigation plan, all parties should understand and approve the conditions upon which permit compliance will be judged. These conditions have generally been scattered diffusely throughout the text of regulatory permits and mitigation plans. Summarizing these clearly and succinctly would ensure that all parties understand the permits and simplify future compliance evaluations.

Within the permitting sequence, a preliminary mitigation plan is generated before all the permit requirements have been established. Rather than a diffuse and potentially ambiguous presentation of mitigation requirements, the regulatory permits should include a summary table with an explicit statement for each condition included in the permit. Then, after obtaining similar tables from all agencies, the permittee would combine these into a single unified table of conditions to be included in the final mitigation plan for approval. The development of this table should be a collaborative effort with all involved agencies (see Section 6.4) and not left solely to the permittee or consultant. In monitoring reports, assessment of compliance should be centered on this table (see Recommendation 7.3.1).

The table of mitigation requirements should distinguish conditions required by different agencies. In addition, the conditions should be organized within the following categories: (1) Permittee-responsible acreage requirements, (2) third party acreage credit purchases, (3) mitigation site implementation, (4) mitigation site maintenance, (5) site protective measures, (6) success and performance standards, (7) monitoring and submission requirements, (8) invocation conditions (e.g., “follow the 404 permit”), and (9) other/miscellaneous.

6.3.4. Permits should be clear about the meaning of enhancement, restoration and creation

Enhancement, restoration and creation can all increase the amount of wetlands functions in ways that can be appropriate for compensatory mitigation, but the amount and nature of the increase varies, and the likelihood of success also varies. Thus, the terms should be useful carefully and consistently. The term “restoration” is often used in a general sense to encompass all three of these terms, but in permit analyses and language they should be used strictly.

Enhancement refers to changes made to an existing habitat (e.g., wetland) to improve its functions or services. Enhancement does not increase the area of a habitat, which is an important consideration when assessing the goal of “no net loss” of wetland acreage. Because many physical processes may already be occurring before enhancement, enhancement projects may be the easiest to achieve successfully. Because some functions are typically occurring in the degraded habitat before enhancement, enhancement generally doesn’t produce as many functions or services (per unit area) as restoration or creation.

Restoration refers to changes made to an area that was once, at some point in the past, the desired habitat (e.g., wetland), but has been converted to a different habitat type. Restoration returns the area to the desired habitat, with the general goal of achieving the level of ecological functioning found in the original habitat. Restoration increases the area of a habitat as well as the amount of functions and services provided by that habitat.

Creation refers to the creation of a habitat in an area that had never supported that habitat. Because none of the physical processes or biological functions characteristic of the habitat, and required to sustain it, occur at the site before the creation, creation can be the most difficult type of “restoration.” Whenever wetland creation is required, wetland delineations, or at least proof of inundation or saturation appropriate for wetland development, should be included as permit requirements to ensure a wetland was actually created (see Recommendation 6.3.6).

In its 2004 Final Mitigation Guidelines and Monitoring Requirements, the Los Angeles District of the Corps uses similar definitions, and has a similar assessment of benefits and risks of the different types of “restoration”:

> Generally, the physical characteristics of the sites considered determine whether establishment (i.e., creation), restoration, enhancement, or, more rarely, preservation are viable compensatory mitigation options. The categories of compensatory mitigation, as defined by Lewis (1990) are:
>
> Restoration: return to a pre-existing condition.
>
> Creation: conversion of a persistent non-wetland habitat into wetland (or other aquatic) habitat. Two subdivisions are recognized: Artificial (i.e., irrigation required) or self-sustaining.
>
> Enhancement: increase in one or more functions due to intentional activities (e.g., plantings, removal of non-native vegetation).
>
> Passive Re-vegetation: allow a disturbed area to naturally re-vegetate without plantings.

Regulatory Guidance Letter 01-1 used the term establishment instead of creation. The former term will be used in this document for consistency with this Corps Headquarters' guidance. Establishment projects have the greatest potential because, in theory, the full suite of functions performed by that habitat type are established; but they also have the highest risks. Establishing aquatic habitat in an area where it did not previously exist is a difficult proposition. Restoration projects have had a higher degree of success in the Los Angeles District. Despite the uncertainties associated with establishment projects, the Corps usually recognizes establishment and restoration equally when it comes to determining compensatory mitigation credit. Enhancement projects generally receive less compensatory mitigation credit, because enhancement targets particular functions instead of the full suite of functions performed by that habitat type. When enhancement is accepted, the Corps will require that the enhancement improve as many of the functions as possible.

Additional terminology has been used in the recent proposed Mitigation Rule from the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers (71 FR 15520). The proposed rule uses the terms reestablishment and rehabilitation. Re-establishment refers to "the manipulation of the physical, chemical, or biological characteristics of the site with the goal of returning natural/historic functions to a former aquatic resource." Re-establishment rebuilds former aquatic resources and results in a gain in aquatic resource area. Rehabilitation refers to "the manipulation of the physical, chemical, or biological characteristics of the site with the goal of repairing natural/historic functions to a degraded aquatic resource." Rehabilitation results in a net gain in functions, but does not result in a gain in aquatic resource area.

In common mitigation practice, restoration and creation focus on the addition of plants (normally facultative riparian or wetland species) to areas where they do not currently occur. These are not true restoration or creation projects. True creation and restoration projects add hydrological, biogeochemical and ecological functions to a site, typically through topographical modifications and/or the establishment or re-establishment of appropriate hydrology. Section 6.1.1 discusses the need to include the full suite of physical and biological processes in mitigation projects.

Note that one other related term, preservation, is sometimes used in a mitigation context. Preservation occurs when an existing habitat (wetland or other) is protected but not manipulated. Although preservation may be an appropriate component of a mitigation requirement (see LAD ACOE guidelines for an example), preservation does not increase the amount of wetland acreage to compensate for acreage losses, nor does it increase the amount of wetland function or services to compensate for losses of those wetland attributes.

6.3.5. When invasive species removal is required, performance standards should be clear about the goal of invasive species control

In our evaluations, we found examples where invasive species eradication was an important goal of the mitigation and specifically required as a permit condition, and others where invasive removal and maintenance were required so that newly planted native species would have less competition for resources at establishment. However, in many instances, the goal of an invasive removal was not clearly defined, and while eradication may have been the intent, the permit language simply required removal. In such cases, we were forced to assign high compliance scores for the condition (some removal had occurred) even though substantial recurrence may have been observed. For some projects (e.g., site-specific invasive removal projects, or in-lieu fee payments for *Arundo donax* eradication), enhancement involving invasive species control was the entire mitigation project. Permits should be specific for the mitigation goal and the permit language should accurately reflect that goal.

6.3.6. If a wetland is planned as part of a mitigation project, proof of inundation or saturation appropriate for wetland development should be required

We found several examples where one of the regulatory agencies had required verification of wetland hydrology or three parameter wetlands as a specific performance standard. Unfortunately, most wetland mitigation projects did not include such a condition. This condition should be included as a performance standard in all permits involving wetland mitigation.

6.4. Improve the assessment of "no net loss"

6.4.1. Pre- and post-construction functional assessments of impact and mitigation sites should be required to ensure "no net loss" of wetland functions

Much of the interest about the success of compensatory wetland mitigation revolves around the question of whether "no net loss" of wetland area and functions has been achieved. It is very difficult to answer this question definitively with respect to functions without suitable data before any impacts have taken place. In our previous study (Ambrose and Lee 2004), we incorporated a method for assessing the net gain or loss of services, but quantitative, objective conclusions are difficult without appropriate "before" data. Conceptually, the correct way to answer this question is to assess wetland functions at the *impact* site before and after the impact occurs to estimate the loss of functions, and to assess functions at the *mitigation* site before and after mitigation occurs to estimate the gain of functions. These paired before-and-after functional assessments would provide the information necessary to assess a net change in wetland functions.

We recommend that functional assessments be conducted before the construction of any development project or mitigation project to establish the baseline conditions at those sites. Then, as part of the monitoring requirements, post-construction assessments should be conducted.

There are a variety of methods that could be used for a functional assessment. Ideally, the State Board would adopt one particular method so the functional assessments were consistent across the state and could be easily compared and aggregated for a state-wide assessment. Some wetland evaluation methods, such as the Hydrogeomorphic

Assessment Method (Hauer and Smith 1998), have been explicitly designed to incorporate “no net loss” analyses of mitigation projects. Others, such as the newly developed California Rapid Assessment Method (CRAM; Collins et al. 2005), which we used in this study, are readily being applied toward this goal. The method should be useable in a wide range of wetland habitats, quick to apply, and provide scientifically rigorous, objective data.

Although paired before-after functional assessments are necessary for a careful assessment of net change in wetland function, they are rarely if ever undertaken. Besides the general difficulty of funding such studies, this particular study design carries the additional logistical difficulty that the “after” samples must be taken some years after the “before” sample. Despite these difficulties, we feel the paired before-and-after study design is needed to address the key policy question of whether compensatory mitigation under the Clean Water Act is accomplishing the goal of “no net loss” of wetland functions.

There are additional benefits of before and/or after functional assessments, of course. A pre-construction functional assessment of the mitigation site would inform the design of the mitigation project, to help the analyst determine whether the proposed design is likely to result in the desired post-construction functions. A post-construction functional assessment of the mitigation site, such as we performed for this study, would show whether the mitigation project actually produced the desired functions. Even for these purposes, adoption of a standard functional assessment method such as CRAM would increase the value of the functional assessments by allowing the compilation of results across the state.

6.5. Coordination with other agencies

Although the Water Board has responsibility for 401 permits, the entire process of regulating impacts to wetlands and “waters of the United States” is closely coordinated with other agencies, especially the U.S. Army Corps of Engineers and the California Department of Fish and Game. Improved information management might improve this coordination (see Recommendation 7.3.2).

6.5.1. Improve incorporation of final permit information into Water Board files

Although the 401 process is integral to wetland permitting, we found a significant number of files where changes to a project (impacts and/or mitigation) that occurred later in the project planning and permitting were not incorporated into Water Board files or 401 permits (see Section 4.1.1). Our review of permit files suggests that the Regional Board staff have not always been included in the planning decisions that occurred after the 401 permit was issued. The Regional Boards should be active through all phases of the project planning or should at least insist on being copied on all subsequent changes that are approved by the other regulatory agencies. Once finalized, the 401 permit should be updated to reflect the actual impacts and mitigation actions/acreage that occurred, and then the database should be updated.

Although our review focused on 401 permits and the information included in them, it is worth noting that 404 permits should be more specific in mandating that the 401 conditions must be complied with. Currently, some 404 permits contain such language while others do not.

6.5.2. Consider developing an integrated permit

Coordination with other agencies would be maximized if there was a single integrated permit required for projects impacting wetlands or "waters of the U.S." Since there must already be significant coordination among the agencies, an integrated permit might not mean additional work, but it would simplify the permitting process for permittees, it would ensure that all relevant information was available and included in Water Board files, and it would eliminate redundant permit conditions.

7. Recommended Compliance Monitoring Program

The SWRCB contract for this work states that this final report shall "provide recommendations on the necessity, frequency, location, and type of ongoing compliance monitoring." Section 7.1 discusses the need for compliance monitoring based on the results of the present study. The next section discusses whether compliance monitoring might be focused at particular locations, how often it might be needed, and what type of monitoring might be required. In addition, we have some specific recommendations (Section 7.3) concerning monitoring.

Our recommendations about compliance monitoring reflect our own experiences, the scientific literature, and other guidelines. A particularly relevant guideline was produced in 2004 by the Los Angeles District of the Army Corps (LAD USACE 2004). Although directed more at monitoring the progress of mitigation projects, aspects of these guidelines are relevant to compliance monitoring.

7.1. The need for compliance monitoring

The results of this study clearly indicate the need to evaluate the compliance of mitigation projects with their permits. Thirteen of the 257 permits we located had to be excluded because of potential compliance issues. This indicates that up to 5% of the files we reviewed may have significant compliance problems (such as the impact occurring but no mitigation being undertaken).

Our analysis of discrepancies between the 401 permit and information in the permit file identified additional compliance issues. For example, 8% of the 143 files we evaluated had information indicating that the actual impacts were greater than authorized in the 401 permit; overall, there appeared to be compliance issues with **42%** of the files we evaluated.

We found relatively high compliance with third-party mitigation requirements, but substantial lack of compliance with nearly every other category of permit conditions we assessed (see Table 7). Only about 65% of acreage requirements were met. Only about 50% of success criteria/performance standards were met. About 53% of monitoring and submission requirements were met. Moreover, many of the categories we assessed had a high fraction of permits for which the conditions could not be assessed; for example, we could not assess monitoring and submission conditions for more than half of the permits.

These results indicate a definite need for compliance monitoring. Without a significant compliance effort, permittees are failing to comply with a wide range of permit conditions without the Water Board staff knowing about it.

7.2. How should compliance monitoring efforts be focused?

Our observations here are based on inferences gained from reviewing the permit files as well as data on compliance with permit conditions. Data from our analysis of compliance might be used to guide decisions about the most effective places to focus compliance monitoring. However, in considering this information, it is important to remember that ours was a retrospective analysis, sometimes assessing compliance many years after the mitigation project was completed, and as a consequence there were many permit conditions we could not assess. It is possible that there were compliance problems with the permit conditions that were not assessable for us, but we cannot determine that. A more complete assessment of compliance (enforcement) problems should focus on contemporary permits so that all conditions could be assessed.

Our data allow us to identify some areas that seem most likely to have low compliance. For example, we found some differences in compliance for different types of permittee. The lowest 401 compliance scores were State/Federal and Municipal agencies. For mitigation plan compliance, Caltrans and private permittees (individual land owners or commercial entities with small "one-time" projects) joined these two as having the lowest compliance. Industry (corporation-owned factories, landfills, etc.) had the highest compliance scores for mitigation plan compliance.

We also found some regional differences in compliance. Among the different Water Board regions, Region 2 had relatively low 401 compliance and Region 8 had lower mitigation plan compliance. The low 401 compliance in Region 2 appears to be the result of higher expectations and more specific permit conditions in Region 2 compared to other regions rather than the permittees in Region 2 being less diligent. For this reason, compliance numbers alone do not reflect the quality of the mitigation undertaken, since better compliance could be achieved by having fewer permit conditions and less demanding conditions. Among the Water Board regions, Regions 8 and 5F had among the fewest specific conditions in the 401 permit and among the highest proportion of redundant conditions.

The mean 401 compliance differed somewhat among the different wetland types (Figure 66). High gradient riverine habitats had the highest compliance rate. Low gradient riverine, depressional, and lagoon (the latter with only a single example) had intermediate compliance rates. Vernal pools (N=10) and estuarine wetlands (N=1) had the lowest compliance rates.

Although the preceding results provide some guidance in terms of possible areas for focusing compliance assessments, in our view it does not provide a very sharp focus. Compliance issues are spread quite broadly across all aspects of the 401 program, so compliance monitoring will also need to be spread quite broadly. The areas identified as having lower compliance might warrant a particular emphasis during compliance monitoring, but compliance was not so high for most other areas (with the possible exception of third-party mitigation conditions) that it would be safe to assume high compliance with them.

Although we have conducted a detailed assessment of compliance with 401 permits, we have little direct knowledge of the State or Regional Boards' current activities for checking compliance. Our review of information in the permit files suggest that there are substantial compliance issues for which there was no evidence of Regional Board response, but we did not follow up on these instances to determine if the Regional Boards were aware of those issues or had taken actions not evident in the file. Hence, we cannot comment on how current compliance efforts might be re-directed. However, we can identify mitigation monitoring reports as a cost-effective vehicle for evaluating a mitigation project.

Although monitoring requirements were regularly included as 401 permit conditions, and evaluated for compliance when appropriate, the relative scarcity of monitoring reports in the permit files we reviewed suggest that compliance with the monitoring requirement is checked infrequently. Our compliance assessment indicated that conditions requiring mitigation monitoring were met only about 53% of the time; it was unclear whether any enforcement actions were undertaken in response to the absence of monitoring reports. While we were conducting our study for the Los Angeles Regional Board, that region was compiling lists of permit files without monitoring reports and contacting permittees to obtain the reports. This seems like a relatively cost-effective area on which to focus compliance monitoring efforts.

In addition to reviewing submissions, it would be ideal if Water Board staff could undertake periodic site visits to confirm the reported monitoring results. However, we recognize that Water Board staff time is extremely limited, and it may not be feasible for existing staff to conduct site visits. Recommendation 7.3.2 suggests an organization that could undertake these site visits.

7.2.1. Frequency of compliance monitoring

There are different phases of a mitigation project, and different types of compliance monitoring would be required for each phase.

In the early construction phase of a mitigation project, many decisions are being made and many activities are being undertaken. Compliance monitoring during this phase would ensure that the mitigation project took shape as envisioned by the 401 staff and described in the mitigation plan. In addition, many compliance problems identified during this early phase are more likely to be resolved easily than if they were to be identified much later.

The best type of compliance monitoring for the early phase would be on-site inspections. However, as noted above, it is unlikely that existing Regional Board staff would have the time to conduct on-site inspections, although perhaps this would be possible for the largest or most complicated projects. (If an independent monitoring cooperative was established, as recommended in Section 7.3.2, they could conduct some site inspections.) In the absence of on-site inspections, mitigation monitoring reports are critical for the determination of permit compliance, especially for the period during and shortly after the initial construction of the mitigation site. This is because the proper hydrology should be established, conditions relating to the preparation and implementation of the mitigation, as well as the basic trajectory of the site, should be discernable. Extensive photographs would assist in documenting the progress of construction and compliance with the permit conditions. The regulatory agencies often require that as-built drawings are submitted during this time, but a full report is needed to identify any initial problems, such as incorrect hydrology or invasive species establishment. Although the permittee (or its consultants) should monitor a mitigation site frequently for the first year after its construction to ensure rapid identification of any unexpected developments or problems, and inform the regulatory agencies if these are identified so that appropriate corrective action can be taken if necessary, a formal annual report should provide the regulatory agencies with sufficient information. It is important to identify potential problems early; if deficiencies are not identified until the end of the monitoring period, there will be limited opportunities for remediation.

After the initial post-construction period, we expect changes to occur at a slower rate (e.g., Zedler and Callaway 1999). Annual monitoring would be appropriate to document the development of the site, identify any shortcomings, and to verify compliance with the permit requirements.

In general, on-site inspections would be the best way to confirm that all permit conditions had been met, but Regional Board staff should be able to assess compliance by careful review of monitoring reports. The most efficient use of staff resources would be to rely on annual monitoring reports through the end of the monitoring period, then confirm the report findings by an on-site inspection. However, on-site visits are often not possible due to staffing constraints. Office review of the monitoring reports would be sufficient in most cases, as long as the monitoring reports were focused and informative. Because we feel that good monitoring reports are essential for an efficient evaluation of permit compliance, we have included a specific recommendation on this topic (Recommendation 7.3.1).

7.3. Specific monitoring recommendations

7.3.1. Mitigation monitoring reports should be streamlined and focused around demonstrating compliance with an established list of permit conditions

Mitigation monitoring reports take a wide variety of forms, from very simple to extensive and detailed. In general, they tend to be large detailed documents that restate much of the background project-related information, often provide highly detailed descriptions of the monitoring methods and results of vegetation monitoring data, and only diffusely and often ambiguously address compliance related issues. The focus on methods and detailed results detract from their utility for assessing compliance with permit condition. The annual monitoring reports should focus on the success-related issues and should clearly document compliance with an established list of permit conditions (see Recommendation 6.3.3).

Because agency permit files are often incomplete and lack key documents (such as the mitigation plan), we do not feel that all background information (such as the restating of project impacts and expected mitigation strategies) should be eliminated from monitoring reports. However, such information should be well organized and succinct. We suspect that the extraneous nature of existing monitoring reports has been an impediment to the regulatory review of these documents.

Some of these issues have been addressed recently in the USACE's Regulatory Guidance Letter No. 06-03 on minimum monitoring requirements (available at http://www.usace.army.mil/cw/cecwo/reg/rgls/rgl06_03.pdf.). Clear guidance on the desired structure and content of the monitoring reports could simplify the task of assessing the progress of mitigation projects, and in particular it would greatly improve their utility for assessing compliance with permit conditions.

7.3.2. Form a multi-agency cooperative for compliance monitoring and project tracking

In California there are typically three to five regulatory agencies involved in the wetland regulatory process: the Corps, the Regional Board, the DFG if the project involves stream or lakebed impacts or State-listed endangered species, the FWS if there are federally-listed endangered species issues, and the Coastal Commission if the project occurs within the Coastal Zone (or the Bay Conservation and Development Commission [BCDC] if the project is in the San Francisco Bay region). Each agency is responsible for independently monitoring compliance with its own permits, including compliance with compensatory mitigation requirements. Compliance monitoring is complicated by the fact that not all agencies receive all required documents (e.g., final mitigation plans, monitoring reports, deeds, proof of payment/credit purchases, and documents describing planning changes) from the permittee. Permittees frequently submit documents to a single agency that they view as the "lead" agency for their project.

Following up on permit compliance includes the time consuming reorientation to the various projects, keeping track of document submissions and other communications, the careful review of mitigation monitoring reports, and site visits, plus maintaining the files and updating the database. Yet each agency suffers from perennial understaffing and limited resources. The result is that little monitoring of compliance is done by any agency.

To help address this problem, we recommend that regulatory agencies establish a multi-agency cooperative to monitor compliance and track wetland losses and mitigation success across the State. This cooperative could report the results of its evaluation to each of the regulatory agencies and serve as a central repository for permit-related information. This could improve compliance monitoring and free-up staff resources.

Costs would be distributed and redundancy would be eliminated, thus maximizing the efficient use of limited resources.

In our study, we reviewed 200-300 permit files and thoroughly assessed almost 150 files within one year with a limited staff. With limited funding from each agency, a small staff could receive and manage copies of documents from across the state, visit a significant percentage of sites as agents of all agencies, and report their findings to each agency. After issuing their permits, project managers would be freer to concentrate on new projects instead of simultaneously tracking multiple existing projects. Such a cooperative would ensure that compliance monitoring would actually get accomplished, while avoiding substantial redundancy of effort and promoting the centralization of permit file information and tracking.

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9. Tables

Table 1. Reference Site information

Site ID	Name	Region	Latitude	Longitude	Research Group*	Wetland Type
WCAP99-R026	Coldwater Creek	1	41.84611	124.02750	CCG	Riverine Low
WCAP99-R029	Clark's Creek	1	41.80861	124.11667	CCG	Riverine High
WCAP99-RO92	Prairie Creek State Park	1	41.40000	124.05806	CCG	Riverine High
BC-Y	Blue Creek	1	41.20000	123.54000	CCG	Riverine High
WCAP99-R037	Horse Linto	1	41.00893	123.60197	CCG	Riverine High
11921	Grove's Prairie	1	40.95667	123.48528	CCG	Riverine Low
WCAP99-R077	Canoe creek	1	40.29490	123.90290	CCG	Riverine Low
FREE 11130	Freeman Meadow	5R	39.67333	120.62075	SFEI	Riverine Low
WCAP99-R003	Trout Creek	1	39.53852	122.86077	SFEI	Riverine High
WCAP99-R008	Rattlesnake Creek	1	39.49388	122.86368	SFEI	Riverine High
WCAP99-0614	Austin Creek East	1	38.53603	123.07221	SFEI	Riverine Low
Ref. 16	Asbury Creek Lo	1	38.35028	122.53793	UCLA	Riverine Low
Ref. 17	Asbury Creek Tributary	1	38.34976	122.53352	UCLA	Riverine High
CA02-0604	Upper Petaluma	2	38.20767	122.56683	SFEI	Estuarine
CA02-0608	Point Edith	2	38.04353	122.07233	SFEI	Estuarine
CA02-0612	China Camp	2	38.01475	122.49280	SFEI	Estuarine
Ref. 22	Briones Regional Park	2	37.92129	122.16454	USF	Riverine High
Ref. 5	Walker	6V	37.90109	119.12983	UCLA	Riverine Low
Ref. 4	McGill Trail Head	6V	37.54992	118.80384	UCLA	Riverine High
Ref. 3	Fish Slough	6V	37.48043	118.40321	UCLA	Seep & Spring
Ref. 9	TNC Vernal Pool Reserve	5F	37.39987	120.45229	UCLA	Vernal Pool
Ref. 10	Chowchilla	5F	37.17623	120.07051	UCLA	Riverine Low
101	Upper Scott's Creek	3	37.07404	122.23793	CCG	Riverine Low
106(a)	East of Seal Bend	3	36.82000	121.77000	CCG	Estuarine
12339	Carmel Valley River	3	36.52243	121.81748	CCG	Riverine Low
12330	San Antonio River	3	35.89417	121.07361	CCG	Riverine Low
310-ADC	Arroyo de la Cruz Creek	3	35.70833	121.30035	CCG	Riverine Low
310-SSU	Upper San Simeon creek	3	35.60921	121.07393	CCG	Riverine Low
310-SSC	Lower San Simeon creek	3	35.59448	120.12112	CCG	Riverine Low
CA02-0031	Chorro Creek, marina	3	35.34553	120.83629	CCG	Estuarine
CA02-0021	Chorro Creek, flats	3	35.34430	120.83168	CCG	Estuarine
CA02-0002	Los Osos creek	3	35.33418	120.83638	CCG	Estuarine
Ref. 12	Coon Creek	3	35.25498	120.88692	UCLA	Riverine Low
310-COO	Coon creek	3	35.25476	120.88549	CCG	Riverine Low
Ref. 1	Pismo Beach Ecological Reserve	3	35.13359	120.62396	UCLA	Lacustrine
Ref. 15	Sedwick Reserve	3	34.73013	120.02692	UCLA	Depressional
Ref. 13	Sedwick Reserve	3	34.72113	120.03613	UCLA	Riverine Low
Ref. 14	Sedwick Reserve	3	34.68298	120.04469	UCLA	Vernal Pool
Ref. 2	Los Padres National Forest	4	34.51467	119.26867	UCLA	Riverine Low
Ref. 20	Arroyo Hondo Canyon	3	34.48702	120.14222	UCLA	Riverine Low
Ref. 21	El Capitan Canyon	3	34.48049	120.01888	UCLA	Riverine High
Ref. 18	Santa Paula Creek	4	34.44172	119.07551	UCLA	Riverine Low
Ref. 11	Upper Santa Clara River	4	34.44020	118.31349	UCLA	Riverine Low
Ref. 7	City Creek Rte 330	8	34.17385	117.18515	UCLA	Riverine High
Ref. 19	Solstice Canyon.	4	34.03935	118.75321	UCLA	Riverine Low
Ref. 8	Upper Santa Margarita River	9	33.40826	117.23828	UCLA	Riverine Low
Ref. 6	Cibola Lake (NWR)	7	33.22461	114.67300	UCLA	Lacustrine

* CCG = Central Coast Group

Table 2. Jurisdictional habitat hierarchy.

Every mitigation site was apportioned into its component habitat types according to this hierarchy. First, the evaluator determined which proportion of the sites consisted of "waters" and which proportion was outside of "waters" (e.g., 60:40). Next, the wetland and non-wetland "waters" percentages would be determined (e.g., 50:10), as would any non-"waters" riparian and upland habitats (e.g., 20:20), and so forth. The sum of the equivalent habitat percentages would equal the above percentage in the hierarchy. These percentages were multiplied by the overall site acreage to determine the individual jurisdictional habitat acreages.

Waters of the United States			
	Wetland		
	Non-Wetland Waters		
		Non-Streambed Open Water	
		Streambed	
			Open Water Stream
			Unvegetated Streambed
			Vegetated Streambed
		Riparian Waters	
Non-Specified Riparian			
Non-waters of the United States			
	Non-waters Riparian		
	Upland		

Table 3. Overall summary of the permit file selection results by region.

This table includes the 429 permit files that were randomly selected from the SWRCB database, and pursued at either the Corps or Regional Board offices, or both. Two files were initially pursued, but later excluded because they had 401 permits that were issued directly by the State Board (SB).

Region	Pursued for review	Not located	Removed during review	Removed after field visit	Not visited or assessed	Assessed for compliance only	Assessed fully
1	32	15	5	0	1	2	9
2	75	29	20	0	0	1	25
3	43	16	4	7	1	2	13
4	44	6	10	9	0	4	15
5F	18	10	0	2	0	2	4
5R	27	17	2	0	2	0	6
5S	54	13	10	2	4	1	24
6T	23	14	4	1	2	0	2
6V	10	4	2	2	0	0	2
7	11	7	1	0	0	1	2
8	25	7	3	2	0	0	13
9	65	33	12	5	0	1	14
SB	2	1	1	0	0	0	0
Total	**429**	**172**	**74**	**30**	**10**	**14**	**129**

Table 4. Number of onsite and offsite mitigation sites for file specific mitigation actions, formal mitigation banks, informal mitigation banks, and in lieu fees.

	N	File-Specific	Formal Mitigation Bank	Informal Mitigation Bank	In-Lieu Fee
On Site Mitigation	127	125	1	1	0
Off Site Mitigation	77	29	31	14	3
Total	**204**	**154**	**32**	**15**	**3**

Table 5. Summary of the discrepancies between the impact and required mitigation acreage values obtained through our detailed permit reviews and the corresponding values in the State Board's permit tracking database. Multiple discrepancy categories may apply to a particular file.

Source of Impact and/or Mitigation Acreage Discrepancy	Number of Files	% of Total Files (N=143)
Discrepancy due to minor rounding issues in 401 permit or in SWRCB database	9	6.2
Data entry issue in SWRCB database (typographical error or misinterpretation of information in 401 permit, often due to ambiguous wording).	26	18.2
Issues with the 401 permit itself, including transcriptional and typographical errors, misinterpretations, or a lack of critical information in the 401 permit text	24	16.8
Discrepancy due to accounting difference (e.g., permanent vs. temporary impacts, or wetlands vs. non-wetland "waters") between reported values and 401 permit	27	18.9
Other agency required more mitigation than RB, but 401 permit not outdated	19	13.4
Mitigation planning modified after 401 permit issuance, permit outdated	12	8.4
Impacts reduced after 401 issuance, mitigation same, 401 permit outdated	3	2.1
Impacts reduced after 401 issuance, mitigation different, 401 permit outdated	13	9.1
401 outdated, impacts greater than 401 approved, mitigation same or different	12	8.4
Revised 401 permit entered separately into SWRCB database resulting in multiple entries and redundant acreage values	7	5.0
Summaries		
Discrepancies between reported values and the SWRCB database	101	70.6
Discrepancies between our reported values and the 401 permits themselves	86	60.1
Regulatory/compliance issues with files from an acreage perspective	60	42.0

Table 6. Summary of compliance scores based on 401 and mitigation plan evaluations including average scores and scores for the percentage of conditions met to 100% satisfaction.

Successful included files with compliance scores greater than 75%, partially successful included files with scores between 25% and 75%, and failure included files with scores less than 25%.

	N	Score	Successful	Partially Successful	Failure
Average 401	124	84.3%	76%	20%	4%
Average 401 percent-met		73.3%	57%	30%	13%
Average mitigation-plan	81	80.7%	68%	32%	0%
Average mitigation plan percent-met		67.6%	48%	35%	6%

Table 7. Compliance breakdowns for 401 and Mitigation Plan compliance grouped by compliance condition category (N=143 files). See Methods for details on condition categories. ND = not determinable.

		401						Mitigation Plan					
Condition Code	Condition Category	Total # Conditions	Average # Conditions	Average # ND	Average Score	Average % Met	Average % ND	Total # Conditions	Average # Conditions	Average # ND	Average Score	Average % Met	Average % ND
1	Third Party	58	1.5	0.1	99.3	99.3	8.8	26	1.6	0.1	90.0	90.0	6.3
2	Acreage	158	1.8	0.2	81.5	64.4	6.9	132	2.0	0.2	83.0	66.8	9.5
3	Site Implementation	411	6.0	2.7	84.8	71.9	45.1	546	7.9	3.1	84.3	72.4	40.4
4	Site Maintenance	49	1.6	0.8	76.0	56.7	45.6	93	2.2	0.7	80.7	68.1	34.3
5	Site Protection	66	1.5	0.6	81.3	72.6	42.5	58	1.6	0.4	77.9	72.4	25.6
6	Success & Performance Standards	199	3.9	1.5	76.4	49.7	31.0	298	4.4	1.3	76.0	52.9	26.3
7	Monitoring & Submission	254	3.6	2.0	59.5	52.3	54.3	220	3.2	1.4	60.9	53.7	45.7
8	Invocation of Other Agency Permits	126	1.7	1.1	N/A	N/A	69.3	5	2.5	1.0	N/A	N/A	100
9	Other	35	1.3	0.6	96.1	94.4	46.8	13	1.3	0.3	93.8	93.8	20.0
3 - 6	Site Implementation, Maintenance, Protection, Success/Performance Standards	725	3.2	1.4	79.6	62.7	41.0	995	4.0	1.4	79.7	66.4	31.6

Table 8. Summary statistics of mitigation CRAM mitigation site scores (N=129) and reference site CRAM scores (N=47) for Total-CRAM scores and the four attributes, along with the percentage of files within each success category.

	Reference Sites		File-wide CRAM Scores				
	Median	Mean ± SE	Median	Mean ± SE	Optimal	Sub Optimal	Marginal to Poor
Overall	82.06	79.13 ± 1.36	60.77	58.61 ± 1.10	19.38	56.59	24.03
Landscape Context	90.28	87.10 ± 1.06	72.32	65.57 ± 1.78	47.29	24.81	27.91
Hydrology	90.74	86.67 ± 1.58	62.96	62.67 ± 1.64	27.13	42.64	30.23
Physical Structure	79.17	76.06 ± 2.48	52.79	53.81 ± 1.61	49.61	27.13	23.26
Biotic Structure	68.33	66.68 ± 2.24	51.78	52.63 ± 1.28	62.02	25.58	12.40

Table 9. Summary statistics and success breakdowns of Total-CRAM scores by SWRCB region (N=129 files).

Total-CRAM Scores (Overall File-wide CRAM Scores)						
Region	N	Mean ± SE	Median	% Optimal	% Sub-Optimal	% Marginal / Poor
1	9	57.12 ± 4.76	50.93	22.22	55.56	22.22
2	25	51.08 ± 2.07	48.40	4.00	44.00	52.00
3	13	55.61 ± 3.81	58.74	15.38	61.54	23.08
4	15	57.67 ± 3.40	57.99	20.00	46.67	33.33
5F	4	61.73 ± 5.26	64.86	25.00	50.00	25.00
5R	6	61.57 ± 2.98	61.33	16.67	83.33	0.00
5S	24	64.40 ± 1.43	64.33	16.67	79.17	4.17
6T	2	74.43 ± 3.83	74.43	100.00	0.00	0.00
6V	2	42.52 ± 14.4	42.52	0.00	50.00	50.00
7	2	56.22 ± 8.17	56.22	0.00	50.00	50.00
8	13	64.25 ± 2.79	67.50	23.08	69.23	7.69
9	14	60.44 ± 4.38	65.63	42.86	35.71	21.43

Table 10. Summary statistics and success breakdowns of landscape context attribute CRAM scores by SWRCB region (N=129 files).

Landscape Context CRAM Scores						
Region	N	Mean ± SE	Median	% Optimal	% Sub-Optimal	% Marginal / Poor
1	9	55.43 ± 6.60	50.86	22.22	22.22	55.56
2	25	57.84 ± 3.80	57.33	28.00	32.00	40.00
3	13	57.52 ± 6.86	53.30	38.46	15.38	46.15
4	15	64.75 ± 3.79	64.25	33.33	40.00	26.67
5F	4	68.40 ± 14.20	81.78	75.00	0.00	25.00
5R	6	76.92 ± 2.90	74.91	66.67	33.33	0.00
5S	24	82.55 ± 1.95	86.65	83.33	16.67	0.00
6T	2	84.44 ± 3.70	84.44	100.00	0.00	0.00
6V	2	34.97 ± 9.30	34.97	0.00	0.00	100.00
7	2	81.83 ± 4.08	81.83	100.00	0.00	0.00
8	13	61.88 ± 5.64	62.69	38.46	30.77	30.77
9	14	62.29 ± 5.50	70.49	42.86	28.57	28.57

Table 11. Summary statistics and success breakdowns of hydrology attribute CRAM scores by SWRCB region (N=129 files).

Hydrology CRAM Scores						
Region	N	Mean ± SE	Median	% Optimal	% Sub-Optimal	% Marginal / Poor
1	9	65.90 ± 7.77	52.50	44.44	0.00	55.56
2	25	61.39 ± 3.84	58.71	28.00	40.00	32.00
3	13	58.20 ± 5.11	64.82	0.00	76.92	23.08
4	15	59.15 ± 4.66	54.63	20.00	40.00	40.00
5F	4	71.79 ± 9.11	74.58	50.00	25.00	25.00
5R	6	73.00 ± 4.66	72.87	50.00	50.00	0.00
5S	24	62.65 ± 4.15	65.16	29.17	37.50	33.33
6T	2	81.20 ± 1.20	81.20	100.00	0.00	0.00
6V	2	35.51 ± 16.3	35.51	0.00	0.00	100.00
7	2	63.75 ± 27.90	63.75	50.00	0.00	50.00
8	13	63.58 ± 4.37	60.83	30.77	38.46	30.77
9	14	64.04 ± 3.79	64.27	14.29	78.57	7.14

Table 12. Summary statistics and success breakdowns of physical structure attribute CRAM scores by SWRCB region (N=129 files).

Physical Structure CRAM Scores						
Region	N	Mean ± SE	Median	Optimal	% Sub-Optimal	% Marginal / Poor
1	9	52.90 ± 4.95	50.00	44.44	33.33	22.22
2	25	40.44 ± 3.52	39.83	24.00	28.00	48.00
3	13	55.55 ± 4.81	58.33	61.54	15.38	23.08
4	15	58.87 ± 5.29	66.67	60.00	26.67	13.33
5F	4	47.18 ± 7.58	45.42	25.00	50.00	25.00
5R	6	50.90 ± 5.32	47.23	33.33	50.00	16.67
5S	24	55.17 ± 2.68	59.56	58.33	25.00	16.67
6T	2	68.75 ± 18.8	68.75	50.00	50.00	0.00
6V	2	52.08 ± 2.08	52.08	50.00	50.00	0.00
7	2	50.69 ± 0.69	50.69	0.00	100.00	0.00
8	13	67.40 ± 3.73	70.83	76.92	23.08	0.00
9	14	57.99 ± 6.49	65.98	57.14	7.14	35.71

Table 13. Summary statistics and success breakdowns of biotic structure attribute CRAM scores by SWRCB region (N=129 files).

Biotic Structure CRAM Scores						
Region	N	Mean ± SE	Median	Optimal	% Sub-Optimal	% Marginal / Poor
1	9	54.24 ± 4.91	54.85	66.67	22.22	11.11
2	25	44.66 ± 2.36	45.00	40.00	36.00	24.00
3	13	51.18 ± 3.39	48.33	61.54	23.08	15.38
4	15	47.89 ± 2.82	45.23	40.00	53.33	6.67
5F	4	59.57 ± 5.32	60.07	75.00	25.00	0.00
5R	6	45.46 ± 4.29	44.55	50.00	33.33	16.67
5S	24	57.23 ± 1.89	60.07	83.33	16.67	0.00
6T	2	63.33 ± 8.33	63.33	100.00	0.00	0.00
6V	2	47.50 ± 30.00	47.50	50.00	0.00	50.00
7	2	28.61 ± 1.39	28.61	0.00	0.00	100.00
8	13	64.14 ± 3.53	65.00	84.62	15.38	0.00
9	14	57.43 ± 5.35	56.04	71.43	14.29	14.29

Table 14. Summary statistics and success breakdowns of CRAM scores by individual CRAM metric (N=204 mitigation sites).

Metric	N	Mean ± SE	Median
Buffer and Landscape Context			
Connectivity	204	68.2 ± 1.8	77.8
% of AA with Buffer	204	81.6 ± 1.4	91.7
Avg. Width of Buffer	204	61.9 ± 1.9	66.7
Buffer Condition	204	60.6 ± 1.4	66.7
Hydrology			
Water Source	204	59.5 ± 1.5	58.3
Hydroperiod	204	64.7 ± 2.0	73.3
Hydrologic Connectivity	117	64.6 ± 2.0	66.7
Physical Structure			
Physical Patch Richness	204	43.5 ± 1.8	41.7
Topographic Complexity	204	63.5 ± 1.4	66.7
Organic Matter Accumulation	204	69.3 ± 1.4	68.9
Biotic Structure			
Biotic Patch Richness	204	45.7 ± 1.4	41.7
Vertical Biotic Structure	190	39.1 ± 1.5	41.7
Interspersion / Zonation	204	58.6 ± 1.5	58.3
% Non-native Plant Species	204	60.5 ± 2.3	52.8
Native Plant Species Richness	204	49.3 ± 2.0	41.7

Table 15. Total impacted and obtained acreage for all files (overall), “waters of U.S.” and non “waters of U.S.,” wetland, and non wetland “waters.”

Overall acreage includes “waters of the U.S.” plus non-“waters” areas. The breakdown for wetlands/non-wetland “waters” does not include 5 permit files for which the jurisdictional impacts could not be distinguished.

	Total Impact	Total Obtained	Proportion Obtained	Net Acreage Gain	Gained /Loss Ratio
Overall Acreage	216.8	417.0	NA	200.2	1.9
Waters of U.S.	212.4	303.2	72.7	90.8	1.4
Non Waters of U.S.	4.4	113.8	27.3	109.4	NA
Waters of U.S.:					
Wetlands	121.2	180.5	63.2	59.3	1.5
Non Wetland Waters	74.5	105.2	36.8	30.7	1.4

Table 16. Permanent impacts and created mitigation acreage, “waters of U.S.” and non “waters of U.S.,” and wetland, non wetland “waters.”

	Permanent Impact	Created Acreage	Proportion Obtained	Net Acreage Gain	Gained /Loss Ratio
Overall Acreage	165.8	270.9	NA	105.1	1.6
Waters of U.S.	162.7	223.1	82.4	60.4	1.4
Non Waters of U.S.	3	47.8	17.6	44.8	NA
Waters of U.S.:					
Wetlands	106.3	146.7	66.4	40.4	1.4
Non Wetland Waters	54.9	74.2	33.6	19.3	1.4

Table 17. Total impacted and obtained acreage for all files (overall), "waters of U.S." and non "waters of U.S.," wetland, and non wetland "waters."

	% Files with Gains	% Files where Gained = Lost	% Files with Losses
Overall Acreage	64	17	20
Waters of U.S.	54	13	33
Non Waters of U.S.	45	55	0
Wetlands	58	19	22
Non Wetland Waters	24	34	42

Table 18. Permanent impacts and created mitigation acreage, "waters of U.S." and non "waters of U.S.," and wetland, non wetland "waters."

	% Files w/Gains	% Files Gained=Lost	% Files w/Loss
Overall Acreage	41	20	39
Waters of U.S.	36	17	47
Non Waters of U.S.	24	76	1
Wetlands	40	32	28
Non Wetland Waters	17	37	46

Table 19. Mitigation success by permit file for each evaluation category: acreage requirement, 401 conditions, mitigation plan conditions, and wetland condition.

Data shown for acreage and compliance are percentages out of a total number of 143 permit files. Wetland condition data are percentages of a total number of 129 files. Numbers in parentheses are the actual number of sites within each category. For the acreage requirements, success was considered 100 percent, partial success was considered 75 to 100 percent (lower and upper bounds not inclusive), and failure was 75 percent and below. For the 401 and MP compliance evaluation, success was considered 75 to 100 percent, partial success was considered 25 to 75 percent (lower and upper bounds not inclusive), and failure was 25 percent and below. For the CRAM evaluation of wetland condition, success was considered 70 to 100 percent, partial success was 50 to 70 percent (lower and upper bounds not inclusive), and failure was 50 percent and below.

Category	Percent Success (N)	Percent Partial Success (N)	Percent Failure (N)	Cannot Be Determined (N)
Acreage Requirement	72 (101)	11 (16)	17 (24)	(2)
401 Conditions	76 (94)	20 (25)	4 (5)	(19)
Mitigation Plan Conditions	68 (55)	32 (26)	0 (0)	(62)
Wetland Condition	19 (25)	55 (71)	26 (33)	Not a category

Table 20. Acreage, compliance, and CRAM summaries by permittee type. These permittee type categories were taken directly from the 401 permit files.

See text for methods used to derive the measures presented in this table.

	Developer	Industry	Caltrans	Municipal	Private	State/Federal
Number of Files	66	9	13	34	13	8
Average Impact Acreage (Total Impact Acreage)	1.17 (76.96)	1.73 (15.54)	2.35 (30.55)	1.75 (59.55)	0.63 (8.19)	3.26 (26.05)
Average Required Acreage for Mitigation (Total Required Acreage)	2.30 (151.80)	7.12 (64.11)	5.22 (67.80)	2.36 (80.30)	0.97 (12.65)	8.57 (68.59)
Average Obtained Acreage (Total Obtained Acreage)	2.15 (141.75)	6.44 (57.95)	4.79 (62.25)	2.28 (77.63)	0.83 (10.84)	8.33 (66.60)
Average Acreage Gained (Total Acreage Gained)	0.98 (64.80)	4.71 (42.41)	2.44 (31.71)	0.53 (18.08)	0.20 (2.66)	5.07 (40.55)
Average Mitigation Ratio (Required)	3.22:1	16.91:1	1.51:1	2.32:1	1.67:1	1.63:1
Average Mitigation Ratio (Obtained)	3.13:1	17.36:1	1.38:1	2.40:1	1.89:1	1.33:1
Average 401 Compliance Score	85.93	84.06	87.60	79.77	87.87	76.20
Average Mitigation Plan Compliance Score	81.70	89.96	73.94	80.56	76.98	79.20
Average Total-CRAM Score	57.42	56.71	61.24	59.81	58.03	63.53
Average CRAM-Adjusted Acreage (Total CRAM-Adjusted Acreage)	1.35 (81.18)	3.55 (31.91)	3.58 (35.79)	1.24 (38.38)	0.44 (4.82)	4.09 (32.71)

Table 21. Summary of administrative and regulatory recommendations.

	Improving mitigation requirements	Information management	Improve permit clarity	Assessment of "no net loss"	Coordination with other agencies
Permit conditions should ensure complete compensation for the full suite of wetland functions and services lost	X				
Ensure that mitigation projects compensate for losses in water quality (pollution) improvement services	X				
There should be a better accounting of the habitat types lost and gained	X				
Mitigation projects should have appropriate landscape context	X				
Offsite mitigation should be within the same catchment, or at least the same watershed	X				
Improvements to Database		X			
Improve permit archiving		X			
Improve tracking the progress of mitigation projects		X			
Important permit information should be clearly delineated in tables			X		
Permit conditions should be written so that the extent of efforts must match the intent of the condition to be in compliance			X		
Every mitigation plan and permit should include a table of requirements upon which compliance will be judged			X		
Permits should be clear about the meaning of enhancement, restoration and creation			X		
Performance standards should be clear about the goal of invasive species control			X		
Proof of inundation or saturation appropriate for wetland development should be required for mitigation wetlands			X		
Pre- and post-construction functional assessments of impact and mitigation sites should be required				X	
Improve incorporation of final permit information into Water Board files					X
Consider developing an integrated permit					X

Table 22. Suggested jurisdictional and non-jurisdictional habitat hierarchy, with structure for tracking losses and gains.

Impact/Mitigation Acreage Accounting	**Impacted**			**Required**				
	Total	Permanent	Temporary	Total	Creation	Restoration	Habitat Enhancement	Preservation
Waters of the United States.								
Wetland (Total)								
Riverine								
Estuarine/Lagoon								
Seasonal/Depressional								
Vernal Pool								
Seep/Spring/Wet Meadow								
Lacustrine Fringe								
Other								
Non-Wetland Waters								
Non-Streambed Open Water								
Streambed (Total)								
Open Water								
Unvegetated Streambed								
Vegetated Streambed								
Other (Ex: Riparian Waters)								
Non-waters of the United States.								
Non-federal Waters of the State								
Isolated Wetlands								
DFG Riparian (i.e., to "drip line")								
Other Riparian (non-jurisdictional)								
Upland								

10.Figures

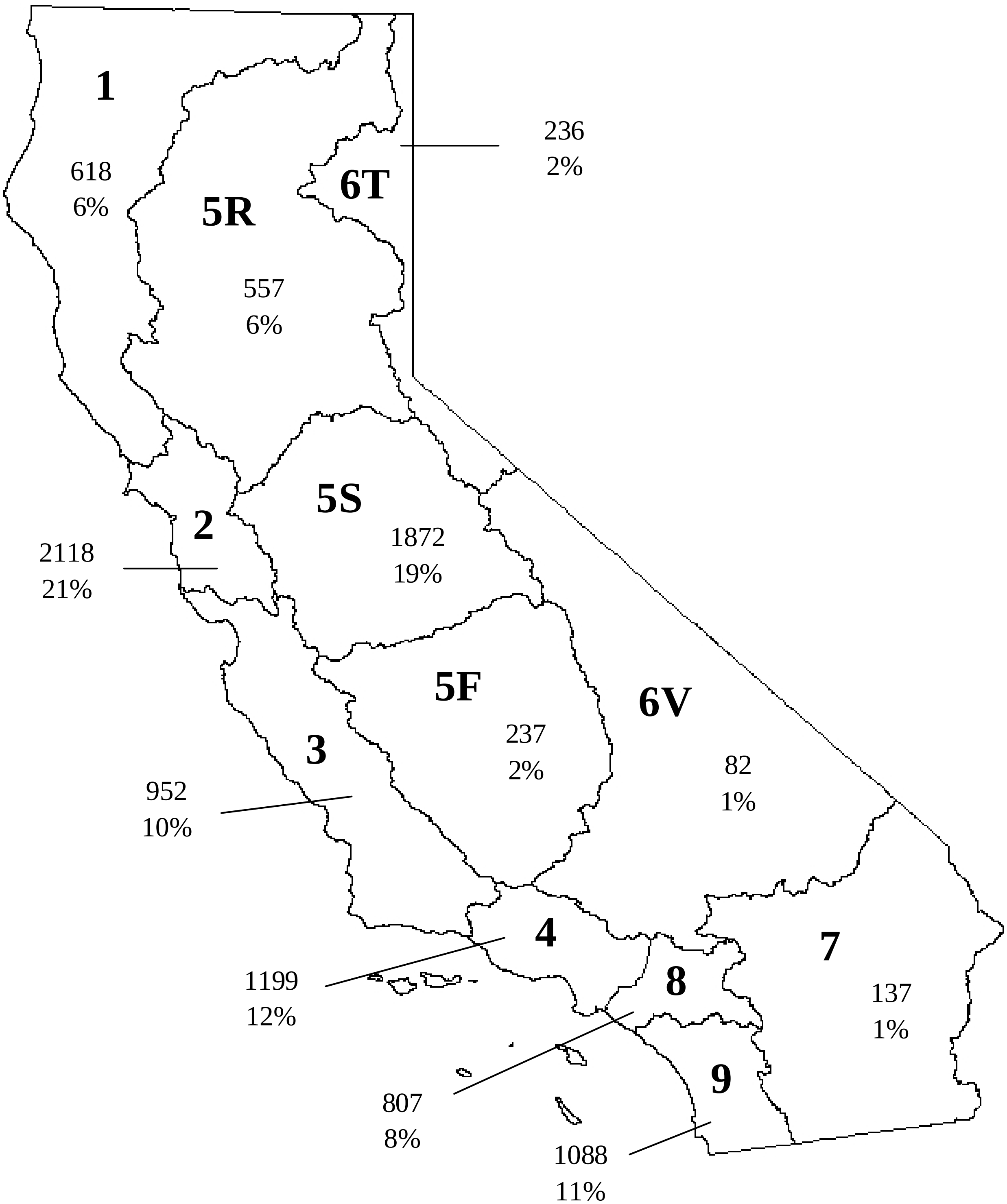

Figure 1. Map of California state board regions with breakdown of number of permit files.

The total number of files listed in the SWRCB database by region from 1991-2002 (N=9924 files) and the percentage of files by region of the total number of files in the SWRCB database from 1991-2002.

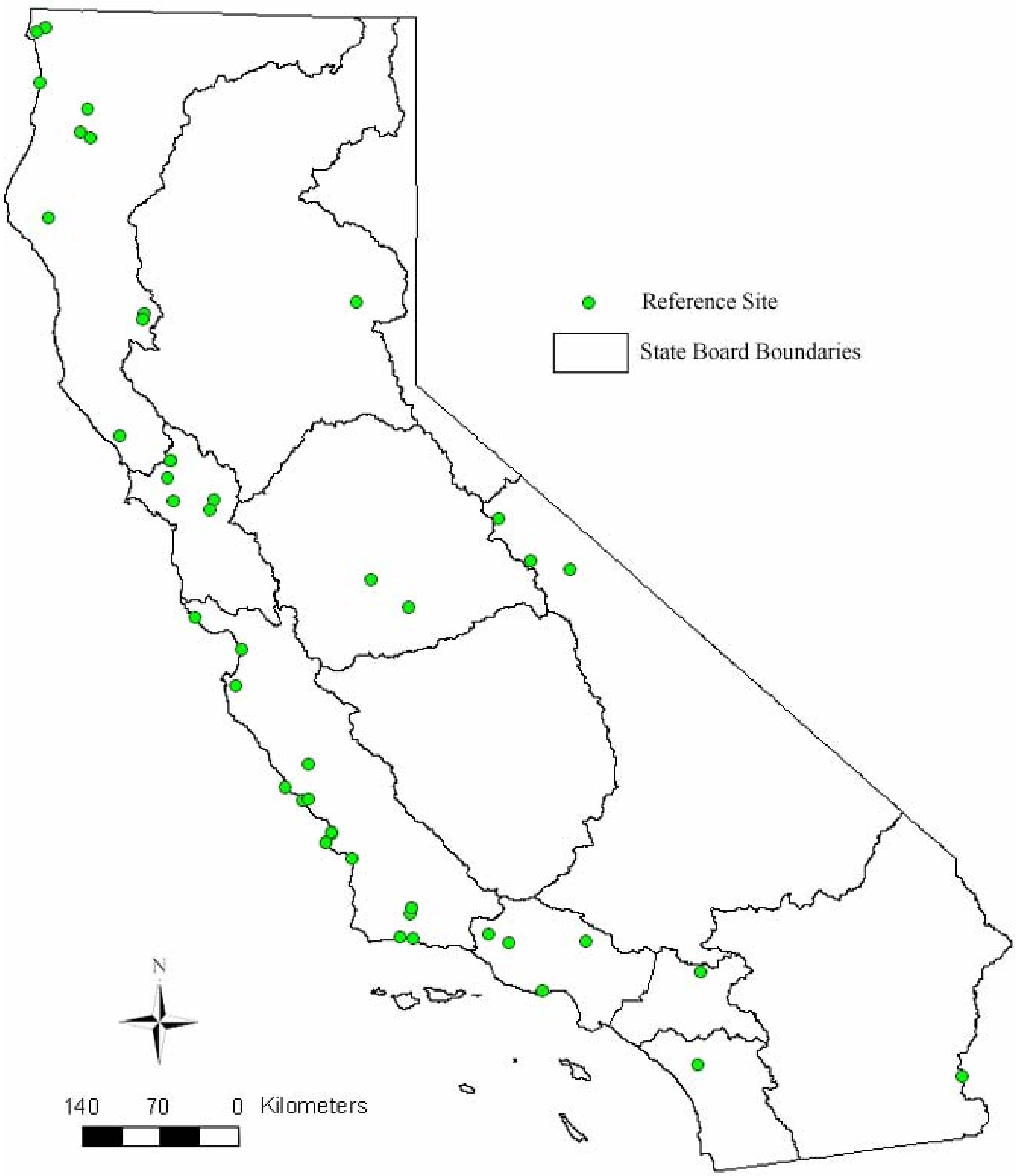

Figure 2. Statewide distribution of reference sites.

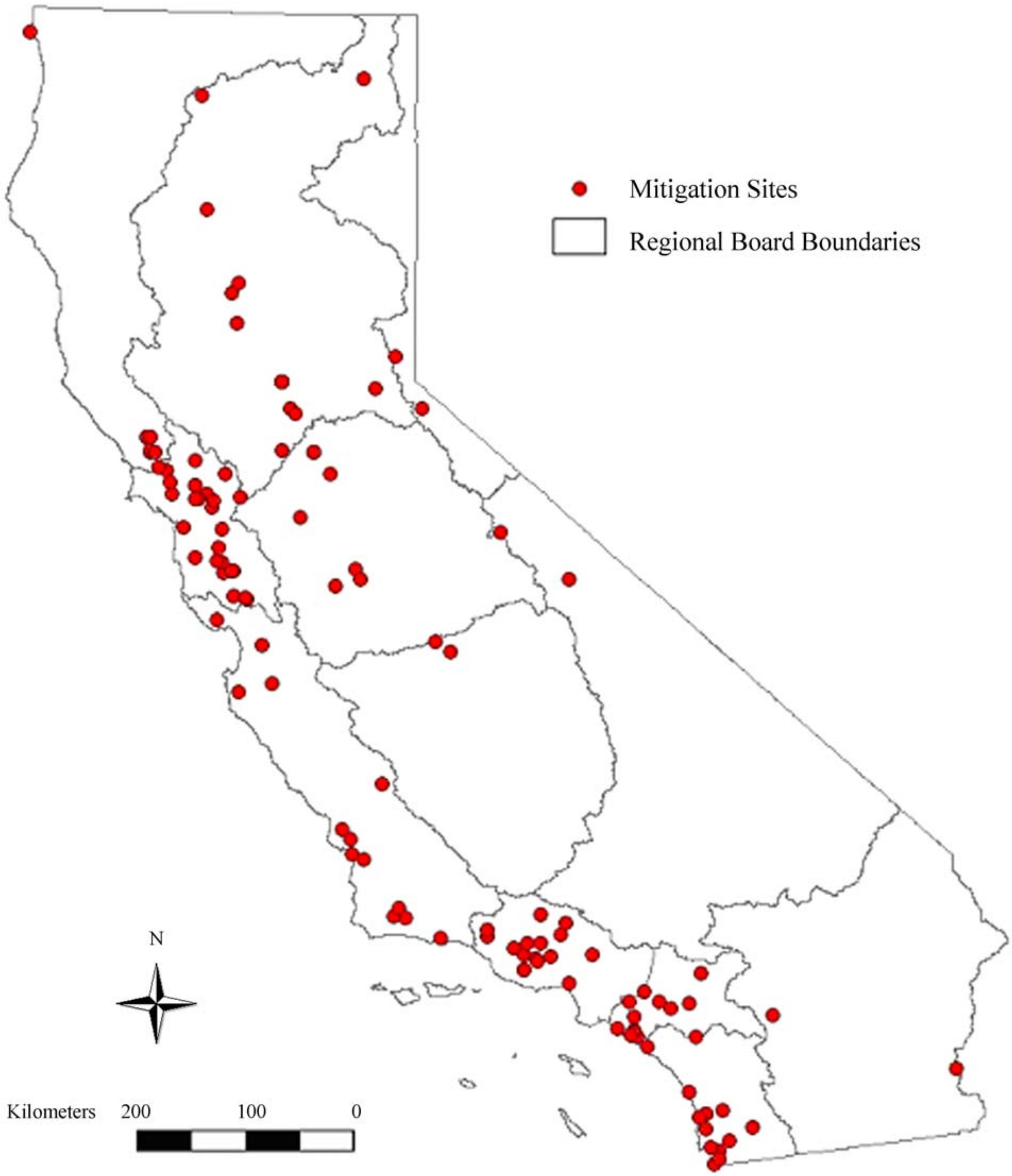

Figure 3. Statewide distribution of the assessed mitigation sites associated with the 143 permit files.

Several of these sites, especially those in the central valley (Region 5) involved a collection of shared mitigation banks which resulted in fewer than 143 mitigation sites. Points represent each assessed mitigation site rather than multiple sites per file.

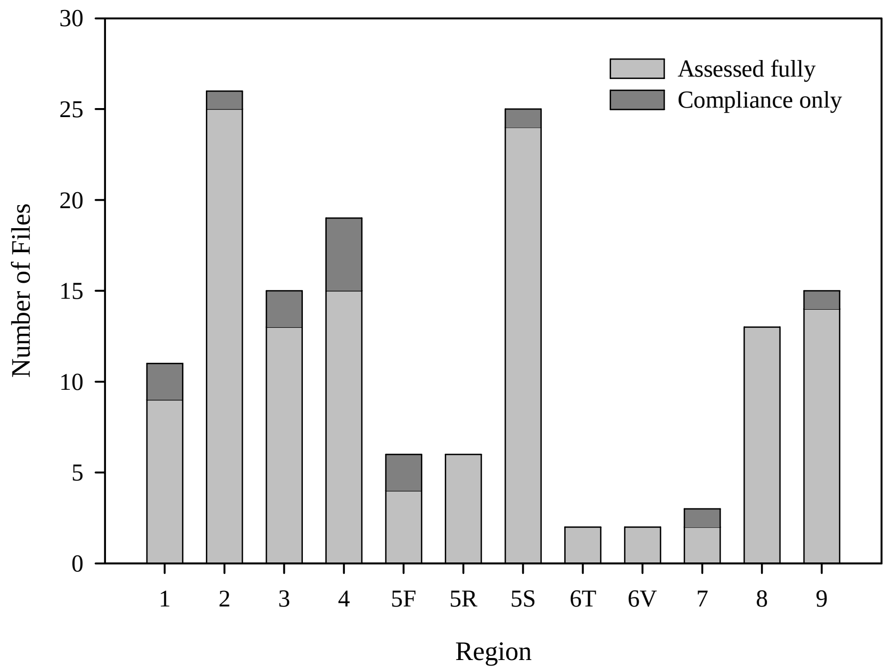

Figure 4. Files assessed fully and for compliance only by state board region.

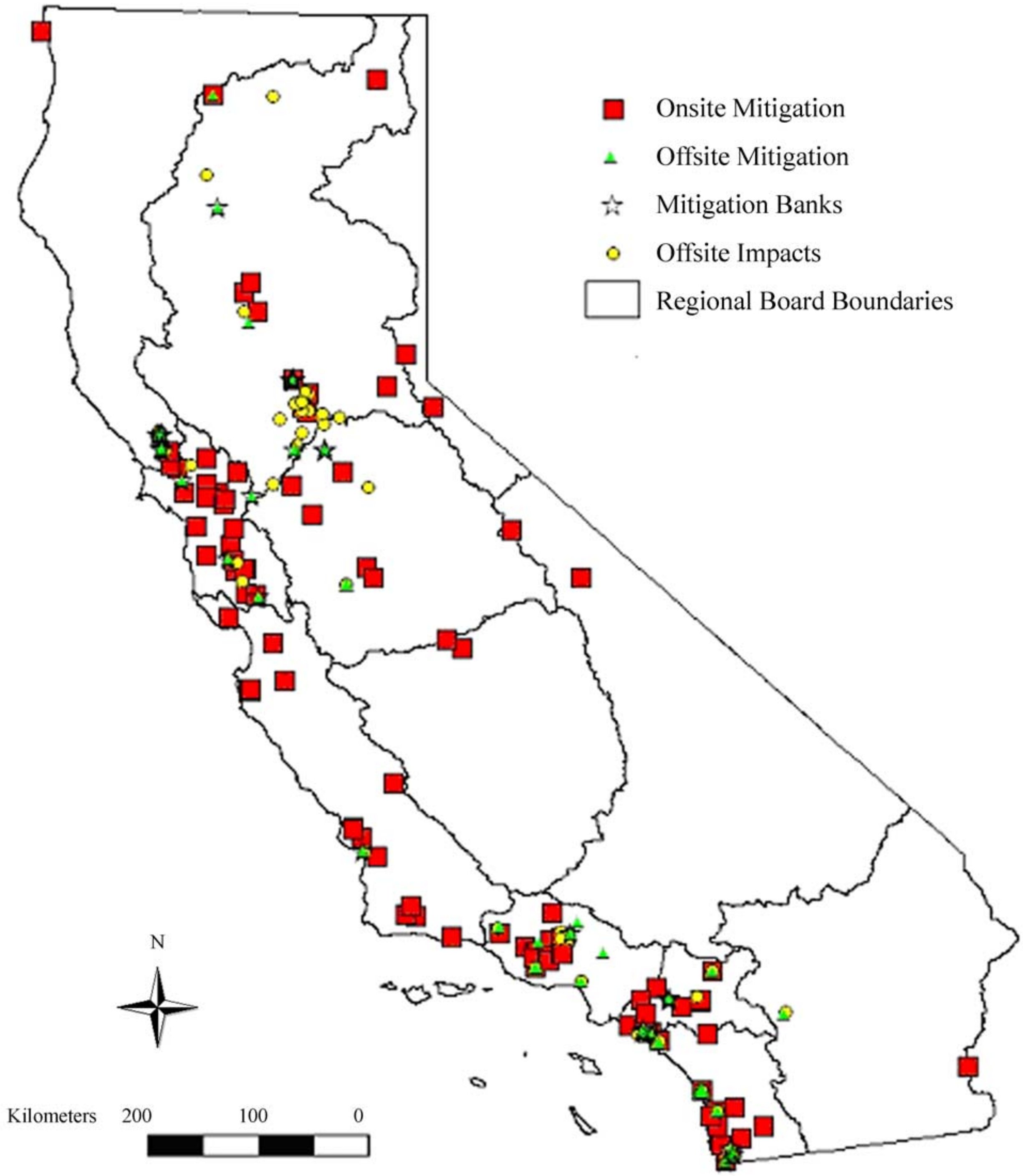

Figure 5. Statewide distribution of the impact and mitigation sites associated with the 143 permit files assessed.

Onsite Mitigation refers to files where impacts and mitigation occurred at the same location. Offsite Mitigation refers to location of a mitigation action that was not in the same location as an impact. Mitigation Banks refers to locations of mitigation banks, which also were not in the same location as an impact. Offsite Impacts indicate the location of an impact that was mitigated with an offsite mitigation action.

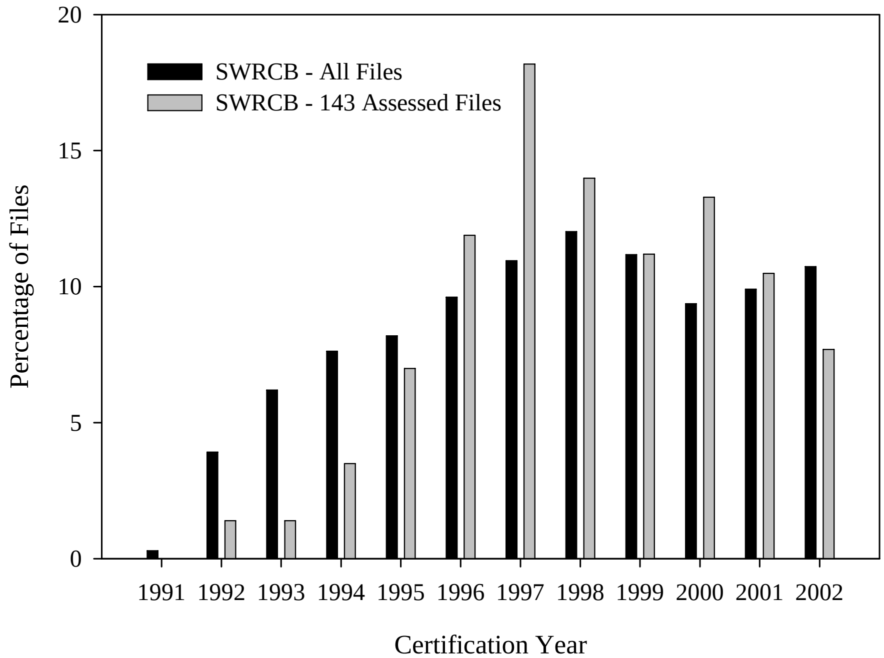

Figure 6. Percentage of applications per certification year listed in the SWRCB database from 1991 to 2002 compared with the percentage of files per year in our sample of files assessed fully and for compliance only (N for files assessed=143, N for SWRCB database=9924).

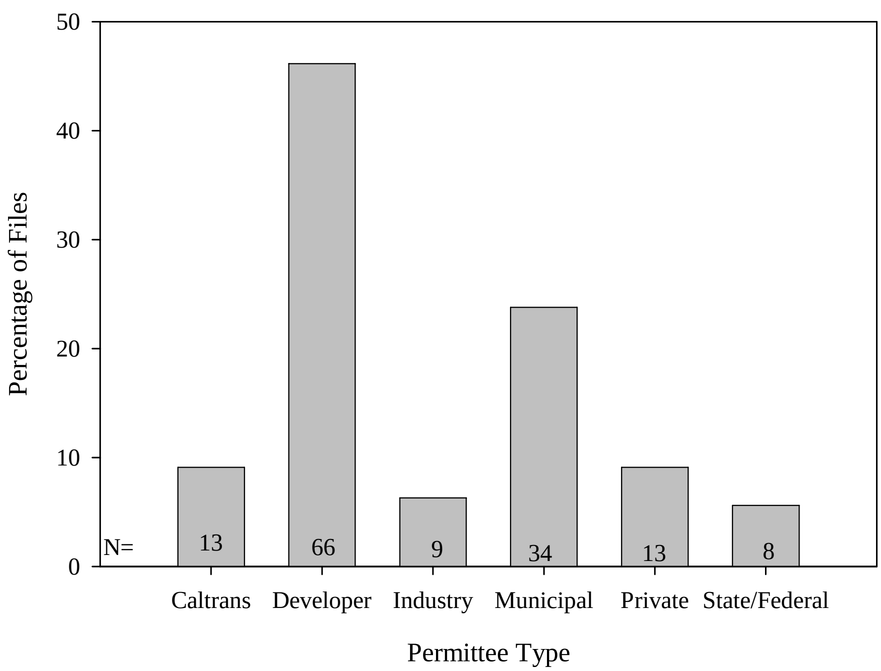

Figure 7. Percentage of files assessed by permittee type (N=143 files).

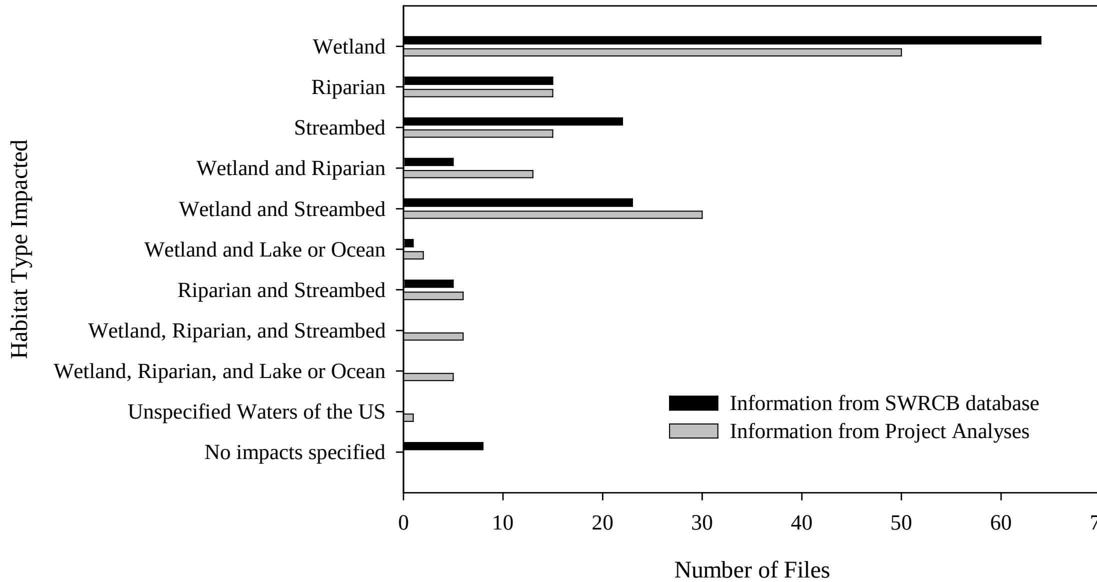

Figure 8. Breakdown of the 143 assessed files by habitat type impacted as reflected by the SWRCB database, and by our detailed permit reviews.

Some files had impacts to a single habitat type while others impacted multiple habitat types. The individual wetland types are not included here as such information is not consistently available in the SWRCB database.

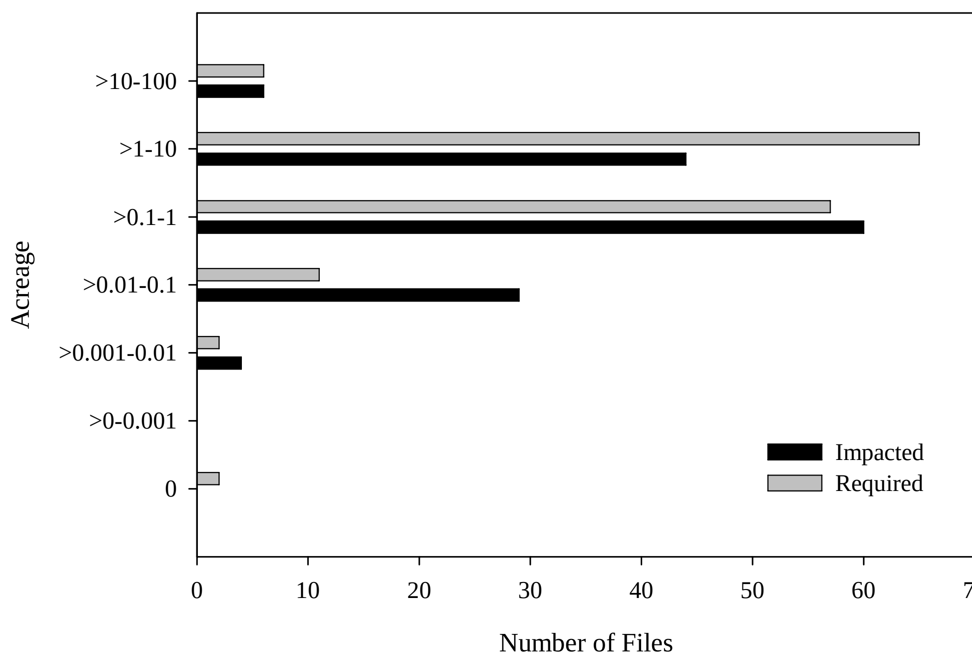

Figure 9. Acres impacted and acres of mitigation required displayed by acreage-size categories using data from project analyses for files assessed (N=143).

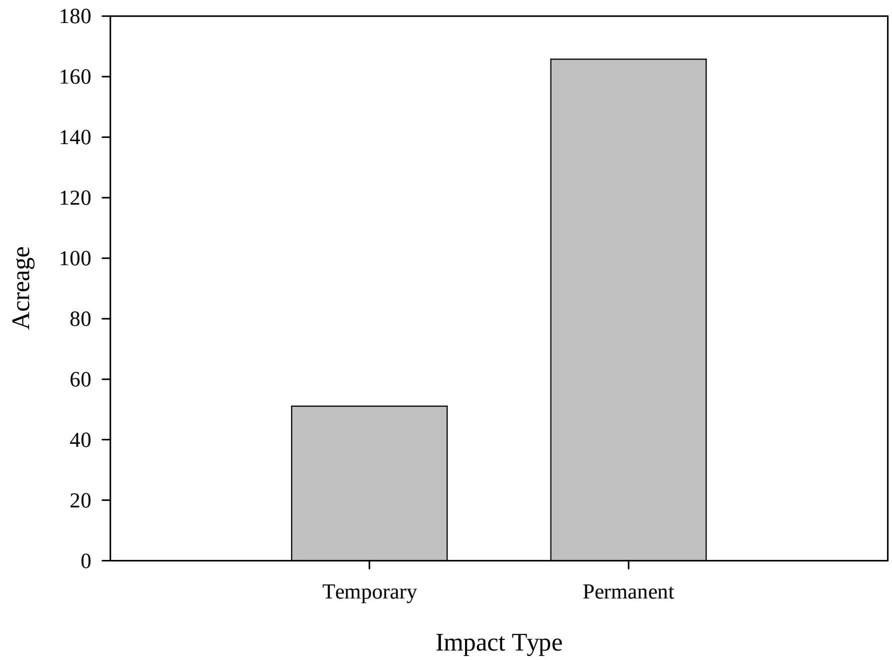

Figure 10. Breakdown of the 143 assessed permit files by permanent and temporary impacts as reflected by the SWRCB database, and by our detailed permit reviews.

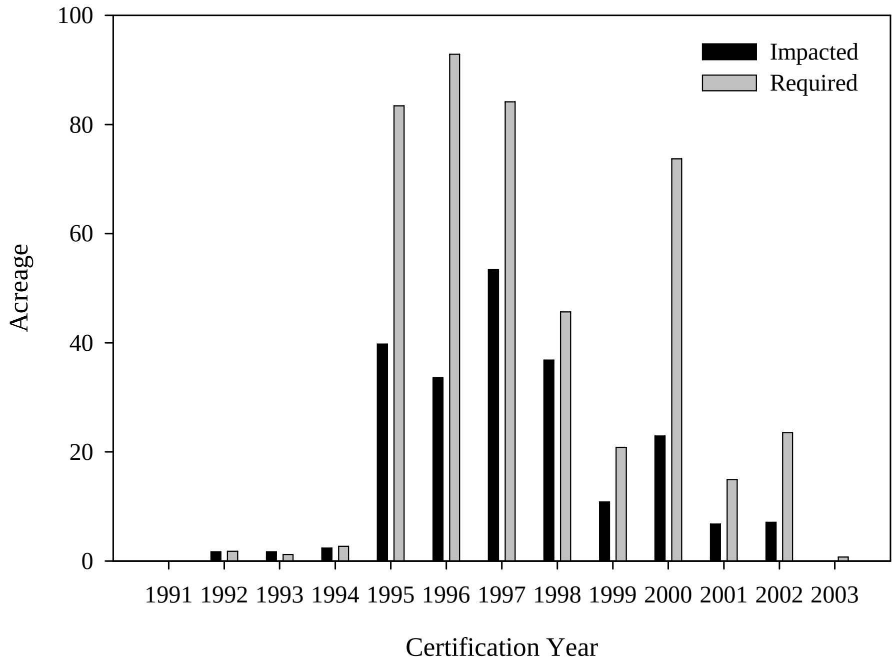

Figure 11. Acres impacted and acres of mitigation required displayed by certification year from the project analyses for files assessed (N=143).

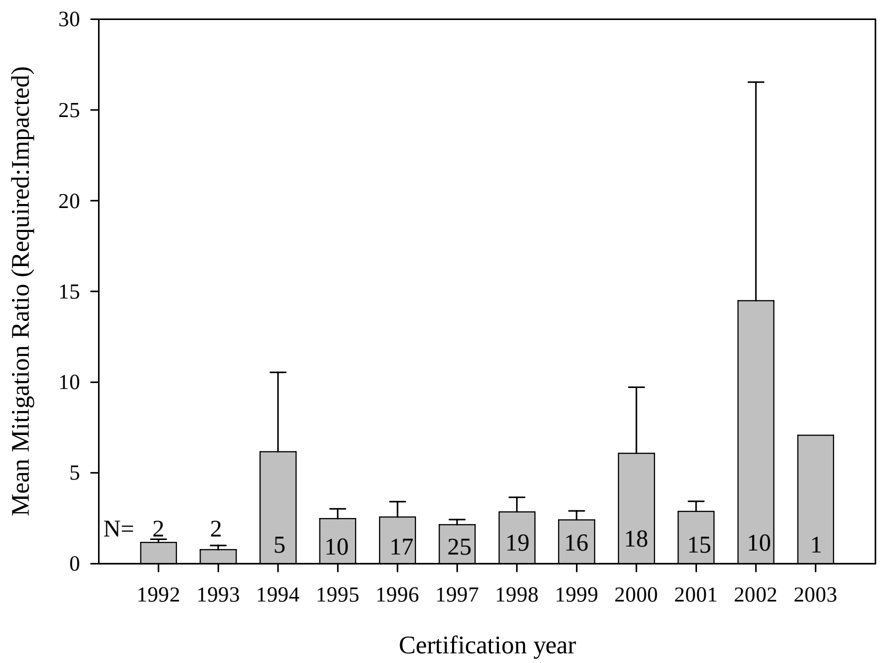

Figure 12. Average mitigation ratios required by certification year as determined from our detailed permit file review (N=143).

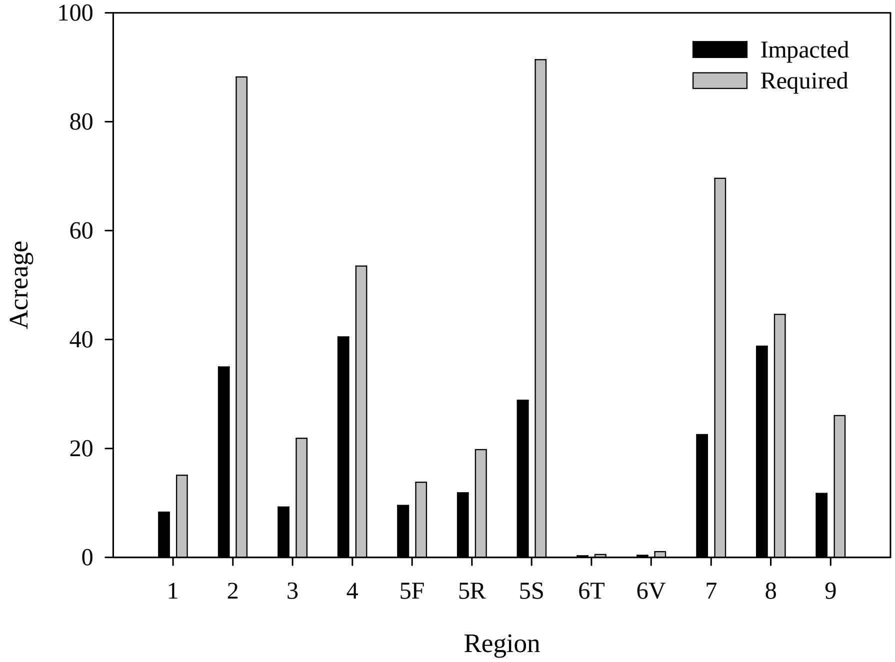

Figure 13. Acres impacted and acres of mitigation required displayed by state board region from the project analyses for files assessed (N=143).

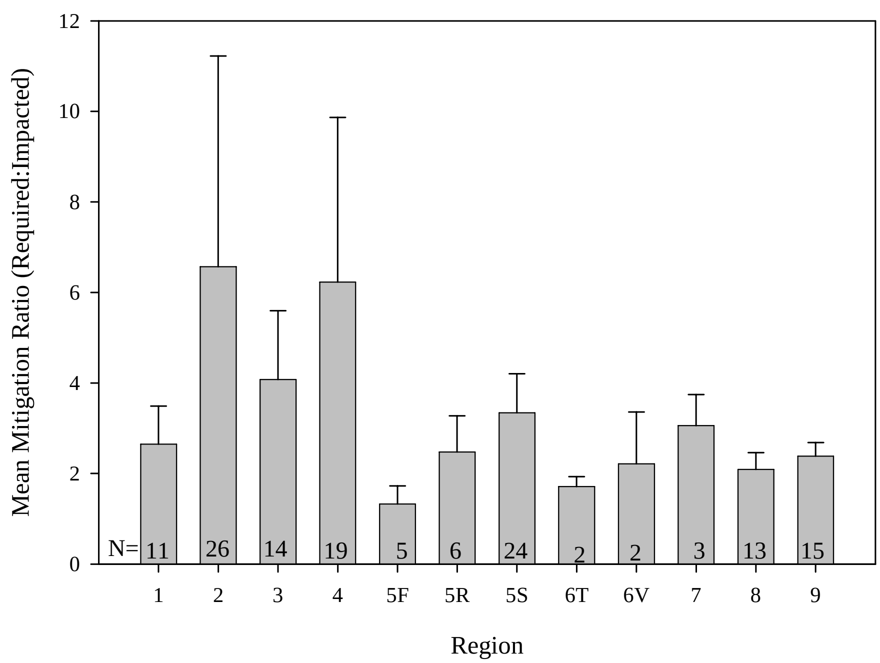

Figure 14. Mitigation ratios required by region (N=143).

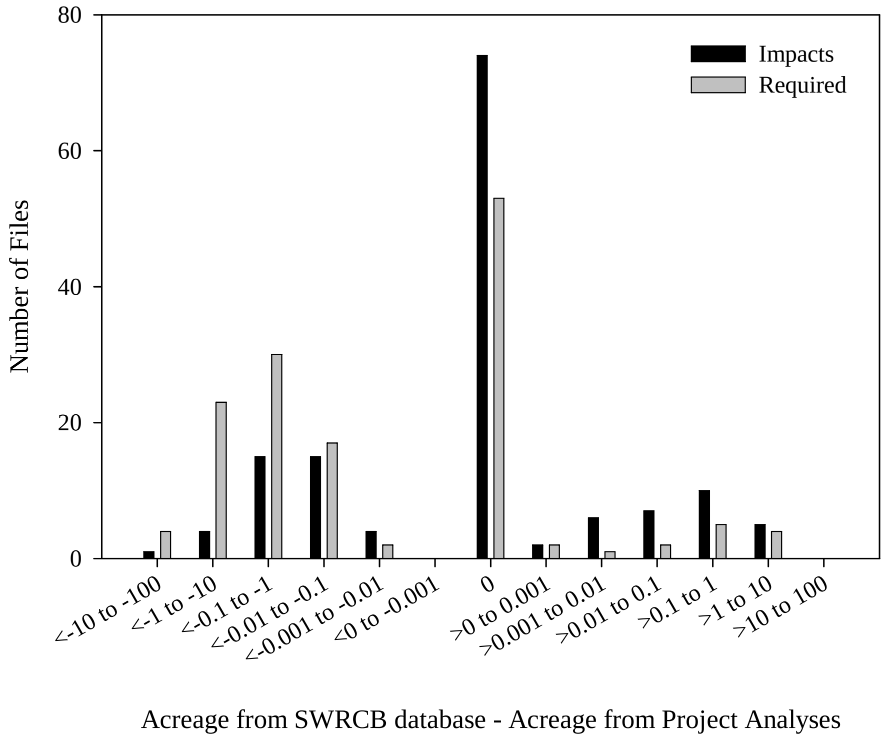

Figure 15. Plot of the differences between the impacted and required acreage values obtained through our detailed file review, and the corresponding values recorded in the SWRCB database.

A logarithmic scale was used for the data bins due to the wide range of acreage values involved. Negative values indicate that a lower value of acreage required was recorded in the SWRCB database compared to the acreage calculated during project analyses.

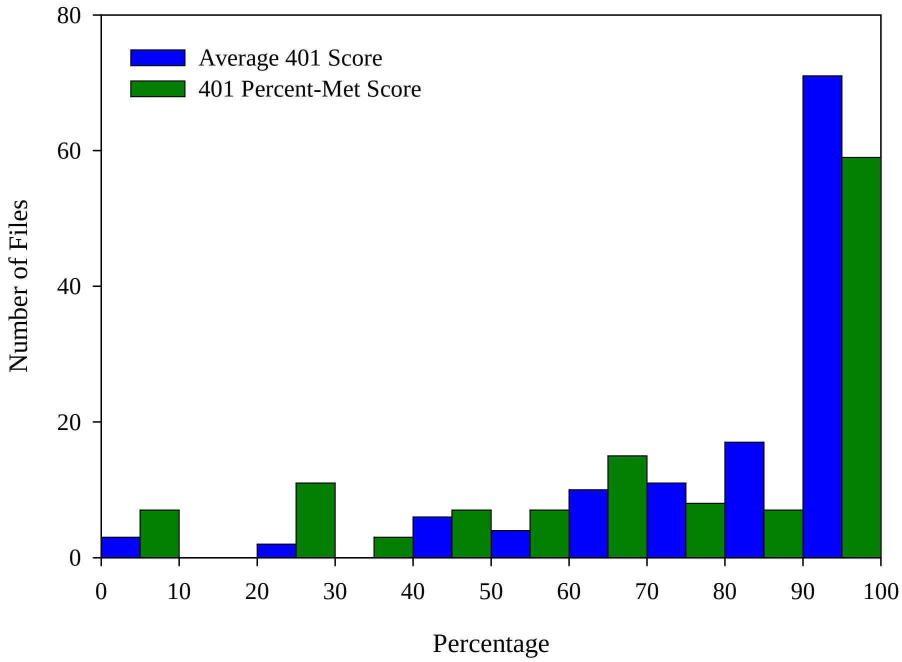

Figure 16. Distribution of files according to the average 401 permit compliance score and 401 percent-met score (N=124 files with assessable 401 permit conditions).

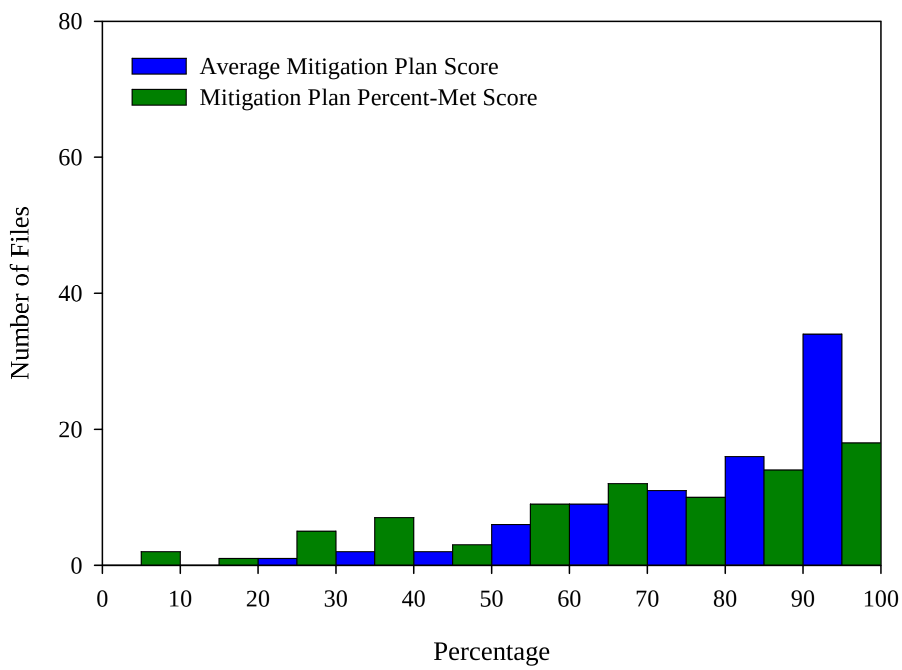

Figure 17. Distribution of files according to the average mitigation plan compliance score and mitigation plan percent-met score (N=81 files with assessable mitigation plan conditions).

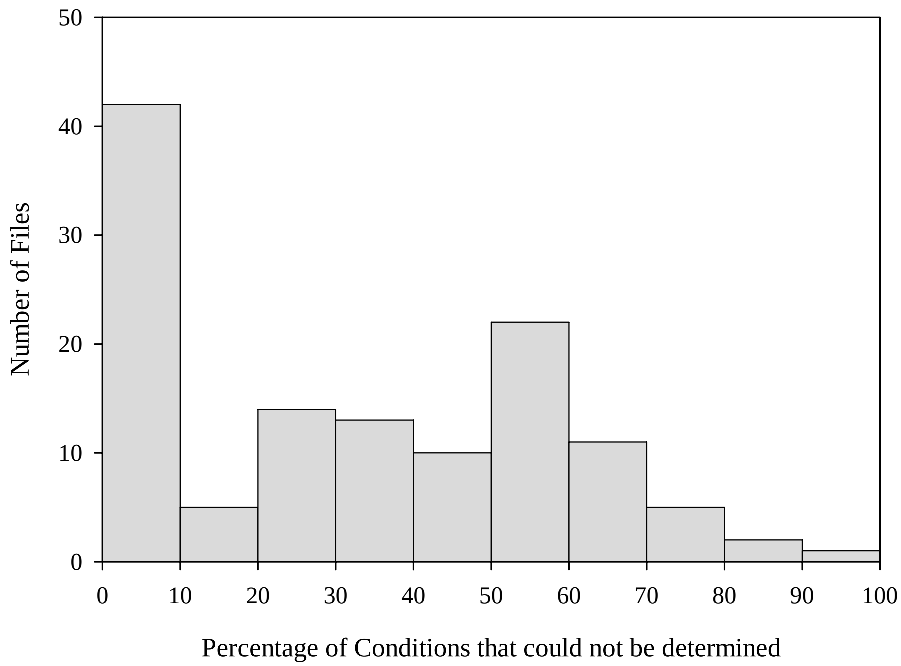

Figure 18. Distribution of files according to the percentage of 401 permit compliance conditions that could not be determined (N=124 files with assessable 401 permit conditions).

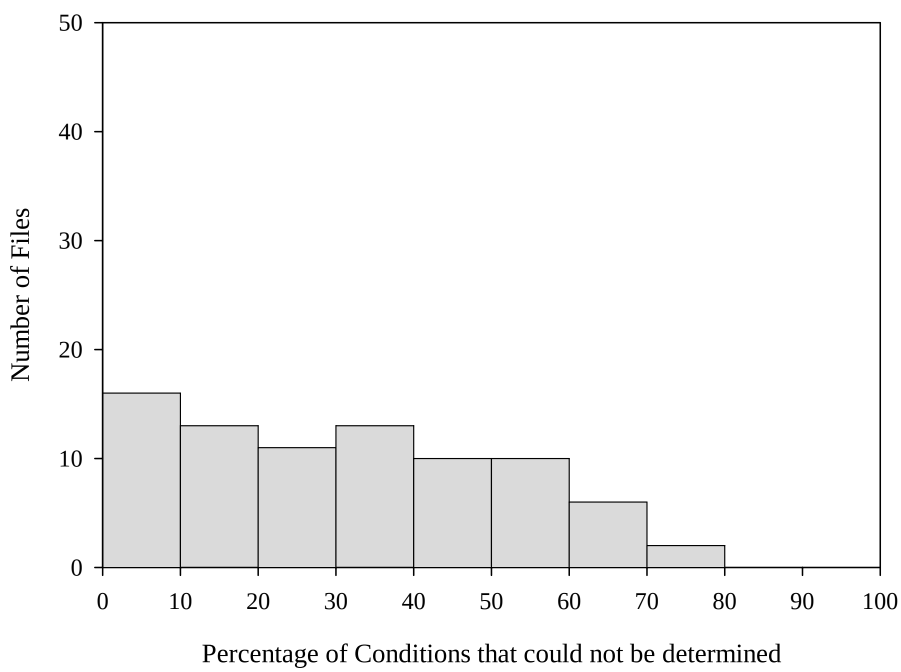

Figure 19. Distribution of files according to the percentage of mitigation plan compliance conditions that could not be determined (N=81 files with assessable mitigation plan conditions).

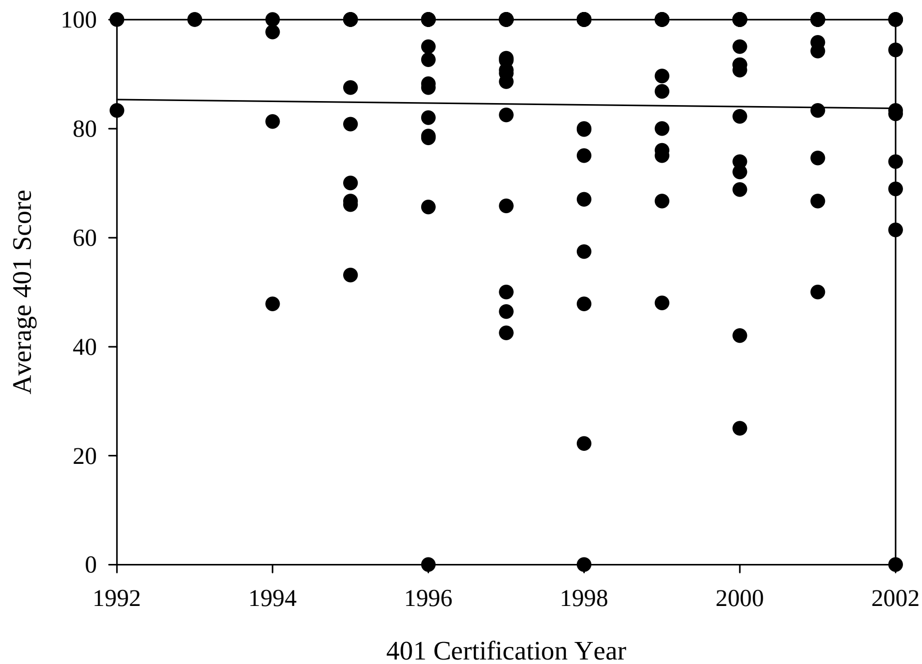

Figure 20. Relationship between 401 certification year and average 401 permit compliance score (N= 124 files with assessable 401 permit conditions; p=0.845, r^2=0.000).

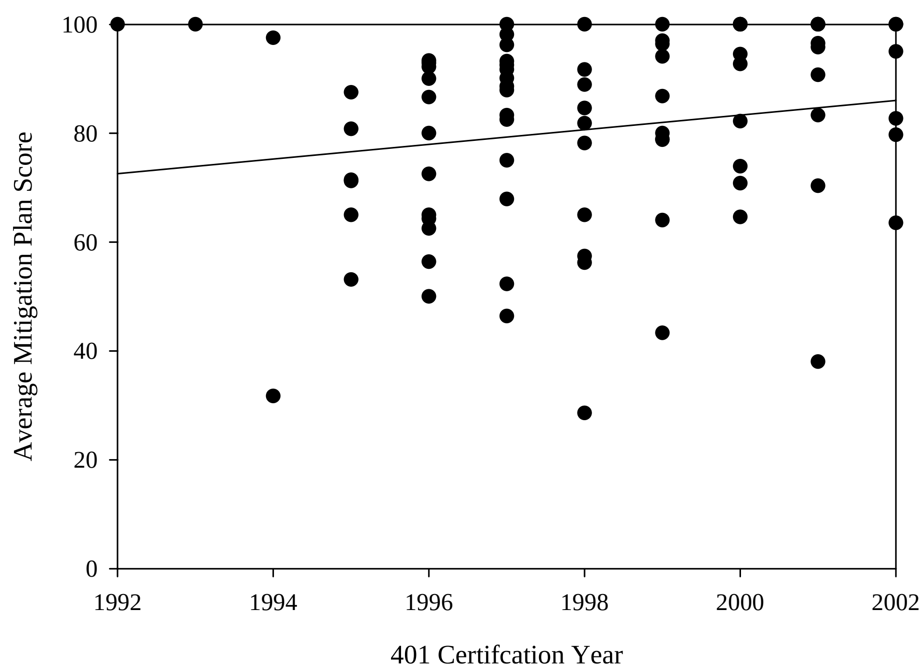

Figure 21. Relationship between 401 certification year and average mitigation plan compliance score (N= 81 files with assessable mitigation plan conditions; p=0.119, r^2=0.030).

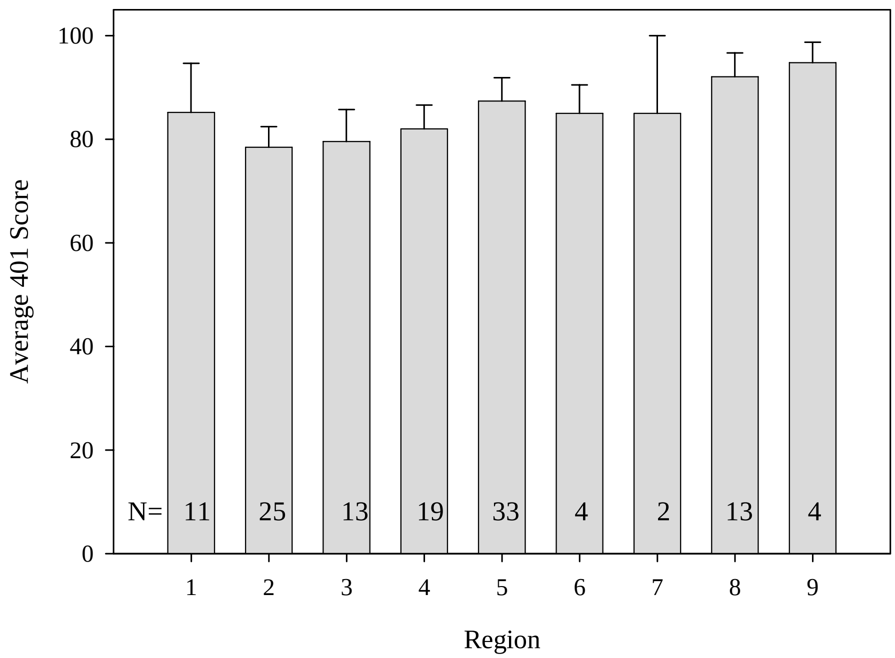

Figure 22. Average percentage score for 401 permit compliance by state board region (N=124 files with assessable 401 permit conditions).

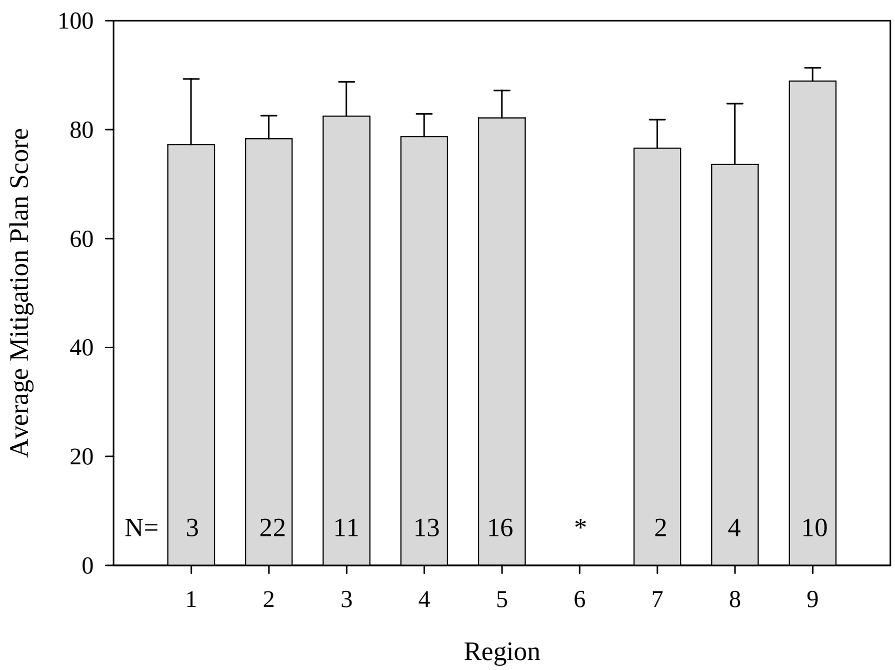

Figure 23. Average percentage score for mitigation plan compliance by state board region (N=81 files with assessable mitigation plan conditions).

*None of the four files from Region 6 included mitigation plans.

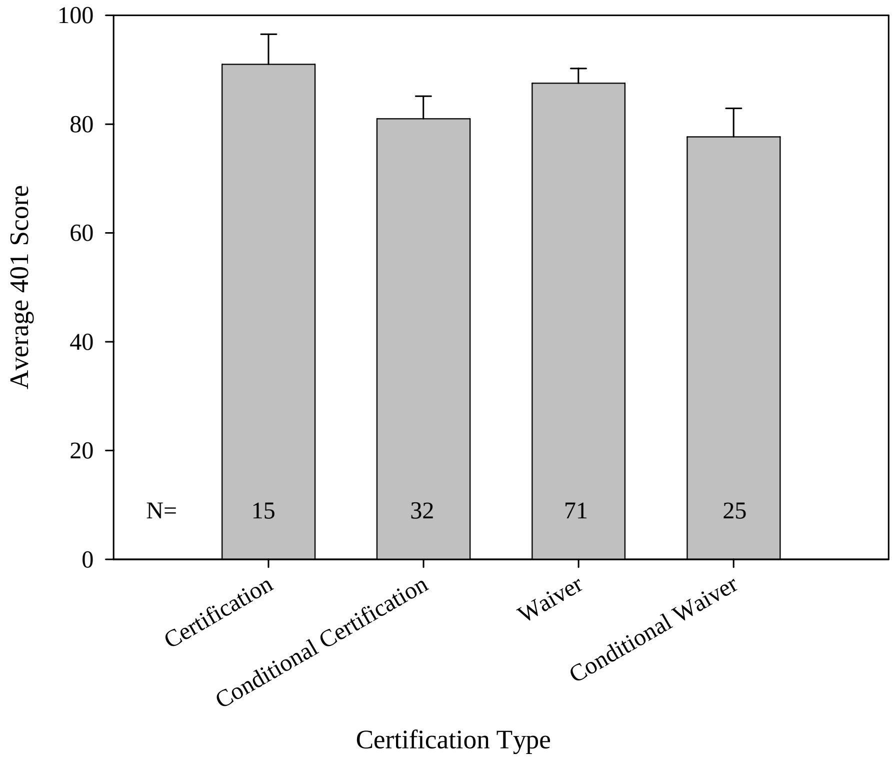

Figure 24. Average 401 score by certification type (N=143 files).

The categories used in this analysis correspond to the categories in the SWRCB database as follows: Certification=CERT, STDCERT, WDR; Conditional Certification=CONDCERT; Waiver=WAIVE, WDRWV; Conditional Waiver=CNDWV, WDRCNDWV. Several files were listed as certifications and as waivers of waste discharge requirements; these files were categorized as certifications for the purposes of this figure. File #0 was not listed in any of these categories in the SWRCB database, so we determined from the 401 permit that it was a certification and waiver of waste discharge requirements. Therefore, it is listed as a certification for this analysis.

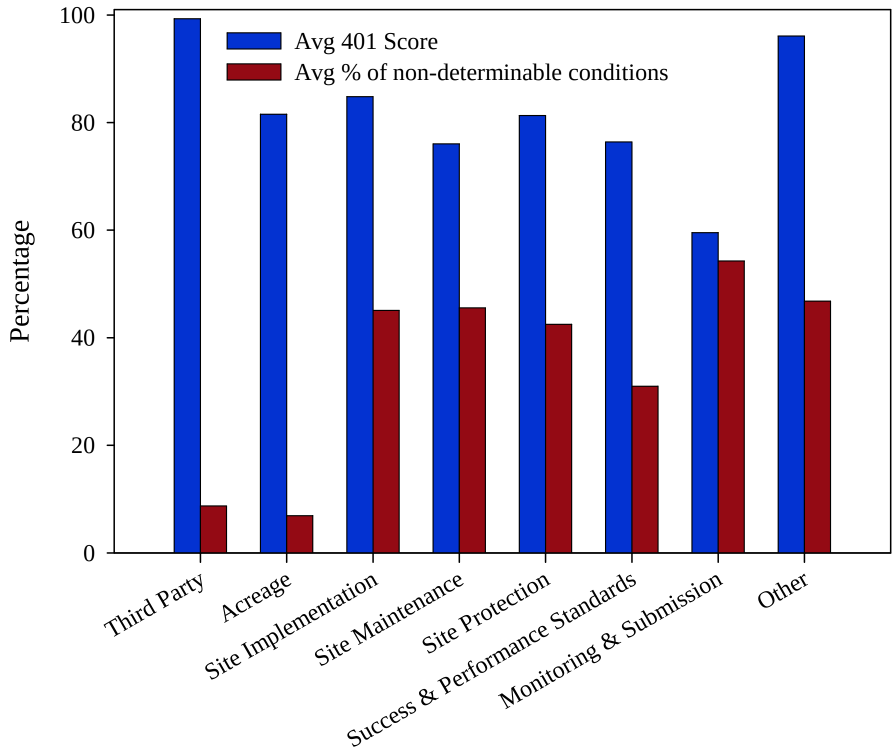

Figure 25. Average scores for 401 permit compliance and average percentage of conditions that could not be determined grouped by the type of permit condition (N=124 files with assessable 401 permit conditions).

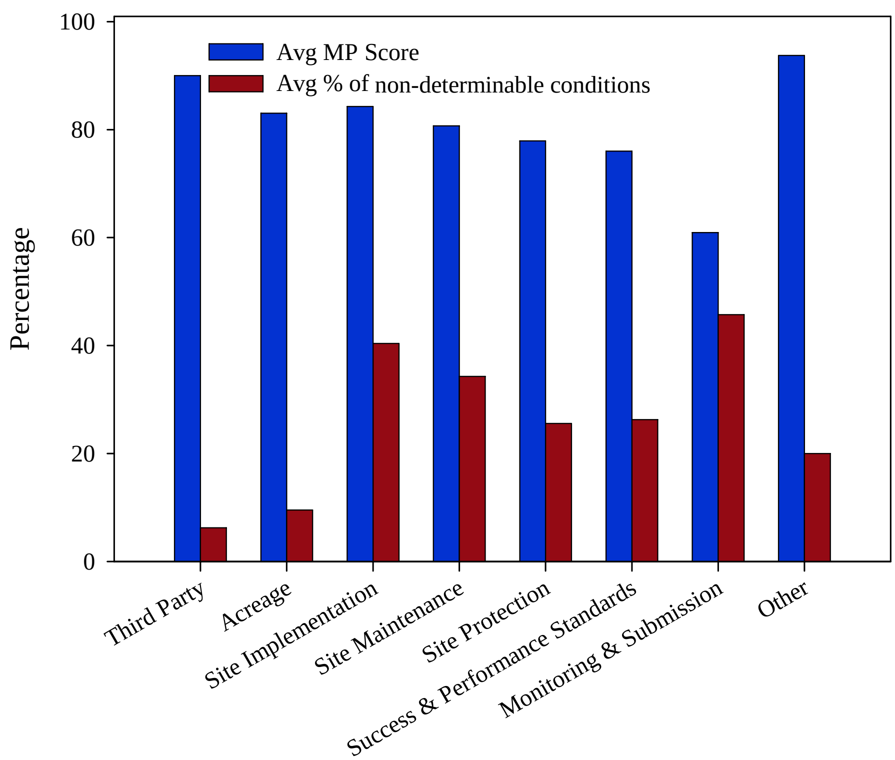

Figure 26. Average scores for mitigation plan compliance and average percentage of conditions that could not be determined grouped by the type of permit condition. (N = 81 files with assessable mitigation plan conditions).

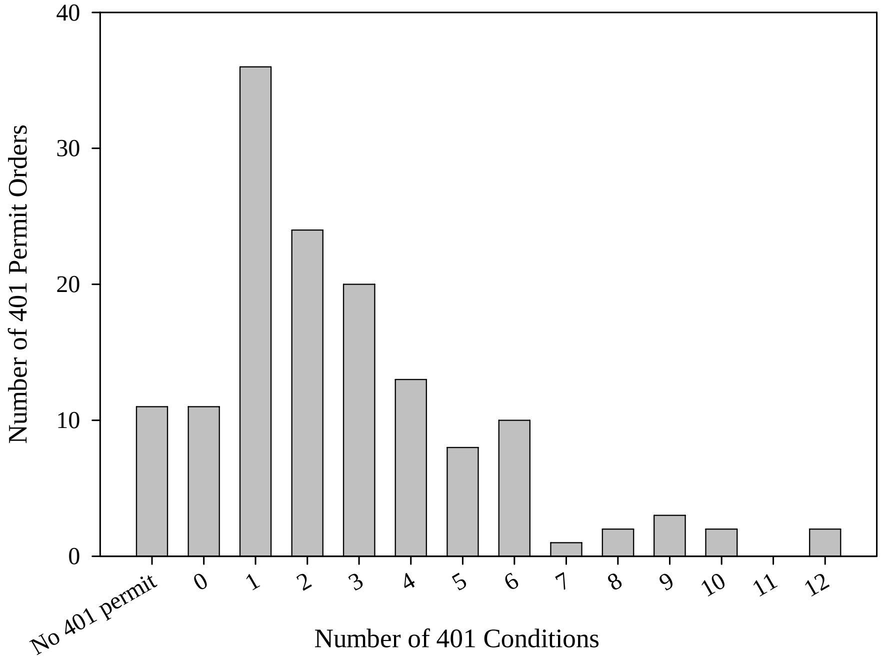

Figure 27. Breakdown of the number of mitigation-related permit requirements (conditions) in each 401 permit order (N=143).

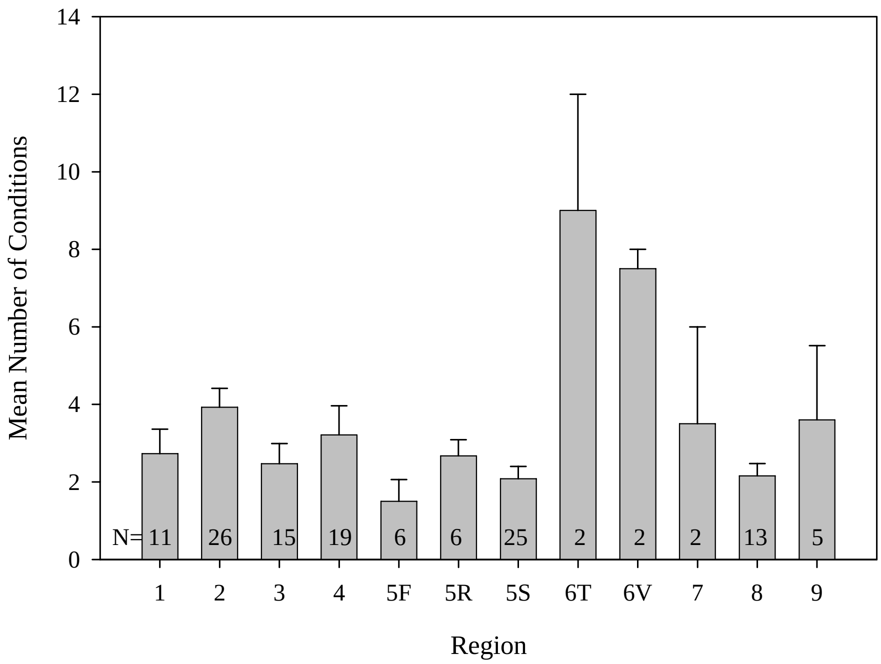

Figure 28. Mean number of mitigation-related 401 conditions per order within each SWRCB Region, including standard error bars (N=132). Eleven files for which no 401 permit was obtained were excluded.

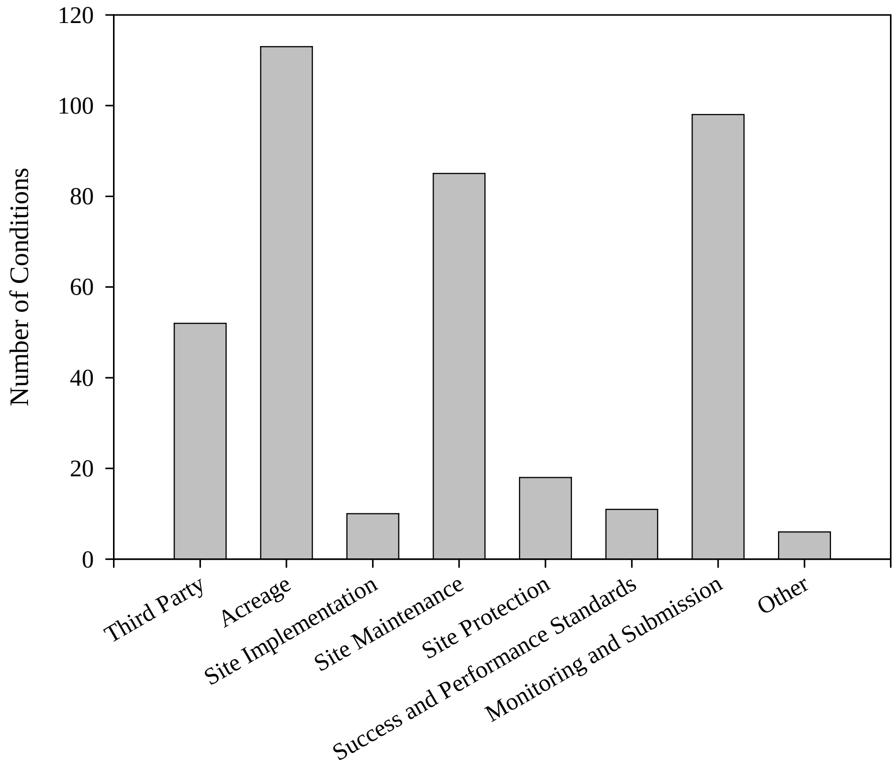

Figure 29. Breakdown of all mitigation-related 401 permit conditions by condition category (N=132).

The conditions from all permit orders were combined into a single list prior to categorization. Eleven files for which no 401 permit was obtained were excluded.

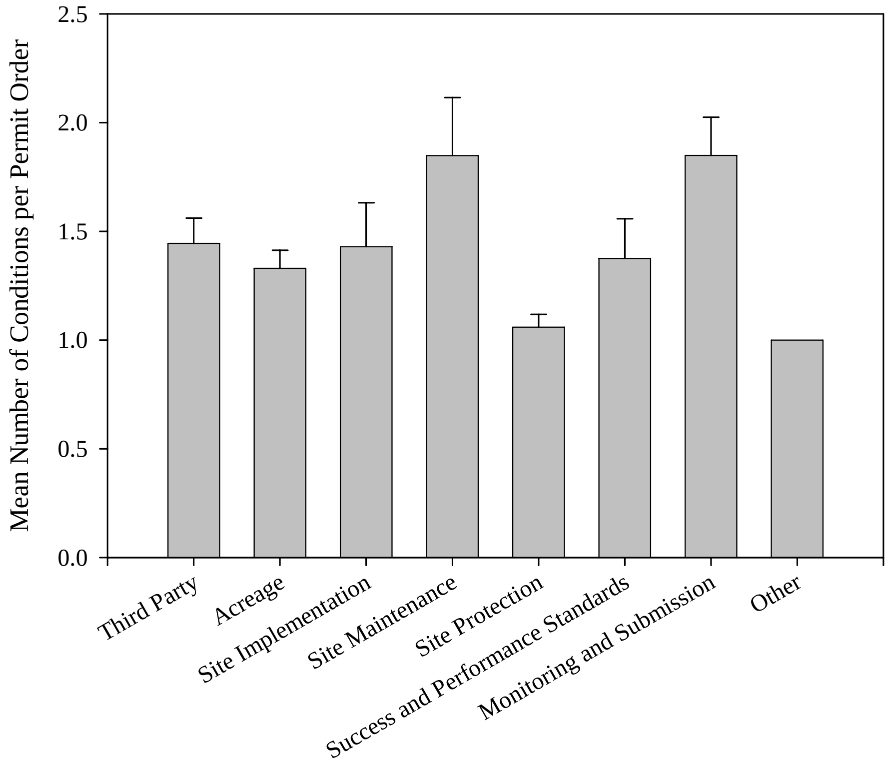

Figure 30. Mean number of mitigation-related 401 permit conditions per permit order (N=132).

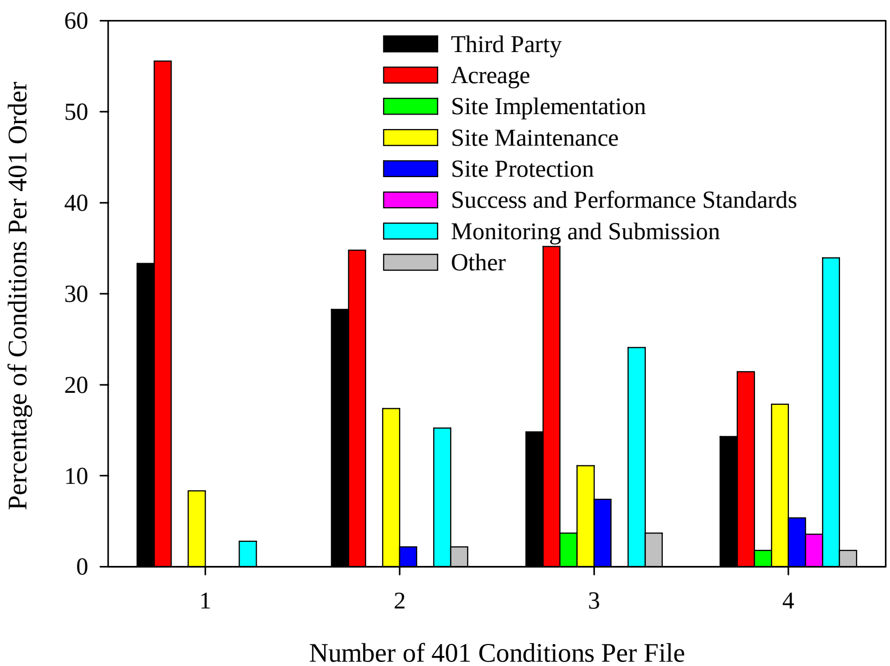

Figure 31. Frequency of occurrence for the eight permit condition categories when the 401 order includes just a single mitigation-related condition, 2 conditions, 3 conditions, or 4 conditions (N=36, 23, 18, 14, respectively).

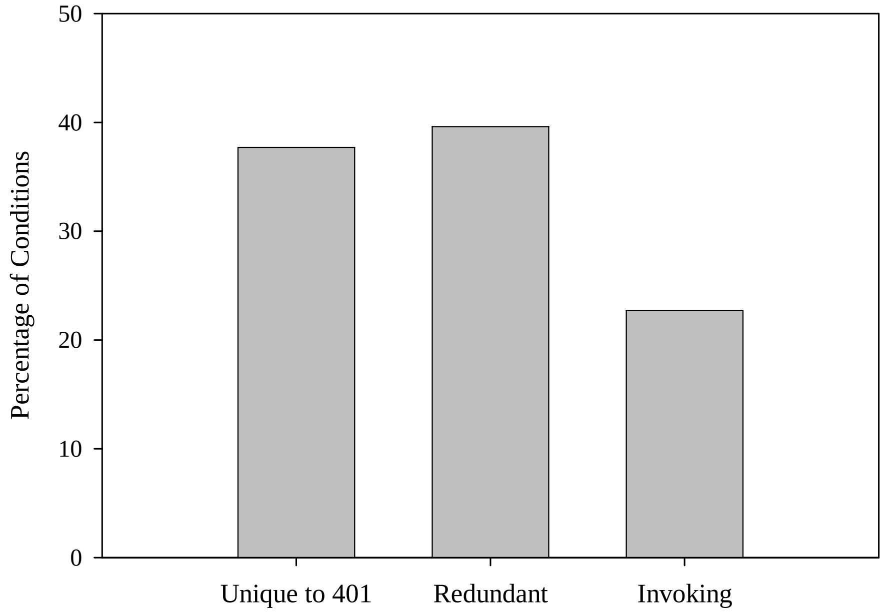

Figure 32. Percentage of mitigation-related conditions found in 401 permit orders that were unique to the 401, redundant with equivalent conditions required by other regulatory agencies, or invoking those other agency permits or the common mitigation plan (i.e., “must follow the 404”) (N=115).

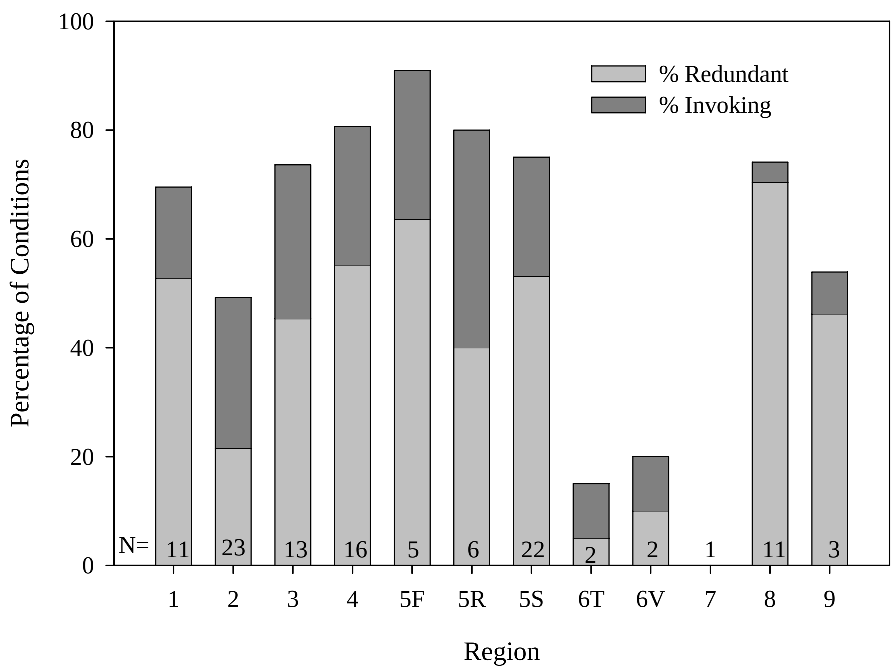

Figure 33. Percentage of redundant and invoking 401 conditions by Region (N=115).

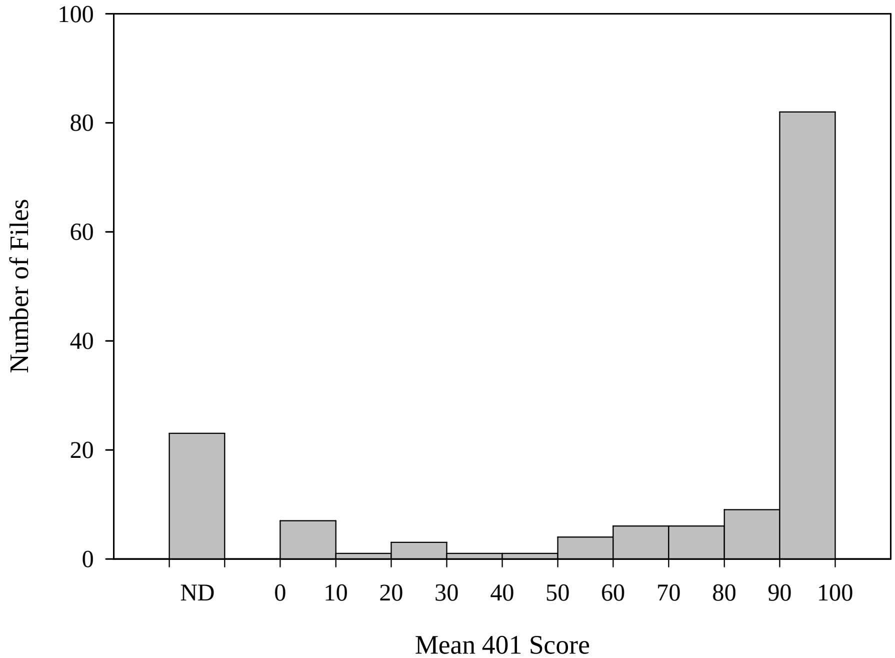

Figure 34. Distribution of files according to the average 401 permit compliance score including only those mitigation conditions explicitly specified in the 401 permit order (N=143).

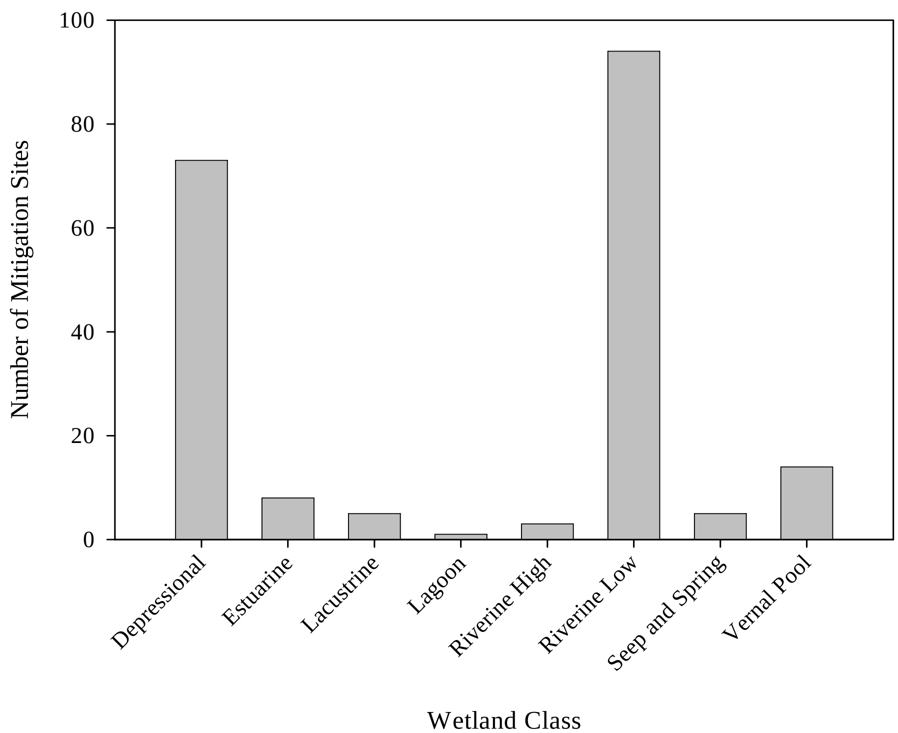

Figure 35. Breakdown of wetland hydrogeomorphic classes as defined and assessed by the CRAM evaluations for all 204 mitigation sites representing 129 files evaluated using CRAM.

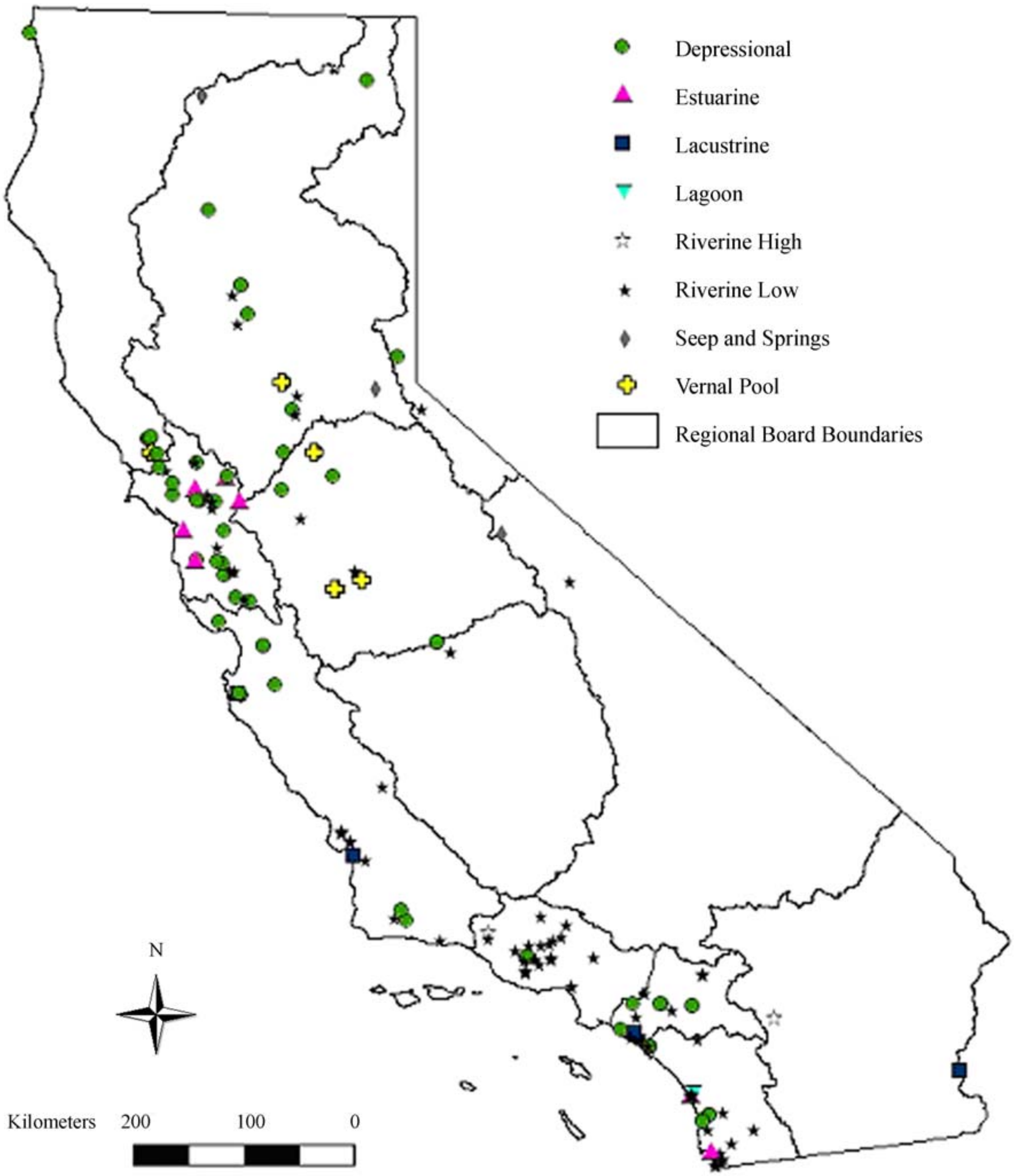

Figure 36. Distribution of assessed mitigation sites by wetland class across the state.

Symbols indicate individual mitigation actions; multiple points may be indicated for individual projects with multiple mitigation actions, and some points may represent multiple projects, e.g., mitigation banks.

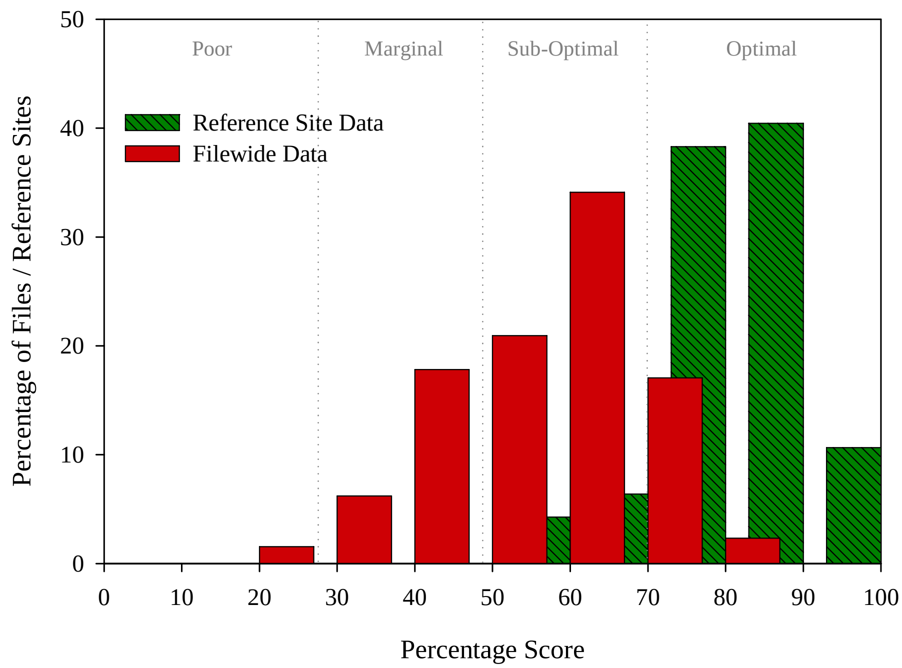

Figure 37. All CRAM data combined into a single overall wetland condition success score for each of the 129 files and 47 reference sites evaluated using CRAM.

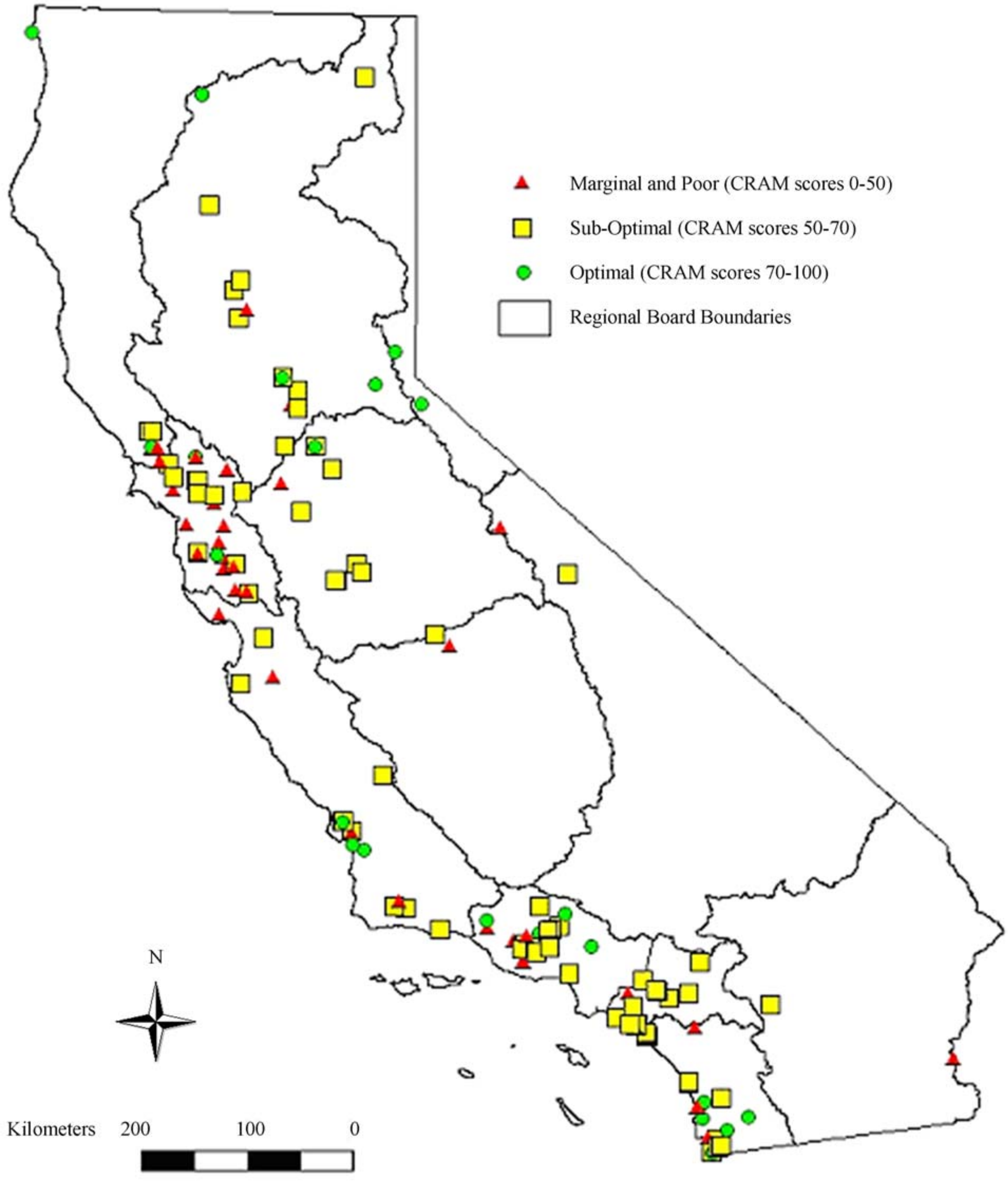

Figure 38. Map of California showing location of mitigation sites color coded by condition score.

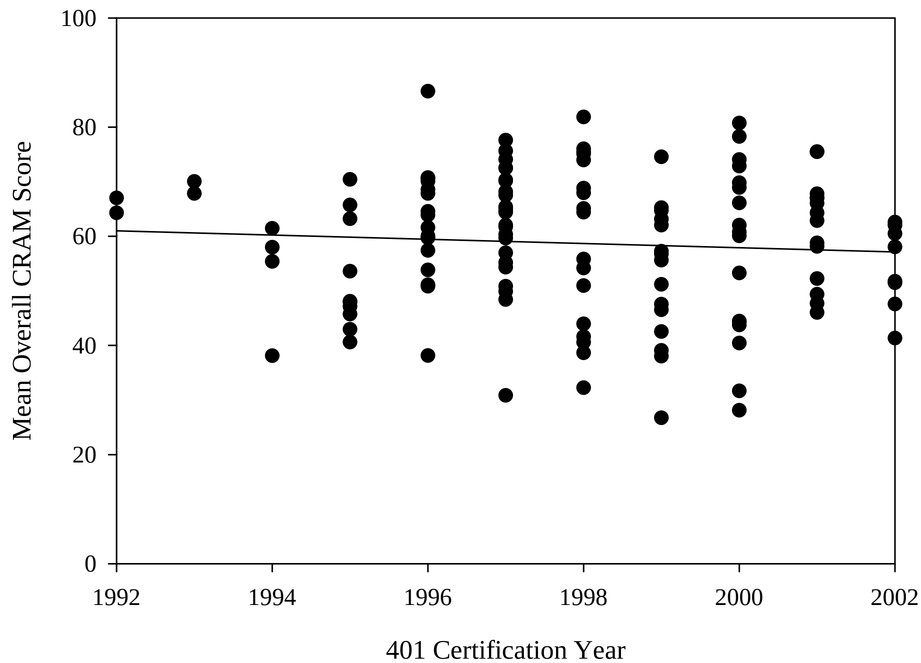

Figure 39. Relationship between 401 certification year and file-wide mean overall CRAM percentage scores grouped by certification year (N=129 files, r^2=0.005, p=0.415).

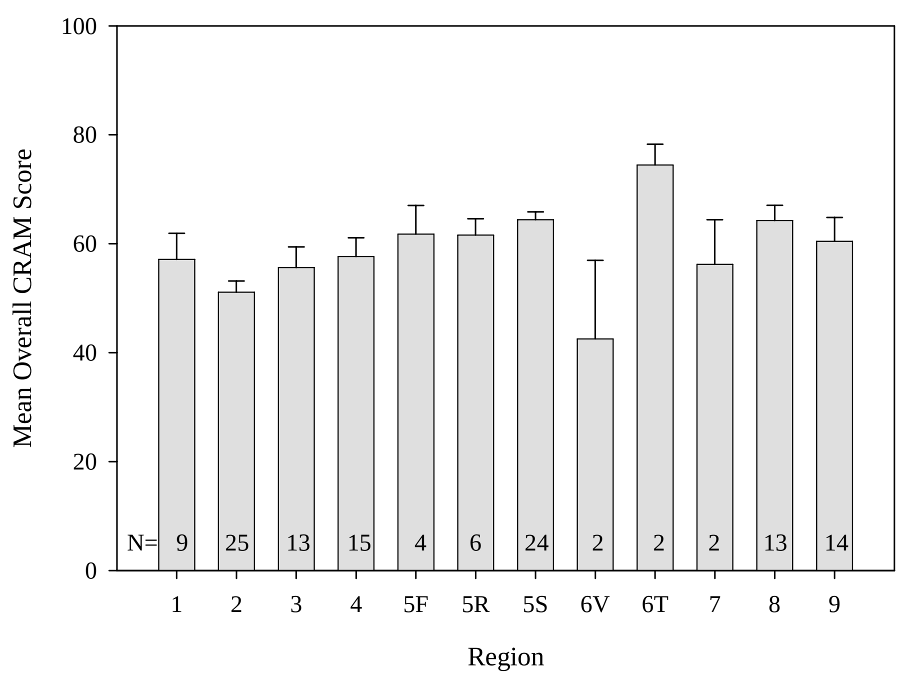

Figure 40. File-wide mean Total-CRAM percentage scores by SB region (N=129 files).

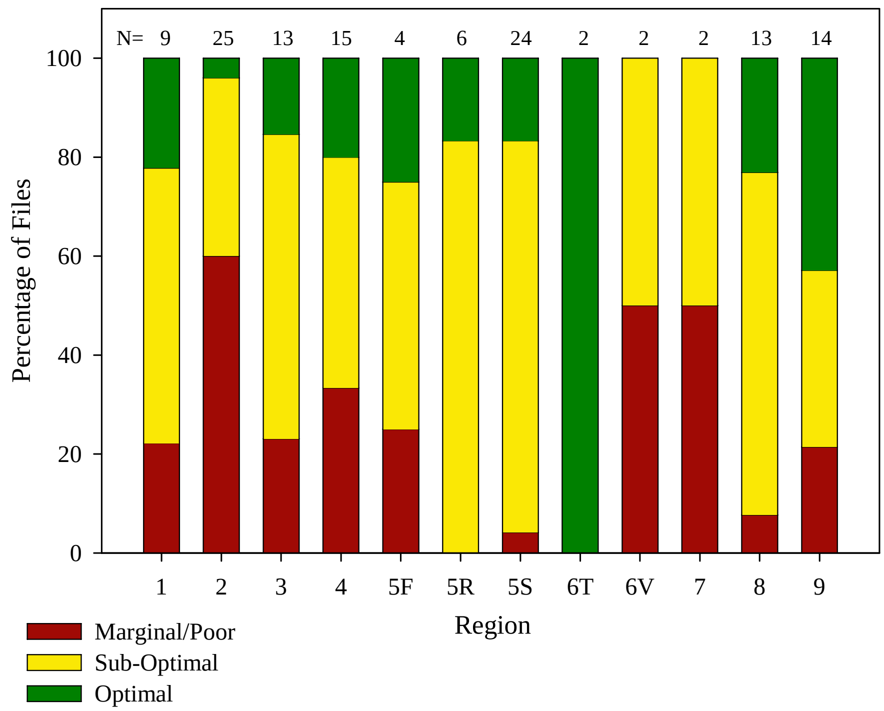

Figure 41. Percentage of files in CRAM success categories by state board region (N=129 files).

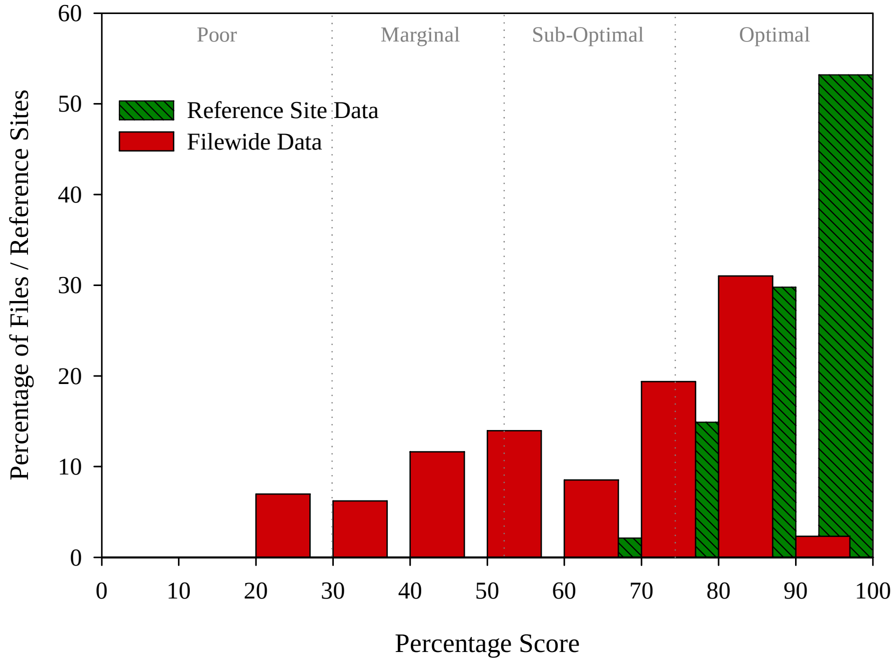

Figure 42. Landscape context attribute CRAM scores compared to reference-site data.

All connectivity, percent of assessment area with buffer, average width of buffer, and buffer condition metrics data combined into a single landscape context score for each of the 129 files and 47 reference sites evaluated using CRAM.

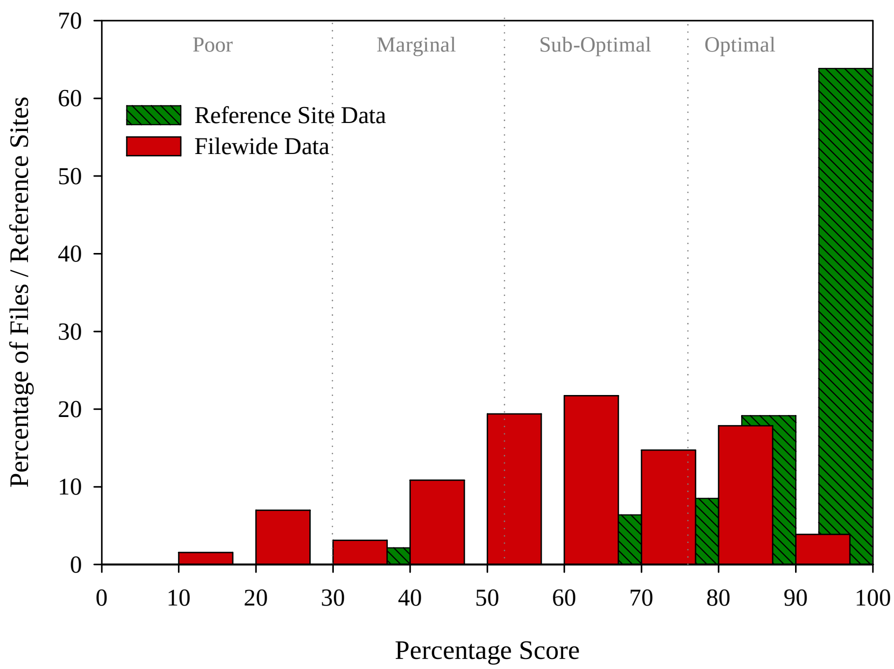

Figure 43. Hydrology attribute CRAM scores compared to reference-site data.

All water source, hydroperiod, and hydrologic connectivity metrics data combined into a single hydrology score for each of the 129 files and 47 reference sites evaluated using CRAM.

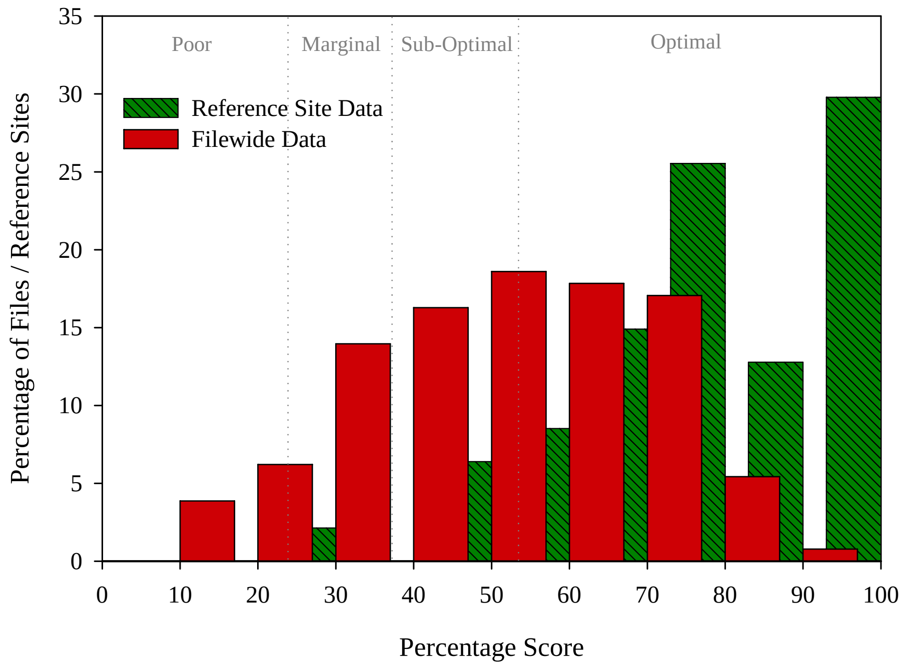

Figure 44. Physical structure attribute CRAM scores compared to reference-site data.

All physical patch richness and topographic complexity metrics data combined into a single physical structure score for each of the 129 files and 47 reference sites evaluated using CRAM.

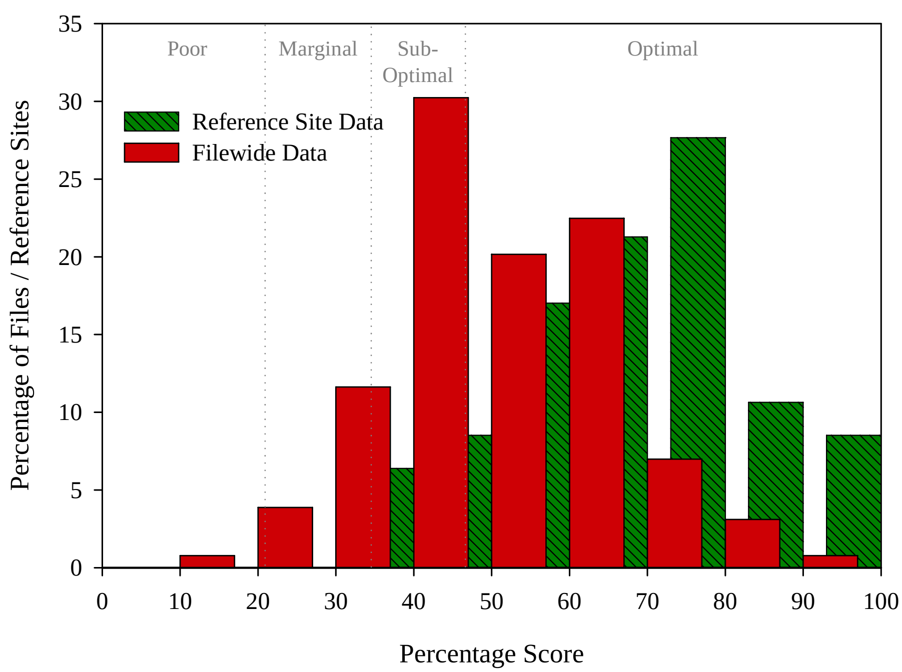

Figure 45. Biotic structure attribute CRAM scores compared to reference-site data.

All organic matter accumulation, biotic patch richness, vertical biotic structure, interspersion and zonation, percent invasive plant species, and native plant species richness metrics data combined into a single biotic structure score for each of the 129 files and 47 reference sites evaluated using CRAM.

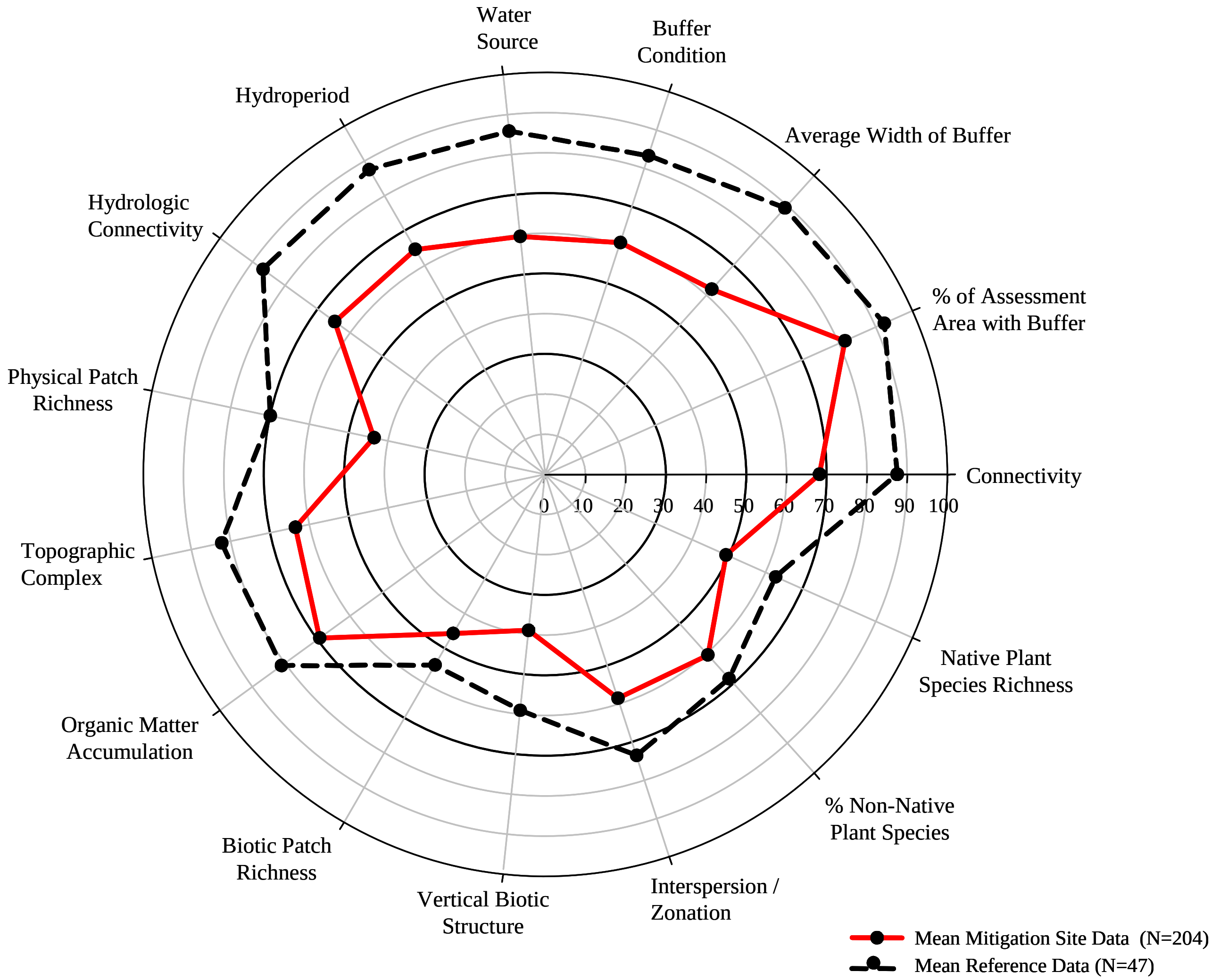

Figure 46. Mean percentage scores for each CRAM metric for mitigation sites (N=204) and reference sites (N=47).

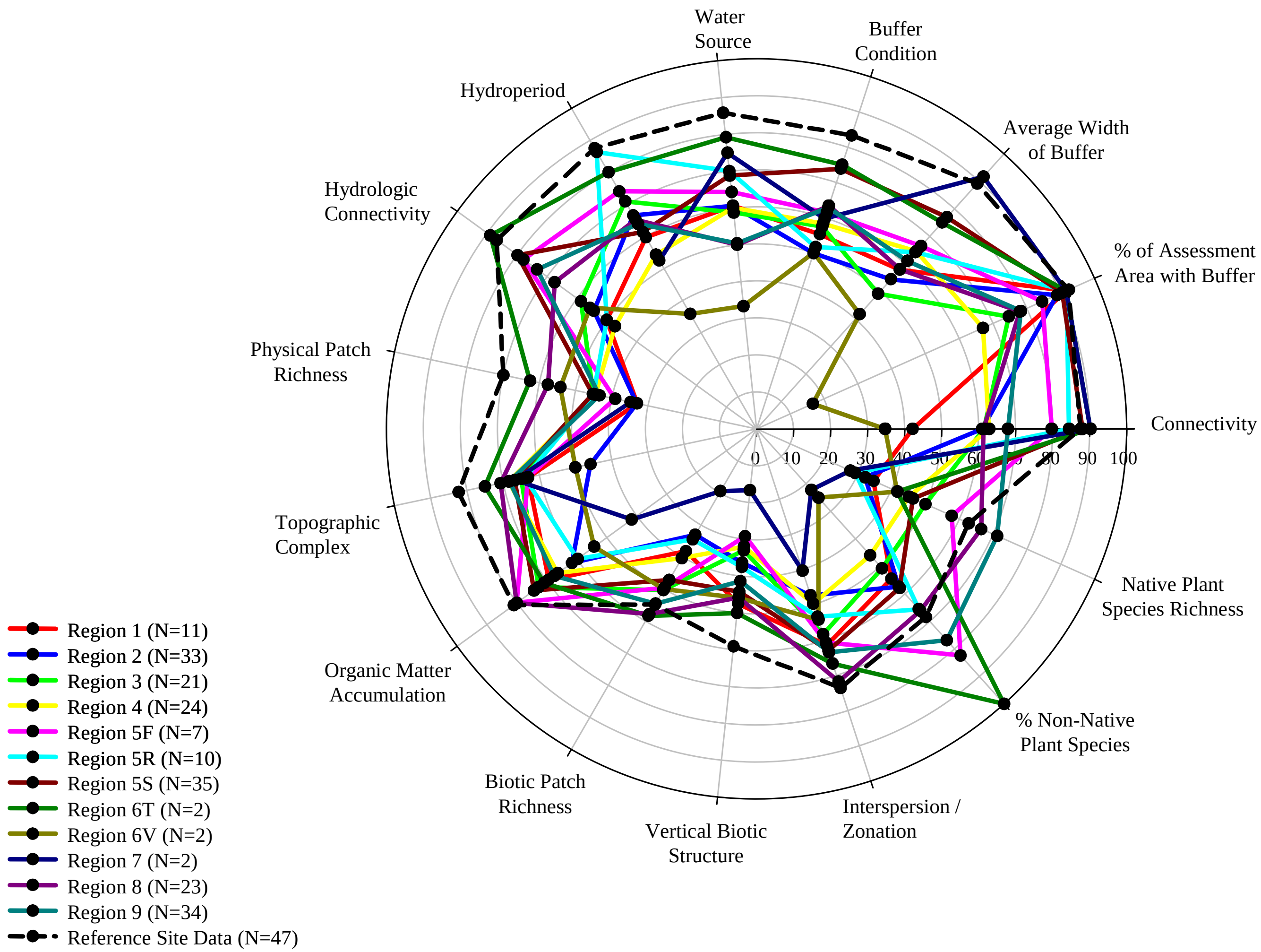

Figure 47. Mean percentage scores for each CRAM metric by state board region. (N=204 mitigation sites)

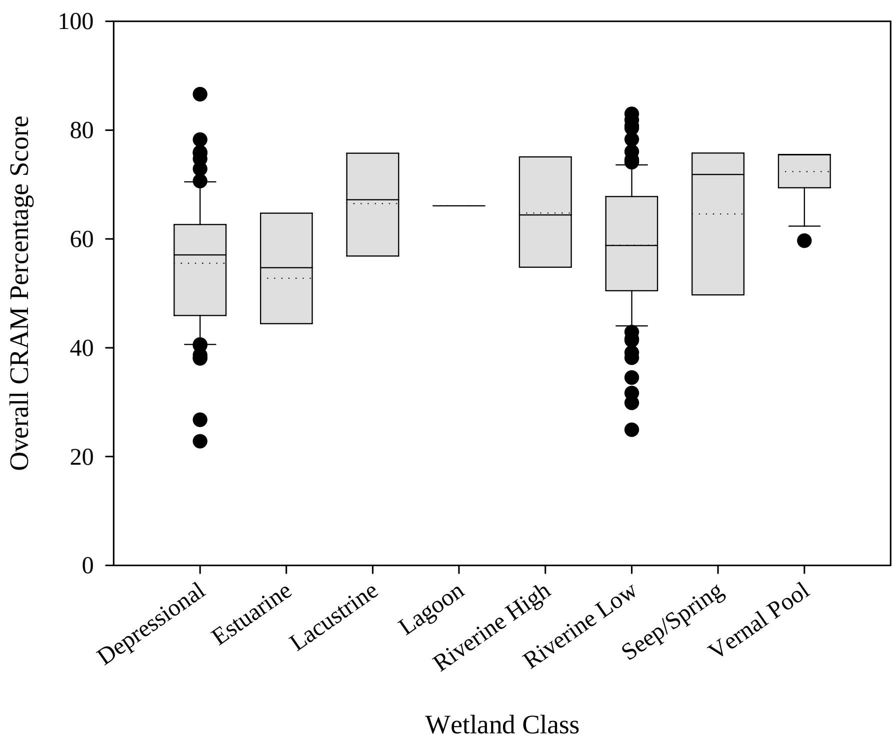

Figure 48. Overall CRAM percentage scores by wetland class (N=204 mitigation sites).

The dotted line represents the mean, the solid line the median. The 10th, 25th, 75th, and 95th percentiles are displayed.

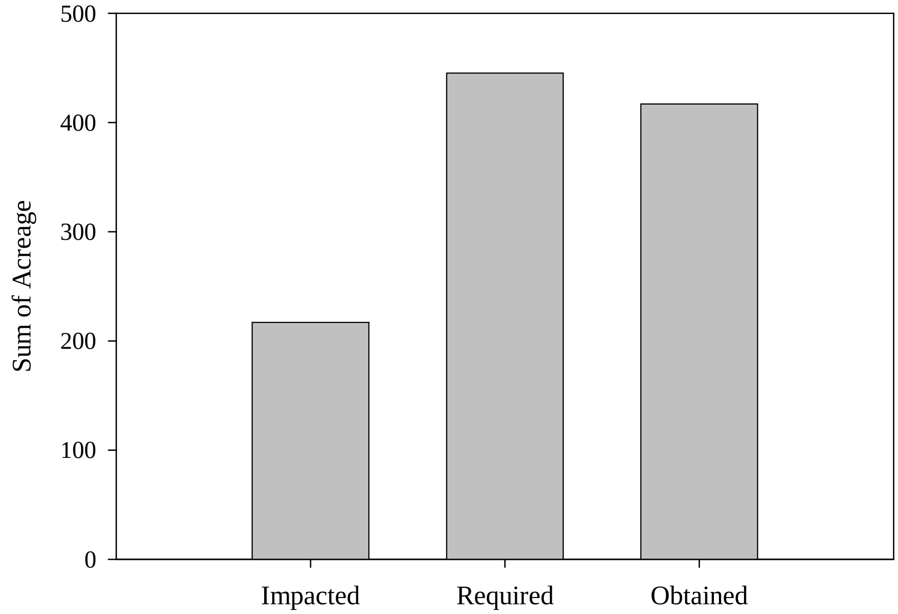

Figure 49. Overall acreage obtained compared to required and impacted (N=143 files).

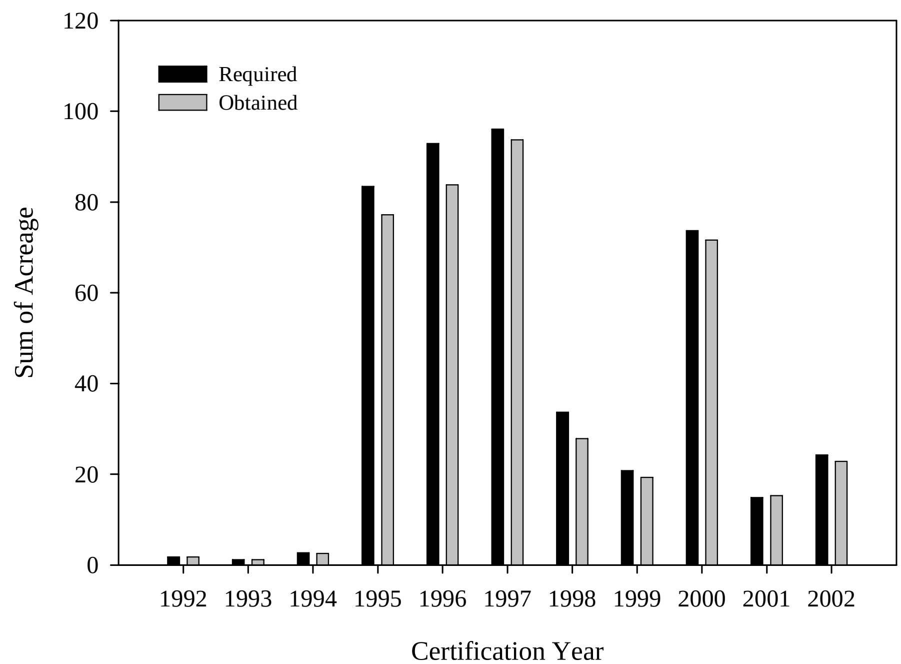

Figure 50. Acreage required and obtained by year (N=143 files).

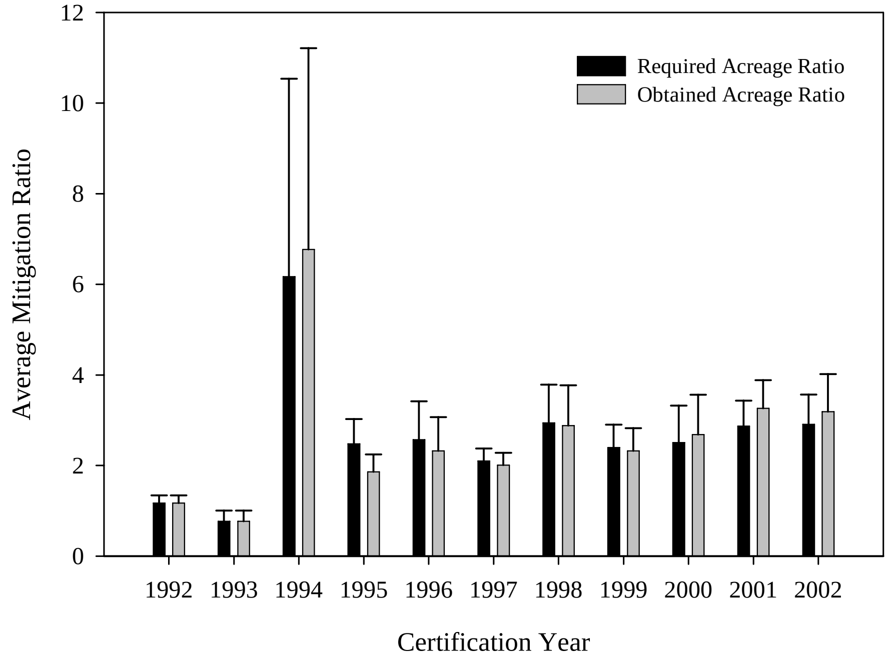

Figure 51. Average mitigation ratios of required and obtained acreage by certification year as determined from our detailed permit file review.

In 2002, one file was removed that had 0.035 acres of impact and 4.30 required and obtained acres, yielding an anomalous mitigation ratio of 122.9. The resulting sample size was N=142.

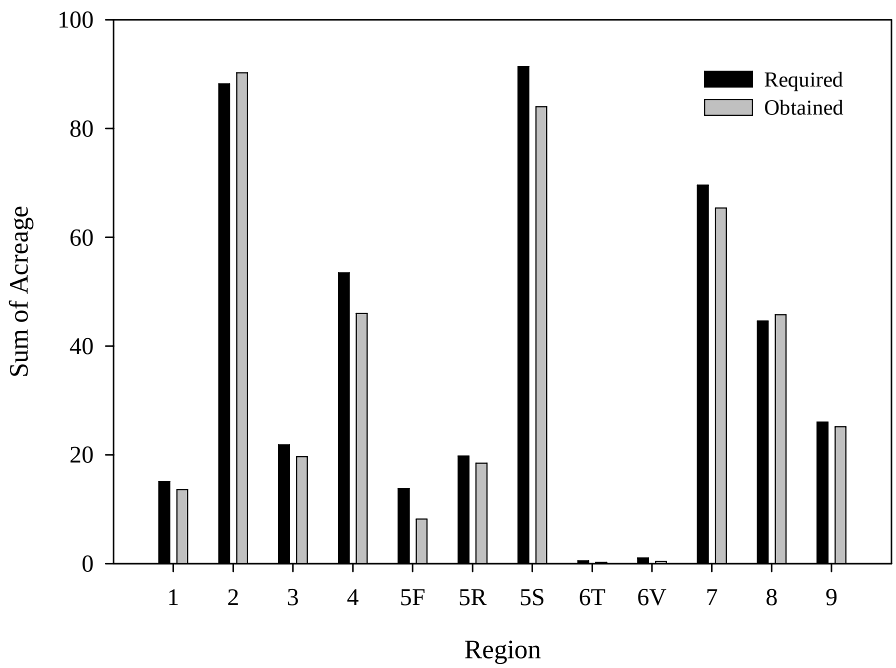

Figure 52. Acreage required and obtained by region.

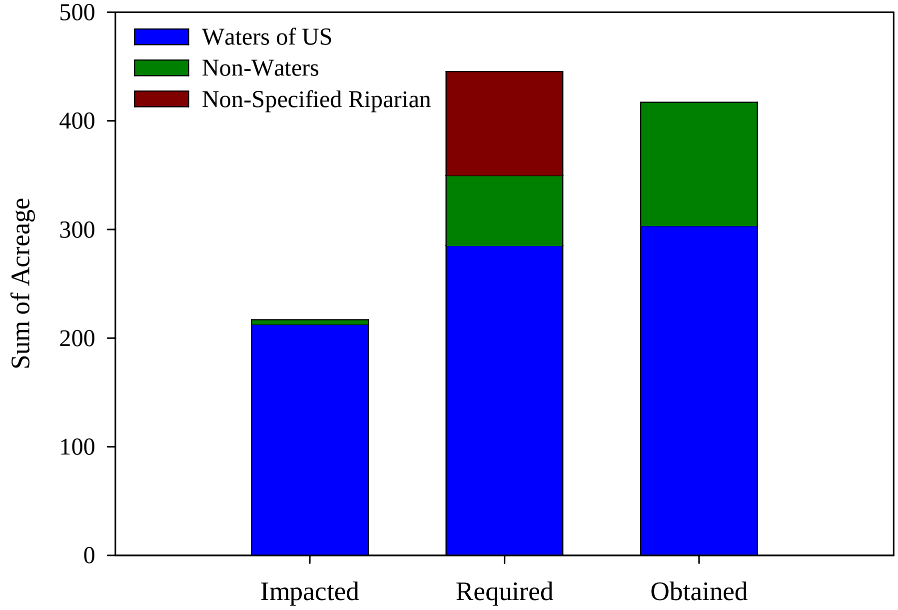

Figure 53. Total acreage impacted, required and obtained for 143 files assessed. Acreage also grouped by jurisdictional habitat classifications: "Waters of the U.S." and non-jurisdictional waters (Non-"Waters").

Required acreage also consists of a "Non-Specified Riparian" component, which represents a mitigation requirement of riparian acres, but non-specified jurisdiction ("waters" or non-"waters").

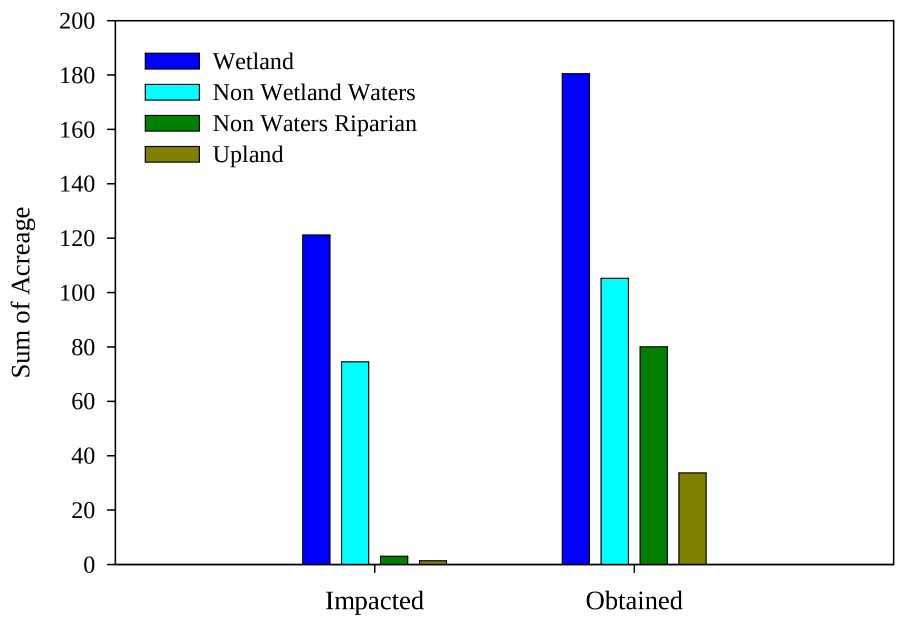

Figure 54. Total acreage impacted and obtained, with jurisdictional habitats data for "waters of the U.S." proportioned into wetland and non-wetland "waters" habitats, and data for non-"waters" proportioned into riparian and upland habitats.

N=138 files (There are five files for which wetland acreage was not specified for "waters of the U.S.").

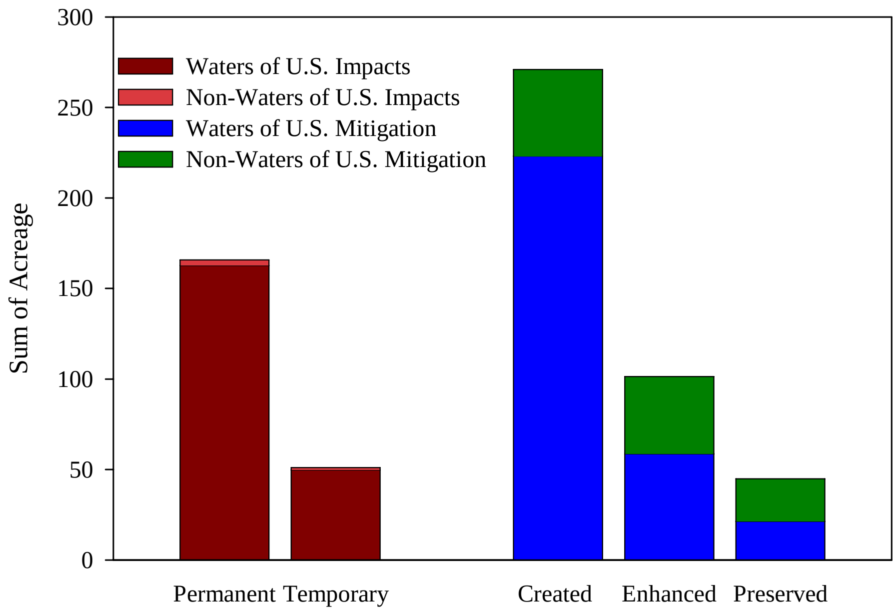

Figure 55. Total acreage impacted proportioned into permanent and temporary impacts, and obtained acreage proportioned into created, enhanced and preserved, each proportioned further into "waters of the U.S." and non-"waters of the U.S." (N=143 files).

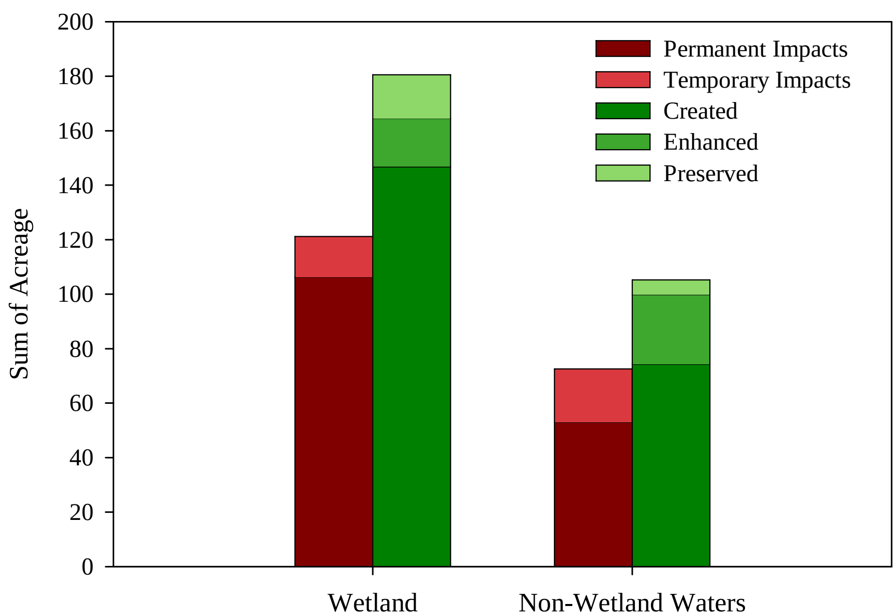

Figure 56. Total acreage for wetland and non-wetland "waters," each displaying impacted and obtained acreage. Impacted acreage is proportioned into permanent and temporary impacts, while obtained acreage is proportioned into created, enhanced and preserved.

N=138 files (There are five files for which wetland acreage was not specified for "waters of the U.S.").

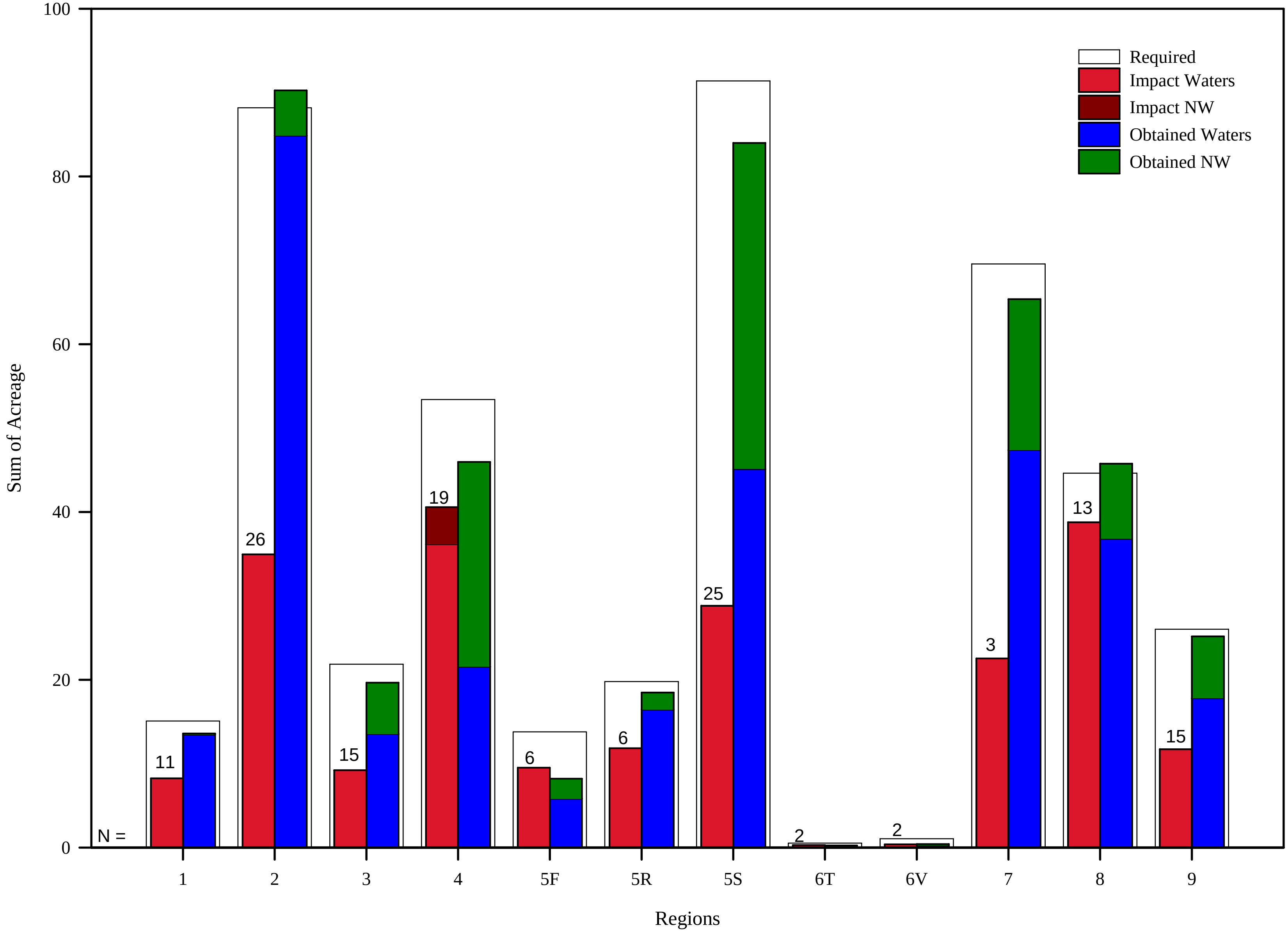

Figure 57. Total acreage impacted and obtained proportioned into “waters of the U.S.” and non-“waters of the U.S.” by state board region (N=143 files). Total required acreage per region is also displayed. N displayed = number of files assessed per region for both impacted and obtained.

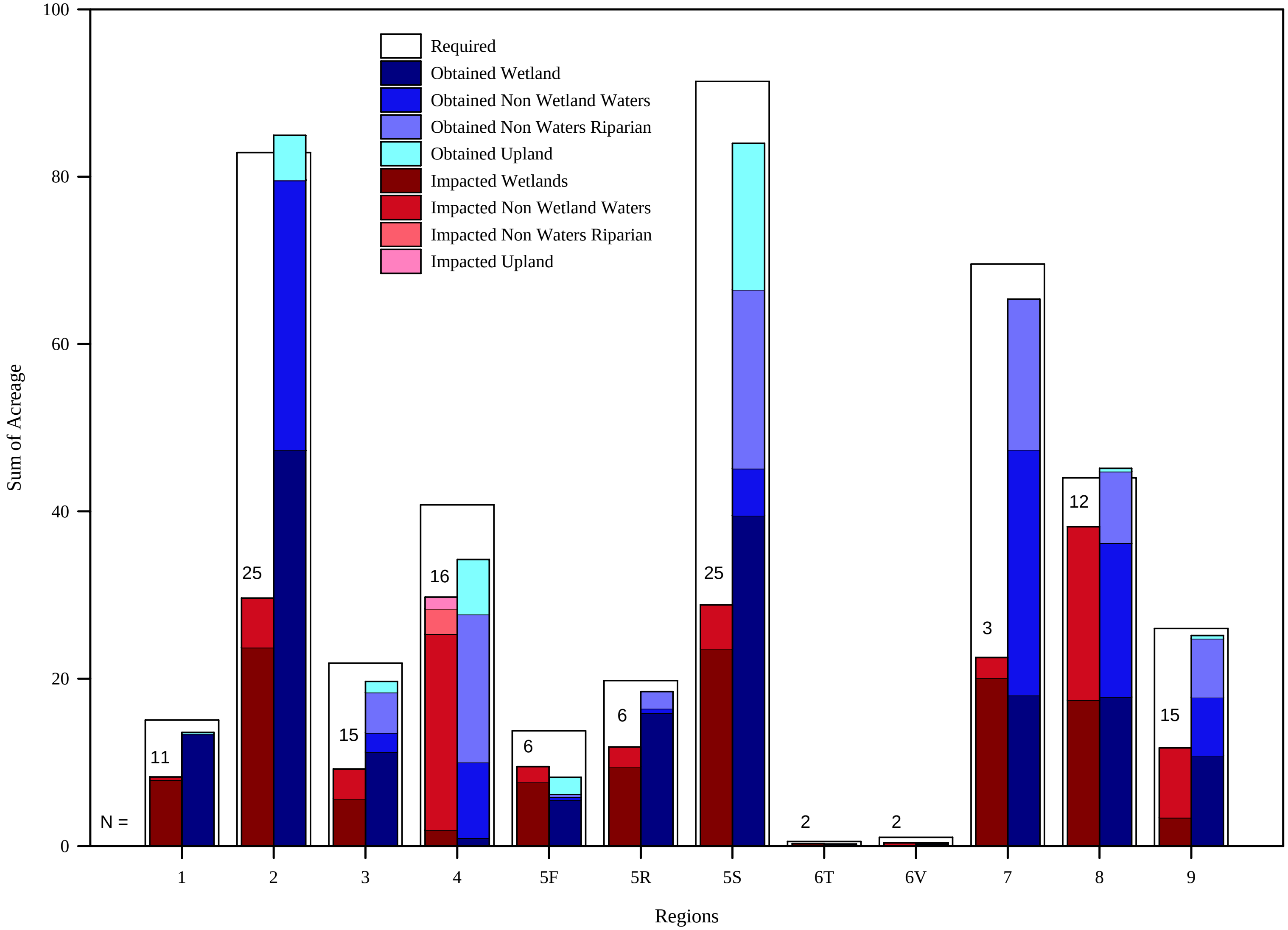

Figure 58. Total acreage impacted and obtained proportioned into wetland, non-wetland "waters," riparian and upland jurisdictional habitats by state board region. Total required acreage per region is also displayed.

N displayed = number of files assessed per region for both impacted and obtained. Total N=138 files (There are five files for which wetland acreage was not specified for "waters of the U.S.").

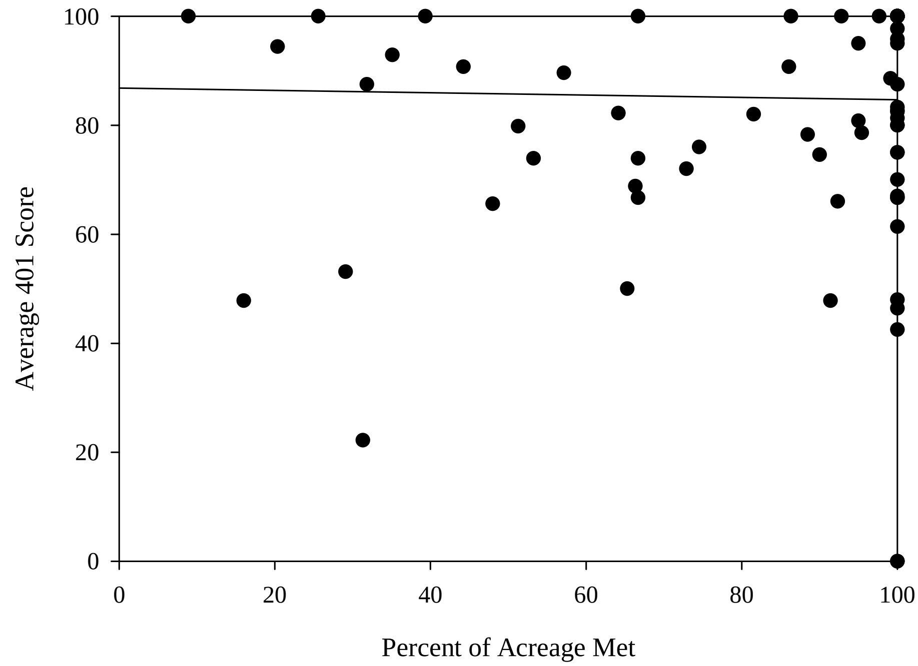

Figure 59. Correlation analysis between percentage of acreage requirement met and average 401 permit compliance score (N=123 files; r^2=0.013, p=0.214).

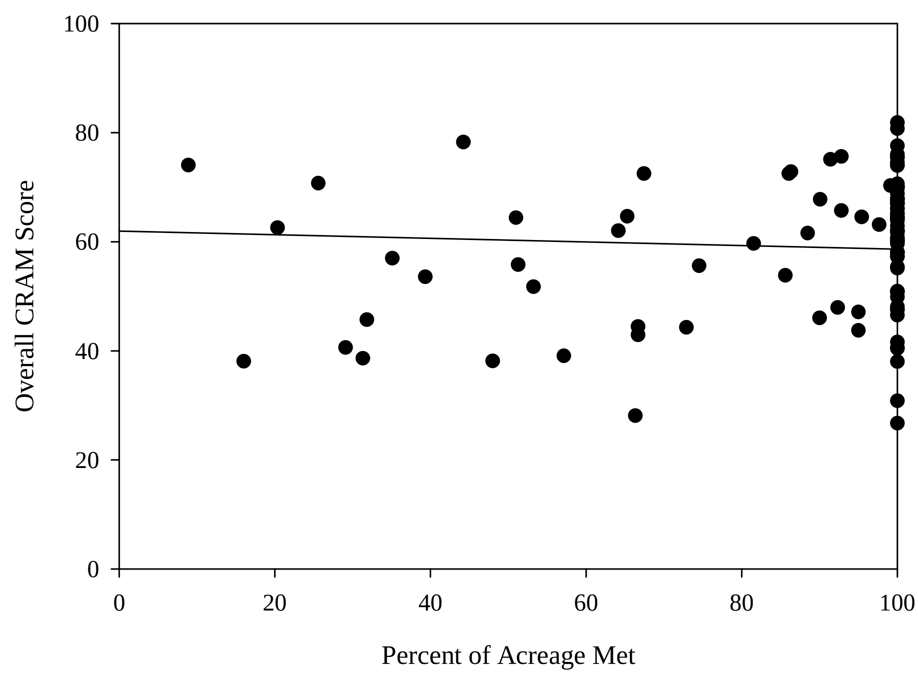

Figure 60. Correlation analysis between percentage of acreage requirement met and overall file-wide CRAM score (N=128 files; r^2=0.015, p=0.173).

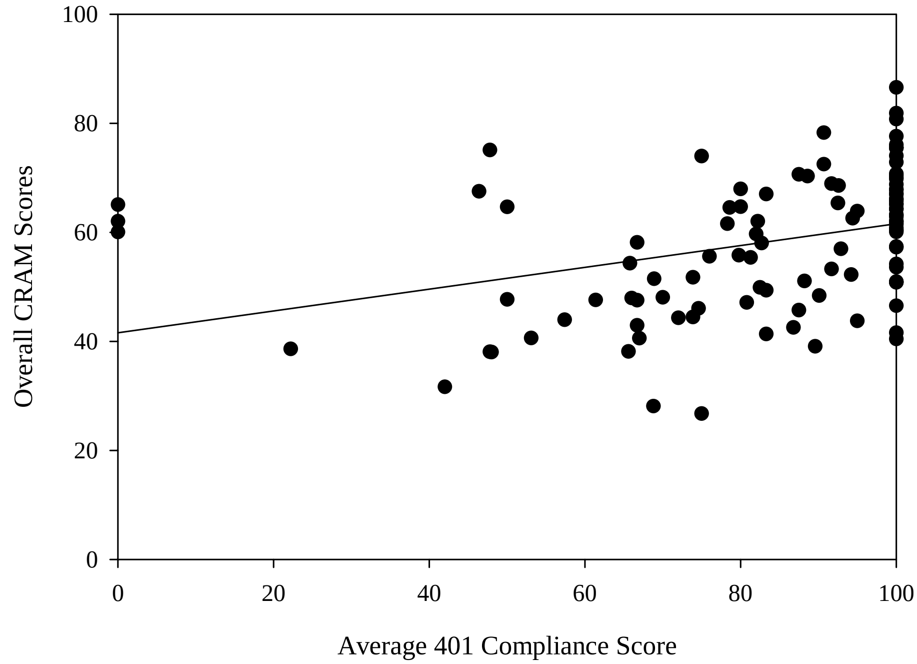

Figure 61. Correlation analysis between average 401 permit compliance score and overall file-wide CRAM score (N= 110 files; r^2=0.126, p=0.000).

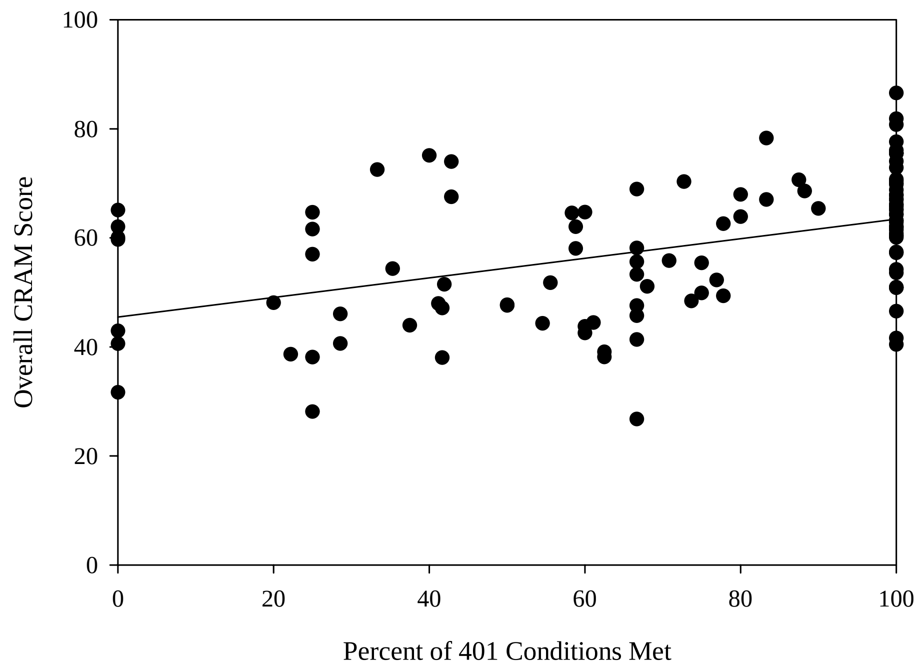

Figure 62. Correlation analysis between percentage of 401 permit conditions met and overall file-wide CRAM score (N=110 files; r^2=0.207, p=0.000).

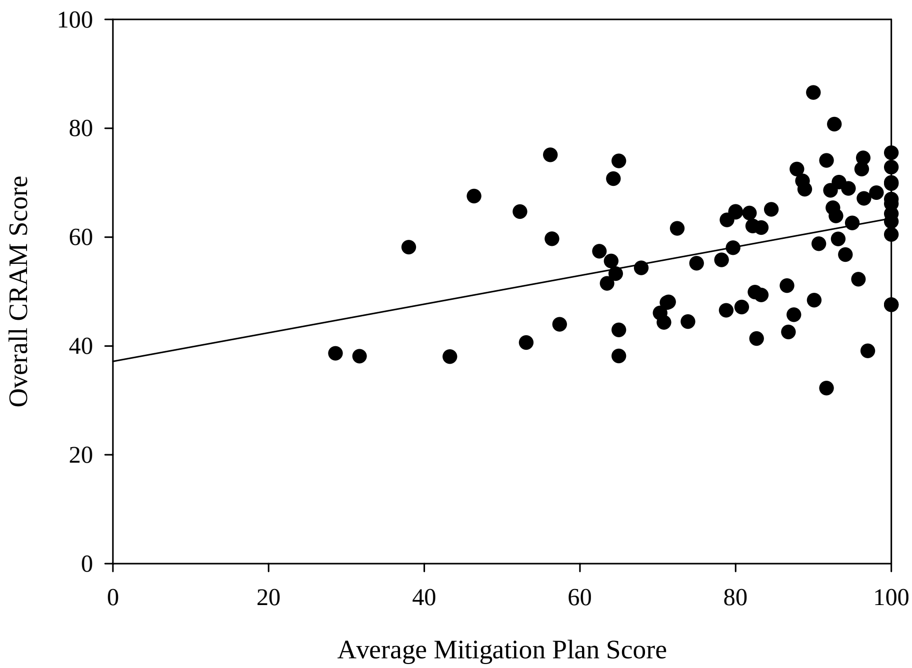

Figure 63. Correlation analysis between average mitigation plan compliance score and overall file-wide CRAM score (N=77 files; r^2=0.150, p=0.001).

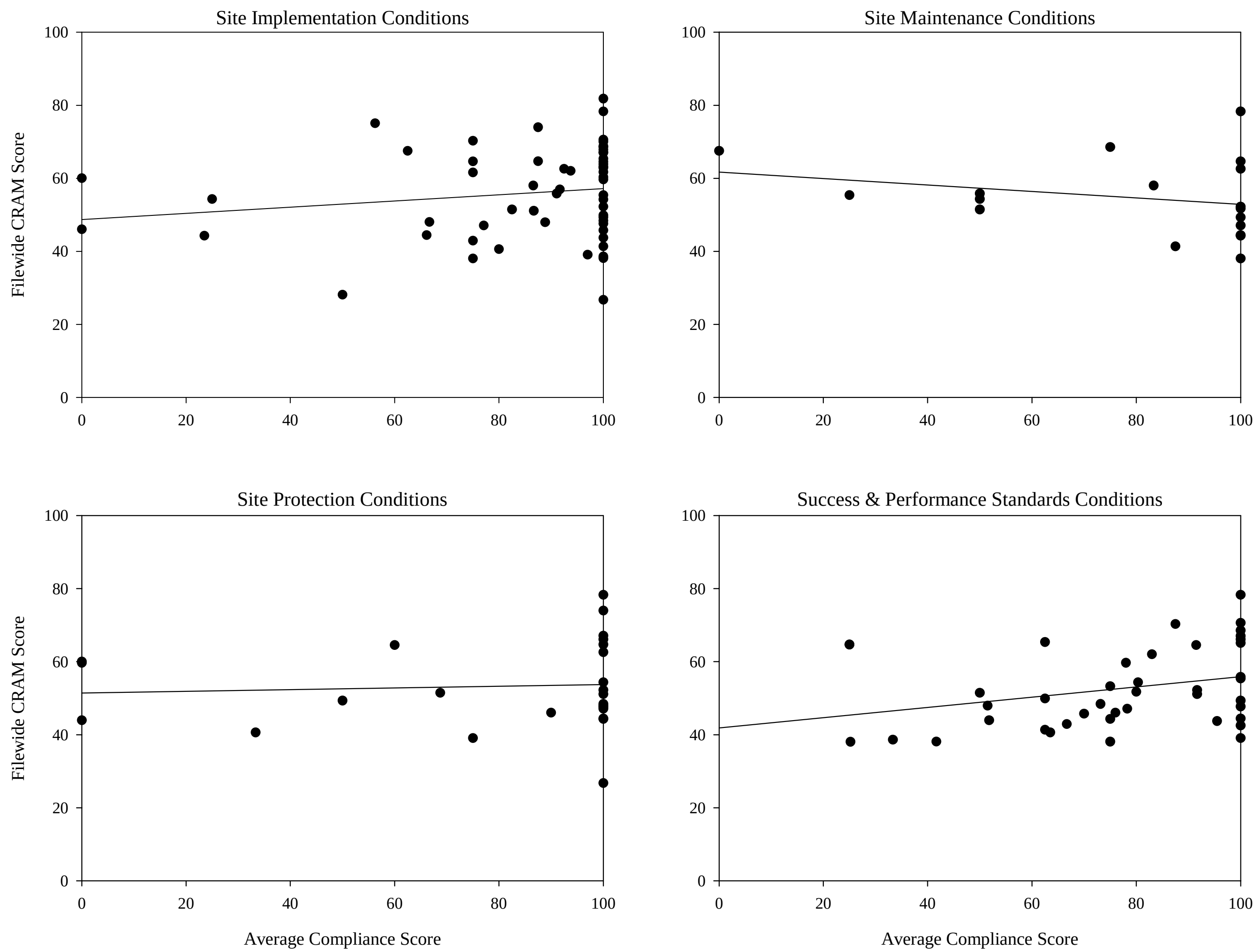

Figure 64. Correlation analysis between overall file-wide CRAM percentage score and average 401 permit compliance score for four of the permit condition categories. Sample sizes and correlation coefficients per condition category are as follows: for site implementation N=57, r^2=0.027, p=0.219; site maintenance N=18, r^2=0.068, p=0.297; site protection N=25, r^2=0.005, p=0.743; success/performance standards N=42, r^2=0.091, p=0.052. See Methods for description of permit condition categories.

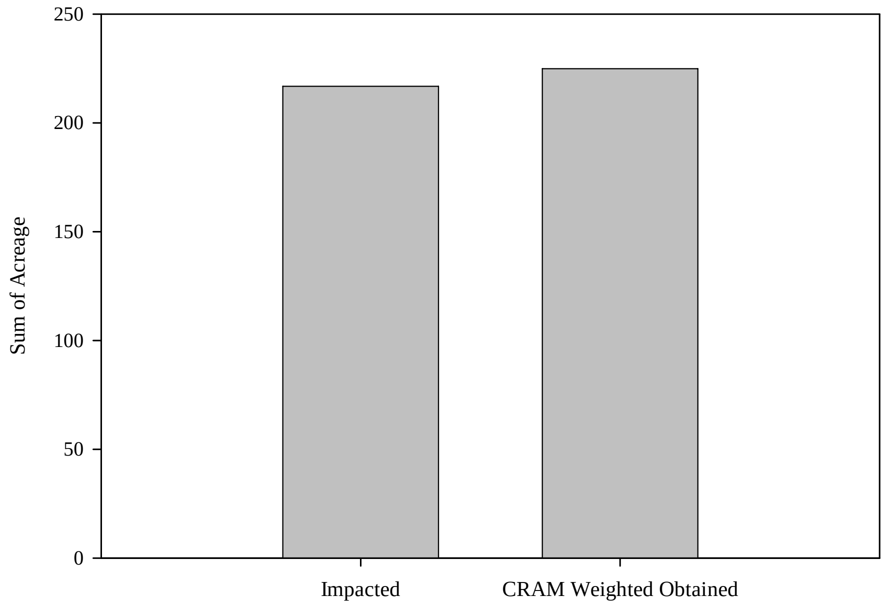

Figure 65. Total impacted acreage and obtained acreage weighted by condition score (N=129 files).

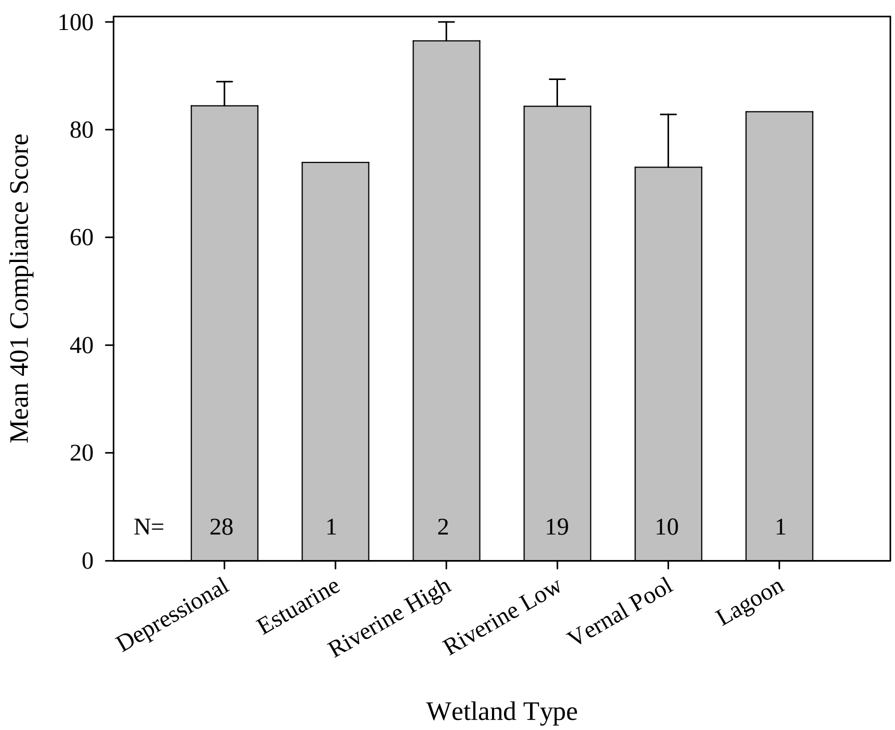

Figure 66. Mean 401 compliance score for different wetland types.

Includes invoked conditions; N=61 files

A Case Study: Systemic Evaluation of Compensatory Mitigation Sites Within the Carlsbad Hydrological Unit

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Abstract

This study took place over the course of four months within the Carlsbad Hydrologic Unit (CHU). The cities (Carlsbad, Encinitas, Vista, Escondido, Oceanside, Solano Beach, and San Marcos) of the CHU are in northern San Diego County, California, USA. The sites under study were complied into a database for the Regional Water Quality Control Board (RWQCB) permit records (from Section 401 of the Clean Water Act (CWA)) and individual Environmental Impact Reports (EIRs) requested from various federal, city, and trustee agencies. The database contained project information such as state clearinghouse number, lead agency, project description, location, affected body of water and watershed, the type of habitat impacted, and the extent of the impact (in acres). Location of the mitigation sites was made using GPS information. For on-site evaluation a systemic, qualitative bioassessment process was created and performed. These mitigation sites were then given a "score" based on the site's internal and external health. A root cause mapping process was employed to identify the systemic relationships among the multiple factors of the bioassessment. The lack of a distinct regulatory mechanism was identified as a key root cause driver.

A cybernetic model was used to model the regulatory relationships within the system and evaluate the effectiveness of current regulatory practices. The CHU is a system with widely varied inputs, complex set of dynamic states, and divided stakeholders. Comparison between an idealized cybernetic regulatory system and the observed system of regulation in CHU allowed me to identify information transfer and feedback-loop break-downs. Recommendations were made to close feedback loops, eliminate delays and lags in the regulatory process, and foster collaborative, unbiased information transfer in an effort to create an evolving regulation system.

Keywords: cybernetic regulation, feedback-loop, root-cause mapping, bioassessment.

Introduction to the Problem Situation

The Carlsbad Hydrologic Unit lies in central and northern San Diego County. The CHU encompasses multiple watersheds from their headwaters to the lagoons that spill into the ocean. Accordingly, each watershed has a conservancy, "friends of" program, and/or various non-profit organizations that are associated with its water. They take-on tasks such as regular clean-ups, watershed health monitoring, and public outreach and education. However, these organizations are typically small, resource-limited, and localized. In other words, each organization is consumed with the business of their own watershed, and inter-watershed collaboration is not a regular process. The necessity of a CHU-wide study, or at the very least accounting, was obvious, but outside the agenda for any watershed-specific groups.

The Natural Reserve System (NRS) provided the appropriate vehicle for an inter-watershed study of the CHU. The Natural Reserve System is a non-profit, research- and conservation-minded organization that maintains several natural reserves inside and around the CHU. The organization plays the role of a "trustee agency" who is involved in the public review and consultation portion of the permitting process. It also acts as a "watchdog", which has the technical and financial abilities to bring specific cases to court. This creates accountability on the part of the cities, developers, and public. NRS's provided the ecological knowledge and tools to approach a multiple watershed problem.

Initial findings showed an up-to-date accounting of the CHU's mitigation status was missing. Environmental impacts were continuously occurring within the watershed (as reported by permit records), but records of their mitigation were not extensive nor reliable. Even central groups within the CHU-- the conservancies and the Carlsbad Watershed Network-- were uninformed about the current impact to mitigation ratio. The extent and location of cumulative impacts was unknown. Therefore, there was no way to evaluate the effectiveness of the "No Net Loss" policy. The foundation of California conservation policy is "No Net Loss", which depends on the amount of mitigated habitat to be quantitatively equal to or greater than what was impacted. The need for a comprehensive study was clear.

Thus, the primary goal of this study was to compile a database of the reported impacts to wetlands and associated habitats (riparian, streambed, lake, and ocean) within the CHU, and their compensatory mitigation measures. Most entries came from the Regional Water Quality Control Board (RWQCB) database. Their records of 401 permits (Clean Water Act) were obtained for the past twenty years. The records were sorted to sites within the jurisdiction of the CHU. The Individual Environmental Impact Reports (EIRs) were obtained by contacting individual agencies such as the Army Corp of Engineers, California Department of Fish and Game and Department of Wildlife, the regional EPA office, and other local regulatory agencies.

A second goal was to articulate the regulatory processes that shape the CHU. There are a complex set of influences and an extensive cast of stakeholders that affect the CHU. Economic development by expanding cities threatens natural habitat. Political struggles for land use, such as the recent proposition addressing urban sprawl, increase the stress on remaining habitat. The rapidly expanding populations within the CHU fuel increasing congestion, air and water pollution, and habitat destruction. There is a wide range of stakeholders often with conflicting agendas. Stakeholders include: the cities of the CHU, the watershed conservancies, contractors and developers, special consultants (biologists, ecologists, etc.), federal, state, and local regulatory agencies, private landowners, non-profit, special interest environmental groups, and the public. When all of these components must coexist, the situation becomes bogged-down in complexity, and a systemic approach must be used to understand their many interactions.

A third goal was recording and evaluating compensatory mitigation sites of the CHU. The reported Global Positioning System (GPS) information was only adequate for about ten percent of the total records. The mitigation sites had to be located in order to determine the distribution of impacted habitat throughout the CHU. It became evident which watersheds had the most impacts and corresponding mitigation. The differences in the impact to mitigation ratios between watersheds distinguished one from another in their regulatory effectiveness and rigor. An on-site evaluation of a given mitigation site provided insight not only into the quantitative extent, but also the quality of mitigation. A specific evaluation process called bioassessment was created for this task. The use of this evaluator in the field was vital to understanding the quantitative and qualitative status of mitigation within the CHU.

Finally, recommendations will be made to revitalize conservation efforts within the system. As it stands now, there are fundamental flaws in the regulatory process that need to be addressed systemically to move toward sustainable success.

Systemic Bioassessment

After the location data was sorted and verified, the study turned towards field work. Armed with viable GPS locations and topographic/road maps, the sites were fairly easy to find. Once there, the site was thoroughly explored and a photographic record taken of the described mitigation. With the bioassessment worksheet (Fig. 1), the site was evaluated based on ecological and functional criteria.

The bioassessment used in this study featured a rating system that ranged from 0 (extreme degradation) to 20 (near pristine/ healthy). The site receives a score for each category based the criteria listed under “Habitat Parameters”. The parameters are then divided again into three classifications for “Habitat Dimensions”, “Productivity”, and “Resiliency”. The scoring criteria included:

	HABITAT PARAMETER	CONDITION CATEGORY			
		HEALTHY		UNHEALTHY	
		NEAR PRISTINE/ HEALTHY	SOME DEGRADATION	UNHEALTHY/ OBVIOUS DEGRADATION	EXTREME DEGRADATION
HABITAT DIMENSIONS	QUALITY OF VEGETATIVE COVER*	Diverse and statified canopy that offers excellent habitat for wildlife.	Inconsistent stratification, but canopy is sufficiently heterogenous to offer wildlife habitat.	One or more levels of trees, woody shrubs, or hebacious plants is absent. Wildlife cover is limited.	Homogenous habitat which offers no cover for willife
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
	PLANT AND ANIMAL SPECIES DOMINANCE	100-75% native species present.	75-50% native species present.	50-25% native species present.	<25% native species present.
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
	VISIBLE BIODIVERSITY**	High family and/or species diversity. High divergence between families with proportional representaiton of each.	Moderate family and/or species diversity. Diversity displays suficent family divergence. Representation may be unbalanced, but no taxa is overly dominate.	Limited family and/or species diversity. Family divergence is reduced and taxa dominaiton is emerging.	Habitat dominated by one or a few species from closely related families.
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
	GROUND COVER (Compared to a control)	Ground cover is heterogeneous and protects against erosion (> 90% protective cover).	Ground cover heterogeny less than prisitne but still diverse. Slight erosion evident (70-90% protective cover).	Ground cover is dominated by several species and significant erosion is evident (50-70% protective cover).	Ground cover consists of one or a few species, and extensive erosion has resulted (<50% protective cover).
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
	FRAGMENTATION	No significant barriers to wildlife and habitat is continuous.	A few barriers to wildlife movement, but not restrictive. Slight fragmentation of habitat.	Significant restrictions of wildlife movement and habitat fragmentation.	Wildlife movement has been disrupted, and habitat exists in islands.
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
PRODUCTIVITY	COMPATIBILITY#	Site flora and fauna, terrain, and hydrology compatible/ complementary with surrounding habitat.	Site flora and fauna, terrain, and hydrology mostly compatible/ complementary with surrounding habitat.	Site flora and fauna, terrain, and hydrology inconsistent with surrounding habitat.	Site flora and fauna, terrain, and hydrology dramatically inconsistent with surrounding habitat.
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
	RIPARIAN FUNCTION	Riparian areas effectively filter run-off, regulate temperature, and provide organic input into the ecosystem.	Riparian areas for the most part filter run-off, regulate temperature, and provide organic input into the ecosystem.	Riparian areas do not filter run-off, regulate temperature, and/or provide organic input into the ecosystem.	Riparian areas absent.
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
	ECONOMIC PURPOSE	Human interaction with site is negligeble. A symbiosis is achieved.	Human interaction with site is passive, but present.	Human interaction with site is temporarily detremental.	Human interaction with site is permenantly detremental.
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
RESILENCY	CUMULATIVE EFFECTS##	Stress(es) to site have little negative synergy.	Stress(es) to site display some negative synergy.	Stress(es) to site display significant negative synergy.	Stress(es) to site display extensive negative synergy.
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**
	REVERSABILTY***	Negative impacts are superfical and can be reversed with little effort.	Negative impacts are significant, but with moderate effort can be reversed.	Negative impacts are extensive and can only be reversed by large-scale efforts.	Negative impacts are irreversible.
	SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1**

*** Are the mitigation measures helping to reerse the impacts? Examine the habitat's overall degradation.

*Layers of vegetation are considered here. Examine the stratification of trees, woody shrubs, and herbacious plants. Is there heirarchy or canopy stratificaiton?

#Consider factors such as continuous terrain (topography and composition), compatible hydrology, and consistent flora and fauna. Compare with surrounding habitat.

**Pay attention to higher taxa diversity. Count the numbers of families and species present

##Stresses can be independent or connected. If the effect of multiple stresses could not have been achieved without the combination of those stresses, then negative synergy has occurred.

Figure 1: The Bioassessment Evaluation Worksheet

•*Visible Biodiversity*: the visible biodiversity is evaluated by family, as opposed to species, divergence that requires less specific species knowledge;
•*Plant and Animal Species Dominance*: the ratio of native to non-native/invasive species;
•*Quality of Vegetative Cover*: the stratification canopy that contains a diversity of vegetation that provides multiple niches for wildlife to occupy;
•*Ground Cover*: the site's susceptibility to erosion-- sufficient ground cover, present in vegetation's root systems, will prevent erosion;
•*Fragmentation*: the site must exhibit no significant barriers to wildlife movement and be continuous;
•*Compatibility*: the natural hydrology must be maintained and the flora compatible with surrounding natural vegetation;
•*Riparian Function*: habitat's ability to filter run-off, regulate temperature, and provide organic input into the system;
•*Economic Purpose*: does the site's extent and nature of human interaction promote sustainable development;
•*Resiliency*: the site's capacity to rebound after cumulative effects of multiple stresses; and
•*Cumulative effects*: did the mitigation measures help reverse impacts to the site, or are the impacts irreversible.

Results

A database containing 208 records was compiled for impact and mitigation sites. It included the type and extent of impacts, compensatory mitigation, the lead agency involved, and the watershed that was affected. Not only was the database a first step towards creating accountability, it also revealed the extent to which the CHU's habitat is being degraded.

From the database, two summary tables were created to make the database's information more accessible (Table 1 and 2). The summary tables give the extent of impacts and mitigation based on totals from individual permits. Both the impacts and mitigation tables divide the CHU into its constituent watersheds, then further into the type of habitat affected. The overall ratio of acres impacted to acres mitigated was 1,392 to 561. The watersheds that effectively implemented mitigation (according to impacts:mitigation ratios) are Agua Hedionda HA(47.77: 57.8), Escondido HSA (5.64: 11.81), Loma Alta HA (32.23: 41.80), Los Manos HSA (10.36: 29.39), and San Elijo HSA (64.44: 71.68). The most effective watershed was Buena Vista Creek HA with a ratio of 18.53: 45.40. On the other end of the spectrum, the watersheds with the least effective implementation were Batiquitos HA (68.63: 33.81) and San Marcos HA. San Marcos had they most unequal ratio of 1,010.05: 126.76, which exceeded the ratio of the entire CHU. The other watersheds (Buena HSA, El Salto HSA, Escondido Creek HA, Richland HSA, Twin Oaks HSA, and Vista HSA) had a ratio near 1:1. Cottonwood HA and Encinas HA had no information reported in their project summaries.

IMPACTS (ACRES)	TYPE OF HABITAT IMPACTED												
	TEMPORARY IMPACTS					TOTAL FOR INDIVIDUAL WATERSHED	PERMANENT IMPACTS					TOTAL FOR INDIVIDUAL WATERSHED	OVERALL IMPACTS TO INDVIDUAL WATERSHED
	WETLANDS	RIPARIAN/ WOODLANDS	STREAMBED	LAKE	OCEAN		WETLANDS	RIPARIAN/ WOODLANDS	STREAMBED	LAKE	OCEAN		
AGUA HEDIONDA HA (904.30)	4.87	0.79	0.11	0	2mil cy	5.77	18	13.22	6.38	4.48	0	42	47.77
BATIQUITOS HA (904.51)	1.133	0	0.17	0	2mil cy	1.303	14.196	5.1302	3.46	44.54	0	67.3262	68.6292
BUENA HSA (904.32)	0.66	0	0.01	0	0	0.67	5.2	0.12	2[illegible]2	0	0	7.44	8.01
BUENA VISTA CREEK HA (904.20)	1.653	0	0.178	0	0	1.831	9	0.68	6.672	0.35	40,000 CY	16.702	18.533
COTTONWOOD HA (904.51) **(NO INFORMATION)**	0	0	0	0	0	0	0	0	0	0	0	0	0
EL SALTO HSA (904.21)	0.06	0	0	0	0	0.06	0	0	0	0	0	0	0.06
ENCINAS HA (904.40) **(NO INFORMATION)**	0	0	0	0	0	0	0	0	0	0	0	0	0
ESCONDIDO CREEK HA (904.60)	2.227	0.176	2.523	45.1	0	50.026	36.355	4.874	7.953	9.62	1.5	60.302	110.328
ESCONDIDO HSA (904.62)	1.734	0.15	2.426	0	0	4.31	1.017	0.105	0.203	0	0	1.325	5.635
LOMA ALTA HA (904.10)	2.95	4.5	0.021	0	0	7.471	8.957	10.53	3.002	2.27	0	24.759	32.23
LOS MANOS HSA (904.31)	0	0	0.04	0	0	0.04	8.34	0	1.98	0	0	10.32	10.36
RICHLAND HSA (904.52)	0.04	0	0	0	0	0.04	0.28	0	0.199	0	0	0.479	0.519
SAN ELIJO HSA (904.61)	0.14	0	0.9	45.1	2mil cy	46.14	17.5744	0	0.724	0	0	18.2984	64.4384
SAN MARCOS HA (904.50)	3.77	0	350.435	0	1.6	355.805	27.674	8.706	605.809	10.63	1.43	654.249	1010.054
TWIN OAKS HSA (904.53)	0	0	0	0	0	0	0	0	0.2	0	0	0.2	0.2
VISTA HSA (904.22)	0.012	14.46	0	0	0	14.472	0.162	0.222	0.08	0	0	0.464	14.936
TOTALS FOR CARLSBAD HYDROLOGIC UNIT	19.249	20.076	356.813	90.2	1.6	487.938	147	43.5872	638.782	71.89	2.93	904	1391.7026

Table 1: Extent of impacts within the CHU divided by watershed and type

MITIGATION (ACRES)	TYPE OF HABITAT MITIGATION									TOTAL FOR INDIVIDUAL WATERSHED
	WETLANDS			RIPARIAN/WOODLANDS			WATERS			
	CREATE	PRESERVE	RESTORE	CREATE	PRESERVE	RESTORE	CREATE	PRESERVE	RESTORE	
AGUA HEDIONDA HA (904.30)	25.996	0.53	7.393	7.798	0.42	11.63	2.51	0.02	1.5	57.797
BATIQUITOS HA (904.51)	22.06	8.34	0.404	0.5	0	0.3	2.12	0	0.09	33.814
BUENA HSA (904.32)	6.02	0	5.43	0	0	0	1.38	0	0.01	12.84
BUENA VISTA CREEK HA (904.20)	17.621	0	16.64	5.832	0	0.72	4.45	0	0.138	45.401
COTTONWOOD HA (904.51) **(NO INFORMATION)**	0	0	0	0	0	0	0	0	0	0
EL SALTO HSA (904.21)	0	0	0.12	0	0	0	0	0	0	0.12
ENCINAS HA (904.40) **(NO INFORMATION)**	0	0	0	0	0	0	0	0	0	0
ESCONDIDO CREEK HA (904.60)	37.184	1.45	12.575	4.991	0	0.291	3.99	0.67	50.744	111.895
ESCONDIDO HSA (904.62)	1.351	0.56	6.29	0	0.835	0.35	0.709	0	1.71	11.805
LOMA ALTA HA (904.10)	10.89	0.78	5.36	21.88	1.41	0	1.38	0	0.1	41.8
LOS MANOS HSA (904.31)	2.84	0	11.9	0	0	6.1	8.518	0	0.025	29.383
RICHLAND HSA (904.52)	0.524	0	0.14	0	0	0	0	0	0.135	0.799
SAN ELIJO HSA (904.61)	20.544	0	0.32	0.9	0	0.21	0.9	0	48.81	71.684
SAN MARCOS HA (904.50)	16.44	70.88	20.27	10.14	0.16	0	3.6	3.23	2.04	126.76
TWIN OAKS HSA (904.53)	0	0	0	0	0	0	0.26	0	0	0.26
VISTA HSA (904.22)	1.458	0	0.04	0.16	0	14.72	0	0	0	16.378
TOTALS FOR CARLSBAD HYDROLOGIC UNIT	162.928	82.54	86.882	52.201	2.825	34.321	29.817	3.92	105.302	560.736

Table 2: Extent of compensatory mitigation within the CHU organized by watershed and type

The tables tell us which habitats were impacted most frequently throughout the CHU, and whether that impact was temporary or permanent. The results show that the most frequently impacted habitat, regardless of the impact's permanence, was streambed. Streambed habitat had 356.81 acres temporarily impacted and 638.78 acres permanently impacted. This suggests that streambed regulation may be currently ineffective. Wetlands were the second-most impacted habitat, but with much more permanent impacts. Wetlands sustained 19.25 acres of temporary impacts and 147 acres of permanent impacts. Lakes were the third most-impacted with 90.2 acres of temporary impacts and 71.89 acres of permanent impacts. Riparian/ Woodlands were fourth most-impacted with 20.10 acres of temporary impacts and 43.59 acres of permanent impacts. Finally, marine habitat was last with 1.6 acres of temporary impacts and 2.93 acres of permanent impacts. These rankings may be important indicators of the level of protection each habitat is receiving. However, it is important to keep in mind that classification of these habitats is a complicated process with varying degrees of accuracy. There are entire manuals dedicated to wetlands delineation, and it is a subjective process determining where "riparian/woodland" and "lake" areas begin and end. It is also significant that despite the extent of wetlands protection in place, wetlands habitat still manages to rank second in most-impacted habitats within the CHU. This information is a red flag for conservationists, and it illustrates the problems within the system; *this is quantitative evidence against the "No Net Loss" policy*.

These numbers illustrated that "No Net Loss" strategy needs to be quantitatively reevaluated, as the CHU's habitat overall is at a 2.5:1 impacts to mitigation ratio. The second phase of this study revealed that there are qualitative issues as well. Evaluation of the 20 visited sites supported the claim that current mitigation measures are ineffective. The health of the resulting mitigation site is well below that of the natural habitat that was impacted. In particular, erosion is much more prevalent in mitigation sites than in the surrounding habitat. Fragmentation, due to off-site, poorly designed, or incomplete mitigation, is adversely affecting the abundance and diversity of wildlife within the CHU. The evaluated sites consistently displayed trends of increased erosion, reduced biodiversity, and incompatibility with surrounding habitat. Another barrier to effective mitigation, was the length of time between the site's impact and mitigation. The longer a site was degraded, the more divergence there was between the previous natural populations of the site and the populations that dominated the site after mitigation. Erosion and altered hydrology change the soil's composition favoring different species than before. Invasive species established footholds where native species have been removed. These findings are particularly significant because the spread of non-native/invasive species is a growing problem in Southern California. It is clear from the evidence that current impact regulations and mitigation practices are ineffective, and without change habitat within the CHU is prone to continued depletion.

Root Cause Mapping and Cybernetic Modeling of the Regulatory Mechanism

Root-cause mapping (Magliocca & Sanders, in press) is a systemic approach to exploring boundaries, articulating barriers, and formulating solutions within a complex system. Typical root cause analysis, as developed in the energy industry (ABS, 1999), identifies a linear process of distinct, causal factors that are unrelated. Root-cause mapping was created for application with systemic issues and through graduated levels of influence it exposes the symptomatic and root-cause problems of the CHU (Fig. 2). The most symptomatic problems are at the top of the root-cause map, as they are the most apparent and are directly influenced by a deeper level problem. Symptomatic problems are those that appear frequently in a system and offer the most immediate difficulty. As one travels down the map, problems grow in their influential power until the deepest level. Root-cause problems are on the lowest level of the map because they are the causal drivers of the system. The most immediate problems within the CHU are the continued degradation of environmental quality and a lack of understanding of current environmental conditions. But there are problems more causal than these. For example, agency responsiveness is weak, elected officials are misinformed about projects and problems occurring within the CHU, and mitigation is not qualitatively equivalent to natural habitat. There are problems deeper still that involve regulation and agency efficiency. These "deep root drivers" pointed to the need for a systems model to identify the issues of regulation underlying the problems. Cybernetic modeling seemed to offer the most robust approach.

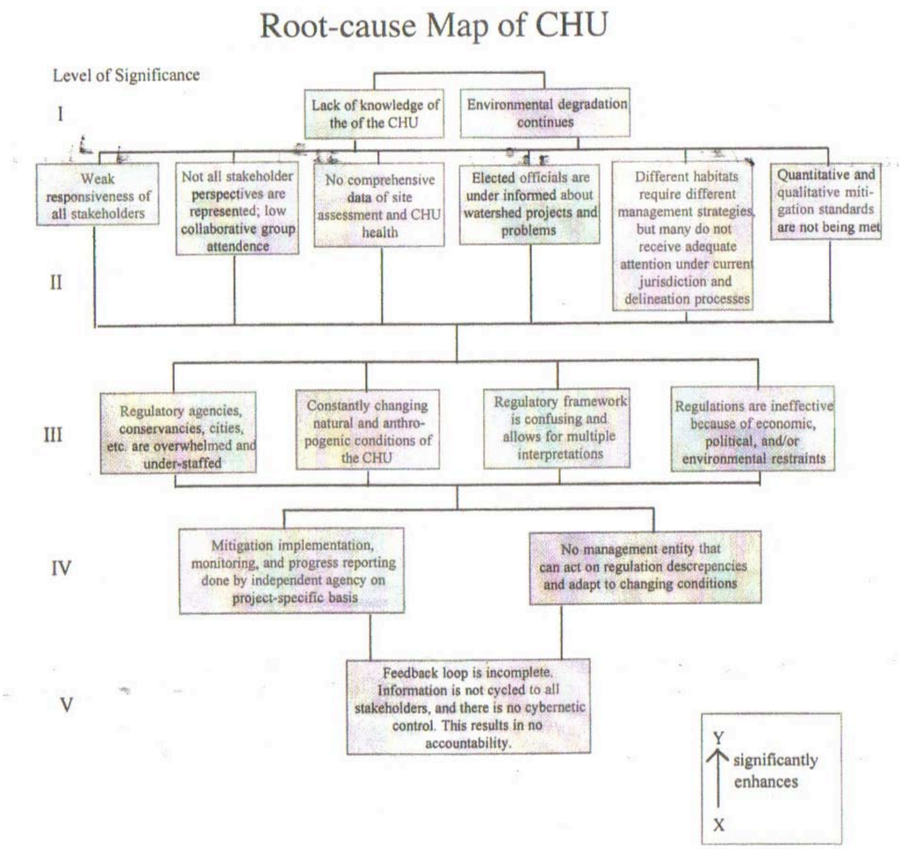

Figure 2: Root-cause map of the CHU. Deep influence increases with level number.

Cybernetic modeling was used to examine the dynamic relationships of the CHU regulatory system. The model used for this study was adapted from the model described in Lars Skyttner's work *General Systems Theory* (2001). The structure of this basic cybernetic regulatory model consists of a *sensor*, *goal setter*, *comparator*, *decision unit*, and *effector*. One path includes information entering the system through the *sensor* as input, passing through the *decision unit* where changes are determined, and exiting the system through the *effector* as output. A more adaptive path of regulation includes a parallel path of information flow and feedbacks (Fig. 3). The *sensor* receives or detects input/feedback which is sent to the *decision unit* and diverted to the *comparator*. The *comparator*, or evaluation mechanism, tests the system's state against predetermined parameters that were fed into the *comparator* by the *goal setter*. The set of goals is determined by the controller, or in the case of the CHU, by a complex, always changing, and often conflicted representation of stakeholders. Evaluation determines whether the system was successful in not only meeting the predetermined goals, but also the system's deviation from equilibrium. The inputs and state of the system are sent to the *decision unit*.

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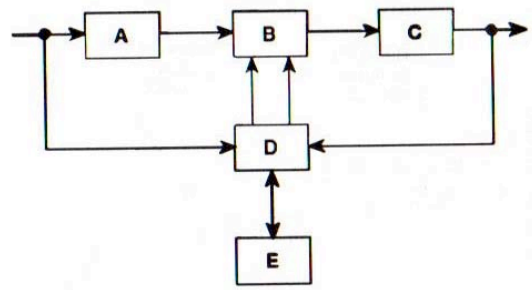

Figure 2.17 Diagram of a learning system.

A = Receptor; B = Educable decision unit; C = Effector; D = Comparator; E = Goal-setter.

Figure 3: Basic cybernetic regulatory system

The decision unit acts to align the system's outputs with its goals, and evaluate feedback from previous cycles. In its latter function, a system can learn through an educable *decision unit*. Feedback allows a *decision unit* to adapt by acting of the rules of the system. "Rules must be adjusted in such a way that a successful behavior is reinforced , whereas an unsuccessful behavior results in modification" (Skyttner 2001). Thus, a system can evolve and maintain dynamic equilibrium through modifications made by the *decision unit* based on feedback in the form of the system's own output. Once changes are made, information is transfered from the *comparator/decision unit* to the *effector*. The *effector* applies the modifications and releases an output. Output can take the form of waste, or in cyclic processes, feedback as input for the next round of operation.

A more sophisticated model that better maps the complexity of the CHU regulatory system is seen in Figure 3 (Skyttner 2001). This model gives the observer an opportunity to examine the system's various functions throughout its life cycle (Fig. 4). In regard to the CHU, a complete "life cycle" is considered to begin with the need for a development project, and end with completed mitigation of its environmental impacts. Its next "generation" entails evaluating, designing, and implementing corrections to its previous cycle. This a revealing conceptualization because it stresses the importance of feedback loops and the cyclic nature of an evolving regulatory system. Feedback and information flow can be examined easily in phases. Note that the first phase is considered a consumer phase, the intermediate a producer phase, and the last consumer again. These are very loose terms as they can be fit to any regulatory system. They make distinctions between the roles of different system components, such as *sensor*, *decision unit*, and *effector*. The division of functions also illustrates how a multi-stakeholder system can be integrated by function towards a common output.

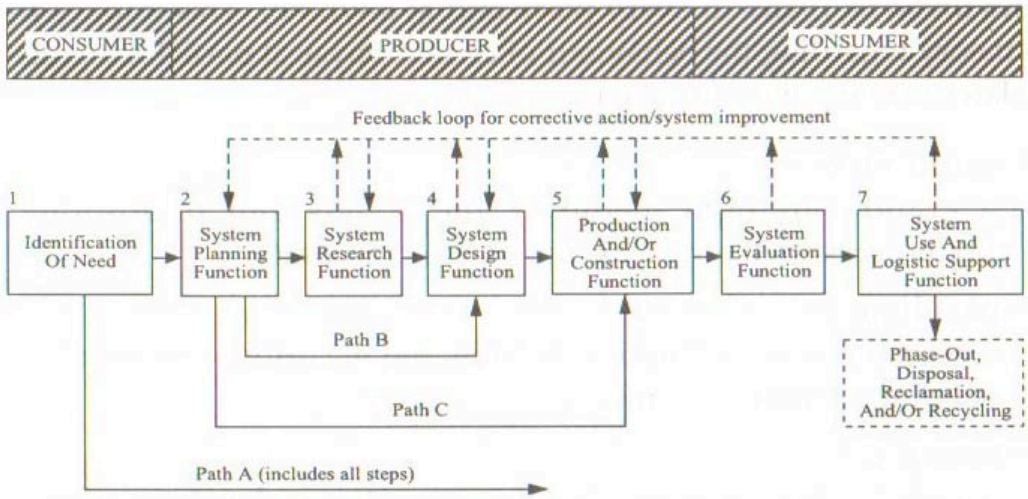

Figure 2.19 System life cycle of advanced artefacts.

Figure 4: Advanced cybernetic regulatory system that best describes the CHU

At different stages in the system's life cycles and generations, the roles of developers and conservationists are separate, and at other times, they are integrated through feedback. These distinctions are very helpful in untangling the various roles and conflicting agendas of developers and conservationists. For instance, Path A unites the process's inputs and outputs making it cyclic, which helps to distinguish between the developers' and conservationists' roles at different stages of development/mitigation. During the system's early life cycle, the developer assumes the role of the consumer. Once a project need has been identified, the producer phase is entered. Here, the system planning, research, and design functions are all integrated phases. The developer receives consultation from government regulatory agencies, biological consultants, and/or, depending on the project's stage of development, corrective feedback from conservation groups. Production is carried-out by the developer, and the last consumer stage begins. Economic success is evaluated by the developer, but the primary evaluation role goes to the conservation groups. Environmental impacts are assessed, mitigation is designed, and then implemented through the last phase of use by the developer. A new "generation" then begins with the conservationists as the first phase consumer, and mitigation becomes the focus of the next life cycle through feedback from the previous one.

Thus, the system evolves through many "generations" in a process of minimizing the environmental impacts from various economic developments. On a larger scale, the CHU acts like the basic model seen in Figure 3. However, a more sophisticated model must be used in order to describe the integrated, dynamic roles of various stakeholders. Through a cyclic process, deviations from preset goals are corrected through negative feedback. These corrections are implemented at the level of the divided functions seen in Figure 4. This becomes a "wicked" problem because of the inherent natural, regulatory, and collaborative complexity that exists in the CHU. Efficient integration of economic and conservationist interests must be achieved to maintain high levels of regulation and eliminate lags/delays on the system.

This is a very basic model of cybernetic regulation, but it illustrates the importance of feedback. Without this information transfer, regulation would be unable to adapt to changing conditions, evolve to cope with increasing complexity, and would eventually collapse. The CHU can be characterized as an open-loop system (Skyttner 2001)--one in which feedback is weak or absent. As a consequence, the state and extent of environmental impacts are not entirely known. Conservation groups are unable to adapt to changing economic development as it continues unchecked. By comparing the deviations of the CHU from the ideal cybernetic model, adjustments can be made to streamline the regulation process and close feedback loops.

Discussion

It is clear from the above analysis that something must be done to alter the path that current practices are leading us down. When one of the largest hydrologic areas, San Marcos Creek, has almost eight times as many impacted as mitigated acres, there are inconsistencies embedded in the system. This study should be viewed as an exploratory venture, as it looked at the CHU as a whole and exposed the complex systems within. This study will hopefully recapture our attention and examine the problem in a new light.

This study did not produce “hard data”, like water quality or benthic macroinvertebrate samples, but instead gave insight into the quality of the mitigation being performed. Again, this was not done by “hard science”, rather by system science, as the site’s internal and external relationships were examined. The root-cause problem is not the impacts to mitigation ratio-- although there is an unequal ratio for the entire CHU-- but with the ineffective and isolated interactions between the system’s multiple components. This is an extremely complex system that encompasses both human and natural systems, and solutions are never simple.

The deep cause of inadequate mitigation, insufficient knowledge of the CHU’s state, and poor stakeholder representation stems from incomplete integration of economic and environmental objectives. There are steps in the regulatory process “life cycle” where conservationists and developers should be collaborating, but they are not. Conflicting agendas are “dysergy” in the regulation and mitigation processes (Corning, 2003). Lags, delays, and/or simple inaction result, and collaborative relationships destabilize and degrade. Information flow becomes stagnant as projects and their mitigation are designed almost entirely by the developers without input from other CHU stakeholders. Mitigation is evaluated and surveyed without feedback to the developers. Collaboration facilitates free information flow that is vital to a regulatory control system. Currently, incentive for the developers to collaborate with conservationist agencies is inadequate. A common set of goals needs to be established to facilitate information exchange, role assignment, and equity. Effective feedback will then be encouraged among all stakeholders.

Feedback-loops are essential cybernetic elements in any complex system. To draw upon a natural example, the “evolutionary arms race” between plants and herbivores is a dynamic, adaptive, and creative process. An herbivore’s actions on a plant are causal to the development of that plant’s defenses, which are in-turn, causal to the herbivore’s evolving predatory behaviors. There is feedback involved in these organisms’ interactions, and the process is iterative, driving adaptation and responsiveness. Adaptation and responsiveness are two elements lacking in the CHU regulatory system. Particularly, an effective feedback loop within the CHU will create accountability for impacts and their mitigation where relatively none currently exists. I believe this to be a *root-cause problem* of the CHU, and creating accountability through feedback is an essential first step towards a solution.

Without sufficient accountability, the system will not progress towards desired conservation, economic, and political objectives. For example, mitigation implementation, monitoring, and progress reporting is left to the party responsible for the impacts. This is an ineffective strategy because there is no method of enforcement nor incentive to consider conservation interests in the mitigation process. These conditions are most likely stem from the fact that a centralized management entity does not currently exist. Without central management, there is no mechanism to enforce stakeholder accountability and facilitate collaborative problem-solving . Collaboration breaks-down in the “Producer” phase of regulation when development and conservation roles are not integrated properly. This creates lags and delays in information transfer that reduce responsiveness and severely limit regulatory power. Thus, the central flaw in the CHU regulatory system is its open feedback loop, and this problem is exacerbated by the lack of a central management entity that can ensure accountability and collaboration.

A Proposed Solution

There are surely many solutions to this problem that are as complex as the system itself. This study, after exploration of the CHU, is prepared to propose a possible solution given the available resources of all stakeholders involved. In is our goal to create an effective feedback loop within the CHU to foster accountability, responsiveness, and adaptability. An entity is needed to feed evaluation and progress information back into the system. Mitigation monitoring and evaluation of mitigation quality and quantity will help assess overall environmental health of individual watersheds and the CHU overall.

It is this study's proposal that the "nature centers", which are associated with each watershed within the CHU, can fulfill the evaluation role. Nature centers are non-profit organizations that monitor watershed health and coordinate projects within their corresponding creek, wetland, or entire watershed. The nature centers could assess system health on a local level and compile that into a monitoring network. Where larger agencies would not be able to efficiently cover each watershed, a nature center network, with the right funding, could collect comprehensive data assessing the status of their ecological regions and compile it into a health report on the entire CHU.

The process will be ineffective, though, unless it has some "teeth". In other words, these nature centers must have solid data to educate all stakeholders on the status of their ecological regions with the purpose of taking transgressors to court for violating environmental standards. However, for this process to be set in motion, the centers would require a grant. Here is where this study and other studies like it come into play. There has been enough research done to make it clear that the CHU's natural resources continue to be depleted, and that current regulations and mitigation practices are ineffective. With these findings as backing, the centers could receive a grant to obtain a comprehensive assessment of the CHU's health. A team could be assembled in order to obtain the technically- and time-intensive "hard data" assessments and systemic indicators of qualitative health of sites in the CHU. This information would serve two purposes. First, it would inform all stakeholders of current conditions, facilitate adaptive management strategies, and encourage responsiveness from all parties involved. Second, there would be sufficient evidence to file lawsuits against parties that do not comply with environmental health standards. Both outcomes would ultimately create accountability within the system, encouraging an iterative, evolutionary process.

However, a central management component must be established for this to be efficient. The Carlsbad Watershed Network (CWN) can fulfill this role. The CWN is a collaborative group of city representatives and conservationists, but it does not represent the complete spectrum of stakeholders within the CHU. Additional parties need to include community members, developers, Amy Corp of Engineer, EPA, National Marine Fisheries, and Department of Fish And Game officials. In some form, each input in the system needs to be represented in the CWN's collaborative management. Responsive and collaborative actions and real face-to-face accountability would then be possible.

This may not may not be the best alternative, but it is a proposal that addresses the problems of the CHU at their most causal level. A cybernetic regulatory approach will address the root-cause problems and facilitate navigation through the complexity present in the CHU. The solution to the CHU's environmental health problems must be able to cope with a complex system and offer an evolutionary approach to an evolving system.

Limitations Of This Study

There are several limitations to this study. The first limitation is the collection of mitigation records. The data obtained from the 401 records and individual EIRs only represented a portion of the CHU's total mitigation. Each watershed was represented, though, which supports the assumption that the data collected was a reasonably accurate reflection of the entire CHU. As a result, there appeared to be no sampling bias. Secondly, the number of visited sites was small relative to the total number of records. In this case, sampling bias may play a major role in the results. Only sites that had viable location data could be visited. There may be a bias towards a particular watershed due to better monitoring or record-keeping practices. Overall better record-keeping practices are essential to ensuring an unbiased and comprehensive study of the CHU.

The most significant limitation in this study involves the evaluation procedure using the bioassessment worksheet. Limitations in resources such as technical expertise, man power, time allotted for study, and sampling tools dictated the nature of the qualitative evaluation process. The extent of the mitigation site was not possible to accurately measure, as some of the sites were reported to be several acres in size. As a result, the bioassessment process contained intrinsic levels of subjectivity. However, what could be viewed as this study's weakness could also be its greatest strength. The bioassessment worksheet was designed to be a qualitative evaluation specifically because of the overwhelming size of most of the sites. It can also be performed by an individual, although it was found to be most effective in a group setting. With a group of evaluators, collective experience created an insightful evaluation. The resulting dialogue revealed underlying internal and external ecological relationships of the site. Therefore, the quality of the mitigation was evaluated, which was an alternate approach to assessing the effectiveness of the "No Net Loss" policy.

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Ecological Performance Standards for Wetland Mitigation

An Approach Based on Ecological Integrity Assessments

A Report to the Environmental Protection Agency

NatureServe
A Network Connecting Science With Conservation

NatureServe is a non-profit organization dedicated to providing the scientific basis for effective conservation.

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Cover photo: Freshwater marsh, Little Pecan Island, LA. © Hal Malde

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Developing ecological performance standards for mitigation requires a variety of tools and expertise. The team of ecologists that helped developed this assessment were part of NatureServe's Ecological Integrity Assessment Working Group. Members consisted of NatureServe and Network member program staff, including Don Faber-Langendoen and Pat Comer (co-chairs), and Elizabeth Byers, John Christy, Greg Kudray, Gwen Kittel, Shannon Menard, Esteban Muldavin, Milo Pyne, Carl Nordman Joe Rocchio, Mike Schafale, Lesley Sneddon, and Linda Vance. We thank Andy Cutko, Tom Foti, Stephanie Neid, and Steve Rust, and David Braun and Dan Salzer of The Nature Conservancy for their input and participation in earlier meetings of the working group during 2004-2006, and Rob Riordan and Marta VanderStarre for their efforts and creative talent in the editing, design and production of this publication. We thank Jennifer Nichols for her assistance with the conceptual model figure.

Members are located in various programs around the country, including state Natural Heritage Programs found in Arkansas, Colorado, Maine, Montana, New Mexico, North Carolina, Oregon and West Virginia. Our various locations allowed us to draw on the expertise of our own and others' experiences in local or state assessment projects, as well as build on the collective history of our standard Heritage methodology for assessing ecological integrity.

As is evident from the results in this report, we have greatly benefited from the Rapid Assessment Methods (RAM) developed by the Ohio EPA, led by John Mack (ORAM), and the California Rapid Assessment Method (CRAM), led by Josh Collins, Marta Sutula and others. Although we differ in various ways from those methods in how we approach the primary goal of RAMs — we separate out ecological integrity or condition from ecological services or functions — we nonetheless have benefited greatly from their publications, phone conversations and workshop discussions.

We are grateful for financial assistance from the Environmental Protection Agency. We especially thank Rich Sumner and Palmer Hough for their encouragement of this follow-up project, which builds on an earlier set of Ecological Integrity Assessment protocols developed by NatureServe for EPA mitigation work (Faber-Langendoen et al. 2006).

The analysis and conclusions documented in this publication are those of NatureServe and may not necessarily reflect the views of the Environmental Protection Agency.

Contents

Appendices are provided in a separate document.

Executive Summary

Wetland mitigation and restoration practitioners, as well as scientists and policy makers, have been calling for stronger ecological performance standards to guide the wetland mitigation process. Here we present two methods for setting those standards: a) a watershed approach and b) ecological performance standards based on ecological integrity assessment methods.

A watershed approach can assist the process of wetland mitigation. The following criteria can be used to create an informal watershed approach.

1. Landscape integrity index – integrate cumulative impacts of past development activities, focusing on ecosystems.
2. Fish faunal intactness index – address cumulative impacts of past development on aquatic species.
3. Locations of critically imperiled (G1) and imperiled (G2) species and rare or high-quality ecosystem types – address presence and need of sensitive species and rare wetland types.
4. Ecosystem maps of the watershed. These are similar to wetland profiles, but integrate both biotic and abiotic aspects of wetlands. These maps will also help identify wetland types throughout the watershed, in order to avoid, where possible, permitting impacts to wetlands that are difficult or impossible to restore, such as fens or bogs, or may have a long time to recovery, such as forested wetlands. We recommend using the U.S. National Vegetation Classification (NVC) formation and NatureServe Ecological Systems levels for mapping, combined with maps of Hydrogeomorphic (HGM) classes.
5. Information on high priority conservation sites identified by a variety of conservation and wildlife agencies, and state and federal agencies.

Our ecological integrity assessment method for establishing performance standards for mitigation builds on the variety of existing wetland rapid assessment methods. It emphasizes metrics that are condition-based, separate from those that are stressor-based. The assessment uses the following steps.

1. Develop a conceptual model with key ecological attributes and identify indicators for wetland types, at multiple classification scales (NVC formation, NatureServe ecological system, coupled with HGM and Cowardin classifications).
2. Use a three-level approach to identify a suite of metrics, including Level 1 (remote sensing), Level 2 (rapid field-based), and Level 3 (intensive field-based) metrics.
3. Identify ratings and thresholds for each metric based on "normal' or "natural range of variation" benchmarks for each formation.
4. Provide a scorecard matrix by which the metrics are rated and integrated into an overall assessment of the ecological integrity of the ecosystem.
5. Provide tools for adapting the metrics over time as new information and methods are developed.

We provide an overview of the metrics and their ratings for the various assessment levels, as well as detailed protocols and scorecards for metrics at Level 1 and Level 2. Level 3 metrics are incomplete at this time, but we provide several examples.

The objective in setting performance standards and in conducting subsequent monitoring is to collect sufficient data to answer the hypothesis: has the mitigation wetland met the performance goal within the monitoring period? The performance standards developed above include a broad range of structural and functional measures, including hydrology, vegetation and soils, and rely on reference wetlands as a model for the dynamics of created or restored sites. We use several examples to show how ecological integrity assessments can be used to set ecological performance standards for mitigated sites, so that a more definitive answer can be given regarding the ecological success of mitigation efforts.

Our methods point towards the kinds of ecological applications that are needed for mitigation. Future studies are needed to advance these methods and test them on a variety of wetland mitigation sites.

Setting Ecological Performance Standards for Wetland Mitigation

Wetlands are a diverse set of ecological communities that occur at the transition between terrestrial and aquatic systems. They are a key habitat for many species that depend on their ecological structure, composition and function. They provide ecosystems services, such as flood control and improvement or maintenance of water quality. Their values to humans are both monetary (tourism opportunities) and non-monetary (recreational enjoyment, biodiversity appreciation).

Yet, globally, freshwater species and habitats are among the most threatened in the world (Saunders et al. 2002). Freshwater withdrawals have doubled since 1960 and more than half of all freshwater runoff is used by humans (Saunders et al. 2002). In the United States, wetland loss has been substantial over the past 200 years, though rates of loss continue to decline in the last few decades and may even have been reversed, based on the latest 1998-2004 survey (Dahl 2006). Prior to European colonization, wetlands comprised approximately 9% of the continental United States (Dahl 1990), but presently nearly 50% of the wetland area has been converted (NRC 1995). There are an estimated 107.7 million acres (43.6 million ha) of wetlands in the conterminous U.S. in 2004 or about 5.5% of the surface area of the conterminous U.S. (Dahl 2006).

Concern about the loss of wetlands in the United States has led to federal policies and regulations that protect wetlands on both public and private land. A primary vehicle for wetland protection and regulation is the Clean Water Act (Section 404). A principle objective of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency define the "waters of the United States" to include many wetlands because of their role in maintaining the water quality of those waters (NRC 2001).[1] Section 404 of the Clean Water Act requires that anyone dredging or filling in "waters of the United States" must request a permit from the U.S. Army Corps of Engineers.

In screening any project to determine the terms for a permit, three approaches are evaluated in sequence: 1) avoidance (avoid impacts to wetlands where practical), 2) minimization (minimize potential impacts to wetlands), and 3) mitigation (provide compensation for any remaining, unavoidable impacts through the restoration or creation of wetlands (Mitsch and Gosselink 2007). Compensatory mitigation, then, refers to the "restoration, creation, enhancement, and in exception cases, preservation of other wetlands, as compensation for impacts to natural wetlands" (NRC 2001). Thus, compensatory mitigation involves a process in which the ecological integrity, function, and/or services created/restored/enhanced from a mitigation wetlands is compared to the ecological integrity, function and/or services lost from an impacted wetland.

There is considerable controversy on the relative success of wetland mitigation (NRC 2001, Mitsch and Gosselink 2007). A key concern is that mitigation guidelines have not adequately addressed both "legal success" – that some type of wetland function and area has been replaced, and "ecological success" – that wetland of the same type occurs in the same setting or contains an acceptable level of function compared to wetlands in the region, often referred to as "reference wetlands" (Mitsch and Gosselink 2007) (see also "Reference Condition" on page 23). A study by the National Research Council (NRC) was asked to evaluate how well and under what conditions compensatory mitigation required under Section 404 is contributing toward satisfying the overall objective of restoring and maintaining the quality of the nation's waters. That report (NRC 2001) produced several key findings:

[1] With recent Court ruling, many isolated wetlands are no longer expected to be regulated under the Clean Water Act and many drier riparian wetlands (especially in the West) do not meet Section 404 definition of "waters of the U.S."

1. The goal of no net loss of wetlands is not being met for wetland functions by the mitigation program, despite progress in the last 20 years.
2. A watershed approach would improve permit decision making.
3. Performance expectations in Section 404 permits have often been unclear, and compliance has often neither been assured nor attained.
4. Support for regulatory decision making is inadequate.
5. Third-party compensation approaches (mitigation banks, in-lieu fee programs) offer some advantages over permittee-responsible mitigation.

In response to these and other critiques of the effectiveness of wetlands compensatory mitigation for authorized losses of wetlands under Section 404 of the Clean Water Act, the Environmental Protection Agency and the Corps of Engineers began working with partner agencies and organizations to identify ways to improve wetland mitigation. A variety of projects and legislative revisions are now underway to improve the performance standards for mitigation. Here we focus on two key aspects of those revisions, relating to #2 (a watershed approach) and #3 (setting performance expectations).

Watershed Approach

Wetland condition or integrity (composition, structure and function) depends on the landscape and watershed within which they are found. There is an increasing desire to include landscape setting and context when planning mitigation projects, in order to improve success in mitigating for both hydrologic functions and wildlife needs that depend on connectivity to adjacent habitats. In addition, mitigation wetlands are more likely to achieve a comparable form and similar function to the original wetlands if they are restored within the same watershed. At the same time, the watershed approach can assist in determining whether an on-site mitigation project is more likely to succeed than an off-site project that is still within the same watershed.

There is also concern that some wetland types, such as bogs and fens, are difficult to restore, and others, such as forested wetlands, may require a long period of evaluation before it is possible to determine mitigation success (NRC 2001). Where possible, these types should be identified within the watershed and impacts should be avoided. A watershed assessment can highlight those wetlands that are more problematic for mitigation success. These and other aspects of a watershed approach need to be developed, including a wetland profile of watersheds based on (1) extent/distribution of HGM types, (2) landscape integrity, and (3) extent, distribution and condition of wetland types (Bedford 1996, Johnson 2005).

Ecological Performance Standards

There has been a strong interest in developing performance expectations for mitigation using an ecological indicator-based approach, coupled with guidance on site design and other mitigation tools. Such an approach is being widely promoted among a number of agencies, conservation organizations and research scientists who focus on the critical role of indicators for assessing ecological integrity of communities and ecosystems, within the context of a thoughtful mitigation or monitoring program (Harwell et al. 1999, Young and Sanzone 2002, U.S. EPA 2002, Parrish et al. 2003, Faber-Langendoen et al. 2006).

Assessing the current "ecological integrity" of an ecosystem requires developing measures of the structure, composition and function of an ecosystem as compared to reference or benchmark ecosystems operating within the bounds of natural or historic disturbance regimes (Lindenmayer and Franklin 2002, Young and Sanzone 2002). The pre- and post-ecological condition of impacted sites can then be compared to these reference sites to determine net loss of ecological integrity. Mitigated sites can then be compared to these reference sites to assess their "success" in replacing the loss of ecological integrity from the impacted sites. However, selection and development

The NatureServe Network

NatureServe is a non-profit conservation organization whose mission is to provide the scientific basis for effective conservation action. NatureServe represents an international network of biological inventories—known as natural heritage programs or conservation data centers—operating in all 50 U.S. states, Canada, Latin America and the Caribbean. The NatureServe network is the leading source for information about rare and endangered species and threatened ecosystems. Together with these network member programs, we not only collect and manage detailed local information on plants, animals, and ecosystems, but also develop information products, data management tools, and conservation services to help meet local, national and global conservation needs.

of indicators to measure ecological integrity can be challenging, given the diversity of organisms and systems, the large number of ecological attributes that could be measured, and concerns over cost-effectiveness and statistical rigor.

Purpose of this Report

The overall purpose of this report is to develop two key methods needed for wetland mitigation: a) a watershed approach and b) ecological performance standards based on ecological integrity assessment methods.

With respect to a watershed approach, NatureServe has worked closely with federal and state partners to classify and map large portions of the U.S. landscape, using Ecological Systems and the revised upper levels of the U.S. National Vegetation Classification (NVC; Comer et al 2003, Comer and Schulz 2007, FGDC 2008, Faber-Langendoen et al. 2008). These classifications and maps can work in concert with existing methodology on at-risk (rare and endangered) species and ecosystems, as well as exemplary occurrences of all ecosystems, to help characterize wetlands. We use these and other landscape characterization methods to develop an informal approach to assessing watersheds to assist with mitigation planning.

With respect to ecological performance standards, NatureServe has been developing a standardized method for evaluating on-site condition of wetlands in the United States using criteria and indicators for ecological integrity (Faber-Langendoen et al. 2006, 2008). Indicators are rated based on "natural" reference benchmark standards, allowing users to determine current wetland status and performance standards to maintain or improve the quality of the wetland. In a previous EPA-funded pilot, we developed criteria, indicators and specific metrics for 18 wetland Ecological System types (Comer et al. 2003) in different regions of the U.S. (Faber-Langendoen et al. 2006). However, our report identified several new directions. First, we found that metrics were similar among related wetland types (fens, marshes, swamps), suggesting that we should consider a more general framework before focusing on specific wetland types. Second, working at the level of detailed wetland types (there are over 200 wetland Ecological System types), while appropriate for some applications, is not always needed for other applications. Third, metrics chosen for the pilots varied from remote sensing based to intensive plot-based within the same assessment, making implementation and interpretation more difficult.

Here, we outline a variety of new methods to structure our selection of indicators for all U.S. wetland systems, including a) use of an improved hierarchical framework for wetland classification, b) a three-level approach to the development of metrics (remote, rapid, intensive), c) ecologically comprehensive rapid (level 2), field-based metrics and ratings for all broad, wetland types, with suggested metrics for level 1 and level 3 and d) a report card structure for aggregating metrics by major ecological attributes (landscape context, size, vegetation, hydrology and soils). We build on the variety of existing rapid wetland assessment and monitoring materials, particularly those in the California Rapid Assessment Manual (CRAM, Collins et al. 2006, 2007), the Ohio Rapid Assessment Manual (Mack 2001), and prior work by NatureServe (Faber-Langendoen et al. 2006). We demonstrate how these methods can be used to help set ecological performance standards for wetland mitigation.

Methods for a Watershed Approach

A watershed approach that can assist the process of wetland mitigation should include the following considerations (adapted from NRC 2001).

1. Consider the hydrogeomorphic and ecological landscape and climate.
2. Identify wetland types throughout the watershed, in order to avoid, where possible, permitting impacts to wetlands that are difficult or impossible to restore, such as fens or bogs, or may have a long time to recovery, such as forested wetlands.
3. Restore or develop natural variability in hydrologic, biologic, and to soil and other physicochemical conditions.
4. Whenever possible, choose wetland restoration over creation.
5. Carefully consider site placement in the context of landscape setting, to ensure that impacts from the surrounding landscape will not compromise the success of the mitigated wetland.
6. Conduct early monitoring for both the site and its landscape setting.

Although an ideal watershed approach would be based on a formal watershed plan, developed by Federal, state, and/or local environmental managers in consultation with affected stakeholders, such plans often do not exist.[2] However, an informal approach may suffice if it is based on “a structured consideration of watershed needs and how wetland types in specific locations can fulfill those needs.” Such information could include current trends in habitat loss or conversion, cumulative impacts of past development activities, current development trends, presence and needs of sensitive species or rare wetland types, site conditions that favor or hinder the success of mitigation projects, such as chronic environmental problems from flooding or poor water quality, local watershed goals and priorities.

We suggest the following methods can be used to create an informal watershed approach.

1. Landscape integrity index – integrate cumulative impacts of past development activities, focusing on ecosystems.
2. Fish faunal intactness index – address cumulative impacts of past development on aquatic species.
3. Locations of critically imperiled (G1) and imperiled (G2) species and rare or high-quality ecosystem types – address presence and need of sensitive species and rare wetland types.
4. Ecosystem maps of the watershed at the NVC formation and NatureServe Ecological Systems levels, combined with maps of Hydrogeomorphic classes of the watershed (akin to wetland profiles, but integrating both biotic and abiotic aspects of wetlands) that:
    - address site placement in the context of landscape setting;
    - address hydrologic functions;
    - identify wetlands that are difficult to restore or have a long time to recovery, and
    - identify exemplary occurrences of all ecosystem types.
5. Information on high-priority conservation sites identified by a variety of partners.

Additional methods could be developed to address trends in habitat loss, conversion and development. Each of these methods is briefly described in the following paragraphs.

[2] *Compensatory Mitigation for Losses of Aquatic Resources, Proposed Rule*. Federal Register, Vol. 71, No. 59. 15520-15556, Tuesday, March 28, 2006.

Landscape Integrity of the Watershed

NatureServe has developed a prototype Landscape Integrity Model (LIM) (Tuffly and Comer 2005, Rocchio 2007), which is a regional Geographic Information System (GIS) model of landscape condition, originally established as a 30m grid of unique values, then segmented into four classes from "highly degraded" to "minimally degraded" (Figure 1). The prototype model is similar to the Landscape Development Index used by Mack (2006) and Tiner (2004), but relies on the use of existing geographical datasets of stressors, such as roads and land use, to characterize the landscape. The index is described in more detail in the "Landscape Integrity Model" section that follows (page 35). It provides a means of characterizing the range of variation in the ecological integrity across a watershed.

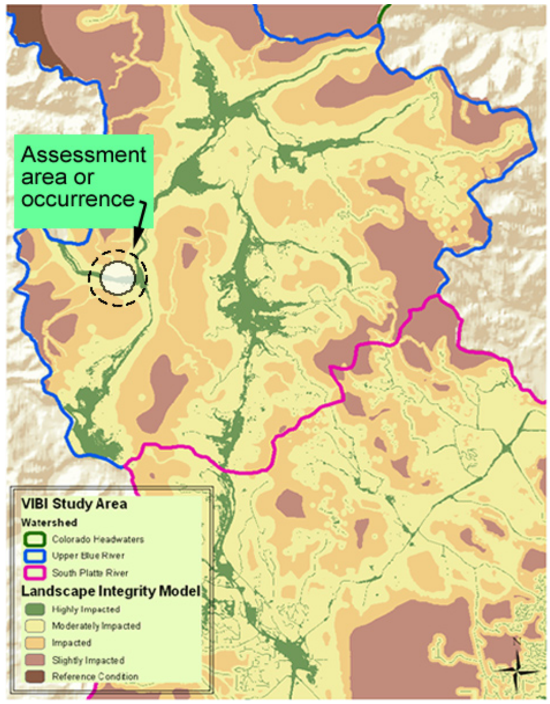

FIGURE 1
Watershed Evaluation Based on a Landscape Integrity Model.
Values for landscape context metrics and condition metrics for a wetland area at a site can be derived from the model (adapted from Rocchio 2007).

To use the landscape integrity model as part of wetland mitigation projects, sites or assessment areas chosen within the watershed or landscape can be overlaid on the model and evaluated with respect to landscape integrity. First the wetland occurrence or polygon is defined and its size measured (Fig. 1). A landscape context area can then be defined around the occurrence. The landscape integrity model provides the data for the "landscape integrity index" metric, based on the average score of the pixels within the landscape context (see "Landscape Integrity Model" on page 35). The same model can be used to assess the condition within the occurrence, particularly if the wetland is large (Fig. 1). Together, these metrics provide a simple means of characterizing the integrity of the occurrence and its setting.

Fish Faunal Intactness

Watershed intactness is a critical aspect of the biological balance of the nation's ecological systems (NRC 2001). It is of particular importance in freshwater systems that are impacted by pollution, habitat alteration, fisheries management and invasive species. One approach to measuring watershed intactness is to focus on a few key indicators. Fish Faunal Intactness is one such approach that can describe the current biotic condition of the watershed (EPA Report on the Environment 2008, Chapter 6). This indicator tracks the intactness of the native freshwater fish fauna in each of the nation's major watersheds by comparing the current faunal composition of those watersheds with their historical composition. In this case, historical data are based on surveys conducted prior to 1970. The indicator specifically measures the reduction in native species diversity in each 6-digit USGS hydrologic cataloging unit (HUC) in the 48 contiguous states. Intactness is expressed as a percent based on the formula:

reduction in diversity = 1 – (# of current native species / # of historic native species).

This indicator makes use of empirical, rather than modeled, data sets and focuses on a well-known group of organisms with a fairly strong historical record. The fish distributional data underlying this indicator have been gathered by NatureServe, and are derived from a number of sources, including species occurrence data from state natural heritage programs, a broad array of relevant scientific literature (e.g., fish faunas), and expert review in nearly every state. Data were assembled during the period 1997-2003. Maps of HUCs (which are not necessarily directly equivalent to watersheds) showing fish fauna intactness are available across the lower 48 states (the underlying data were recorded across small 8-digit HUCs, but data were pooled and reported by larger 6-digit HUCs to reduce potential errors of omission in the smaller "watersheds").

Information from this indicator provides an important summary of the cumulative impacts that have occurred in a HUC or watershed. For those HUCs or watersheds where the indicator points to a unit or watershed in good condition, impacts to wetlands should be avoided. For HUCs or watersheds in poor condition, efforts to restore wetlands through mitigation could be encouraged.

Locations of At-risk Species and Ecosystems

Several layers of information could be developed to identify the locations of rare and endangered species and community types:

- Data on the locations of populations of species or locations of rare community types that are imperiled throughout their range (at risk of extinction). Examples of such data include NatureServe's list of species or communities ranked globally critically imperiled (G1) and imperiled (G2) or species with status under the U.S. Endangered Species Act.
- Data on the locations of species populations or communities that are imperiled within the state (at risk of extirpation from that state). Examples of such data include NatureServe's list of species or communities that are ranked state critically imperiled (S1) or imperiled (S2) or with any legal protected status within the state.

This information can be used to prioritize potential mitigation sites based on the locations of wetlands in need of restoration and that support rare species (thus restoration presumably benefits these species). In addition, this same information may help in the permitting process by giving wetlands that support rare elements a higher level of scrutiny prior to any permit being released.

Ecosystem Maps and Exemplary Sites

Maps of wetland types at the NVC formation and NatureServe Ecological Systems levels, combined with Hydrogeomorphic wetland class maps of the watershed provide a ready tool for addressing watershed approaches (Figure 2, following page). These maps will allow mitigation planners to address site placement in the context of landscape setting of mitigated and reference wetlands, to assess their hydrologic functions, and to identify wetlands that differ in how they should be handled in the process of mitigation review. For example, impacts to wetlands that are difficult to restore, such as bogs and fens, should be avoided. Wetlands with a long recovery or restoration period, such as many forested wetlands, should require a longer monitoring period.

These maps can be integrated with known community and ecosystem occurrences from Natural Heritage databases that document the exemplary locations of important ecosystems in the watershed. For over twenty-five years, NatureServe and the Natural Heritage Network have been documenting the viability and integrity of individual occurrences of ecosystems[3] (Stein et al. 2000, NatureServe 2002, Brown et al. 2004). Working from the concept of ecological integrity, NatureServe assigns levels of integrity and conservation value using a report-card style approach (Harwell et

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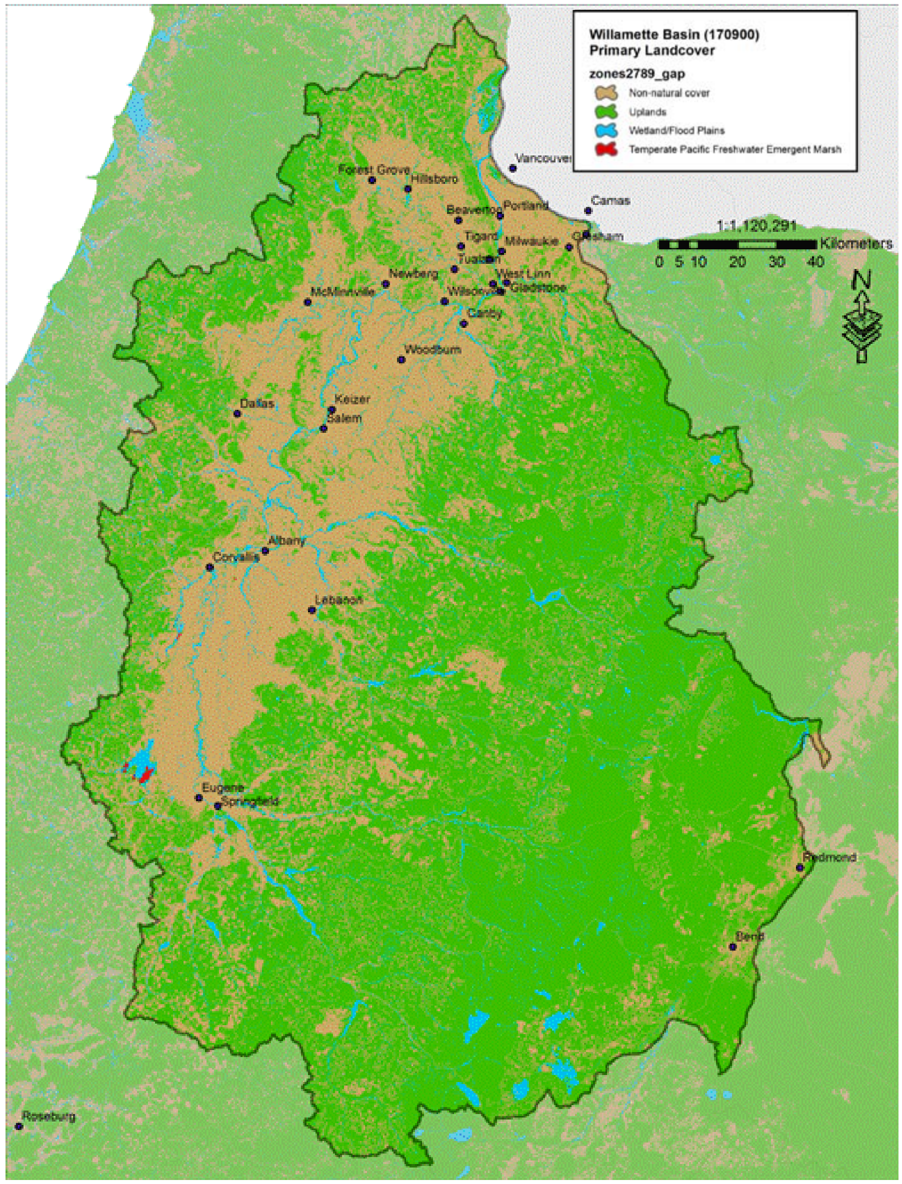
[3] The Natural Heritage methodology was originally developed by The Nature Conservancy (TNC), but Heritage methods staff transferred to NatureServe when it was formed in 2000. Since then, NatureServe has worked with the Network of Natural Heritage Programs to maintain and improve the methodology, while continuing to collaborate with TNC.

FIGURE 2A
Ecosystem Characterization of the Willamette Basin Watershed (6 digit HUC). The source for this portion is National GAP Program data using ETM (3-season multi-temporal) imagery with the classification based on using a mix of CART (non-forest) and GNN (forest) (J. Kagan pers. com. 2008).



al. 1999). Occurrences with higher levels of integrity and conservation value would generally be ranked A, B, or C (from "excellent" to at least "fair"), and those with significant degradation would be ranked D ("poor"). The "grades" are referred to in NatureServe databases as an "Element Occurrence Rank" (EO Rank), which is akin to an "Ecological Integrity Rank." This rank is defined as "a succinct assessment of the degree to which, under current conditions, an occurrence of an ecosystem matches reference conditions for structure, composition, and function, operating within the bounds of natural or historic disturbance regimes, and is of exemplary size" (Faber-Langendoen et al. 2008). This definition contains the core concept of ecological integrity but includes reference to size, given its importance in assessing conservation value.

The overall rank is assigned by first rolling up the major attributes of vegetation, hydrology and soils into a Condition rank, then combining Condition, Size and Landscape Context into an overall rank. Element occurrences and their ranks are assigned by Natural Heritage Programs throughout the country, and are a good source for identification of exemplary wetland occurrences within watersheds (Brown et al. 2004). When combined with ecosystem maps, these ranked occurrences can provide a comprehensive spatial view of the overall condition of ecosystems across the watershed (Fig. 2).

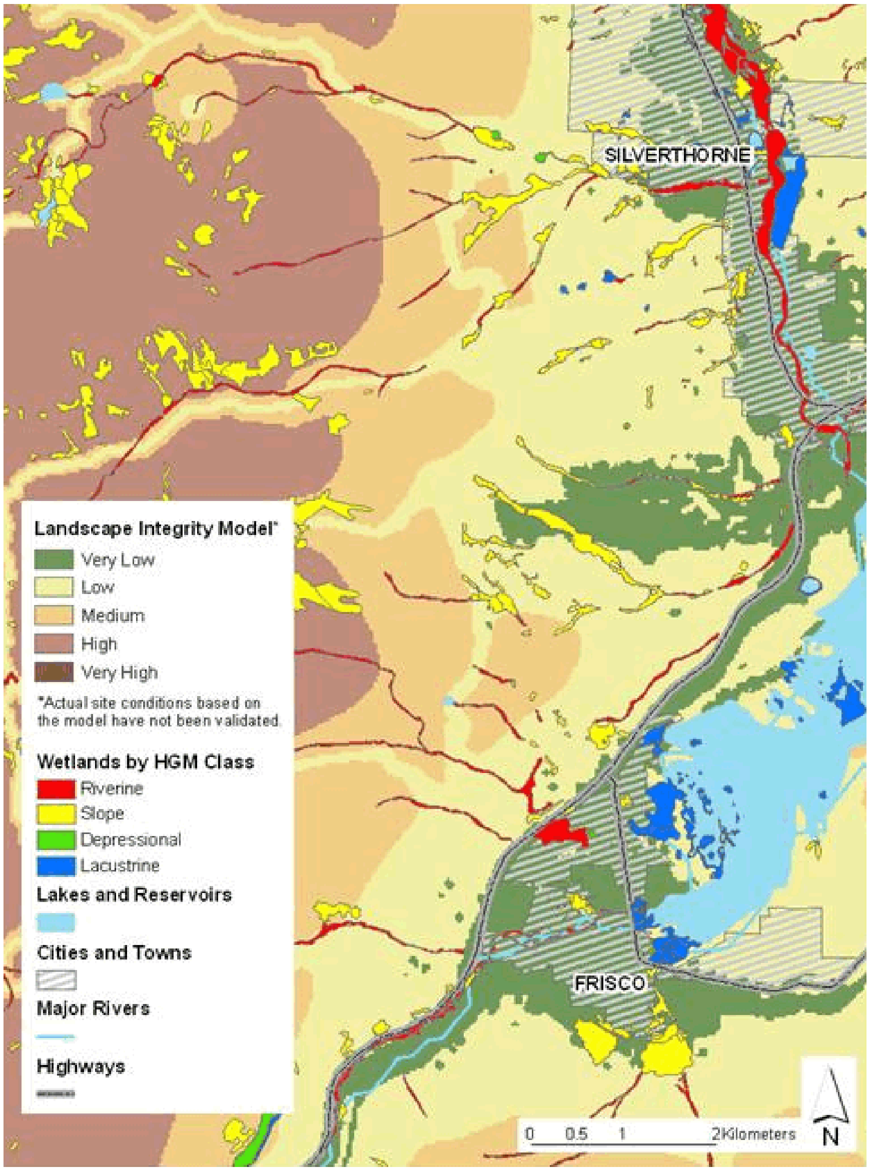


FIGURE 2B
A map of Summit County showing wetland polygons labeled by hydrogeomorphic wetland class superimposed on a map of landscape integrity. The landscape integrity values are based on the Landscape Integrity Model from Rocchio (2007). Data sources for HGM layer include Johnson (2005), based on work by SAIC (2000). Map created by Joanna Lemly, Colorado Natural Heritage Program.

High-Priority Conservation Sites and Focal Areas

There are a variety of agencies and organizations that identify sites of high conservation value or have high priority for wildlife, birds and other organisms. Among these are The Nature Conservancy's (TNC's) portfolio of conservation sites, and State Wildlife Action Plans that list high-priority focal areas. But it has been difficult to access this information.

LandScope America (www.landscope.org), NatureServe's joint website with the National Geographic Society, will publish a full, aggregated set of conservation sites across the U.S. for the first time later this year. The conservation priorities theme of LandScope America will include maps and data on local, state and national conservation priorities (such as public agency plans, TNC ecoregional plans, State Wildlife Action Plans, regional greenprints, and so on). By displaying multiple sets of priorities in a single view, LandScope will show how these various approaches relate to each other and where they overlap. The information can be used to characterize high-priority sites across a watershed.

Information on high-priority conservation sites and focal areas will help mitigation projects avoid impacting existing wetland within these areas, as well as encourage restoration efforts in sites proximal to these areas. Partners can be identified that may be interested in working with the mitigation process because of the opportunity to increase wetland values.

Summarizing the Watershed Approach for Mitigation

The five components of our suggested watershed approach — landscape integrity index, fish faunal intactness index, locations of at-risk species and ecosystem types, ecosystem maps of the watershed, and information on high priority conservation sites — address many of the key needs of a watershed approach for mitigation (NRC 2001). The watershed approach considers the hydrogeomorphic and ecological landscape of the sites. It identifies wetland types throughout the watershed in order to avoid, where possible, permitting impacts to wetlands that are difficult or impossible to restore, such as fens or bogs, or may have a long time to recovery, such as forested wetlands. It identifies watersheds where restoration may be a priority, and where optimal areas of wetlands may be for restoration. It provides guidance on site placement in the context of landscape setting, including where those settings are seriously degraded or disturbed. Finally, it provides some simple landscape-based tools for monitoring the site and the landscape setting (Figures 1 and 2).

There is growing interest in using a watershed approach to guide wetland mitigation and restoration. For example, the Colorado Wetlands Program is a voluntary, incentive-based program to protect wetlands and wetland-dependent wildlife on public and private land. Statewide strategies are being considered to better guide and coordinate these efforts. A Rio Grande project within the state proposes a scientific foundation upon which statewide strategic goals can be built and set priorities to more effectively protect, sustain or restore the ecological health of Colorado's wetland ecosystems by creating a wetland profile that describes the types, abundance and ecological condition of wetlands in Colorado (Rocchio pers. comm. 2008). This profile will then be used to formulate statewide strategies for setting wetland protection, mitigation and restoration priorities (see also Johnson 2005). These watershed datasets can also be used to model the suitability of potential watershed sites for mitigation purposes (Van Lonkhuyzen et al. 2004).

Ecological Performance Standards and Ecological Integrity

There is a growing consensus on the performance requirements needed for mitigated wetlands (NRC 2001, ELI 2004). Our suggested performance standards build on the following recommendations (adapted from NRC 2001):

1. Mitigation goals are set in the context of a watershed approach.
2. Impacted sites are evaluated using the same ecological and functional assessment tools as used at the mitigated site (i.e., it should be possible to determine how similar the mitigated site is to the impacted site). This requires identification of the wetland type and its hydrogeomorphic position at both sites.
3. Mitigation projects evaluate the full range of ecological integrity and natural functions.
4. Mitigation goals are clearly stated so that the desired range of ecological integrity and function are specified. Structure, composition and function are all relevant to the goals.
5. Assessing wetland ecological integrity and function requires a science-based, rapid assessment procedure.

We rely on three major tools to address these recommendations. First, the overall watershed approach noted in #1 above has been addressed earlier (see "Methods for a Watershed Approach" above). Second, we use standardized classifications of ecosystem types, including descriptions of diagnostic or distinguishing characteristics. These classifications provide important guidance on recommendations #2–#4 above by ensuring that mitigated sites are as equivalent to impacted sites both in terms of the type of wetland being mitigated and its condition. We emphasize the formation and formation subclass levels of the NVC, the Ecological Systems of NatureServe and the HGM classes (Brinson 1993, Smith et al. 1995). Classifications also provide a ready means of understanding what the expected range of integrity and functions might be. For example, when a site has been identified as having a bald cypress-tupelo forest type within a riverine context, it provides important guidance on what the range of integrity and functional values are, and what the desired range might be for mitigation.

Third, we assess wetland composition, structure and function using an ecological integrity assessment approach based on reference conditions and natural and historic ranges of variation. Measures of ecological integrity provide the needed tools to address wetland functions identified in #5 above, coupled with recommendations #2–#4. Identifying criteria (metrics) that describe the major ecological attributes will ensure that the basic components of wetland pattern and process are covered (Figure 3).

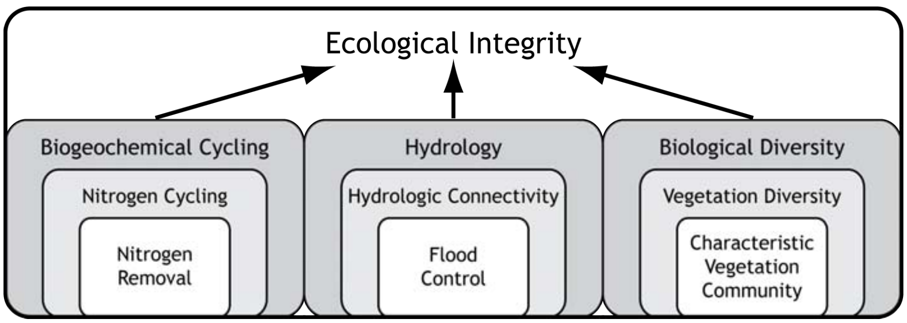


FIGURE 3
A schematic illustration of ecological integrity as the integrating function of wetlands, encompassing both ecosystem structure and processes. Integrity includes processes such as hydrology and hydrologic connectivity that address functions such as flood control (from Fennessey et al. 2007; based on Smith et al. 1995).

Wetland Classification and Performance Standards

The success of developing indicators of wetland ecological integrity depends on an understanding of the structure, composition and processes that govern the wide variety of wetland systems. Ecological classifications can be helpful tools in categorizing this variety. These classifications help wetland managers to better cope with natural variability within and among types so that differences between occurrences with good integrity and poor integrity can be more clearly recognized. Classifications are also important in establishing "ecological equivalency;" for example, an impacted salt marsh should be replaced with a mitigated salt marsh with equivalent or better integrity.

There are a variety of classifications for structuring ecological integrity assessments and for establishing ecological equivalency. The HGM classification developed by Brinson (1993) was developed in order to assist the Corps of Engineers with the evaluation of wetland impacts. HGM identifies groups of wetlands that function similarly, based on three fundamental factors that influence how wetlands function, including geomorphic setting, water source and hydrodynamics (Smith et al. 1995). Typically, function is assessed through compositional and structural surrogates. Nationally, there are seven broad wetland classes, with regional variants. No detailed set of wetland types are nationally available. The HGM classification meets several important needs for mitigation:

- It specifically addresses wetland function, using a surrogate approach based on structure and composition.
- Manuals for its application are available across many regions of the country.

The wetland classification system of Cowardin et al. (1979) forms the basis for the National Wetlands Inventory (NWI) Classification and Mapping Program across the United States. This classification was designed to be used as an inventory tool for wetlands and deepwater habitats. The NWI system has been widely used for reporting on the status and trends of wetland acres across the U.S. (e.g. Dahl 2006). Table 2 (page 17) and Appendix IV show how the NWI classification can be structured to link to the U.S. National Vegetation Classification.

A third major classification is that of the U.S. National Vegetation Classification (FGDC 1997, 2008, Grossman et al. 1998, Jennings et al. 2008). It was developed to classify both wetlands and uplands, and identifies types based on vegetation composition and structure and associated ecological factors. Nationally, there are eight very broad classes, but seven other nested hierarchical levels permit resolution of types from broad-scale formations to fine-scale associations. At the formation level, there are thirteen wetland types, and at the association scale there are two-thousand wetland types recognized across the U.S. Each of the associations has been assessed for conservation status, so their relative rarity on the landscape is also known. Thus the NVC meets several important needs for mitigation:

- It can be used to characterize the entire watershed, both upland and wetland
- It uses broad categories that are helpful in assessing the relative difficulty of mitigating certain kinds of wetlands (e.g., floodplain and swamp forest, bog & fen, etc.).
- It provides information on the relative rarity of wetland types.
- It is very compatible with Cowardin classification, allowing for reporting of status and trends assessments for both wetland area and wetland integrity.
- It is a federal standard for all agencies, facilitating sharing of information on wetland types in other contexts (FGDC 19997, 2008).

An additional classification approach, the Ecological Systems classification (Comer et al. 2003), can be used in conjunction with the NVC. Ecological Systems provide a spatial-ecologic perspective on the relation of associations and alliances (fine-scale plant community types), integrating vegetation with natural dynamics, soils, hydrology, landscape setting and other ecological processes. They can also provide a mapping application of the NVC, much as soil associations help portray the spatial-ecologic relations among soil series in a soil taxonomic hierarchy. Systems types facilitate mapping at meso-scales (1:24,000–1:100,000). Increasingly, comprehensive systems maps are becoming available across the country. Currently there are about 600 ecological systems, of which about 250 are wetlands. Ecological Systems are somewhat comparable to the group level of the revised NVC hierarchy, and can be linked to higher levels of the NVC hierarchy, including formations. Thus Ecological Systems meet several important needs for mitigation:

- Ecological Systems integrate biotic and abiotic variables that take advantage of the hydrologic perspective of HGM and the vegetation emphasis of the NVC. They can be more effective at constraining both biotic and abiotic variability within one classification unit than either NVC or HGM, which should facilitate development of ecological indicators.
- Mid-scale valuable for mitigation equivalency.
- Comprehensive maps of all major wetland types, suitable for characterizing watersheds.
- Explicitly linked to the NVC.

Although use of a single classification would be desirable, each of the above classifications addresses important needs. The NWI (Cowardin) classification is the mapping standard for wetlands across the U.S. and is the source of information on trends in wetland acreages (Dahl 2006). The NVC formation types correspond to the Cowardin types that are commonly used to report wetland acreages, and provide a link to the federal NVC classification standard. The NVC and Ecological Systems provide a multi-scale set of wetland types, allowing users to systematically refine the classification scale, including to a level of association types, which are commonly used by state Natural Heritage programs to track wetland diversity and by NatureServe and state programs to assess wetlands conservation status. HGM provides an important means of addressing a critical aspect of wetland function, namely hydrology and landscape setting. Many wetland assessment tools have been developed around HGM classifications, and where individual sites are classified using other classifications, they should also be assigned to the HGM class, to determine how this might factor into assessments of its ecological performance. We provide guidance on the integration of these various classifications (see "Wetland Classification and Performance Standards" above).

Ecological Integrity Assessments

Our approach to establishing performance standards for mitigation builds on the NatureServe methodology for conducting ecological integrity assessments (Brown et al. 2004, Faber-Langendoen et al. 2008). We develop the assessments using the following steps.

1. Develop a conceptual model with key ecological attributes and identify indicators for wetland types, at multiple classification scales (NVC formation, NatureServe ecological system, coupled with HGM and Cowardin classifications).
2. Use a three-level approach to identify a suite of metrics, including remote sensing, rapid ground-based, and intensive ground-based metrics.
3. Identify ratings and thresholds for each metric based on "normal" or "natural range of variation" benchmarks for each formation.
4. Provide a scorecard matrix by which the metrics are rated and integrated into an overall assessment of the ecological integrity of the ecosystem.
5. Provide tools for adapting the metrics over time as new information and methods are developed.

Ecological Integrity Model and Identification of Metrics

Definition of Ecological Integrity

Building on the related concepts of biological integrity and ecological health, ecological integrity is a broad and useful endpoint for ecological assessment and reporting (Harwell et al. 1999). "Integrity" is the quality of being unimpaired, sound or complete. To have integrity, an ecosystem should be relatively unimpaired across a range of characteristics and spatial and temporal scales (De Leo and Levin 1997). Ecological integrity can be defined as "an assessment of the structure, composition, and function of an ecosystem as compared to reference ecosystems operating within the bounds of natural or historic disturbance regimes" (adapted from Lindenmayer and Franklin 2002, Young and Sanzone 2002, Parrish et al. 2003).

Our approach to assessing ecological integrity is similar to the Index of Biotic Integrity (IBI) approach for aquatic systems. The original IBI interpreted stream integrity from twelve metrics reflecting the health, reproduction, composition and abundance of fish species (Karr and Chu 1999). Each metric was rated by comparing measured values with values expected under relatively unimpaired (reference standard) conditions, and the ratings were aggregated into a total score. Building upon this foundation, others suggested interpreting the integrity of ecosystems by developing suites of indicators or metrics comprising key biological, physical and functional attributes of those ecosystems (Harwell et al. 1999, Andreasen et al. 2001, Parrish et al. 2003). Our index of ecological integrity brings together metrics of biotic and abiotic condition, size, and landscape context.

Conceptual Model

A conceptual ecological model delineating linkages between key ecosystem attributes and known stressors or agents of change is a useful tool for identifying and interpreting metrics with high ecological and management relevance (Noon 2003). We developed a simple conceptual model identifying a) major attributes of wetland ecosystems, such as vegetation, hydrology, and soils, landscape context, and size that help characterize overall structure, composition and process, as well as various aspects of wetland function, and b) important drivers and stressors acting upon wetland systems (Figure 4).

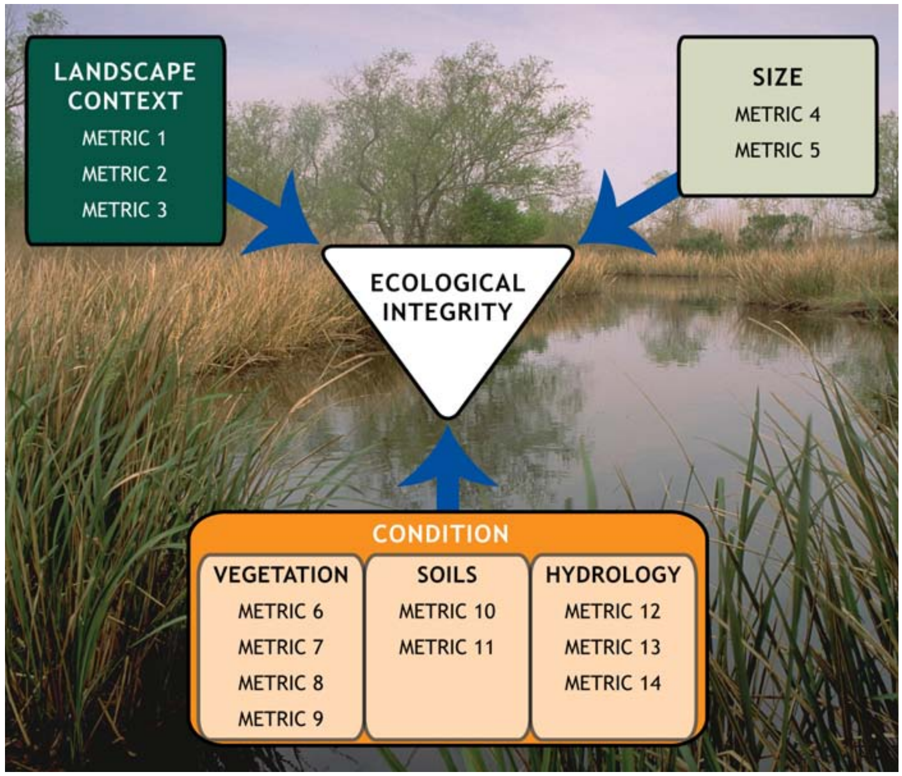


FIGURE 4
Conceptual Model for Wetland Ecosystems. The major attributes of ecosystem integrity are shown in the model. Ecosystem drivers, such as climate, geomorphology and natural disturbances maintain the overall integrity of the system, whereas stressors act to degrade it.

Using the model as a guide, we identify a core set of metrics that best distinguish a highly impacted, degraded or depauperate state from a relatively unimpaired, complete and functioning state. Metrics may be properties that typify a particular ecosystem or attributes that change predictably in response to anthropogenic stress. The suite of metrics selected should be comprehensive enough to incorporate composition, structure and function of an ecosystem across a range of spatial scales. Ideally, indicators of the magnitude of key stressors acting upon the system will be included to increase understanding of relationships between stressors and effects (Tierney et al. 2008).

In the last ten years, there has been a great deal of research to identify practical suites of metrics that address the different aspects of ecosystem structure, composition and function. To select our level 2 (rapid field) metrics, we build on a variety of existing remote and rapid assessments manuals, particularly that of the California Rapid Assessment Manual (CRAM, Collins et al. 2006, 2007), the Ohio Rapid Assessment Manual (Mack 2001), and NatureServe (Faber-Langendoen et al. 2006). We engaged ecologists from across our own Network of Natural Heritage Programs and from other agencies and organizations to review and test the metrics. Our current list of 14 condition metrics is summarized in Table 1.

TABLE 1

Example of an ecological integrity table, showing the rank factors, major ecological attributes, and indicators for wetland ecosystems, showing only condition metrics. The checklists provide additional information on stressors to the wetland site or occurrence. See Table 10 (page 37) for a complete list of condition and stressor metrics.

Rank Factor	Major Ecological Attribute	Indicator
Landscape Context	Landscape Structure	Landscape Connectivity
		Buffer Index
		Surrounding Land Use Index
	Landscape Stressors	Landscape Stressors Checklist
Size	Size	Patch Size Condition*
		Patch Size
Condition	Vegetation (Biota)	Vegetation Structure
		Organic Matter Accumulation
		Vegetation Composition
		Relative Total Cover of Native Plant Species
	Vegetation (Biota) Stressors	Vegetation (Biota) Stressors Checklist
	Hydrology	Water Source
		Hydroperiod
		Hydrologic Connectivity
	Hydrology Stressors	Hydrology Stressors Checklist
	Soils (Physicochemical)	Physical Patch Types
		Water Quality
		Soil Surface Condition
	Soils (Physicochemical) Stressors	Soils (Physicochemical) Stressors Checklist

* *optional metric*

Metrics can be thought of as the measurable expressions of an indicator (Table 1). For example, "Relative Total Cover of Native Plant Species" is an indicator of "community composition," a key ecological attribute, but a specific metric is needed to quantify this indicator (e.g., total cover of exotic species subtracted from total cover of all vegetation and divided by 100). Another example is "organic matter accumulation," which is an indicator of a key ecological attribute of "community structure." A specific metric used to quantify this indicator for forested wetlands may be "coarse woody debris: volume per hectare of fallen stems over 10 cm diameter."

The primary emphasis of the metrics is on measuring a relevant aspect of the ecosystem itself that responds to stressors. We refer to these as "condition metrics." We can also measure the stressors themselves, but information from these metrics provides only an indirect measure of the status of the system – we will need to infer that changes in the stressor correspond to changes in the condition of the system. We refer to these as "stressor metrics." We prefer to use condition metrics, but occasionally a stressor metric is measured when measuring condition may be challenging or not cost-effective (e.g., Surrounding Land Use Index indicator within Landscape Context).

Regardless of whether stressors are used as metrics, it is helpful to catalogue known stressors at a site to guide interpretation and possible correlations between ecological integrity and stressors. Table 1 refers to checklists of stressors for all major attributes to help interpret the integrity of the major attributes of an ecosystem occurrence. Checklists of stressors are included in the "Stressor Checklists" section (page 50).

The metrics are placed within an interpretive framework, based on our conceptual model, organizing the metric by major ecological attributes — broad attributes that have an important (driving) function in the viability or integrity of the element — and by rank factors (Table 1). The conceptual model is fairly general, but helps guide the selection of metrics, organized across a standard set of ecological attributes and factors (e.g., Harwell et al. 1999, Young and Sanzone 2002, Parrish et al. 2003).

Metrics and Wetland Types

The success of developing indicators of wetland ecological integrity depends on an understanding of the structure, composition and processes that govern the wide variety of wetland systems. Ecological classifications can be helpful tools in categorizing this variety. These classifications help set realistic performance standards for wetland mitigation by allowing assessments to better cope with natural variability within and among types, so that differences between occurrences with good integrity and poor integrity can be more clearly recognized, and realistic expectations can be set for whether and how bogs, fens, swamp forests and other types can be successfully mitigated.

The HGM classification developed by Brinson (1993) was developed in order to assist the Corps of Engineers with the evaluation of wetland impacts (see "Wetland Classification and Performance Standards" above). HGM identifies groups of wetlands that function similarly, based on three fundamental factors that influence how wetlands function, including geomorphic setting, water source and hydrodynamics (Smith et al. 1995). Typically, function is assessed through compositional and structural surrogates. There are limitations in using structural surrogates to address function (Hruby 2001), and the wetland classes identified through HGM do not always address the uniqueness of certain wetland types (e.g., bogs and fens, or swamp forests). Conversely, other important classifications of wetlands, such as the NVC and the NWI (Cowardin) classifications (see "Wetland Classification and Performance Standards" above) do not always distinguish between various hydrogeomorphic classes, at least not at higher levels. We recommend that the HGM and NVC classifications supplement each other when addressing wetland mitigation (Table 2).

	NVC Type	HGM Class						
Wetland Category	Formation	Riverine	Depressional	Slope	Flats – Minearl	Flats – Organic	Estuarine Fringe	Lacustrine Fringe
Swamp	Mangrove	X	X				X	
	Tropical Flooded & Swamp Forest	X	X			(X)		X
	Temperate Flooded & Swamp Forest	X	X	(X)	(X)			X
	Boreal Flooded & Swamp Forest	X	X					X
Bog & Fen	Tropical Bog & Fen		X	X		X		
	Temperate & Boreal Bog & Fen	(X)	X	X		X		
Marsh	Salt Marsh		X				X	
	Tropical Freshwater Marsh	X	X	(X)	X			X
	Temperate & Boreal Freshwater Marsh	X	X	X	X			X
	Tundra Wet Meadow	X	X	(X)	X			X
Aquatic	Marine and Estuarine Aquatic Vegetation						X	
	Freshwater Aquatic Vegetation	X	X		X	(X)		X

TABLE 2
Formation types of the U.S. National Vegetation Classification guide the specificity of metrics, including their relation to HGM class (Brinson 1993). The NWI types can be readily crosswalked to the NVC formation level.

Thus for the purposes of developing an ecological integrity assessment, we start our organization of metric by using the broadest levels of the NVC, the formation level. We then step down, as needed, to finer scales, based on HGM and Ecological System level differences that are important to setting performance standards (Table 2). For example, a metric developed for the hydrology of Temperate Flooded & Swamp Forest may have variants for riverine, depressional and other HGM classes, as needed. A complete set of NVC wetland types, from Formation to Macrogroup, with links to Ecological Systems, is provided in Appendix VII.

A more detailed comparison of wetland classifications is provided in Appendix IV.

A 3-Level Approach to Selection of Metrics

The selection of metrics to assess ecological integrity can be executed at three levels of intensity depending on the design of the data collection effort (Brooks et al. 2004, Tiner 2004, US EPA 2006). This "3-level approach" to assessments, summarized in Table 3 (following page), allows the flexibility to develop data for many sites that cannot readily be visited or intensively studied, permits more widespread assessment, while still allowing for detailed monitoring data at selected sites. In the context of mitigation projects, the three levels allow for comparison of impacted sites against mitigated sites in a cost-effective manner.

Level 1 Remote Assessments rely almost entirely on GIS and remote sensing data to obtain information about landscape integrity and the distribution and abundance of ecological types in the landscape or watershed (Mack 2006, US EPA 2006). Limited ground-truthing may be a component of some sites.

Level 2 Rapid Assessments use relatively rapid field-based metrics that are a combination of qualitative and narrative-based metrics with quantitative or semi-quantitative metrics. Field observations are required for many metrics, and observations will typically require professional expertise and judgment (Fennessey et al. 2007).

Level 3 Intensive Assessments require more rigorous, intensive field-based methods and metrics that provide higher-resolution information on the integrity of occurrences within a site. They often use quantitative, plot-based assessment procedures coupled with a sampling design to provide data for detailed metrics (Barbour et al. 1996, Blocksom et al. 2002). Calculations of indices for assessing Biotic Condition are often used, e.g., Floristic Quality Index, or Vegetation Index of Biotic Integrity ("VIBI") (DeKeyser et al. 2003, Mack 2004, Miller and Wardrop 2006, Miller et al. 2006). The focus of the general Level 3 assessment for biota is on the vegetation, since this is readily observable and measurable, and has been found to be a good indicator of overall condition, but Level 3 assessments typically can include metrics for soils, hydrology, water chemistry, and the surrounding landscape.

Ideally, information at the three levels of assessment provides relatively consistent information about ecological integrity, with improved interpretations as the level of intensity goes up. To achieve this, the various levels need to be calibrated against each other. For example, a rapid metric for assessing vegetation composition may use either an expert evaluation of a "Vegetation Composition" narrative metric, or perhaps a rapid version of a Floristic Quality Assessment Index based on walking through an occurrence and compiling a plant species list. The corresponding intensive metric may require a detailed listing of the plant species and their abundance based on plots and transects. Data gathered using both methods can be calibrated against each other (Mack 2004). Similarly an overall Level 3 index of vegetation or ecological integrity can be used to calibrate the Level 1 remote-sensing-based index of integrity (Mack 2006, Mita et al. 2007).

Although vegetation is the main biotic attribute measured for Level 3 assessments, other components of biodiversity can also be measured for specialized studies. The most common ones are birds, amphibians, insects and other macroinvertebrates. They are typically more time-consuming and costly to measure, but their response may differ enough from that of the vegetation that they provide additional valuable information on ecological integrity.

To ensure that the 3-level approach is consistent in how ecological integrity is assessed among levels, a standard framework or conceptual model for choosing metrics is used (as shown in Figure 1). Using this model, a similar set of metrics are chosen across the three levels, organized by the standard set of ecological attributes and factors: landscape context, size, condition (vegetation, hydrology, soils).

TABLE 3

Summary of 3-level approach to conducting ecological integrity assessments (adapted from Brooks et al. 2004, USEPA 2006).

	Level 1 – Remote Assessment	Level 2 – Rapid Assessment	Level 3 – Intensive Assessment
General description	Remote assessment	Rapid field-based assessment	Detailed field-based assessment
Evaluates condition of individual assessment areas/sites using:	• Metrics within the site that are visible with remote sensing data • Landscape/watershed condition metrics around the site • Limited ground truthing	• Relatively qualitative or narrative field metrics within the site • Remote sensing metrics for landscape context, with limited to expanded ground truthing	• Relatively detailed quantitative field metrics • Remote sensing and/or field metrics for landscape context, expanded ground truthing/resolution
Based on:	• GIS and remote sensing data • Layers typically include: –Land cover –Land use –Other ecological maps • Stressor metrics (e.g., land use, roads)	• Condition metrics (e.g., hydrologic regime, species composition) • Stressor metrics (e.g., ditching, road crossings, pollutant inputs) • Calibration based on reference sites	• Condition metrics that have been calibrated to measure responses of the ecological system to disturbances (e.g., indices of biotic or ecological integrity) • Validation of metrics based on reference sites
Potential mitigation uses	• Identifies priority sites • Identifies status and trends of acreages across the landscape • Identifies integrity of ecological types across the landscape • Informs targeted restoration and monitoring	• Identifies/confirms priority sites • Informs monitoring of many attributes • Provides baseline data for implementation of restoration or mitigation projects • Supports landscape/ watershed planning • Supports rapid assessment of mitigation based on reference sites	• Informs monitoring of a select set of attributes • Identifies status and trends of specific occurrences or indicators • Supports monitoring for restoration, mitigation and management projects
Example metrics	• Landscape Development Index (integrated a series of land use categories) • Land Use Map • Road Density • Impervious Surface	• Landscape Connectivity • Vegetation Structure • Invasive Exotic Plant Species • Forest Floor Condition	• Landscape Connectivity • Structural Stage Index • Invasive Exotic Plant Species • Floristic Quality Index (mean C) • Vegetation Index of Biotic Integrity • Soil Calcium:Aluminum Ratio

Development of Metric Ratings

Metrics are chosen because they are considered informative about the overall integrity or sustainability of the site; that is, they show a "stressor-dose response" to changes in stressor levels. The response of the metrics can be summarized either as a continuous function or through a series of categorical ratings. For rapid metrics, it is more common to use the categorical ratings. At the level of individual metrics, ratings may range from simple pass/fail to A – F. The more ratings a metric has the more sensitive it is judged to be in indicating degradation or restoration. For example, the relative total cover of exotics may be essentially zero in highly intact examples of ecosystems. Even small percentage changes of 1-2% are considered significant indicators of decline in condition. Thus the metric is divided into five ratings, when applied as a Level 2, field-based metric (see Table 4).

TABLE 4

This metric can be used for Level 2 rapid field-based assessments, where estimates of cover would be made rapidly over the site. It could also be refined to be a Level 3 metric, if vegetation plots were laid to carefully estimate cover. Rarely, it could be used as a Level 1 metric, where invasive exotics are visible from imagery, but the rating scheme could be simplified, combining A–C, then D, then E.

RANK FACTOR – Major Attribute	CONDITION – Vegetation
Metric:	Relative Total Cover of Native Plant Species
Definition:	Percent cover of the plant species that are native, relative to total cover (sum by species)
Metric Ratings	**Metric Criteria**
A = Excellent	>99% cover of native plant species
B = Good	97-99% cover of native plant species
C = Fair	90-96% cover of native plant species
D = Poor	50-89% cover of native plant species
E = Very Poor	<50% cover of native plant species

Level 1 metrics and rating

A comprehensive set of Level 1 metrics are developed for all wetlands beginning on page 33. Rating for the metrics are still under development. Protocols for evaluating metrics from remote sensing imagery are still under development. These protocols will provide details on how to measure, score and weight each metric, and include justification for how the metric rating criteria were developed.

Level 2 metrics and ratings

A comprehensive set of metrics and ratings are developed for all Level 2 metrics beginning on page 36. Protocols for evaluating Level 2 metrics in the field are provided in Appendix II. These protocols ensure that metrics are consistently measured, evaluated and scored. They also include justification for how the metric rating criteria were developed.

These metrics and their variants are intended to be comprehensive across the nation, based on a number of broad wetland classes. The metrics have not yet been widely calibrated, but various tests are underway. Further testing is also needed to determine if greater specificity is needed in the wetland classes (i.e. moving from NVC Formation to Ecological Systems) in order to be able to consistently rate the metrics. For example, if the variation in the amount of coarse and fine woody debris consistently differs between Pacific salt marshes and Atlantic salt marshes, then it would be difficult to apply the current version of that metric to both kinds of saltmarshes, or the variation would have to be explicitly stated in the narrative of that metric.

Level 3 metrics and ratings

Level 3 assessments are an active area of research. A number of field studies have been conducted in which a Vegetation Index of Biotic Integrity (VIBI) was developed (e.g., DeKeyser et al. 2003, Mack 2004, Miller et al. 2006, Rocchio 2007). A VIBI can be developed that either serves as an indicator of all ecological attributes, or, if other metrics are developed for hydrology and soils, it serves as an indicator of the biotic attribute of the wetland. In addition, other biotic components, such as amphibians or macroinvertebrates, could be measured separately.

It may be harder to create a general set of Level 3 metrics across the nation. Level 3 metrics are often more sensitive to regional variation and differences caused by finer-scale differences among wetlands. A brief introduction to Level 3 metrics is provided beginning on page 57, but much more work is needed on how to conduct a Level 3 assessment. Protocols for evaluating metrics in the field are also under development. Some example protocols are provided in Appendix III.

Given the focus on a particular site for mitigation, and the need for quantifiable evaluations of mitigation success, it may often be desirable to use at least a few Level 3 metrics for setting performance standards. More work is needed on the concept of how Level 2 and Level 3 assessment information is combined to generate performance standards

Ecological Integrity Scorecard

The goal of our mitigation assessment is to both establish the level of integrity at a given site, and relate this to reference sites. Ratings for each metric provide us with a quantifiable level of detail. But, it will often be useful to provide an overall synopsis or to guide the managers about the overall status of a mitigated wetland. We develop a scorecard, whereby occurrences are ranked using "A" (excellent), "B" (good), "C" (fair), and "D" (poor) integrity.

A number of approaches for aggregating rapid field-based metrics are available, each with a variety of strengths and weaknesses (Faber-Langendoen et al. 2007). Here, for Level 1 and Level 2 assessments, we use a simple non-interaction point-based approach, where we treat each metric independently. We first structure the system so that each metric is assigned a weight, based on how important it is considered to be in evaluating ecological integrity and each rating for a metric is assigned a point value with A = 5 points, B = 4 points, etc. (see Table 5, following page). When a field value is assigned for a metric (e.g., the Buffer Index is given a B rating), it is first converted to a point rating (i.e. B = 4), then the points are multiplied by the weight (4 x 2 = 8). The weighted points for each metric in a major attribute (e.g., landscape context) are summed and divided by the sum of the weights to get a weighted average. Presuming each major attribute is weighted the same, the weighted average of each attribute can be summed and divided by the total number of attributes. A fully worked example is shown in Table 5. The point-based approach is consistent with that of many IBI scoring methods (e.g. Karr and Chu 1999) (for additional information on the scorecard approach see "Scorecard Protocols for Level 2 Assessments: Point-Based Approach" on page 53).

The scorecard provides a ready means of evaluating both impacted and wetland sites for Level 1 and 2 assessments. Level 3 assessments, based on VIBI and other metrics ,may require somewhat different approaches to aggregating metrics.

Many mitigation projects would benefit from a scorecard approach, where reference, impacted and mitigated sites are all scored using the same metrics. Then over time, as evaluations are completed using the metrics, their values, and that of the major attributes, can be compared (see "Adapting the Method Over Time" on page 23).

TABLE 5

Summary of scores and ranks for metrics, factors, and the overall ecological integrity for a Level 2 Rapid Field-based Assessment. Vegetation, Hydrology and Soils are major attributes within the Condition rank factor.

MAJOR ATTRIBUTES / Metric	Assigned Metric Rating	Assigned Metric Points	Weight (W)	Metric Score (M)	Rank Factor Score (M/W)	Rank Factor Rank	Ecological Integrity Score	Ecological Integrity Rank (EO rank)
VEGETATION (BIOTA)					3.6	C		
Vegetation Structure	C	3	1	3				
Organic Matter Accumulation	C	3	0.5	1.5				
Vegetation Composition	B	4	1	4				
Relative Total Cover of Native Plant Species	B	4	1	4				
			∑=3.5	∑=12.5				
HYDROLOGY					4.0	B		
Water Source	C	3	1	3				
Hydroperiod	B	4	1	4				
Hydrologic Connectivity	A	5	1	5				
			∑=3	∑=12				
SOILS (PHYSICOCHEMISTRY)					4.0	B		
Physical Patch Types	B	4	0.5	2				
Water Quality	B	4	1	4				
Soil Surface Condition	B	4	1	4				
			∑=2.5	∑=10				
SIZE					4.3	B		
Relative Size	A	5	0.5	2.5				
Absolute Size	B	4	1	4				
			∑=1.5	∑=6.5				
LANDSCAPE CONTEXT					4.3	B		
Landscape Connectivity	A	5	1	5				
Buffer Index	B	4	1	4				
Surrounding Land Use	B	4	1	4				
			∑=3	∑=13				
					∑=20.5		4.1	B
RATING: A = 4.5–5.0, B = 3.5–4.4, C = 2.5–3.4, D = 1.0–2.4								

Adapting the Method over Time

It is important to remember that our efforts to assess ecological integrity are approximations of our current understanding of the system. In reality, ecosystems are far too complex to be fully represented by a suite of metrics and attributes. Moreover, our metrics, indices and scorecards must be flexible enough to allow change over time as our knowledge grows. What is important is that we present as clearly as we can how we are conducting our assessments, so that we foster communication and understanding among people with different backgrounds, goals and points of view.

NatureServe upgrades its databases to manage and store the ecological assessments, including the component metrics, and will accept improved versions of metrics as they are field-tested and validated. It is critical that such metrics become standardized across the range-wide distribution of wetland types, so that consistent and repeatable assessments of ecological integrity are available. Programs and partners are encouraged to test and refine these metrics, keeping in mind the overall definitions and purposes of ecological integrity assessments.

Reference Condition

In selecting and establishing metrics for assessing ecological integrity, an assumption is made that some type of reference condition can be defined; that is, it is possible to describe a series of states of wetland integrity, from minimally disturbed to degraded. Optimal conditions are typically defined with respect to an acceptable or natural range of variation (or historic range of variation). For many elements, what is natural or historical is difficult to define, given the vagaries of those concepts and the relative extent of human disturbance over time. For example, in an undocumented past, people may have used fire to clear patches of forest over several millennia, altering land/waterscapes and influencing species distributions. However, through careful scientific study, reflections on historical data, and comparisons with the best-preserved occurrences, we can often distinguish effects of intensive human uses and begin to describe a natural range of variation for ecological attributes that maintain the occurrence over the long term. It is this practical concept that we apply to evaluating wetland integrity.

Reference wetlands (or reference set) are the wetland sites selected to represent the range of variability that occurs in a wetland type as a result of natural processes and disturbances (e.g., succession, channel migration, fire, erosion and sedimentation), as well as anthropogenic alteration (e.g., grazing, timber harvest, and clearing) (Klimas et al. 2006). Reference wetlands serve several purposes. First, they establish a basis for defining what constitutes a characteristic and sustainable level of integrity across the suite of attributes selected for a type. Second, reference wetlands establish the range and variability of conditions exhibited by assessment variables and provide the data necessary for calibrating assessment variables and models. Finally, they provide a concrete physical representation of wetland ecosystems that can be observed and re-measured as needed (Smith et al. 1995, Klimas et al. 2006). Reference standard wetlands are the subset of reference wetlands that exhibit metric ratings for the type at a level that is characteristic of the least altered (or minimally disturbed) wetland sites in the least altered landscapes (Klimas et al. 2006, Stoddard et al. 2006). As defined below, these reference standards would typically have "A" (excellent) ratings for individual metrics and categories. To complete the full reference set, B-, C- and D-rated sites will be identified and rated as variously degraded versions of A-ranked reference standards.

In establishing reference standards, the geographic area from which reference wetlands are selected is sometimes referred to as the reference domain (Smith et al. 1995). The reference domain may include all (ideally), or part, of the geographic area in which a type occurs.

Ecological Integrity Assessment and Mitigation

As a tool in mitigation, Ecological Integrity Assessments address the recognized need for enhancing the ecological performance standards of wetlands. It does so by addressing the key requirements of such standards listed by the NRC (2001):

1. *Mitigation goals are set in the context of a watershed approach.* See "Methods for a Watershed Approach" on page 5, where this topic is addressed.

2. *Impacted sites and mitigated sites are evaluated using the same ecological assessment tools.* Ecological Integrity Assessment methods provide a general framework for addressing the range of conditions of ecosystems. The same metrics that are used to address condition for mitigation sites are part of general assessments of the condition of ecosystems elsewhere. For example, there are many rapid assessment methods that rely on the same kinds of metrics needed for mitigation (e.g., Mack et al. 2004, Sutula et al. 2006). NatureServe's methodology for evaluating wetlands of all types, as described in this report, is also based on similar metrics. Thus measures of ecological performance are becoming more widely available for a variety of ecological systems.

3. *Mitigation projects evaluate the full range of ecological integrity and ecological attributes relevant to functions.* Ecological integrity assessments (EIAs) address the major attributes relevant to assessing ecological functions of ecological systems, including vegetation, hydrology, soils (physicochemistry), landscape context and size (see Table 1). The EIA approach does not make explicit statements about "functions" that a wetland performs; however, it does implicitly assume that a wetland with high ecological integrity is performing all the expected functions for the HGM class in which it is found (see Figure 3).

4. *Mitigation goals are clearly stated so that the desired range of ecological integrity and function are specified.* Structure, composition and function are all relevant to the goals. Ecological integrity assessments are based on clearly stated metrics and ratings that assess the full range of ecological integrity and function. In so far as mitigation goals require clarity on these aspects of mitigation, they can be addressed by using EIAs.

5. *Assessing wetland function is based on a science-based, rapid assessment procedure that incorporates at least the following characteristics:*
    a. Effectively assess goals of wetland mitigation projects,
    b. Assess all recognized functions,
    c. Incorporate effects of the position in the landscape,
    d. Reliably indicate important wetland processes or scientifically established structural surrogates of these processes,
    e. Scale the assessment to results from reference sites,
    f. Sensitivity to changes in performance over a dynamic range (i.e., the metric is sensitive enough to show a range of responses to a stressor, not just a pass/fail),
    g. Integrate over space and time (i.e., the metric should be useful across the spatial range of a type and be useful for monitoring over time), and
    h. Generate parametric and dimensioned units, rather than non-parametric ranks, in order to allow for greater rigor in statistical testing.

    The EIA approach outlined here incorporates all of these characteristics. In particular, characteristic "a" is summarized in "Outline of the Mitigation Application" (page 27). Characteristic "e" is still under development, but reference sites are in the process of being compiled and tested for these metrics. Characteristics f, g, and h depend in part on the level of assessment (1, 2, or 3) chosen. Level 2 metrics do not perform as well for characteristic "h."

The ecological integrity assessment approach addresses the goals of mitigation, namely the "restoration, creation, enhancement, and in exceptional cases, preservation of other wetlands, as compensation for impacts to natural wetlands" (NRC 2001) because it provides standardized measures to assess wetland integrity and function at both the impacted and mitigated site. Our methods are developed in a general and comprehensive way. They point toward the kinds of applications that are needed for mitigation. Future studies are needed to advance these methods and test them on a variety of wetland mitigation sites.

Ecological Integrity and Wetland Function

Major recognized functions of wetlands are assessed in an EIA through major structural, composition and process attributes, such as vegetation, soils, hydrology and landscape context, which can be thought of as surrogates for function, but more importantly are direct measures of integrity. This approach to assessing function differs from previous methods such as HGM (Smith et al. 1995) in that these surrogates are not combined into additional algorithms whose endpoints are expected to measure or estimate a function. Rather, endpoints directly relate to the integrity or condition of the surrogate attributes. In other words, we assume that most natural, wetland functions are directly related to the integrity of the surrogate attributes (Fig. 3; Mack et al. 2004).

Much of the data collected by HGM methods emphasizes similar compositional, structural and abiotic features of wetlands to that of an EIA approach. It should be possible to collaborate on protocols so that similar data are collected by both approaches. In this way, even if an EIA approach does not compute the actual functional indices, it can make use of the data to assess ecological integrity, and provide that perspective alongside the functional assessment of the wetland. An extended comparison of the EIA metrics proposed here with those of an HGM functional assessment is provided in Table 6 (page 26), based on the work of Klimas et al. (2004).

TABLE 6

Comparison of Rapid Field-Based Metrics for Assessing Wetland Integrity with HGM Metrics for Assessing Wetland Function.

The table is provided courtesy of T. Foti. The HGM variables are taken from a study of the Mississippi River Alluvial Plain in Arkansas by Klimas et al. (2004). HGM metrics are subclass-specific and ecoregion-specific; they have been simplified for this table. See Klimas et al. (2006) for a similar study elsewhere in Arkansas. Details of each NatureServe metric are provided in Table 10 (page 37).

Major Attribute	NatureServe Metric (Level 2)	Klimas et al. 2004 Variables (Level 3 equivalent)
LANDSCAPE CONTEXT	Landscape Connectivity	Non-riverine or riverine: $V_{CONNECT}$ – Percentage of wetland tract perimeter within 0.5 km of suitable habitat
	Buffer Index	Non-riverine or riverine: V_{CORE} – Percentage of wetland tract perimeter with 300 ft (~100 m) buffer from surrounding land uses. No measure of condition of buffer.
SIZE	Patch Size Condition*	None
	Patch Size (ha)	V_{TRACT} – Size of the assessment area and all contiguous forested wetland areas
VEGETATION (BIOTA)	Vegetation Structure	V_{STRATA} – Number of strata present V_{TBA} – Tree basal area V_{TDEN} - Tree density V_{SSD} – Shrub/sapling density V_{GVC} – Ground vegetation cover
	Organic Matter Accumulation (coarse and fine debris)	V_{LITTER} – Litter cover V_{OHOR} – Thickness of O horiz. V_{AHOR} – Thickness of A horiz. V_{SNAG} – Snag density V_{WD} – Small and medium woody debris V_{LOG} – Large woody debris
	Vegetation Composition	V_{TCOMP}, V_{COMP} – Species dominance related to reference standard
	Relative Total Cover of Native Plant Species	Not recorded, but notes on invasives has been used is specific studies
HYDROLOGY	Water Source	In HGM, overall water source determines the classification
	Hydroperiod	V_{FREQ} – Flood frequency [rarely Flood Duration]
	Hydrologic Connectivity	This is either a "natural" aspect of HGM "water source" or could be treated as one of the "stressors" V_{POND} – Percentage of site capable of ponding water
SOILS (PHYSICO-CHEMISTRY)	Physical Patch Types	None
	Water Quality	None
	Soil Surface Condition	V_{SOIL} – V_{CEC} – Cation Exchange Capacity (estimated from texture) – for altered areas. Soil integrity.

* *optional metric*

Outline of the Mitigation Application

The objective in setting performance standards and in conducting subsequent monitoring is "to collect sufficient data to answer the hypothesis: has the mitigation wetland met the performance goal within the monitoring period" (Mack et al. 2004). As outlined previously, the performance standards developed for mitigation include a broad range of structural and functional measures, including hydrology, vegetation and soils, and rely on reference wetlands as a model for the dynamics of created or restored sites. We introduce, by way of example, some ways in which ecological integrity assessments can be used to set ecological performance standards. Other aspects of performance standards, such as site preparation, are not addressed.

Table 7A (following page) summarizes a series of performance standards for wetland mitigation developed for Ohio (Mack et al. 2004). It also includes a list of Level 2 (rapid field-based) and Level 3 (intensive field-based) metrics from the EIA approach developed in this study that are relevant to measuring progress on those performance standards. Thus the metrics developed for this EIA methodology cover many of the performance standards needed for mitigation. It may not be necessary to measure all metrics, but metrics should be chosen that span the range of major ecological attributes.

Table 7B (page 29) illustrates how field values and thresholds for these EIA metrics can be used to track the progress of a mitigated site. The table is incomplete and provides a few examples only. There can be substantial challenges in achieving benchmarks for certain metrics in certain wetlands. Figure 5 (page 30) shows how mitigation of vegetation structure for swamp forests in Ohio may require a 10- to 100-year monitoring window (see Mack et al. 2004, Klimas et al. 2006). However, many forested (bottomland hardwood) wetlands in Arkansas and across the Lower Mississippi Valley may develop structural features more quickly than in Ohio. Thus, where studies from Ohio show that 15 cm (6") trees require 30 years to develop, 10" trees, 60 years, etc., such development may be twice as rapid in the Lower Mississippi Valley. Restoration of forested swamps in mitigation projects appears very practical there over short (decadal) time frames. Many hundreds of thousands of acres have been mitigated or restored, often with good success, and there is a broad understanding of the requirements for mitigation (T. Foti pers. comm. 2008). Thus performance standards will need to be adjusted to specific Ecological Systems.

TABLE 7A

Performance Standards for Wetland Mitigation (based primarily on standards developed for Ohio mitigation projects by Mack et al. (2004), and corresponding metrics that provide data to assess performance.

These examples provide a sense of direction for how EIAs can be applied to mitigation. Case studies are now needed to apply the method.

Performance Metrics (Mack et al. 2004)	Level 2 (NatureServe)	Level 3 (NatureServe)
A. Site		
Design		
Acreage	Patch Size	Patch Size
Basin morphometry	—	
Perimeter-area ratio	—	
Hydrology		
Hydrologic regime	• Hydroperiod • Water Source • Hydrologic Connectivity	TBD
Unvegetated Open Water	—	
Biota – Vegetation		
Perennial native hydrophytes	Vegetation Composition	
Invasive species	• Relative Cover of Native Plant Species • Invasive Exotic Plant Species	• Relative Cover of Native Plant Species • Invasive Exotic Plant Species
Vegetation-ecological standards	Vegetation Composition	Floristic Quality Assessment (Mean C) Vegetation Index of Biotic Integrity
Woody Species Establishment (Shrub Swamps, Swamp Forests)	Vegetation Structure	Vegetation Structure
Other Biota:		
Amphibians – Ecologic standards	—	
Other taxa groups – Ecologic standards (breeding birds, macro-invertebrates)	—	
Soil		
Biogeochemical standards	• Water Quality • Soil Disturbance	TBD
Other		
Ecological Services	Physical Patch Types	TBD
B. Landscape Context/Watershed		
—	Landscape Connectivity	Landscape Connectivity
—	Buffer Index	Buffer Index
—	Surrounding Land Use	Surrounding Land Use

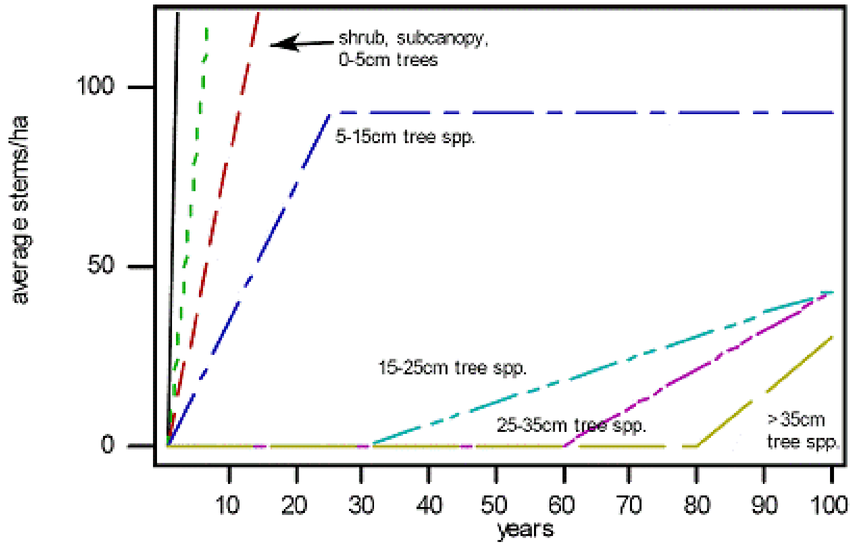
TABLE 7B

Conceptual schedule for required monitoring and reporting activities, with benchmark variables. X_R= the reference site or impacted site value that is chosen as the basis for assessing performance. X_1= the measure of a metric in Year 1, etc. At Year 5, the X value can be compared against the reference value and a decision made on the progress of the mitigation project. Examples of possible benchmark values are shown for various metrics and performance standards. Metrics in shaded rows were not chosen as part of the monitoring project.

Performance Standards (Mack et al. 2004, NatureServe, this report)	Reference	Year				
	Impacted wetland/ Reference site (R)	1	2	3	4	5
A. Site						
Design						
Acreage	Size = X_R acres	Size = X_1 acres	Size = X_2 acres	Size = X_3 acres	Size = X_4 acres	Size = X_5 acres
Basin morphometry						
Perimeter-area ratio						
Hydrology	H Index = X_R	H Index = X_1	H Index = X_2	H Index = X_3	H Index = X_4	H Index = X_5
Hydrologic regime						
Unvegetated Open Water	—					—
Biota – Vegetation	V Index = X_R	V Index = X_1	V Index = X_2	V Index = X_3	V Index = X_4	V Index = X_5
Perennial native hydrophytes						
Invasive species	Invasives = $X_{R\%}$	Invasives = $X_{1\%}$	Invasives = $X_{2\%}$	Invasives = $X_{3\%}$	Invasives = $X_{4\%}$	Invasives = $X_{5\%}$
Vegetation-ecological standards						
Woody Species Establishment (Shrub Swamps, Swamp Forests)						
Other Biota:						
Amphibians – Ecologic standards	—					—
Other taxa groups – Ecologic standards (breeding birds, macro-invertebrates)	—					—
Soil	S Index = X_R	S Index = X_1	S Index = X_2	S Index = X_3	S Index = X_4	S Index = X_5
Biogeochemical standards						
Other						
Ecological Services						
B. Landscape Context/ Watershed	L Index = X_R	L Index = X_1	L Index = X_2	L Index = X_3	L Index = X_4	L Index = X_5
Landscape Connectivity						
Buffer Index						
Surrounding Land Use						

FIGURE 5

Hypothetical performance curves for tree and shrub establishment. Graph shows expected performance at 10 and 100 years derived from reference wetland data for depressional wetland forests (from Mack et al. 2004, Figure 16).



Examples of Ecological Performance Standards for Wetland Mitigation

We conclude with a few case studies illustrating the use of ecological performance standards based on ecological integrity metrics for mitigation purposes. These examples highlight existing guidelines that are similar to and compatible with the proposed NatureServe approach. There are currently a variety of approaches to addressing compensatory mitigation, including mitigation banks, in-lieu-of-fee mitigation programs, and umbrella banking agreements (Wilkinson and Thompson 2005). Future studies are needed to test these performance standards on a variety of wetland mitigation sites.

U.S. Army Corps of Engineers, Chicago District

The Chicago District provides a technical guide for Clean Water Act Section 404 permit applicants preparing compensatory mitigation plans. The purpose of the document is:

> *"to identify the types and extent of information that agency personnel need to assess the likelihood of success of a mitigation proposal. Success is generally defined as: a healthy sustainable wetland/water that – to the extent practicable – compensates for the lost functions of the impacted water in an appropriate landscape/watershed position. This checklist provides a basic framework that will improve predictability and consistency in the development of mitigation plans for permit applicants."*

Details of the supplemental mitigation performance requirements in the Chicago District are presented in Attachment C to the technical guide (www.lrc.usace.army.mil/co-r/mitgr.htm). Table 8 provides an abbreviated set of specifications that are needed for documenting baseline information and for establishing the mitigation work plan.

TABLE 8

U.S. Army Corps of Engineers, Chicago District, Compensatory Mitigation Plan Checklist – Supplement (abbreviated text).

Mitigation Work Plan
a. Maps marking boundaries of proposed mitigation types
b. Timing of mitigation: before, concurrent or after authorized impacts
c. Grading plan (elevations, slopes, microtopography)
d. Description of construction methods
e. Description of soil erosion and sediment control measures
f. Construction schedule
g. Planned hydrology 1. Source of water 2. Connection(s) to existing waters 3. Hydroperiod, percent open water, water velocity 4. Potential interaction with groundwater 5. Existing monitoring data, if applicable; location of monitoring wells and stream gauges on site map 6. Stream or other open water geomorphic features (e.g., riffles, pools, bends, deflectors) 7. Structures requiring maintenance (show on map) 8. Representational cross sections
h. Planned vegetation 1. Native plant species composition (e.g., list of acceptable native hydrophytic vegetation) 2. Source of native plant species ... stock type (bare root, potted, seed) and plant age(s)/size(s) 3. Plant zonation/location map (refer to grading plan to ensure plants have acceptable hydrological environment) 4. Plant spatial structure – quantities/densities, % cover, community structure (e.g., canopy stratification) 5. Expected natural regeneration from existing seed bank, plantings, and natural recruitment
i. Planned soils 1. Soil profile 2. Source of soils … target soil characteristics … soil amendments (e.g., organic material or topsoil) 3. Soil compaction control measures
j. Planned habitat features (identify large woody debris, rock mounds, etc., on map)
k. Planned buffer (identify on map) 1. Evaluation of the buffer's expected contribution to aquatic resource functions 2. Physical characteristics (location, dimensions, native plant composition, spatial and vertical structure)
l. Other planned features, such as interpretive signs, trails, fence(s), etc.

Ohio Environmental Protection Agency

The Ohio EPA has developed a series of wetland assessment tools to assist in setting performance standards for wetlands (Mack et al. 2006). They developed a condition-based approach to assessing functional replacement for wetland mitigation using a reference wetland data set of natural wetlands. All major wetlands types were sampled, spanning a gradient of human disturbance. From this data set, wetland program tools were developed, including 1) multi-metric biological indices (IBIs) and hydrological and biogeochemical indicators; 2) a rapid (condition-based) wetland assessment tool (Ohio Rapid Assessment Method for Wetlands); and 3) a wetland classification scheme that accounts for variability in ecosystem processes (functions) and ecological services (values) of different types of natural wetlands. Ensuring functional replacement occurs in a several-step process. Mack et al. (2006) summarized the steps as follows:

> *"First, as part of permit application, the HGM class and dominant plant community of the impacted wetland(s) are determined. This determination accounts for the ecosystem processes (functions) and ecological services (values) of different wetland types without the necessity of developing a comprehensive list of those functions and values.*
>
> *Second, the condition of the impacted wetland is assessed with the rapid condition tool (ORAM v. 5.0) or a wetland IBI providing a measure of 'functional capacity.'*
>
> *Third, the size of the wetland to be impacted is determined and appropriate mitigation ratios are applied.*
>
> *Fourth, any residual moderate to high functions or values the impacted wetland(s) may still be providing, despite moderate to severe degradation, are evaluated using checklist with a narrative discussion.*
>
> *Fifth and finally, requirements for mitigation are specified in the permit. If there is 1) replacement by size of the impacted wetland, 2) replacement of the type of wetland impacted, and 3) replacement of the quality of the impacted wetland as measured by quantitative, condition-based ecological performance targets, then there is very strong assurance that functional replacement is occurring since there was 'no net loss' of wetland acreage, a mitigation wetland of same HGM class and dominant plant community was created with functions and ecological services equivalent to the impacted wetland, and a mitigation wetland was created of equivalent 'quality' as measured by biological (e.g. IBIs), hydrological, and biogeochemical indicators (and therefore of equivalent functional performance)."*

Performance standards, quantitative monitoring and data analysis techniques were developed for wetland size, basin morphometry, perimeter:area ratio, hydrologic regime, basic vegetation establishment, woody species establishment (successional trends), soil chemistry and wetland IBIs. The steps provide a clear, ecologically based set of performance standards. The standards are rigorous enough to allow for statistical testing of mitigation performance, based on monitoring data. A meaningful and adequate mitigation monitoring program is absolutely necessary to determine whether the mitigation wetland has "succeeded" or "failed."

Level 1 (Remote Sensing) Metrics for Wetlands

Level 1 Assessments are based primarily on metrics derived from remote sensing imagery. A variety of remote-sensing based methods have been proposed for assessing ecological integrity. The assessments are often used as a means of prioritizing sites for field visits, and the ecological integrity ranks that can be developed from remote sensing imagery may be somewhat coarse. Using Level 2 or Level 3 assessments methods will provide a more accurate assessment, and ranks based on those assessments would supersede these ranks. Level 1 ranks can also be tested as predictors of Level 2 or 3 ranks, to see how successful the Level 1 metrics are in predicting the level of integrity found at a site (Mita et al. 2007). Completing the iteration, the Level 2 and 3 ranks can also be used to re-calibrate the landscape metrics and ranks in subsequent applications.

Metrics for Level 1 Assessment

A synopsis of the ecological metrics and ratings for Level 1 assessments is presented in Table 9 (following page). Metrics may belong on one or more "tiers," referring to levels of intensity of sampling required to document a metric. Tier 1 metrics are able to be assessed using remote sensing imagery, such as satellite or aerial photos. Tier 2 metrics typically require some kind of ground sampling, but may require only qualitative or semi-quantitative data. For Level 1 assessment, Tier 1 metrics are emphasized, but some Tier 2 metrics may also be used, where some limited ground-truthing is possible.

The assessment of integrity includes landscape context, size and condition of occurrences, as best as these can be assessed using remote sensing imagery. Together, metrics for these three rank factors are used to assign an ecological integrity index for an occurrence or site.

Metrics may be categorized as either condition or stressor metrics. Condition metrics are used to assess the ecological characteristics of the system (e.g., vegetation structure of a stand). Stressor metrics are used to measure activities or processes which are known or hypothesized to degrade the condition of the system, such as surrounding land use, air pollution or roads. Although condition metrics are the preferred tool for assessing ecological integrity, these can be hard to obtain for Level 1 assessments; stressor metrics are a rapid and cost-effective way of assessing the likelihood that a system is in good condition.

For each metric, a rating will be developed and scored, from excellent (A) to poor (D), usually in a 4-category scale, but sometimes 3 or 5. Currently these are only available for the Landscape Integrity Index. Protocols are still being developed for Level 1 metrics.

TABLE 9

Overview of remote sensing-based metrics for assessing wetland condition and stressors.

Rank Factor	Major Ecological Attribute	Metric Name	Tier	Metric Type	Metrics Definition
Landscape Context	Landscape Context	Landscape Integrity Index	1	S	A measure of the intensity of human-dominated land uses within 4000 ha (10,000 ac) landscape area from the center of the occurrence. Each land use type occurring in the landscape area is assigned a coefficient ranging from 0.0 to 1.0 indicating its relative impact to the target system.
	Landscape Context Stressors	Landscape Stressors Checklist	1	S	A measure of the distance to nearest road, which addresses the potential impacts to the site of roads or major trails.
Size	Size	Patch Size	1	C	A measure of the current size (ha) of the occurrence or stand.
Condition	Biota	Vegetation Structure	1	C	An assessment of the overall structural complexity of the vegetation layers, including presence of multiple strata, age and structural complexity of canopy layer, and evidence of disease or mortality.
	Biota Stressors	Biotic Condition Stressors Checklist	1	S	A checklist of stressors that could affect biotic condition.
	Soils & Substrate	Land Use Within the Site	1	S	A measure of the intensity of human-dominated land uses within the site.
	Soils & Substrate Stressors	Physical Stressors Checklist	1	S	A checklist of stressors that could affect physicochemical condition.

Landscape Integrity Model

Table 9 includes a Landscape Integrity Index. Because this index plays a key role in Level 1 assessments, we summarize its use here. The index is derived from a Landscape Integrity Model developed by NatureServe (Tuffly and Comer 2005, Rocchio 2007). The model is similar in approach to the Landscape Development Index used by Mack (2006) and that of Tiner (2004). The algorithm integrates various land use GIS layers (roads, land cover, water diversions, groundwater wells, dams, mines, etc.) that are considered potential stressors to wetland integrity. These layers are the basis for developing a stressor-based set of metrics that are combined into an overall landscape integrity index. The metrics are weighted according to their perceived impact on ecological integrity, into a distance-based, decay function to determine what effect these stressors have on landscape integrity. The result is that each grid-cell (30 m) is assigned an integrity "score." The product is a landscape or watershed map depicting areas according to their potential "integrity." The index can be divided into four rank classes, from Excellent (slightly impacted), "A," to Poor (highly impacted), "D" (Figure 6).

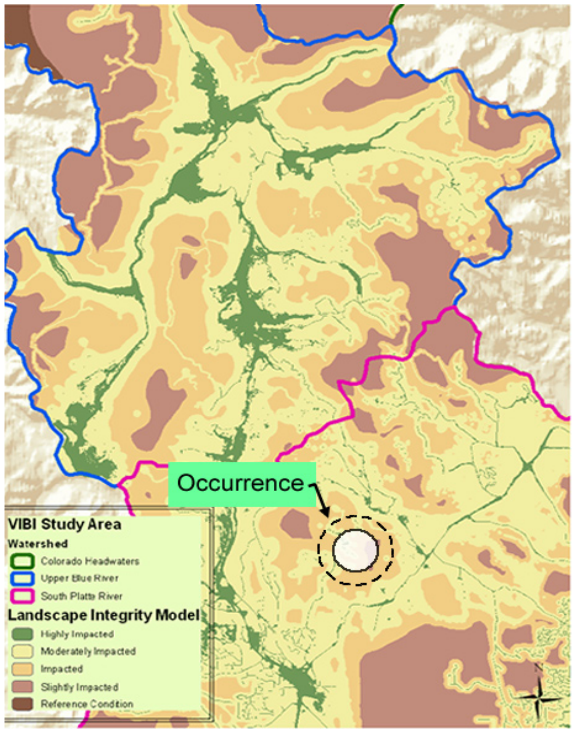


FIGURE 6

Demonstration of the Level 1 Assessment based on a Landscape Integrity Model. Values for landscape context metrics and condition metrics for an occurrence can be derived from the model (adapted from Rocchio 2007).

To use the landscape integrity model as part of a Level 1 assessment, locations are chosen within the watershed or landscape (see occurrence labeled in Fig. 6). These locations are any or all examples of an ecosystem type that is of interest, e.g., all or some forest stands, or wetlands, identified to level of ecosystem type. Points or polygons are established for each of these locations, and these are overlaid on the Landscape Integrity Model. A landscape context area is defined around the occurrence (Fig. 6). The landscape integrity model provides the data for the "landscape integrity index" metric, based on the average score of the pixels within the landscape context. The same model can be used to produce the data for the "land use within the site" metric. Finally, size of the occurrence can also be measured. Together these metrics provide a simple means of characterizing the integrity and EO rank of the occurrence.

Scorecard Protocols for Level 1

Scorecard protocols for Level 1 metrics are under development, but are expected to follow the protocols for Level 2 assessments (see "Ecological Integrity Scorecared" on page 21 and "Scorecard Protocols for Level 2 Assessments" on page 53).

Level 2 (Rapid Field-Based) Metrics for Wetlands

Based on the overall ecological integrity conceptual model (Fig. 1, Table 1), we compiled a list of indicators/metrics of integrity for each wetland type that covered the five major attributes: hydrology, soils, vegetation, size and landscape context. These metrics should reflect the composition, structure and function (pattern and process) of the type. We also reviewed a variety of existing rapid wetland assessment and monitoring materials to develop the general method, particularly that of the California Rapid Assessment Manual (CRAM, Sutula et al. 2006, Collins et al. 2006, 2007), the Ohio Rapid Assessment Manual (Mack 2001), and NatureServe (Faber-Langendoen et al. 2006).

Metrics for Level 2 Assessment

A synopsis of the ecological metrics and ratings is presented in Table 2. Metrics may belong on one of three possible "tiers," referring to levels of intensity of sampling required to document a metric. Tier 1 metrics are able to be assessed using remote sensing imagery, such as satellite or aerial photos. Tier 2 typically require some kind of ground sampling, but may require only qualitative or semi-quantitative data. Tier 3 metrics typically require a more intensive plot sampling or other intensive sampling approach. A given metric could be assessed at multiple tiers, though some metrics cannot be used at Tier 1 (i.e., they require a ground visit). As part of a rapid assessment, we emphasize Tier 2 metrics for most attributes, but rely on Tier 1 metrics to assess the landscape context attribute.

Metrics may also be categorized as either condition or stressor metrics. Condition metrics are used to assess the ecological characteristics of the system (e.g., hydroperiod of a wetland). Stressor metrics are used to measure activities or structures which are known or hypothesized to degrade the integrity of the system (e.g., number of dams on a river or in a watershed surrounding a wetland). Condition metrics are the primary tool for generating an ecological integrity rank. Stressor metrics can, however, be a rapid and cost-effective way of assessing the likelihood that a system is in good condition, but they typically should be scored separately from condition metrics and used as supporting information. Separating the metrics into these two categories also allows the ecologist to assess the relative correlation of stressors to condition.

For each metric, a rating is developed and scored, from excellent (A) to poor (D), usually in a 4-category scale, but sometimes 3 or 5. Protocols for each metric (including definition, background, methods and scaling rationale) are provided under "Procedures for Conducting Ecological Integrity Assesessments" (page 59). Each metric is rated and then aggregated with other metrics by major ecological attribute: Landscape Context, Size, Vegetation, Hydrology and Soils.

The metrics vary in their level of quantification. Ratings for some of the metrics are based on quantifiable, measurable ratings; others are more narrative in context and may require expert judgment and experience. In some cases, such as vegetation structure and composition, it is possible to gather quantitative data (see Appendix VI for an example field form). But at the level of broad wetland formations, such as Temperate & Boreal Freshwater Marsh or Bog & Fen, it is very difficult to specify with reliability any quantitative metrics that are meaningful to ecological integrity. Nonetheless the data are a valuable record of the condition of the vegetation, and can provide documentation for later use, as we better understand how to apply these metrics. In addition, gathering at least some data will also improve the ability to calibrate this rapid assessment approach against more detailed surveys, and, perhaps more importantly, at a finer scale of classification, such as Macrogroup or Ecological System. Finally, many vegetation ecologists will find that they can easily add a Level 3 vegetation metric, such as the Floristic Quality Index (see Appendix III), as part of their Level 2 assessment, and thereby substitute that metric for the Vegetation Composition metric.

TABLE 10A

Overview of Rapid Field-Based (Level 2) Metrics for Assessing Wetland Integrity.

Tier: 1 = Remote sensing-based metric, 2 = Rapid field-based metric. Metric Type: C = condition metric, S = stressor metric or checklist (grey shaded cells). Shaded rows contain metrics that are not used directly to assess integrity, but are considered informative. Ratings for each metric are provided in Table 10B.

Major Attribute	Key Ecological Attribute	Metric Name	Tier	Metric Type	Metrics Definition
LANDSCAPE CONTEXT	Landscape Structure	Landscape Connectivity	1, 2	C	Non-riverine: A measure of the percent of unfragmented landscape within 500 m radius (non-riverine types). Riverine: A measure of the degree to which the riverine corridor above and below a floodplain area exhibits connectivity with adjacent natural systems (riverine types). Assessed segment is 500 m upstream and 500 m downstream.
		Buffer Index			An index of the overall area and condition of the buffer immediately surrounding the wetland, using three measures: Percent of Wetland with Buffer, Average Buffer Width (with slope correction), and Buffer Condition. Wetland buffers are vegetated, natural (non-anthropogenic) areas that surround a wetland.
	Landscape Composition	Surrounding Land Use Index	1, 2	S	A measure of the intensity of human-dominated land uses within a specific landscape area (such as a catchment) from the center of the occurrence. Each land use type occurring in the landscape area is assigned a coefficient ranging from 0.0 to 1.0 indicating its relative impact to the target system.
	Landscape Context Stressors	Landscape Stressors Checklist	2	S	A checklist of stressors that could affect landscape context condition.
SIZE	Size	Patch Size Condition*	1, 2	C	A measure of the current size of the wetland (ha) relative to the original natural size. Assessed by dividing the best estimate of historic size by current absolute size, multiplied by 100.
		Patch Size (ha)	1, 2	C	A measure of the current size (ha) of the occurrence or stand. Assessed relative to reference stands of a type, globally.
VEGETATION (BIOTA)	Community Structure	Vegetation Structure	2	C	An assessment of the overall structural complexity of the vegetation layers, including presence of multiple strata, age and structural complexity of canopy layer, and evidence of disease or mortality.
		Organic Matter Accumulation (coarse and fine debris)	2	C	An assessment of the overall organic matter accumulation, whether both fine and coarse litter (non-forested wetlands) or coarse woody debris and snags (forested wetlands).
	Community Composition	Vegetation Composition	2	C	An assessment of the overall species composition and diversity, including by layer, and evidence of specific species diseases or mortality.
		Relative Total Cover of Native Plant Species	2	C	A measure of the relative percent cover of all plant species that are native to the region. Typically measured by estimating total absolute cover and subtracting total exotic species cover.

(Continued on next page.)

TABLE 10A (continued from previous page)

Major Attribute	Key Ecological Attribute	Metric Name	Tier	Metric Type	Metrics Definition
VEGETATION (BIOTA) (cont.)	Biotic Stressors	Invasive Exotic Plant Species	2	S	A measure of the percent cover of a set of exotic plant species that are considered invasive.
		Biotic Condition Stressors Checklist	2	S	A checklist of stressors that could affect biotic condition.
HYDROLOGY	Hydrological Regime	Water Source	2	C	An assessment of the extent, duration and frequency of saturated or ponded conditions within a wetland, as affected by the kinds of direct inputs of water into, or any diversions of water away from, the wetland.
		Hydroperiod	2	C	An assessment of the characteristic frequency and duration of inundation or saturation of a wetland during a typical year.
		Hydrologic Connectivity	2	C	An assessment of the ability of the water to flow into or out of the wetland, or to inundate adjacent areas.
	Hydrologic Stressors	Upstream Surface Water Retention	1	S	A measure of the percentage of the contributing watershed which drains into water storage facilities capable of storing surface water from several days to months. Applies to riverine systems.
		Upstream/Onsite Water Diversions	1	S	A measure of the number of water diversions and their impact in the contributing watershed and in the wetland. Applies to riverine systems.
		Groundwater Diversions	1, 2	S	Under development for non-riverine systems.
		Hydrologic Stressors Checklist	2	S	A checklist of stressors that could affect hydrologic condition.
SOILS (PHYSICO-CHEMISTRY)	Physical Structure	Physical Patch Types	2	C	A checklist of the number of different physical surfaces or features that may provide habitat for species.
		Water Quality	2	C	An assessment of water quality based on visual evidence of water clarity and eutrophic species abundance.
		Soil Surface Condition	2	S	An assessment of soil surface disturbances (e.g. bare soil, tracks).
	Soils (Physico-chemical) Stressors Checklist	On-Site Land Use Index	2	S	A measure of the intensity of human-dominated land uses within the site. Each land use type occurring within the site is assigned a coefficient ranging from 0.0 to 1.0 indicating its relative impact to the target system.
		Soils (Physico-chemical) Stressors Checklist	2	S	A checklist of stressors that could affect soils and physicochemical condition.

** optional metric*

(End of Table 10A.)

TABLE 10B

Summary of Ratings for Rapid Field-Based (Level 2) Metrics used to Assess Wetland Integrity.

Tier: 1 = Remote sensing-based metric, 2 = Rapid field-based metric. Metric Type: C = condition metric, S = stressor metric or checklist (grey cells). Shaded rows contain metrics that are not used directly to assess integrity, but are considered informative. Formations listed are all temperate and boreal wetland formations, except for Tropical Mangrove. References to "riverine," etc., follow standard HGM definitions. Detailed protocols for each metric are provided separately in Appendix II.

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Landscape Context	Landscape Connectivity–*Non-Riverine*	1	C	Intact: Embedded in 90–100% natural habitat of around wetland, preferably within the watershed	Variegated: Embedded in 60–90% natural habitat	Fragmented: Embedded in 20–60% natural habitat	Relictual: Embedded in <20% natural habitat
	Riverine	1		The combined total length of all non-buffer segments is less than 200 m (<10%) for wadable (2-sided) sites, 100 m (<10%) for non-wadable (1-sided) sites	Combined length of all non-buffer segments is between 200 m and 800 m (10-40%) for "2-sided" sites; between 100 m and 400 m (10–40%) for "1-sided" sites	Combined length of all non-buffer segments is between 800 and 1800 m (40–90%) for "2-sided" sites; between 400 m and 900 m (40–90%) for "1-sided" sites	Combined length of all non-buffer segments is greater than 1800 m for "2-sided" (>90%) sites, greater than 900 m for "1-sided" sites (>90%)
	Buffer Index–*Length*	1,2	C	Buffer is 75–100% of occurrence perimeter	Buffer is 50–74% of occurrence perimeter	Buffer is 25–49% of occurrence perimeter	Buffer is <25% of occurrence perimeter
	Width			Average buffer width of occurrence is >200 m, adjusted for slope	Average buffer width is 100–199 m, after adjusting for slope	Average buffer width is 50–99 m, after adjusting for slope	Average buffer width (m) is, after adjusting for slope: D: 10–49; E: <10 m
	Condition			Buffer for occurrence is characterized by abundant (>95%) cover of native vegetation and little to no (<5%) cover of non-native plants, with intact soils, and little or no trash or refuse	Buffer for occurrence is characterized by substantial (75–95%) cover of native vegetation, low (5–25%) cover of non-native plants, intact or moderately disrupted soils, moderate or lesser amounts of trash or refuse, and minor intensity of human visitation or recreation	Buffer for occurrence is characterized by a moderate (25–50%) cover of non-native plants, and either moderate or extensive soil disruption, moderate or greater amounts of trash or refuse, and moderate intensity of human visitation or recreation	Buffer for occurrence is dominated by non-native plant cover (>50%) characterized by barren ground and highly compacted or otherwise disrupted soils, with moderate or greater amounts of trash or refuse, and moderate or greater intensity of human visitation or recreation; OR there is no buffer present

(Continued on next page.)

TABLE 10B (continued from previous page)

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Landscape Context (cont.)	Surrounding Land Use Index– *Non-Tidal*	1, 2	S	Average Land Use Score = 1.0–0.95	Average Land Use Score = 0.80–0.95	Average Land Use Score = 0.4–0.80	Average Land Use Score = <0.4
	Tidal		S	Land use index = 85–100	Land use index = 65–84	Land use index = 45–64	Land use index <44
	Landscape Stressors Checklist	2	S				
Size	Patch Size Condition	1, 2	S	Occurrence is at, or only minimally reduced from, its full original, natural extent (<95%), and has not been artificially reduced in size. Reduction can include destroyed or severely disturbed (e.g., large changes in hydrology due to roads, impoundments, development, human-induced drainage; or changes caused by recent clearcutting).	Occurrence is only modestly reduced from its original, natural extent (80–95% or more). Reduction includes...(see A).	Occurrence is substantially reduced from its original, natural extent (50–80%). Reduction includes... (see A).	Occurrence is heavily reduced from its original natural extent (>50%). Reduction includes... (see A).
	Patch Size	1, 2		Patch size is very large compared to other examples of the same type (e.g., top 10% based on known and historic occurrences, or area-sensitive indicator species very abundant within occurrence)	Patch size is large compared to other examples of the same type (e.g. within 10–30%, based on known and historic occurrences, or most area-sensitive indicator species moderately abundant within occurrence)	Patch size is moderate compared to other examples of the same type, (e.g., within 30–70% of known or historic sizes; or many area-sensitive indicator species are able to sustain a minimally viable population, or many characteristic species are but present)	Patch size is too small to sustain full diversity and full function of the type. (e.g., smallest 30% of known or historic occurrences, or both key area-sensitive indicator species and characteristic species are sparse to absent)

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Vegetation (Biota)	Vegetation Structure– *Bog & Fen*	2	C	Peatland is supporting vegetation to its reference standard condition. Some very wet peatlands may not have any woody vegetation or only scattered stunted individuals. Woody vegetation mortality is due to natural factors and is not being influenced by anthropomorphic factors. Tree diameters and heights are near reference standard condition.	Generally, peatland vegetation has only minor anthropogenic influences present or the site is still recovering from major past human disturbances. Mortality or degradation due to grazing, limited timber harvesting or other anthropomorphic factors may be present although not widespread. The site can be expected to meet reference standard condition in the near future if negative human influence does not continue.	Peatland vegetation has been moderately influenced by anthropogenic factors. Expected structural classes or species are not present. Human factors may have diminished the standard condition for woody vegetation. The site will recover to reference standard condition only with the removal of degrading human influences and moderate recovery times.	Expected peatland vegetation is absent or much degraded due to anthropogenic factors. Woody regeneration is minimal and existing vegetation is in poor condition, unnaturally sparse, or depauperate in expected species. Recovery to reference standard condition is questionable without restoration or will take many decades.
	Floodplain & Swamp Forest, Mangrove [east U.S. versus west U.S.]?			Canopy a mosaic of small patches of different ages or sizes, including old trees and canopy gaps containing regeneration. Overall density moderate and average tree cover generally greater than 25%.	Canopy largely heterogeneous in age or size, but with some gaps containing regeneration or some variation in tree sizes AND overall density moderate and greater than 25% tree cover.	Canopy somewhat homogeneous in density and age, AND extremely dense or very open. Canopy cover may be very high or very low (>90%, <25%).	Canopy extremely homogeneous, sparse or absent (<10% cover).
	Freshwater Marsh [separate out vernal pools, prairie potholes]			Vegetation is at or near reference standard condition in structural proportions. No structural indicators of degradation evident.		Vegetation is moderately altered from reference standard condition in structural proportions. Several structural indicators of degradation evident.	Vegetation is greatly altered from reference condition in structural proportions. Many structural indicators of degradation evident.

(Continued on next page.)

TABLE 10B (continued from previous page)

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Vegetation (Biota) (cont.)	*Aquatic Vegetation*			Vegetation is at or near reference standard condition in structural proportions. No structural indicators of degradation evident.		Vegetation is moderately altered from reference standard condition in structural proportions. Several structural indicators of degradation evident.	Vegetation is greatly altered from reference condition in structural proportions. Many structural indicators of degradation evident.
	Organic Matter Accumulation (coarse and fine debris)– *Floodplain & Swamp Forest, Mangrove*	2	C	A wide size-class diversity of downed coarse woody debris (logs) and standing snags, with 5–9 or more logs and snags exceeding 30 cm dbh and 2 m in length, and logs in various stages of decay. [An Excellent rating could be based on: with >10 logs and snags exceeding 30 cm dbh and 2 m in length.]		A moderately wide size-class diversity of downed coarse woody debris (logs) and standing snags, with 1–4 logs and snags exceeding 30 cm dbh and 2 m in length, and logs in various stages of decay.	A low size-class diversity of downed coarse woody debris (logs) and standing snags, with logs and snags absent to rarely exceeding 30 cm dbh and 2 m in length, and logs in mostly early stages of decay (if present).
	Bog & Fen			The site is characterized by an accumulation of peaty, hummocky, organic matter. There is some matter of various sizes, some very old.		The site is characterized by some areas lacking an accumulation of peaty hummocky, organic matter. Size of materials does not vary greatly, nor do any appear old.	The site is characterized by large areas without peaty, hummocky organic matter (e.g., peat mining). Size of materials does not vary greatly, nor do any appear old.
	Freshwater Marsh, Salt Marsh, and Aquatic Vegetation	2		The site is characterized by a moderate amount of fine organic matter. There is some matter of various sizes, but new materials seem much more prevalent than old materials. Litter layers, duff layers and leaf piles in pools or topographic lows are thin. In North American Pacific Salt Marsh, with 5–9 or more logs and snags exceeding 30 cm dbh and 2 m in length, and logs in various stages of decay. [An Excellent rating could be established using: >10 logs and snags exceeding 30 cm dbh and 2 m in length.]		The site is characterized by occasional small amounts of coarse organic debris, such as leaf litter or thatch, with only traces of fine debris, and with little evidence of organic matter recruitment, or somewhat excessive litter. In North American Pacific Salt Marsh, with 1–4 logs and snags exceeding 30 cm dbh and 2 m in length, and logs in various stages of decay.	The site contains essentially no significant amounts of coarse plant debris, and only scant amounts of fine debris. OR too much debris. In North American Pacific Salt Marsh, with logs and snags absent to rarely exceeding 30 cm dbh and 2 m in length, and logs in mostly early stages of decay.

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Vegetation (Biota) (cont.)	Vegetation Composition	2, 3	C	Vegetation is at or near reference standard condition in species present and their proportions. Lower strata composed of appropriate species, and regeneration good. Native species sensitive to anthropogenic degradation are present, functional groups indicative of anthropogenic disturbance (ruderal or "weedy" species) are absent to minor, and full range of diagnostic/indicator species are present.	Vegetation is close to reference standard condition in species present and their proportions. Upper or lower strata may be composed of some native species reflective of past anthropogenic degradation (ruderal or "weedy" species). Some indicator/diagnostic species may be absent.	Vegetation is different from reference standard condition in species diversity or proportions, but still largely composed of native species characteristic of the type. This may include ruderal ("weedy") species. Regeneration of expected native trees may be sparse. Many indicator/diagnostic species may be absent.	Vegetation severely altered from reference standard in composition. Expected strata are absent or dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species. Regeneration of expected native trees minimal or absent. Most or all indicator/diagnostic species are absent.
	Relative Total Cover of Native Plant Species	2, 3	C	>99% relative cover of native plant species	97–99% relative cover of native plant species	90–96% relative cover of native plant species	D: 50–89% relative cover of native plant species E: <50% relative cover of native plant species
	Invasive Exotic Plant Species	2, 3	C	No key invasive exotic species present in area	Total abundance of key invasive exotic species less than 3%	Total abundance of key invasive exotic species 3–5%	Total abundance of key invasive exotic species greater than 5%
	Biotic Condition Stressors Checklist	2	S				

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TABLE 10B (continued from previous page)

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Hydrology	Water Source	2		Water source for site is precipitation, groundwater, tidal, natural runoff from an adjacent freshwater body, or system naturally lacks water in the growing season. There is no indication of direct artificial water sources. Land use in the local drainage area of the site is primarily open space or low density, passive uses. No large point sources discharge into or adjacent to the site.	Water source is mostly natural, but site directly receives occasional or small amounts of inflow from anthropogenic sources. Indications of anthropogenic input include developed land or agricultural land (<20%) in the immediate drainage area of the site, or the presence of small stormdrains or other local discharges emptying into the site, road runoff, or the presence of scattered homes along the wetland that probably have septic systems. No large point sources discharge into or adjacent to the site.	Water source is primarily urban runoff, direct irrigation, pumped water, artificially impounded water, or other artificial hydrology. Indications of substantial artificial hydrology include >20% developed or agricultural land adjacent to the site, and the presence of major point sources that discharge into or adjacent to the site.	Water flow exists but has been substantially diminished by known impoundments or diversions of water or other withdrawals directly from the site, its encompassing wetland, or from areas adjacent to the site or its wetland, OR water source has been several altered to the point where they no longer support wetland vegetation (e.g., flashy runoff from impervious surfaces).
	Hydroperiod–*All Non-riverine wetlands, except Bog & Fen*	2		Hydroperiod of the site is characterized by natural patterns of filling or inundation and drying or drawdown	The filling or inundation patterns in the site are of *greater* magnitude (and greater or lesser duration than would be expected under natural conditions, but thereafter, the site is subject to *natural drawdown or drying.*	The filling or inundation patterns in the site are characterized by *natural* conditions, but thereafter are subject to *more rapid or extreme drawdown or drying*, as compared to more natural wetlands, OR the filling or inundation patterns in the site are of substantially *lower magnitude or duration* than would be expected under natural conditions, but thereafter, the site is subject to *natural drawdown or drying*	Both the filling/inundation and drawdown/drying of the site deviate from natural conditions (either increased or decreased in magnitude and/or duration)

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Hydrology (cont.)	*Bog & Fen (non-riverine)*			Hydroperiod of the site is characterized by stable, saturated hydrology, or by naturally damped cycles of saturation and partial drying	Hydroperiod of the site experiences minor altered inflows or drawdown/ drying, as compared to more natural wetlands (e.g., ditching)	Hydroperiod of the site is somewhat altered by greater increased inflow from runoff, or experiences moderate drawdown or drying, as compared to more natural wetlands (e.g., ditching)	Hydroperiod of the site is greatly altered by greater increased inflow from runoff, or experiences large drawdown or drying, as compared to more natural wetlands (e.g., ditching)
	Salt Marsh, Mangrove			Estuary: Area is subject to the full tidal prism, with two daily tidal minima and maxima. Lagoon: Area subject to natural interannual tidal fluctuations (range may be severely muted or vary seasonally), and is episodically fully tidal by natural breaching due to either fluvial flooding or storm surge.	Estuary: Area is subject to reduced, or muted, tidal prism, although two daily minima and maxima are observed. Lagoon: Area is subject to full tidal range more often than would be expected under natural circumstances, because of artificial breaching of the tidal barrier.	Estuary: Area is subject to muted tidal prism, with tidal fluctuations evident only in relation to extreme daily highs or spring tides. Lagoon: Area is subject to full tidal range less often than would be expected under natural circumstances due to management of the breach to prevent its opening.	Estuary: Area is subject to muted tidal prism, plus there is inadequate drainage, such that the marsh plain tends to remain flooded during low tide. Lagoon: Area probably has no episodes of full tidal exchange.
	Riverine			Most of the channel through the site is characterized by equilibrium conditions, with no evidence of severe aggradation or degradation (based on the field indicators listed in metric protocol).	Most of the channel through the site is characterized by some aggradation or degradation, none of which is severe, and the channel seems to be approaching an equilibrium form (based on the field indicators listed in metric protocol).	There is evidence of severe aggradation or degradation of most of the channel through the site (based on the field indicators listed in metric protocol)	Concrete, or otherwise artificially hardened, channels through most of the site (based on the field indicators listed in metric protocol).

(Continued on next page.)

TABLE 10B (continued from previous page)

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Hydrology (cont.)	Hydrologic Connectivity– *All non-riverine wetlands, excluding Bogs and other isolated wetlands, Salt Marsh and Mangrove (see below)*	2	C	Rising water in the site has unrestricted access to adjacent upland, without levees, excessively high banks, artificial barriers, or other obstructions to the lateral movement of flood flows	Lateral excursion of rising waters in the site is partially restricted by unnatural features, such as levees or excessively high banks, but less than 50% of the site is restricted by barriers to drainage. Restrictions may be intermittent along the site, or the restrictions may occur only along one bank or shore. Flood flows may exceed the obstructions, but drainage back to the wetland is incomplete due to impoundment.	Lateral excursion of rising waters in the site is partially restricted by unnatural features, such as levees or excessively high banks, and *50-90%* of the site is restricted by barriers to drainage. Flood flows may exceed the obstructions, but drainage back to the wetland is incomplete due to impoundment.	All water stages in the site are contained within artificial banks, levees, sea walls, or comparable features, or *greater than 90%* of wetland is restricted by barriers to drainage. There is essentially no hydrologic connection to adjacent uplands.
	Bogs and other isolated wetlands				No connectivity	Partial connectivity. (e.g., ditching or where duripan is intentionally broken by drilling or blasting	Substantial to full connectivity
	Salt Marsh			Average tidal channel sinuosity >4.0; absence of channelization. Marsh receives unimpeded tidal flooding. Total absence of tide gates, flaps, dikes culverts, or human-made channels.	Average tidal channel sinuosity = 2.5–3.9. Marsh receives essentially unimpeded tidal flooding, with few tidal channels blocked by dikes or tide gates, and human-made channels are few. Culvert, if present, is of large diameter and does not significantly change tidal flow, as evidenced by similar vegetation on either side of the culvert.	Average tidal channel sinuosity = 1.0–2.4. Marsh channels are frequently blocked by dikes or tide gates. Tidal flooding is somewhat impeded by small culvert size, as evidenced by obvious differences in vegetation on either side of the culvert.	Average tidal channel sinuosity <1.0. Tidal channels are extensively blocked by dikes and tide gates; evidence of extensive human channelization. Tidal flooding is totally or almost totally impeded by tidal gates or obstructed culverts.

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Hydrology (cont.)	*Mangrove*			Excellent connectivity to other estuarine communities (e.g., marsh-mangrove, lagoon-bay estuaries, freshwater marshes) to ensure wide salinity gradients. Tidal flow is unimpeded.	Good connectivity to other estuarine communities (e.g., marsh-mangrove, lagoon-bay estuaries, freshwater marshes), with minimally reduced salinity gradients. Tidal flow is only minimally impeded by un-natural barriers.	Fair connectivity to other estuarine communities (e.g., marsh-mangrove, lagoon-bay estuaries, freshwater marshes) with moderately reduced salinity gradients. Tidal flow is moderately impeded by un-natural barriers.	Poor connectivity to other estuarine communities (e.g., marsh-mangrove, lagoon-bay estuaries, freshwater marshes) with little gradient in salinity. Tidal flow is extensively impeded by unnatural barriers.
	Riverine–Unconfined		C	Entrenchment ratio is >4.0. Completely connected to floodplain (backwater sloughs and channels).	Entrenchment ratio is 1.4–2.2. Minimally disconnected from floodplain by dikes, tide gates, elevated culverts, etc.	Entrenchment ratio is <1.4. Moderately disconnected from floodplain by dikes, tide gates, elevated culverts, etc.	Extensively disconnected from floodplain by dikes, tide gates, elevated culverts, etc.
	Riverine–Confined		C	Entrenchment ratio is >1.4	Entrenchment ratio is 1.0 –1.4	Entrenchment ratio is <1.0	—
	Upstream Surface Water Retention–*Riverine wetlands only?*	1	S	<5% of drainage basin drains to surface water storage facilities	>5–20% of drainage basin drains to surface water storage facilities	>20–50% of drainage basin drains to surface water storage facilities	>50% of drainage basin drains to surface water storage facilities
	Upstream/On-site Water Diversions–*Riverine wetlands only?*	1	S	No upstream, on-site or nearby downstream water diversions present	Few diversions present or impacts from diversions minor relative to contributing watershed size. On-site or nearby downstream diversions, if present, appear to have only minor impact on local hydrology.	Many diversions present or impacts from diversions moderate relative to contributing watershed size. Onsite or nearby downstream diversions, if present, appear to have a major impact on local hydrology.	Water diversions are very numerous or impacts from diversions high relative to contributing watershed size. Onsite or nearby downstream diversions, if present, have drastically altered local hydrology.
	Groundwater Diversions	1	S	Under development	Under development.	Under development	Under development
	Hydrologic Stressors Checklist	2	S				

(Continued on next page.)

TABLE 10B (continued from previous page)

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Soils (Physico-chemistry)	Physical Patch Types		C		Physical patch types typical of reference standard condition are present (see checklist).	Some physical patch types typical of reference standard condition are lacking (see checklist).	Many physical patch types typical of reference standard condition are lacking (see checklist).
	Water Quality	2	C	There is no visual evidence of degraded water quality. Wetland species that respond to un-naturally high nutrient levels are minimally present, if at all. Water is clear with no strong green tint or sheen.	Some negative water quality indicators are present, but limited to small and localized areas within the wetland. Wetland species that respond to unnaturally high nutrient levels may be present but are not dominant. Water may have a minimal greenish tint or cloudiness, or sheen.	Negative water quality indicators or wetland species that respond to unnaturally high nutrient levels are common. Wetland is not dominated by these vegetation species. Sources of water quality degradation are typically apparent. Water may have a moderate greenish tint, sheen or other turbidity with common algae.	Wetland is dominated by vegetation species that respond to unnaturally high nutrient levels or there is widespread evidence of other negative water quality indicators. Algae mats may be extensive. Sources of water quality degradation are typically apparent. Water may have a strong greenish tint, sheen or turbidity. The bottom will be difficult to see during the growing season. Surface algal mats and other vegetation block light to the bottom.
	Soil Surface Condition–*All freshwater wetlands*	2	C, S	Bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails	Some amount of bare soil due to human causes is present but the extent and impact is minimal. The depth of disturbance is limited to only a few inches and does not show evidence of ponding or channeling water. Any disturbance is likely to recover within a few years after the disturbance is removed.	Bare soil areas due to human causes are common and will be slow to recover. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts. Damage is not excessive and the site will recover to potential with the removal of degrading human influences and moderate recovery times.	Bare soil areas substantially degrade the site due to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded. The site will not recover without restoration and/or long recovery times.

Major Attribute	Metric Name	Tier	Metric Type	Metric Rating Criteria			
				Excellent (A)	Good (B)	Fair (C)	Poor (D)
Soils (Physico-chemistry) (cont.)	*Salt marsh and Mangrove*			Excluding mud flats, bare soils are limited to salt panes	Limited exposure of bare soils caused by erosion of marsh and channel banks due to excavation or marine traffic	Frequent exposure of bare soils caused by erosion of marsh and channel banks due to excavation by marine traffic [heavy animal grazing?]	Extensive bare soils caused by erosion of marsh and channel banks due to excavation by marine traffic [heavy animal grazing?]
	On-Site Land Use	2	S	Average Land Use Score = 1.0–0.95	Average Land Use Score = 0.80–0.95	Average Land Use Score = 0.4–0.80	Average Land Use Score = <0.4
	Soils (Physico-chemical) Stressors Checklist	2	S				

(End of Table 10B.)

Stressor Checklists

Stressor checklists can be useful as additional information when evaluating the ecological integrity of an occurrence. Typically, they are an aid to further understanding the overall condition of the wetland. In some cases, where stressors appear to be having a negative impact on the site, but the condition metrics do not reflect these impacts, it may lead to changes in the overall ecological integrity rank of a wetland. This should be done only in exceptional circumstances. The need for manual over-rides may suggest that the current condition metrics may be insensitive to degradation of certain stressors, and future adjustments to the metrics used may be needed. See also Appendix II for protocols in using the checklist.

TABLE 11

Stressor Checklist Worksheets for Assessment Area (site). Checklist adapted from Collins et al. (2006).

LANDSCAPE CONTEXT STRESSORS CHECKLIST	Present, but at low levels (<10% of stand or polygon)	Present at high levels (>10% of stand or polygon)
Urban residential		
Industrial/commercial		
Military training/air traffic		
Transportation corridor (paved roads, highways)		
Dryland farming		
Intensive row-crop agriculture		
Orchards/nurseries		
Dairies		
Commercial feedlots (high-density livestock)		
Ranching, moderate-density livestock (enclosed livestock grazing or horse paddock)		
Rangeland, low-density livestock (livestock rangeland also managed for native vegetation)		
Sports fields and urban parklands (golf courses, soccer fields, etc.)		
Passive recreation (bird-watching, hiking, etc.)		
Active recreation (off-road vehicles, mountain biking, hunting, fishing)		
Physical resource extraction, mining, quarrying (rock, sediment, oil/gas)		
Biological resource extraction (aquaculture, commercial fisheries, horticultural and medical plant collecting)		
Lack of appropriate treatment of invasive plant species in surrounding area		
Comments		

VEGETATION (BIOTA) STRESSORS CHECKLIST	Present, but at low levels (<10% of stand or polygon)	Present at high levels (>10% of stand or polygon)
Mowing, grazing, excessive herbivory (within occurrence)		
Excessive human visitation		
Predation and habitat destruction by non-native vertebrates, including feral introduced naturalized species, such as feral livestock, exotic game animals, pet predators (e.g., Virginia possum, oryx, pigs, goats, burros, cats, dogs)		
Tree/sapling or shrub removal (cutting, chaining, cabling, herbiciding)		
Removal of woody debris		
Lack of appropriate treatment of invasive plant species in the area		
Damage caused by treatment of non-native and nuisance plant species		
Pesticide application or vector control		
Lack of fire or too frequent fire		
Lack of floods or excessive floods for riparian areas		
Biological resource extraction or stocking (e.g., aquaculture, commercial fisheries, horticultural and medical plant collecting)		
Excessive organic debris (for recently logged sites)		
Other lack of vegetation management to conserve natural resources [please specify]		
Comments		

(Continued on next page.)

TABLE 11 (continued from previous page)

SOIL/SUBSTRATE STRESSORS CHECKLIST	Present, but at low levels (<10% of stand or polygon)	Present at high levels (>10% of stand or polygon)
Filling or dumping of sediment or soils (N/A for restoration areas)		
Grading/compaction (N/A for restoration areas)		
Plowing/discing (N/A for restoration areas)		
Resource extraction (sediment, gravel, mineral, oil and/or gas)		
Impact of vegetation management on soils/ substrate (e.g., terracing, pitting, drilling seed, chaining, root plowing)		
Excessive sediment or organic debris (e.g., excessive erosion, gullying, slope failure)		
Physical disturbance of soil/substrate by recreational vehicle tracks, livestock, logger skidding, etc.		
Pesticides or toxic chemicals (PS or non-PS pollution) (on-site evidence)		
Trash or refuse dumping		
Comments		

HYDROLOGY STRESSORS CHECKLIST	Present, but at low levels (<10% of stand or polygon)	Present at high levels (>10% of stand or polygon)
Point Source (PS) Discharges (POTW, other non-stormwater discharge)		
Non-point Source (Non-PS) Discharges (urban runoff, farm drainage onto site)		
Flow diversions or unnatural inflows (restrictions and augmentations)		
Dams (reservoirs, detention basins, recharge basins)		
Flow obstructions (culverts, paved stream crossings)		
Weir/drop structure, tide gates		
Dredged inlet/channel		
Engineered channel (riprap, armored channel bank, bed)		
Dike/levees		
Groundwater extraction (water table lowered)		
Ditches (borrow, agricultural drainage, mosquito control, etc.)		
Actively managed hydrology (e.g., lake levels controlled)		
Comments		

Scorecard Protocols for Level 2 Assessments

Point-Based Approach

Individual metrics can be aggregated to provide a rating of the condition of each major attribute — landscape context, vegetation, hydrology and soils (aggregating by key ecological attribute is typically not needed, as they often have only one or two metrics). The major attributes can be further aggregated into an overall Index of Ecological Integrity (IEI) rank. IEIs can be calculated at multiple scales (e.g., sample plot, polygon, occurrence, site, jurisdictional area), depending on the sampling design and the scale of the question. Here we focus on an assessment of an occurrence of a wetland type at a site.

A number of approaches for aggregating, or "rolling up" rapid-based field metrics are available, each with a variety of strengths and weaknesses. In a point-based approach, each metric is assessed independently, assigned a rating of a metric a consistent weight, regardless of the scores of other metrics (e.g., A = 5 points, B = 4 points, etc.), then added up the points across all metrics. In this sense it is a *non-interaction approach* (common to point-based methods).[1] Rules and weights can be added to account for some interactions. Point-based approaches have been widely used in biotic integrity assessments, and are appropriate when the scaling of the metrics is standardized to equate to have the same meaning based on use of reference condition (i.e., all D ratings for metrics equate to a system that is well outside the natural range of variation) (Karr and Chu 1999). Although many of our metrics are based on ordinal scales, which make it harder to combine metrics, they are more easily justified in terms of biological, ecological and mathematical criteria. That is, as stated by Sutula et al. (2006), "ordinal scales require only the ability to rank wetlands based on their relative similarity to the desired assessment endpoint without knowing precisely how close the condition is to that endpoint or to the next highest rating category." The key is to scale the ordinal values so that the full range of each of the metrics is indicating something comparable in terms of ecological integrity. Given that premise, it can be acceptable to use a relatively simple, point-based approach to both score and aggregate the metrics together, without developing any statistical applications. The overall interpretation should remain focused on the general ratings of A–D and not on the details of the points themselves (i.e., whether an A of 96 is better than an A of 90). In addition, the original metrics themselves are available to further explain the reasons for the aggregated scores.

When aggregating metrics or categories, one can simply calculate an arithmetic mean, which assumes that all categories have an equal weight and contribution to the overall integrity index. But, one could weight some metrics or categories more than others, so that they contribute an overall higher proportion of the total points to the final index. As noted above, another approach is to add some rules, so that specific combinations of metrics or categories define a particular level of integrity. The limitations of aggregating scores should always be kept in mind.

For the point-based approach developed here, the default set of points for the basic four category rating scheme are A = 5, B = 4, C = 3, D = 1. The weights are derived from Karr's Index of Biotic Integrity approach) (Karr and Chu 1999), where 5 (good),

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[1] An *interaction approach* allows the role of a metric to vary depending on other metrics. A set of combination rules or tables are established based on our best knowledge of the ecological interactions among metrics. The interactive approach typically uses a series of Boolean logic statements throughout (e.g., if metric 1 = A, metric 2 = B, etc., then the category rating = B). For example, in a forested system, the Vegetation attribute may be assessed using two metrics — ground layer plant species composition and canopy structure. Using the non-interactive, point-based approach, if the ground layer is rated B and canopy structure is rated D, the points might be added and averaged to give an overall category rating of C. Using the combination rule approach, the canopy structure metric may only count when ground layer composition has at least a C rating. That is, when the ground layer is dominated by exotics and assigned a D rating, the overall vegetation rating is based solely on the ground layer metric, regardless of whether the canopy structure is pole stage or old growth. Such approaches require good knowledge of the ecological relations among the metrics and their effect on ecological integrity.

3 (fair) and 1 (poor) points were used. Distinctions between excellent (A) and good (B) can be subtle, compared to the C/D break, so only a single point separates them. Some metrics have a five- or six-point rating scheme (A–E or A–F), and the points are then spread out evenly from 5 to 1. The metrics are rolled up into four categories (landscape context, biota, hydrology and physicochemistry condition), and in turn, these categories are rolled up into an overall Index of Ecological Integrity (see "Landscape Integrity of the Watershed" on page 6, and Table 5 on page 22).

Use of Range-Ratings when Assessing Metrics
The metrics may also be scored using "range ratings." That is, an assessor may not be able to decide between an A or a B rating for a metric. In this case, it may be best to assign an AB rating (that is, the rating may be either A or B). The low and high scores (e.g., A = 5, B = 4) will both be used in the calculation. When roll-ups to the four categories are completed, both the total low scores and high scores across the metrics are calculated, and if the final low and high score span two ratings, a range rating is assigned to the category. A similar approach can be used for the overall IEI. The use of range ratings should only be applied in cases of great uncertainty. Exact ratings are encouraged. But the range rating is helpful whenever rating proves challenging because of unusual situations in the field or assessor inexperience with a metric.

Role of Stressor Checklists
Typically, stressor checklists are used only for informative purposes, as an aid to further understanding the overall condition of the wetland. In some cases, where stressors appear to be having a negative impact on the site, but the condition metrics do not reflect these impacts, it may be important to over-ride the calculated IEI. This should only be done in exceptional circumstances. The need for manual over-rides may suggest that the current condition metrics may be insensitive to degradation of certain stressors, and future adjustments to the metrics used may be needed.

Weighting Metrics by Formation
Not all metrics are equally relevant to each formation. A metric such as Vegetation Structure has greater interpretive value for forested wetlands, where changes in structure can be linked to ecological integrity, than it does to freshwater marshes, where changes in structure are more subtle. Thus the rating protocols specified below may need to be varied by formation.

Landscape Context Rating Protocol
Rate the Landscape Context metrics according to their specified ratings (see Table 10B). Use the scoring table below to roll up the metrics into an overall Landscape Context rating.

Rationale for Scoring: Three factors are judged equally important.

Thus, the following weights apply to the Landscape Context metrics:

Landscape Context Rating Calculation						
Measure	A	B	C	D	Weight	Score (sum of weighted scores/ sum of weights)
Landscape Connectivity	5	4	3	1		
Buffer Index	5	4	3	1		
Surrounding Land Use	5	4	3	1		
Landscape Context Rating: A = 4.5–5.0, B = 3.5–4.4, C = 2.5–3.4, D = 1.0–2.4						Total = sum of N scores

Size Rating Protocol
Rate the Size metrics according to their specified ratings (see Table 10B). Use the scoring table below to roll up the metrics into an overall Size rating.

Rationale for Scoring: Absolute Size is always used as a metric, but Relative Size is optional. Even when used, it does not carry the same weight as absolute size. The focus is on current condition, not historic patterns per se.

Thus, the following weights apply to the Size metrics:

Size Rating Calculation						
Measure	A	B	C	D	Weight	Score (sum of weighted scores/ sum of weights)
Patch Size (ha)	5	4	3	1		
Patch Size Condition*		5	3	0.25		
Size Rating: A = 4.5–5.0, B = 3.5–4.4, C = 2.5–3.4, D = 1.0–2.4						Total = sum of N scores

* *optional metric*

Vegetation (Biota) Rating Protocol
Rate the Vegetation metrics according to their specified ratings (see Table 10B). Use the scoring table below to roll up the metrics into an overall Vegetation rating.

Rationale for Scoring: Each of the metrics is judged to be equally important as a measure of biotic integrity. Further work is needed to improve their evaluation in a rapid assessment.

Vegetation (Biota) Rating Calculation							
Measure	A	B	C	D	E	Weight	Score (sum of weighted scores/ sum of weights)
Vegetation Structure	5	4	3	1			
Organic Matter Accumulation (coarse and fine debris)		5	3	1			
Vegetation Composition	5	4	3	1			
Relative Total Cover of Native Plant Species	5	4	3	2	1		
Vegetation (Biota) Rating: A = 4.5–5.0, B = 3.5–4.4, C = 2.5–3.4, D = 1.0–2.4							Total = sum of N scores

Hydrology Rating Protocol
Rate the measures according to the metrics protocols (see Table 10B). Use the scoring table below to roll up the metrics into an overall Hydrology rating.

Rationale for Scoring: Each of the hydrologic metrics is judged to be equally important to the overall measure of hydrologic integrity.

Hydrology Rating Calculation						
Measure	A	B	C	D	Weight	Score (sum of weighted scores/ sum of weights)
Water Source	5	4	3	1		
Hydroperiod	5	4	3	1		
Hydrologic Connectivity	5	4	3	1		
Hydrology Rating: A = 4.5–5.0, B = 3.5–4.4, C = 2.5–3.4, D = 1.0–2.4						Total = sum of N scores

Soils (Physicochemistry) Rating Protocol

Rate the Physicochemistry metrics according to their specified ratings (see Table 10B). Use the scoring table below to roll up the metrics into an overall Physicochemistry rating.

Rationale for Scoring: The three metrics are judged to be equally important to the overall measure of physicochemistry integrity.

Soils (Physicochemistry) Rating Calculation						
Measure	A	B	C	D	Weight	Score (sum of weighted scores/ sum of weights)
Physical Patch Types		5	3	1		
Water Quality	5	4	3	1		
Soil Surface Condition	5	4	3	1		
Soils (Physicochemistry) Rating: A = 4.5–5.0, B = 3.5–4.4, C = 2.5–3.4, D = 1.0–2.4						Total = sum of N scores

Overall Index of Ecological Integrity Rank

Rate the overall ecological integrity of the occurrence based on the major categories (Landscape Context, Size, Biota, Hydrology and Physicochemistry Attributes). Use the scoring table below to roll up the metrics into an overall rating.

Overall EIA Rating Calculation						
Category	A	B	C	D	Weight	Score (sum of weighted scores/ sum of weights)
Landscape Context	5	4	3	1	1	
Size	5	4	3	1	0.5	
Vegetation (Biota)	5	4	3	1	1	
Hydrology	5	4	3	1	1	
Soils (Physico-chemistry)	5	4	3	1	0.5	
EIA Rating: A = 4.5–5.0, B = 3.5–4.4, C = 2.5–3.4, D = 1.0–2.4						Total = sum of N scores

Level 3 (Intensive Field-Based) Metrics for Wetlands

Based on the conceptual model developed above, we are in the early stages of compiling a list of indicators/metrics of integrity for each wetland type that covers the major attributes of hydrology, landscape context, size, vegetation, hydrology and soils (physicochemistry) (see Fig. 1). We have reviewed a variety of existing rapid and intensive wetland assessment and monitoring materials as well as draft reports for intensive wetland monitoring in the National Park Service Northeast Temperate Network (Mack 2001, Collins et al. 2006, Neckles et al. 2006, Faber-Langendoen et al. 2006).

Many researchers have approached the development of Level 3 assessments by focusing primarily on the vegetation. A vegetation index of biotic integrity is developed by sampling various attributes of the vegetation assemblage in wetlands exposed to varying degrees of human disturbance. An important component to VIBI is that it moves beyond the simple diversity approach to assessing the status of a vegetation community, which has been criticized as a method for assessing ecological condition.

The underlying assumption of the VIBI approach to wetland assessment is that vegetation effectively integrates the hydrological, physical, chemical and biological status of a wetland and thus provides a cost-effective and efficient method of assessing wetland integrity. Because of their ability to reflect current and historical ecological condition, plants are one of the most commonly used taxa for wetland bioassessment. In other words, if the chemical, physical and/or biological processes of an ecosystem have been altered, vegetation composition and abundance will reflect those alterations. In summary, the ecological basis for using vegetation as an indicator in wetlands is as follows (U.S. EPA 2002a, b, Rocchio 2007):

- Vegetation is known to be a sensitive measure of human impacts;
- Vegetation structure and composition provide habitat for other taxonomic groups such as waterbirds, migratory songbirds, macroinvertebrates, fish, large and small mammals, etc.;
- Strong correlations exist between vegetation and water chemistry;
- Vegetation influences most wetland functions;
- Vegetation supports the food chain and is the primary vector of energy flow through an ecosystem;
- Plants are found in all wetlands and are the most conspicuous biological feature of wetland ecosystems; and
- Ecological tolerances for many plant species are known and could be used to identify specific disturbances or stressors that may be responsible for a change in wetland biotic integrity.

Typical field methods to develop a Vegetation Index of Biotic Integrity include (Rocchio 2007):

- Developing a sampling design to assess all major wetlands types across varying degrees of human-induced disturbance.
- Scoring human disturbances at each site according to the type, severity and duration of human-induced alterations to the wetland and surrounding area's ecological processes.
- Choosing vegetation attributes which had strong discriminatory power and were strongly correlated to the human disturbance gradient as metrics for the VIBI.
- Scaling each metric's field values to a numeric score resulting in a standardized scoring system across all metrics.

The total VIBI score is derived by summing scores for all the metrics. There are an increasing number of VIBI studies being conducted. The increased precision and accuracy of these studies also makes them more applicable only within the region of study.

It is important to collect some hydrologic or soils data, in order to validate the integrative role that the VIBI has. Moreover, it is not always necessary to have the VIBI serve as a surrogate for the other major attributes. Metrics can also be developed for hydrology and soils. In these cases the VIBI's major function is to serve as an indicator of the biotic attributes of the wetland, rather than the entire set of ecological attributes.

Metrics for Level 3 Assessment

A synopsis of the ecological metrics and ratings is presented in Table 12. Our list is still preliminary but further development is beyond the scope of this report.

Protocols describing some of these metrics are provided in Appendix III.

TABLE 12

Examples of metrics applicable to intensive (Level 3) metrics for wetlands.

Major Attribute	Proposed Metric	Description
Landscape Context	Landscape connectivity Landscape integrity index	• Percent area of natural ecosystems in surrounding landscape • Anthropogenic stressor index based on % agriculture, % urban, human population density, road density, and % impervious surface
Size	Patch size	The area in hectares occupied by a wetland type
Vegetation	Vegetation Structure Vegetation Composition, Invasive Exotic Species Floristic Quality Assessment Vegetation Index of Biotic Integrity	Transect establishment and vegetation sampling
Hydrology	Groundwater level	Level of water in monitoring wells
	Surface water level	Level of water at deepest point in the wetland surrounding the monitoring wells
Soil (Physicochemistry)	Groundwater Conductivity Surface Water Conductivity	Conductivity for ground and surface water chemistry
	Temperature	Temperature for ground and surface water chemistry
	Groundwater pH Surface water pH	pH for ground and surface water chemistry

Procedures for Conducting Ecological Integrity Assessments

At this time we have not developed a formal set of procedures for conducting an ecological integrity assessment as it relates to mitigation. Further study is needed to provide such guidance. We provide a brief overview below of how such an assessment can be conducted.

The general procedure for using EIA Assessment consists of a series of steps (adapted from Collins et al. 2006, see Chapter 3):

Step 1: Assemble background information about the management and history of the wetland.
Step 2: Classify the wetland using the U.S. National Vegetation Classification, the NatureServe Ecological Systems, the Hydrogeomorphic Classification, and an appropriate state classification. State classifications that are crosswalked to the above classifications may give a ready answer for all classifications.
Step 3: Establish the landscape context boundary for the occurrence.
Step 4: Determine wetland size.
Step 5: Verify the appropriate season and other timing aspects of field assessment.
Step 6: Determine the boundary and estimate the size of the assessment area (if it is not the same as the wetland) and allocate observation points or plots, if plots or points are to be used.
Step 7: Conduct the office assessment of stressors, landscape context and on-site conditions of the wetland or assessment area.
Step 8: Conduct the field assessment of stressors and on-site conditions of the wetland or assessment area.
Step 9: Complete assessment scores and QA/QC procedures.
Step 10: Upload results into Biotics Database or other regional and statewide information systems.

Some Guidelines for Field Methods

At this time we have not developed a formal set of field methods for conducting an ecological integrity assessment as it relates to mitigation. Further study is needed to provide such guidance. We do provide a few guidelines below of how such an assessment can be conducted.

A few guidelines are provided for conducting Ecological Integrity Assessments:

1. Determine where the assessment areas or sites of a wetland type are and classify them using the NVC.

Wetlands will be classified using the U.S. National Vegetation Classification (FGDC 2007), Ecological Systems (Comer et al. 2003, NatureServe 2008), the Hydrogeomorphic type, and a state classification. For example, a local marsh occurrence along a river is identified as a Temperate & Boreal Freshwater Marsh formation. Knowing the formation will determine which metrics and ratings are used, and knowing the HGM class will determine which metric variant to use. That is, assessing the Landscape Connectivity metric of a freshwater marsh found along a river corridor (riverine HGM) requires a different form of the metric than for marshes found in depressions (depressional HGM).

2. The field data collection protocols should be fairly standard, regardless of the intent of the survey, since the fundamental metrics of the EIA need to be included. Protocols for how to measure the metrics are briefly described in Appendix II. These documentations will help inform the field data collection protocols. In many cases the metrics can be documented from remote sensing/aerial photo imagery; in other cases,

by walking an assessment area (site); yet in others, by taking a few relatively simple field measures.

3. Rapid field assessments should be able to be completed within two hours, plus two hours preparation time assessing the imagery (see #4 below). By and large, once the crew leaves the field, the field forms are essentially complete.

Field crew expertise should be akin to that needed for wetland delineation; that is, field crews should have some knowledge of hydrology, soils, and vegetation, sufficient to assess hydrologic dynamics, perhaps examine a soil core for mottling, and be able to identify all prominent exotic species in a region.

4. Field methods for applying ecological integrity assessments vary, depending on the purpose of the assessment. But several general comments can be provided, in the context of a rapid assessment.

First, it must be established what the "unit of observation" is. Most commonly, for ecological surveys, this is an occurrence of a wetland, at the scale of a site. We refer to this as the Ecological Assessment Area (EAA). Accordingly we may define the EAA as "the entire area, sub-area, or point of an occurrence of a wetland type."

If the occurrence at a site is the focus, then a sampling design could still vary as follows:

a) conduct an assessment survey of the entire area of the occurrence, e.g., a rapid qualitative assessment;
b) conduct an assessment survey of a typical sub-area(s) of the occurrence, or
c) collect a series of plots, placed either in representative or un-biased locations, throughout the entire area or sub-area occurrence.

In all three cases, the intent is to assess the ecological integrity of a particular wetland occurrence.

The focus of an EIA for mitigation purposes is primarily to assess the integrity of an occurrence at a site, irrespective of the property or management regime it may be found on, and however large it is. This area may be equivalent to a Project Assessment Area, (Hauer et al. 2002), or a Wetland Assessment Area, by many HGM manuals (Hauer et al. 2002), though those areas are determined by property lines or management areas.

5. Many of the metrics can be assessed, at least preliminarily, in the office, using remote sensing imagery. Many other additional sources of information can help determine the condition and threats to a site (see Rocchio 2007):

- Digital orthophoto quadrangles (1 m resolution)
- GIS layers (roads, utility lines, trails, mines, wilderness areas, National Land Cover Dataset, irrigation, ditches, groundwater wells, etc.)
- Element occurrence records from Natural Heritage Programs
- State or Federal agency surveys
- Soils map, etc,

6. It is usually helpful to map the extent of the occurrence as part of the field survey (see Rocchio 2007), using the following steps.

a) *Estimation of Wetland Boundaries*
The first step is to map the wetland area. Readily observable ecological criteria such as vegetation, soil and hydrological characteristics were used to define wetland boundaries, regardless of whether they met jurisdictional criteria for wetlands regulated under the Clean Water Act.

b) *Delineating Formation and Ecological System Boundaries*
The second step is to delineate the targeted type present within the wetland boundary. Formation and Ecological System descriptions can be used to guide a subjective determination of the target system's boundaries in the field. A minimum map size criteria should be specified, and each patch of a wetland type would be considered separate potential EAA or sub-EAA and thus as an independent sample. If a patch was less than its minimum size then it would be considered to be associated with internal variation of the type in which it is embedded.

c) *Size and Land Use Related Boundaries*
Once the targeted type boundaries are delineated, then size and land use can be used to further refine EAA boundaries. For example, depending on the size or variation of the wetland area, the EAA may consist of the entire site or only a portion of the wetland/riparian area. For small wetlands or those with a clearly defined boundary (e.g., isolated fens or wet meadows) this boundary was almost always the entire wetland. In very large wetlands or extensive and contiguous riparian types, a sub-sample of the area can be defined as the EAA for the project. For other project purposes such as regulatory wetland projects, there may be multiple EAAs in one large wetland.

Significant change in management or land use can result in distinct ecological differences. Some examples follow:

i. A heavily grazed wetland on one side of a fence line and ungrazed wetland on the other would result in two subunits of EAAs.
ii. Natural changes in hydrology could also be the basis for a separate assessment. For example, a drastic change in water table levels or fluctuations, confluence with a tributary, etc., would dictate at least a separate set of sub-EAAs.
iii. Anthropogenic changes in hydrology. For example, ditches, water diversions, irrigation inputs, roadbeds, etc., that substantially alter a site's hydrology relative to adjacent areas would dictate at least a separate set of sub-EAAs.

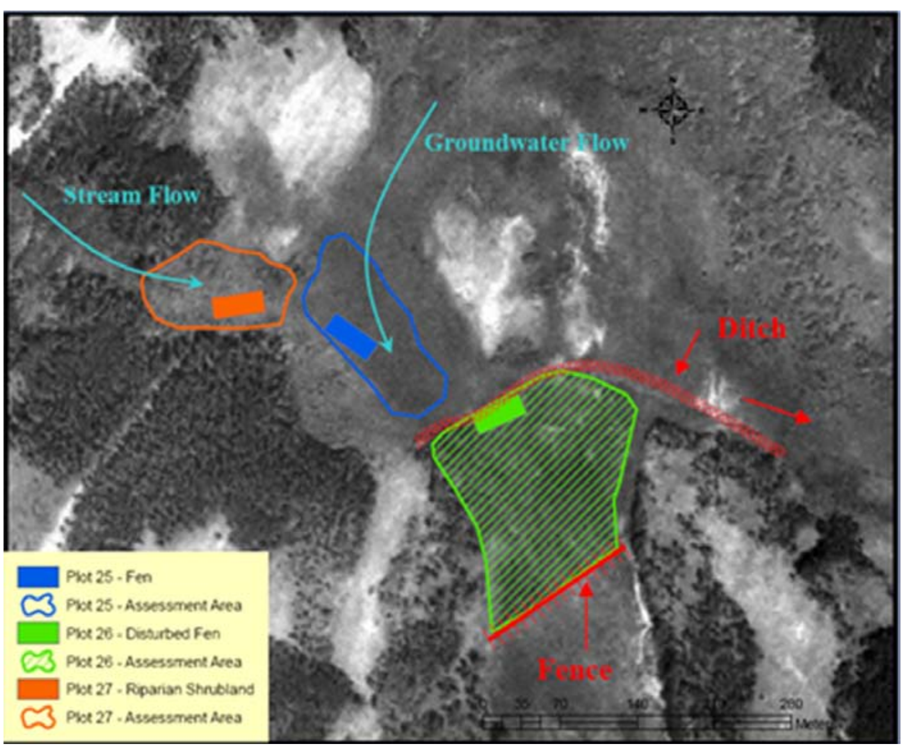

FIGURE 7
Examples of delineated Ecological Assessment Areas (EAAs). Although contiguous with each other, the fen and the riparian shrubland were delineated as distinct EAAs because they were distinct ecological system types (i.e., fen vs. riparian shrubland). The fen was divided into sub-EAAs due to a human-induced disturbance (e.g., ditch) which significantly altered a large portion of an otherwise contiguous wetland type (e.g., intact vs. disturbed fen) (adapted from Rocchio 2007).

7. Vegetation plots can be subjectively placed within the EAA to maximize abiotic/biotic heterogeneity within the plot. Capturing heterogeneity within the plot ensures adequate representation of local, micro-variations produced by such things as hummocks, water tracks, side-channels, pools, wetland edge, micro-topography, etc., in the floristic data. Plots can also be placed objectively, if enough plots are laid.

The following guidelines can be used to determine plot locations within the EAA (adapted from Mack 2004, Rocchio 2007).

- The plot can be located in a representative area of the EAA which incorporated as much micro-topographic variation as possible; or a series of unbiased plots can be located in the EAA or sub-EAA.
- If a small patch of another wetland type is present in the EAA (but not large enough to be delineated as a separate ecological system type), a plot can be placed so that at least a portion of the patch is in the plot.
- Uplands should be excluded from plots; however, mesic micro-topographic features such as hummocks, if present, can be included in the plots.
- Localized, small areas of human-induced disturbance can be included in the plot according to their relative representation of the EAA. Large areas of human-induced disturbance should be delineated as a separate sub-EAA.

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Appendices are provided in a separate document.

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Wetland Mitigation in Washington State
Part 1: Agency Policies and Guidance

Washington Department of Ecology

US Army Corps of Engineers
Seattle District

Environmental Protection Agency
Region 10

Version 1, March 2006
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Wetland Mitigation in Washington State
Part 1: Agency Policies and Guidance

Version 1, March 2006
Publication # 06-06-011a
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This document is available on the Department of Ecology Wetlands web site (Mitigation Guidance Revisions) at www.ecy.wa.gov/biblio/0606011a.html. See this web page for instructions on receiving a printed copy.

This document updates and replaces the portions of the 1997 Ecology publication, *How Ecology Regulates Wetlands* (McMillan 1998), pertaining to wetland mitigation.

For *Part 2 - Developing Wetland Mitigation Plans* refer to publication #06-06-011b. Part 2 replaces and expands on the 1994 *Guidelines for Freshwater Mitigation Plans and Proposals* (Ecology 1994).

Make sure you have the most recent version of this document

Due to the dynamic nature of wetland science and regulatory frameworks, the guidance found in this document is subject to revision. Make sure you have the most recent version, plus any addendums. You can find the most up-to-date version at: http://www.ecy.wa.gov/biblio/0606011a.html. The document can also be found via the Seattle Corps Regulatory Branch and EPA Region 10 Wetlands home page (see *On-Line Resources*).

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Table of Contents

List of Acronyms and Abbreviations

BAS . . . . Best Available Science

CFR . . . . Code of Federal Regulations

Corps or USACE . . . United States Army Corps of Engineers

CWA . . . . Clean Water Act (formerly known as Federal Water Pollution Control Act)

Ecology . . . . Washington State Department of Ecology

ESA . . . . Endangered Species Act

EPA . . . . United States Environmental Protection Agency

FR . . . . Federal Register

HGM . . . . Hydrogeomorphic

ILF . . . . In-Lieu Fee

NMFS . . . . National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service

NWP . . . . Nationwide Permit

PCC . . . . Prior Converted Cropland

RCW . . . . Revised Code of Washington

SEPA . . . . State Environmental Policy Act

USC . . . . United States Code

USFW . . . . United States Fish and Wildlife Service

WAC . . . . Washington Administrative Code

WDFW . . . . Washington State Department of Fish and Wildlife

WDNR . . . . Washington Department of Natural Resources

WSDOT . . . . Washington State Department of Transportation

§ . . . . Section (e.g., Section 404 of the CWA)

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We'd like to thank all of those who helped develop this document, including the members of the Agency Advisory Team. Others, including wetland consultants and local government staff also provided much needed input. Thanks to their help, we hope that this document will prove valuable to both wetland professionals and those simply seeking a basic understanding of wetland mitigation in Washington State.

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This document was written by the Project Team of the Washington State Department of Ecology's Wetland Section with contributions from the Agency Advisory Committee. In addition, Gail Terzi, Joan Cabreza, and David Martin contributed to significant portions of the document. Dana Mock performed the critical role of managing the project as well as writing and editing portions of the document.

We especially would like to thank all those who took time out of their very busy schedules to respond to the agencies' requests for comments on this document. Please refer to Appendix A for a list of the individuals and organizations that reviewed the document and provided comments. Their suggestions and materials have greatly improved this document.

Thanks to all those who attended the focus groups and provided input on what technical and policy issues should be addressed or clarified and what tools would be desirable for reviewing, approving, writing, or implementing mitigation plans. Also, thanks to all those who attended the public meetings during the public-review period for the draft.

This project could not have been completed without the support and expertise of Ecology's Wetlands Technical Advisory Group. Please see Appendix C where they are listed. We would like to especially thank Tom Hruby for his review of the numerous drafts and his technical expertise, Richard Robohm for his thoughtful review and editing of Part 1, Teri Granger for her help in editing and reorganizing the document, and Erik Stockdale, Kim Harper, and Laura Casey for their technical contribution to portions of Part 2. In addition we would like to thank staff from the Washington Department of Transportation Wetland Mitigation Technical Group for their practical input on mitigation.

Key Messages

The U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology (the agencies) developed this two-part document cooperatively. This guidance aims at improving the quality and effectiveness of compensatory mitigation in Washington State.

Part 1, *Agency Policies and Guidance,* provides a brief background on wetlands, an overview of the factors that go into the agencies' permitting decisions, and detailed guidance on the agencies' policies on wetland mitigation, particularly compensatory mitigation. It outlines the information the agencies use to determine whether specific mitigation plans are appropriate and adequate. Part 2, *Developing Mitigation Plans,* provides technical information on preparing plans for compensatory mitigation.

Wetland mitigation is usually implemented as a sequence of steps or actions (i.e., mitigation sequencing). Compensatory mitigation is the step in the mitigation sequence that occurs after avoidance and minimization. It involves restoring (re-establishing, rehabilitating), creating (establishing), enhancing, or preserving wetlands to replace those lost or degraded through permitted activities.

Several key messages have emerged in reviewing the success of wetland compensatory mitigation in the last two decades. The single most important message is that compensatory mitigation should make ecological sense in the context of the landscape in which it is conducted. This entails using information about the landscape when making decisions about the type, location, and design of compensatory mitigation. Landscape information may include data accessed through geographic information systems and resource inventories, as well as local or regional plans that were developed using such information. This includes watershed, sub-basin, community, and restoration plans that are based on scientific information. These should be consulted when developing compensatory mitigation projects.

The following points should be considered when selecting, designing, and implementing compensatory mitigation to ensure that it is appropriate and complies with agency policies.

Consult With the Agencies If Proposed Work May Affect Wetlands

If your project may affect a wetland, contact your local government, the Corps, and Ecology before you begin work. The agencies, not applicants or their consultants, have the authority to determine whether or not a wetland is subject to any regulations. See Appendix C for agency contacts.

Apply Mitigation Sequencing

Applicants who propose to alter wetlands must apply mitigation sequencing before determining whether compensatory mitigation is appropriate. They must first avoid and minimize impacts to wetlands and their buffers as much as practicable before proposing compensation for the impacts.

A Conceptual Mitigation Plan is Highly Recommended

An applicant can save time and money by developing a conceptual approach to mitigation, including multiple options for how to compensate for an impact. Arrange a pre-application meeting with agency staff and present the conceptual mitigation plan. Get feedback from agency staff early before developing a final mitigation plan.

Assess Functions

If impacts are unavoidable and compensation is required, the agencies typically ask for an assessment of wetland functions to determine the most appropriate compensation for the impacts. An assessment of functions at the proposed compensation site (both before and after mitigation actions are completed) is usually required to determine the relative level of functions that would be provided as compensation.

Compensate for What Has Been Lost

Sites to be used for compensatory wetland mitigation should be designed to replace lost acreage and/or functions and to be sustainable in the landscape. Requirements for compensation are commensurate with the level and degree of impact.

Mitigation Area Required Is Generally Greater than the Area of Impact

Because of the length of time it takes to successfully create, restore, or enhance a wetland and due to the poor track record of compensatory mitigation, the agencies typically require greater acreage of mitigation to compensate for what was lost. Mitigation ratios provide guidance while specific requirements for compensation are determined by the agencies on a case-by-case basis.

Consider the Landscape

Land uses and the geomorphic setting of a landscape will influence how wetlands and sites used for mitigation perform functions. As a result, available information on the landscape and environmental (landscape) processes (e.g., surficial geology, hydrologic processes) should be used when selecting and designing mitigation sites.

Consider the Source of Water

Water is the most critical environmental variable in selecting and designing a wetland mitigation site. Available information on the source of water should therefore be used when selecting and designing them. Failure to establish an adequate and self-sustaining source of water is a major reason why wetland mitigation projects are unsuccessful.

On-Site Mitigation Isn't Always the Best Choice

Compensating for lost or degraded wetlands on-site is not always the best option. Preference should be given to a site that provides the highest ecological benefits, whether on-site, off-site, in-kind, or out-of kind. Compensatory mitigation projects that contribute to the functioning of a larger landscape are preferable to simply replacing acreage at the site of the impact.

Restore Wetlands and Environmental Processes When Possible

Re-establishment and rehabilitation are the preferred approaches for compensatory mitigation when available. Applicants should strive to compensate for wetland area and/or functions through re-establishment, rehabilitation, or creation before considering the use of enhancement or preservation.

Provide Adequate Buffers

Buffers are important to protect the functions provided by wetlands. They reduce the adverse impacts of adjacent land uses and provide important habitat for wildlife. The width of a buffer is based on the minimum distance necessary to protect the most sensitive functions provided by the wetland. Compensatory mitigation sites need buffers to adequately protect expected functions at the site.

A Mitigation Plan is the Document Agencies Rely on to Evaluate a Mitigation Project

Generally, mitigation plans should describe the rationale for the site selected, the project's goals and objectives, performance standards, construction specifications, monitoring and maintenance protocols, buffers, and mechanisms for long-term protection. Part 2 describes in detail what should be included in a mitigation plan.

Legal Requirements Change Over Time

Please contact the agencies and check the following web page for the most up-to-date guidance: A link to the document can also be found via the Seattle Corps Regulatory Branch and EPA Region 10 Wetlands home page (see *On-line Resources*).

Chapter 1 - Introduction to the Document

This document is the product of a joint effort between the Washington State Department of Ecology (Ecology), the Seattle District of the United States Army Corps of Engineers (Corps), and Region 10 of the United States Environmental Protection Agency (EPA), herein called the agencies. The agencies provide this guidance to help the regulated community comply with environmental laws and policies and to improve the quality and effectiveness of mitigation in Washington State.

Part 1 of this two-part document includes the following:

- A brief background on wetlands.
- Overview of the wetland regulatory process and requirements for wetland mitigation.
- Definitions and descriptions of *compensatory mitigation* types and approaches.
- Guidance on key decisions about mitigation such as buffers and the location, type, and amount of compensatory mitigation.
- Discussion of other considerations when mitigating for impacts to wetlands.

Part 1 replaces the portions of the 1997 Ecology publication, *How Ecology Regulates Wetlands* (McMillan 1998), pertaining to wetland mitigation.

Technical information needed for preparing compensatory mitigation plans is provided in Part 2 (*Developing Mitigation Plans*). Part 2 updates and replaces the 1994 *Guidelines for Developing Freshwater Mitigation Plans and Proposals* (Ecology 1994).

Clarification of Mitigation Terms

"Mitigation" literally means to reduce the severity of an action or situation.

"Wetland mitigation" is usually implemented as a sequence of steps or actions in order to reduce impacts to wetlands. So, *mitigation sequencing* refers to the prescribed order of the different mitigation steps (see Section 3.5.1, *Mitigation Sequencing*).

Wetland *compensatory mitigation* is the stage of the mitigation sequence, where impacts to wetland functions are offset (i.e., compensated for) through creation (establishment), restoration (re-establishment, rehabilitation), enhancement, or preservation of other wetlands. Because regulatory requirements and policies tend to focus on compensatory mitigation, the term "mitigation" is often used to refer to compensation, which is just one part of the overall mitigation sequence.

Throughout this document the term "mitigation" is used interchangeably with the term "compensation" unless referring to the entire mitigation sequence (i.e., "mitigation site," "compensatory mitigation site," or "compensation site" refers to the site that is being used for compensation).

1.1 Organization

The rest of this chapter discusses the purpose of the document and provides background information and an overview of recent changes in how wetland mitigation is viewed and practiced. Chapter 2, *Background on Wetlands*, discusses wetlands and their functions, the importance of water, and wetlands as part of the landscape. The contents of Chapter 3, *Overview of the Wetland Regulatory Process*; Chapter 4, *Approaches to Compensatory Mitigation*; and Chapter 5, *Types of Wetland Compensatory Mitigation*, are indicated by their titles. Chapter 6, *Determining Appropriate and Adequate Compensatory Mitigation*, provides detailed agency guidance on key mitigation decisions such as buffers and the location, type, and amount of compensatory mitigation. Chapter 7, *Other Mitigation Considerations*, discusses such things as stormwater issues related to wetland mitigation and agency policies on invasive species.

This document ranges from basic principles of wetland mitigation to more detailed information and guidance for wetland professionals. The guidance is general to allow for site-specific flexibility, and project-specific mitigation requirements may supersede this general guidance. Because wetland science and regulations change over time, the guidance is subject to revision. Make sure you have the most recent version of this document and any addenda (find the most up-to-date version at http://www.ecy.wa.gov/programs/sea/wet-updatedocs.htm or via the Seattle Corps Regulatory Branch and EPA Region 10 Wetlands home page [see *On-Line Resources*]).

> Part 2 provides technical information and guidance on developing wetland mitigation projects and plans anad documenting mitigation performance.

Links to on-line references

The document contains many references to additional sources of information pertinent to wetland mitigation. If connected to the Internet use the external hyperlinks to referenced documents. Just press the CTRL key and click on the link.

See the *On-Line Resources* and *References* sections at the end of the document for a list of Internet addresses and references for hyperlinked documents.

Glossary

The first time a term defined in the glossary is used in a chapter it will be *italicized.* It may or may not be defined in the text. If not, go to the *Glossary* at the end of the document.

“Best Available Science” for Wetlands

Ecology and the Washington Department of Fish and Wildlife (WDFW) completed two documents in 2005 that compiled and synthesized the current science on freshwater wetlands and made recommendations for managing wetlands based on that scientific information (the documents are sometimes referred to as the “Best Available Science” for freshwater wetlands).

Wetlands in Washington State – Volume 1: A Synthesis of the Science (Sheldon et al. 2005)

Wetlands in Washington State – Volume 2: Guidance for Protecting and Managing Wetlands (Granger et al. 2005)

There are numerous references to these documents throughout the text. These documents can be found at http://www.ecy.wa.gov/programs/sea/bas_wetlands.

1.2 Background of the Document

In 1994, the Seattle District of the Corps, Ecology, Region 10 of the EPA, WDFW, and the U.S. Fish and Wildlife Service (USFWS) jointly published the *Guidelines for Developing Freshwater Mitigation Plans and Proposals* (Ecology 1994). Subsequently, Ecology published *How Ecology Regulates Wetlands* (McMillan 1998).

Over the past decade numerous studies of wetland mitigation have been conducted. By 2002 it had become clear that the documents cited above no longer reflected the current scientific information and policies being used by the agencies. Many studies have revealed that mitigation continues to have significant shortcomings. Recent research (Johnson et. al 2000 and 2002) suggests that the State of Washington is still experiencing a net loss of wetland acreage and functions due to failure of mitigation projects to adequately compensate for permitted impacts to wetlands. However, these studies (and others elsewhere in the U.S.) suggested several actions that could substantially improve the success of wetland mitigation. These include better site selection and design and more consistent compliance monitoring and *adaptive management*. For more information on the studies and their recommendations, see Chapter 6 of *Wetlands in Washington State - Volume 1: A Synthesis of the Science* (Sheldon et. al 2005).

In response to these studies, Ecology, the Corps, and EPA began a process to update and improve their guidance on wetland mitigation. The agencies held two public meetings and met with the Washington State Department of Transportation’s compensatory mitigation technical group to gather suggestions and new information for the updated guidance. The agencies drew on the experience of staff from natural resource agencies and evaluated information from Ecology’s *Washington State Wetland Mitigation Evaluation Study* (Johnson et. al 2000 and 2002), Ecology’s “Best Available Science” for freshwater wetlands project (Sheldon et. al 2005, Granger et. al. 2005), a study by the National Academy of Sciences (NAS) called *Compensating for Wetland Losses under the Clean Water Act* (National Research Council 2001), and other research. The agencies also received many comments via the Internet and e-mail. The result is this substantially revised and expanded guidance.

1.3 Purpose of the Document

Ecology, the Corps, and EPA (the agencies) developed this document to clearly outline the agencies' requirements and expectations for wetland mitigation, particularly compensatory mitigation. This guidance does not itself set new requirements for wetland mitigation. Rather, it compiles current scientific information and incorporates the many changes in mitigation policy that have occurred in recent years. It also outlines how the agencies make permit decisions with regard to mitigation.

This guidance was prepared as part of the National Wetlands Mitigation Action Plan[1], which stems from the recommendations of the 2001 NAS study mentioned above. The plan aims at advancing the success of compensatory mitigation nationwide and improving the consistency of mitigation policy and requirements among the regulatory agencies. This guidance is consistent with the plan's *Model Compensatory Mitigation Plan Checklist*, national guidance on *Incorporating the National Research Council's Mitigation Guidelines Into the Clean Water Act Section 404 Program* (see Appendix B), and guidance from the Corps (e.g., Regulatory Guidance Letter (RGL) 02-02, *Guidance on Compensatory Mitigation Projects for Aquatic Resource Impacts Under the Corps Regulatory Program Pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899*[2]*)*.

The Corps and EPA regulations (33 CFR 320-331 and 40 CFR 230) and Ecology law and regulations (Chapter 90.48 RCW and Chapter 173-201A WAC) authorize these agencies to require compensatory mitigation for unavoidable impacts to wetlands and other waterbodies defined as *waters of the United States* or *waters of the state*. The agencies have noted the problems with past compensatory mitigation projects and are committed to improving the quality and success of future compensatory mitigation. *Wetland Mitigation in Washington State* will help the regulated public meet the mitigation requirements for federal and state permits and help ensure that future mitigation projects successfully compensate for lost or degraded wetland functions.

This document focuses on mitigation for impacts to freshwater wetlands

While both parts of this guidance focus on freshwater wetlands, some of the topics (such as the basic requirements for a mitigation project, mitigation sequencing, and compensating for area and/or functions) are relevant to estuarine and tidal wetlands. The guidance can apply generally to federal regulation of other *aquatic resources*, such as streams and upland buffers associated with these resources (see Section 7.1, *Compensatory Mitigation and Other Aquatic Resources*). Contact the agencies if you have questions about how this guidance might apply to a particular project (see Appendix C, *Agency Contacts*).

1 More information on the National Wetlands Mitigation Action Plan can be found at: http://www.mitigationactionplan.gov/.

2 RGL 02-02 can be found on-line at: http://www.usace.army.mil/inet/functions/cw/hot_topics/RGL_02-2.pdf

What are the objectives of this document?

The agencies developed this guidance to:

- Improve the quality and effectiveness of compensatory mitigation in Washington State.
- Provide more predictability by clearly outlining the requirements of state and federal agencies for compensatory mitigation.
- Provide guidance on compensatory mitigation that is consistent among several federal and state agencies in Washington (Corps, EPA, and Ecology) that regulate wetlands.
- Provide guidance on compensatory mitigation that is based on "Best Available Science" (BAS).
- Provide guidance that local governments can use to develop consistent mitigation requirements as they update their wetland regulations to include BAS under the Growth Management Act.
- Provide guidance in a format that is user-friendly, easy to update, and web-accessible.

This guidance will help in developing mitigation proposals for impacts to wetlands (primarily for individual projects) authorized under Section 404 of the Clean Water Act (33 USC § 1344) or the State of Washington's Water Pollution Control Act (Chapter 90.48 RCW).

Highlights of this guidance compared to previously published guidance?

- This guidance replaces and expands on the 1994 *Guidelines for Freshwater Mitigation Plans and Proposals* (Ecology 1994), with more details on environmental considerations for mitigation planning. The old document consisted of only an annotated outline of what should be in a mitigation plan. Part 2 of this document has an updated version of that outline.
- Previous guidance documents were published separately by the agencies. This document is a joint document, to provide guidance that is consistent among the Corps, Ecology, and EPA.
- This document incorporates key findings and recommendations related to mitigation policy. Examples include:
  - There has been a shift away from <u>always</u> requiring "on-site and in-kind" mitigation and having that preference drive site design (see Section 6.3, *Choosing the Location and Type of Compensatory Mitigation*). As a result, the recommended approach to compensation is to do what makes the most ecological sense and has the greatest potential to replace or improve upon what is being lost, especially in a landscape context.
  - Mitigation for individual projects often has not utilized landscape-scale information. If a watershed plan exists in the area of project development, considering the plan in site selection should be a priority.

- This document incorporates current scientific information related to technical approaches to mitigation. Examples include:
  - The emphasis of mitigation designs should be shifted from excessive engineering to designs that make ecological sense and are self-sustaining (i.e., long-term maintenance should not be required). This includes assuring that there is an ample and stable supply of water for the wetlands, that *invasive species* are minimized, and that the design is appropriate for its landscape location.
  - The emphasis of mitigation designs should be shifted from climax communities and complex planting schemes to paying attention to the basic principles of plant succession and keeping the planting scheme simple (see Part 2 for more discussion of vegetation).
  - The emphasis of mitigation designs should be on restoring environmental processes rather than structure.

The following section discusses in detail how some of the changes of the last decade have affected mitigation.

1.4 Changes in Wetland Mitigation

The practice of mitigating for impacts to wetlands has long been considered a mixture of science and art. The need to replace wetland functions lost to growth and development has always outpaced the scientific understanding of how wetlands function and how functions can be maintained or replaced. Scientists, landscape architects, consultants, and regulators have worked together for many years to develop ways to restore, create, or enhance wetlands to make up for those lost to human actions. However, virtually every study of wetland mitigation over the past two decades has shown that efforts to replace lost wetland acreage and functions have fallen short.

The recent evaluation by the National Academy of Sciences (National Research Council 2001), as well as detailed studies in Washington, confirms the results of past studies. However, it is believed that the overall success of wetland compensatory mitigation can be significantly improved. For one thing, there are examples of successful mitigation projects that can be emulated. For another, a growing understanding of how wetlands interact with landscape-scale processes has changed how the agencies look at mitigation.

The literature suggests many ways to improve compensatory mitigation:

- Use a landscape-scale approach to improve site selection.
- Improve goals, objectives, and performance standards so that they are measurable, meaningful, achievable, and enforceable.
- Increase maintenance and monitoring.
- Increase follow-up and enforcement.

For more information see *Wetlands in Washington State – Volume 1*: *A Synthesis of the Science* (Sheldon et al. 2005), Section 6.10.

Although wetlands are connected to and interact with a larger landscape, most regulatory programs and mitigation decisions have focused on individual sites, unrelated to the rest of the landscape (see Section 2.3, *Wetlands as Part of the Landscape*). This site-scale approach results in fragmented wetland systems, disconnected from other habitats and the processes that maintain them in the larger landscape. Wetland scientists, policy-makers, regulators, and the regulated community are working together to develop approaches that reflect an understanding of landscape-scale processes. Mitigation projects that are located and designed this way will provide targeted functions that are sustainable. This holds great promise for more effective, efficient, and cost-effective mitigation of wetland impacts. For more information on approaches to compensatory mitigation, see Chapter 4.

New tools have been developed for assessing wetland functions. *Function assessments* are critical to deciding where to locate and how to design mitigation projects that can replace the functions being lost to development. Monitoring and maintenance are improving and new techniques of adaptive management are being introduced that will help improve on past practices. It is now better understood that successful mitigation requires a big investment of time and energy by applicants, their consultants, and the agencies to monitor and maintain wetland mitigation sites as they develop. Simply digging a hole, putting plants in the ground, watching it for a few years, and walking away simply does not work. Mitigation sites require more care and feeding for more time than was once thought. At the same time, the agencies are learning to be more realistic about what can be achieved, and to understand the limitations on what can develop in a given time.

Despite these advances in our understanding of wetland ecology and compensatory mitigation, the agencies cannot offer a cookbook approach to mitigating wetland impacts. With so many factors and such a variety of situations, the agencies must still make many site-by-site and case-by-case decisions. To provide greater consistency for applicants who must navigate a maze of laws, policies, and science, the agencies have tried to provide some sideboards. The agencies hope this guidance will steer applicants toward proposals that merit timely approval from federal and state regulatory agencies and that succeed at compensating for lost or degraded wetland functions.

Chapter 2 - Background on Wetlands

2.1 Wetlands and Their Functions

Wetlands are transitional areas between upland and aquatic environments where water is present long enough to form distinct soils and where specialized, water-tolerant plants grow. Several definitions of wetlands have been developed over the years. The National Academy of Sciences provided what they call a "reference definition": "A wetland is an ecosystem that depends on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical and biological features reflective of recurrent, sustained inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where specific physiochemical, biotic, or anthropogenic factors have removed them or prevented their development."

A wetland function is something that a wetland does, regardless of whether it is valued by society or not. Wetland functions are often grouped into three broad categories:

- Improving water quality (i.e., the functions that trap and transform pollutants through biological, geological, and chemical processes).
- Maintaining the *water regime* (or *hydroperiod*) in a watershed (i.e., reducing peak flows and recharging groundwater).
- Habitat (i.e., supporting food webs and habitat for wildlife).

Not all wetlands perform all functions and wetlands provide functions to varying degrees (Novitzki et al. 1996). For example, a wetland with organic or clay soils may retain more heavy metals or toxic organic chemicals than wetlands without those types of soils. A *depressional wetland* without an outlet will remove sediment, nutrients, and toxicants more effectively than a wetland on a slope.

A wetland value, sometimes called a social function, is something that benefits, is worthwhile, or desirable to society (Novitzki et al. 1996). The value to society of each wetland function may vary. If a wetland provides habitat for birds, its value to society may be the opportunities it provides for bird watching or hunting. Society values the ability of wetlands to reduce peak flows during flood events. In an urban center, recreation and open space may be important; in an area prone to flooding, the flood-attenuation functions may be highly valued. In addition, the functions performed by a wetland and society's value of them are also relative to the landscape context in which they perform the functions (see Section 2.3, *Wetlands as Part of the Landscape*).

For a more detailed description of functions, see Part 2, Appendix I (*List and Description of Functions*) or Chapter 2 of *Wetlands in Washington State – Volume 1* (Sheldon et. al 2005).

2.2 The Importance of Water

Water is the most critical environmental variable in the wetland ecosystem. Without enough of it, a site will not be a wetland. With too much water, a site becomes a deep-water aquatic environment (i.e., a site ≥ 6.6 feet in depth) instead of a wetland.

The amount of water and how long it remains on a site (also called *hydroperiod*) determines the plant and animal species living there as well as the chemical and biological characteristics of the soil. Besides affecting the type of wetland that develops on a site, the hydroperiod influences the functions that a wetland provides. For more information on hydroperiod, see Part 2 of this document, Section 3.3.1.1 and 3.4.1.1.

Wetlands may have several sources of water: precipitation, surface flow, subsurface flow, groundwater, etc. Where hydrologic processes have not been substantially altered, the source of water and the hydroperiod generally depend on a wetland's position in the landscape. The type of soils, the permeability of the soils, and the landforms all affect how water moves through the landscape (Bedford 1996). Freshwater wetlands form where:

- The shape of the land allows water to pool at or near the surface of the ground (depressional wetlands).
- Water flows laterally between different soil layers near the surface due to differences in permeability (slope or depressional wetland).
- Breaks in the topography and subsurface flows are exposed (slope wetlands).
- Surface waters regularly flood in valleys (riverine wetlands).
- Large bodies of water are shallow enough to allow light penetration to the bottom (wetlands along the shores of lakes, also called lacustrine fringe wetlands).

2.3 Wetlands as Part of the Landscape

A wetland's position in the landscape, its source of water, and its hydroperiod (i.e., its hydrogeomorphic characteristics) collectively affect the functions that the wetland performs. These characteristics, and therefore the formation and the functions of wetlands, result from the interaction of climate, water, geology, and topography. The most important environmental or landscape factors that influence an individual wetland and its functions may occur outside the wetland boundary. For example, wetlands regularly inundated by river flooding are greatly affected by processes operating at the scale of the entire watershed. Conversely, an individual wetland may influence important environmental factors well beyond its boundaries. Riverine wetlands, for example, may affect such downstream processes as the movement of water, sediment, and nutrients.

The processes that affect a wetland occur mainly within the basin that supplies its water. The factors that control the structure and functions of a wetland occur at both the landscape scale (in the watershed where the wetland is located and beyond) and at the site scale (in and near the wetland). These factors should be considered when making decisions about activities affecting wetlands and associated mitigation opportunities.

For more about wetlands and the landscape, see Chapters 4 and 5 of *Wetlands in Washington State - Volume 2: Guidance for Protecting and Managing Wetlands* (Granger et al. 2005).

Chapter 3 - Overview of the Wetland Regulatory Process

3.1 Introduction

This chapter explains: generally, how the wetland regulatory process works; what agencies may require of applicants; and who applicants need to work with to develop a mitigation project successfully and get it approved. Following chapters provide more details on mitigation requirements.

You can think of the wetland regulatory process as a series of questions you need to answer:

1. Do you have a wetland on your property?
2. What type and size of wetlands are present?
3. What regulations apply?
4. Can you avoid impacts to the wetland?
5. What type of impacts are you proposing?
6. How much and what type of compensatory mitigation may be required?
7. How do you develop a mitigation plan?
8. What are the basic requirements for a compensatory mitigation project?

Consult With the Agencies Early in the Process

If proposed work may affect wetlands, applicants are encouraged to consult with the agencies early on. Rules and requirements change so it is important to contact your local government, the Corps, and Ecology before you begin work. For agency contacts refer to Appendix C.

3.2 Do You Have a Wetland on Your Property?

The first thing you need to know is whether you have a wetland on site that is subject to any wetland laws and rules. You also need to know how big it is, what type it is, and where it is located, relative to other water bodies.

A wetland has particular physical, biological and chemical characteristics. Wetlands are defined differently in various laws, but legal definitions of wetlands in Washington are relatively consistent. They all include the same basic language about having water present long enough to form distinctive soils and specialized vegetation (see Section 2.1, *Wetlands and Their Functions*).

The essential characteristics of a wetland are:

- Recurrent, sustained water above or near the surface of the soil.
- The presence of physical, chemical, and biological features, such as hydric soils and hydrophytic vegetation, which reflect this condition.

> **Not sure if your project site contains wetlands?**
>
> Hire a wetland consultant to delineate potential wetland areas on the property. See *Hiring a Qualified Wetland Professional* in Appendix D.

In Washington State, federal, state and local regulatory agencies are all required to use the same basic method of determining if wetland conditions are present. While the federal agencies use the 1987 *Corps of Engineers Wetlands Delineation Manual* (U.S. Army Corps of Engineers 1987)[3], and state and local agencies use the 1997 *Washington State Wetland Identification and Delineation Manual* (Ecology 1997), these two manuals are consistent. Accurate use of either manual will result in the same conclusion being drawn about whether a wetland is present and what its boundaries are. For more information on delineating wetlands see Part 2, Section 3.1, *Delineating Wetlands and Assessing Impacts*.

> **State definition of wetlands**
>
> The Corps (33CFR 328.3(b)), the EPA (40 CFR 230.3(t)), the Shoreline Management Act (Chapter 90.58.030 RCW (2)(h)), Washington's Water Quality Standards (WAC 173-201A-020), and the Growth Management Act (Chapter 36.70A.030(20) RCW) all define wetlands as: "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."
>
> The Shoreline Management Act, Washington's Water Quality Standards, and Growth Management Act definitions add: "Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands. (Water bodies not included in the definition of wetlands as well as those mentioned in the definition are still waters of the state.)"

3 At the time this document was written, an ongoing effort by the Corps to "regionalize" the 1987 delineation manual was underway. The Corps is working in collaboration with states, federal agencies, and others to develop supplemental regional criteria to refine the 1987 delineation manual. Two regions fall within the state of Washington: the Arid West (dry lands west of the Continental Divide, from Idaho and eastern Washington south to the U.S.–Mexico border) and the Western Mountains and Valleys. Check the web page of the Regulatory Branch of the Corps, Seattle District, for updated information on these regional manuals: http://www.nws.usace.army.mil (Regulatory).

3.3 What Type and Size of Wetlands Are Present?

Once you know a wetland is present, you usually need an accurate delineation of its boundary. For some projects, you may need only an approximate delineation of the wetland area, especially if no direct impacts (filling, clearing, grading, etc.) will occur in or near the wetland. For most projects, however, you need an accurate delineation of the wetland boundary to calculate how much wetland area will be lost or disturbed and to determine appropriate *buffers*.

While some wetlands are obvious and their boundaries easily determined, many other wetlands can be hard to recognize and to delineate accurately. In most cases, a wetland professional is needed to accurately identify and delineate wetland boundaries for regulatory purposes (see Appendix D, *Hiring a Qualified Wetland Professional*).

There is a great variation in the types of wetlands found in the state and there is an even greater variation in the functions they perform. In addition to the size and location of a wetland, information about the type of wetland is usually needed early in the regulatory process. Wetlands are regulated differently according to their rarity, sensitivity, functions, etc. There are many ways to rate or classify wetlands. Greater consistency is being achieved in the state through wider use of the Washington State wetland rating systems (eastern and western Washington versions) (Hruby 2004a and b). The federal and state agencies and many local governments use this rating system in Washington State. It is a qualitative tool for identifying key wetland attributes that are relevant to regulatory decisions. (Appendix G describes the rating systems and other methods used to analyze the functions of wetlands.)

Mitigation requirements are partly based on the wetland rating or category

A rating system sorts wetlands into categories based on an understanding of how wetlands function and how they are affected by human activities. In the Washington State systems, the categories are based on: the rarity of the type of wetland, our ability to replace it, its sensitivity to adjacent human disturbances, and the functions it performs.

The objective of the rating systems is to divide wetlands into groups that have similar needs for protection. This allows the regulations to be tailored to the protection needs of each type of wetland. Buffer widths and typical compensatory mitigation ratios provided in this guidance are partly based on the wetland rating (see Chapter 6).

In 2004, based on current wetland science, Ecology revised the wetland rating systems that were first developed in 1992 for eastern and western Washington. The revised wetland rating systems (Hruby 2004a and 2004b) are available at http://www.ecy.wa.gov/programs/sea/wetlan.html.

The Corps determines whether a wetland meets the federal requirements for being isolated

Applicants and consultants must coordinate all projects potentially affecting isolated wetlands with the Corps and receive a written jurisdictional determination.[5] Consultants can provide information to the agencies, but the final determination must be made by the Corps.

3.3.1 Isolated Wetlands

Some types of wetlands are regulated by state and local governments but not by the federal government. The most common type is isolated wetlands. *Isolated wetlands* generally have no surface water connections to other *aquatic resources*. Though not always protected under federal law, isolated wetlands often perform many of the same important environmental functions as other wetlands, including recharging streams and aquifers, storing flood waters, filtering pollutants from water, and providing habitat for a host of plants and animals (see Chapter 5 of *Wetlands in Washington State – Volume 1* (Sheldon et al. 2005). These wetlands continue to be protected under state and local laws and rules.

A 2001 Supreme Court decision (Solid Waste Agency of Northern Cook County v. United States Army Corps of Engineers et al., also known as the SWANCC decision[4]) excluded many isolated wetlands from federal regulation. The Supreme Court based this decision on a legal interpretation of jurisdiction under the federal Clean Water Act (CWA). The key factor was the language in the Act that relates to *navigable waters*. Under Section 404 of the CWA, federal protection extends to those wetlands located on or adjacent to navigable waters of the United States or their tributary systems. Wetlands that do not meet this requirement, such as isolated wetlands with no link to interstate commerce, are not regulated as waters of the United States and are therefore not protected under the CWA.

Prior to the SWANCC decision, the presence of migratory birds was considered enough to establish a link to interstate commerce, and thus CWA protection for isolated wetlands. In SWANCC however the Court ruled that the mere presence of migratory birds is not sufficient for asserting CWA jurisdiction over isolated, intrastate, non-navigable water bodies. As a result of this ruling, many isolated wetlands in Washington are no longer protected by federal law.

4 The SWANCC decision can be found on the EPA web page at: http://www.epa.gov/owow/wetlands/guidance/SWANCC/2001supremecourt.pdf .

5 *Jurisdictional Determination* is the evaluation of a piece of property for the presence of wetlands that would fall under the regulatory authority of the Corps of Engineers.

In general, the Corps considers isolated wetlands to be those of any size that are not adjacent[6] to or do not have a sufficient hydrologic connection to navigable waters. Corps policy regarding the definition and regulation of isolated wetlands is currently in flux, and future court or administrative decisions may further change how isolated wetlands are regulated by the federal government.[7]

The Supreme Court's SWANCC ruling does not change Washington State laws governing wetlands

The state Water Pollution Control Act (Chapter 90.48 RCW) and associated water quality regulations (Chapter 173-201A WAC) make no distinction between isolated and non-isolated wetlands. All *waters of the state,* including isolated wetlands, are covered by state law. The Shoreline Management Act and the Growth Management Act also regulate isolated wetlands (see Appendix E).

Ecology continues to regulate isolated wetlands and to apply the water quality standards prescribed by state law. However, Ecology's process for regulating projects involving isolated wetlands is now different from the process for federally regulated wetlands. The standards of review however, remain the same. For more information see Appendix F, *Focus: Isolated Wetlands – Changes in the Regulatory Process.*

3.3.2 Prior Converted Cropland

Prior Converted Cropland (PCC) is identified for the purpose of implementing the Food Security Act (FSA), and refers to wetlands that were converted from a non-agricultural use to production of a commodity crop prior to December 23, 1985. After 1985 these sites must continue to be in active agricultural use. This means a commodity crop that requires annual tilling must be produced at least once every five years.

In addition, PCCs must not have standing water present for more than 14 consecutive days during the growing season[8]. While many PCC areas have been extensively manipulated and drained, and some may no longer be wetlands, a PCC area may meet the Corps' wetland hydrology criterion. If the land changes to non-agricultural use, or is abandoned, a PCC may be regulated under the CWA.

Even if not abandoned, PCC wetlands, like isolated wetlands that meet the state's delineation criteria (Chapter 173-22-080 WAC) are still regulated under the state's Water

6 The term "adjacent" means bordering, contiguous, or neighboring. Wetlands separated from other waters of the United States by man-made dikes or barriers, natural river berms, beach dunes and the like are "adjacent wetlands" (33 CFR 328.3[c]).

7 Check the following web pages for updates http://www.ecy.wa.gov/programs/sea/pac/iso-wetlands.html or via the Corps regulatory web page at http://www.nws.usace.army.mil/ (Regulatory, Waters & Wetlands Information).

8 If an agricultural site has standing water for greater than 14 consecutive days it would be considered a "farmed wetland." Many farmed areas in valleys flood throughout the winter and would not be considered PCC. It is important to document surface water levels throughout the year. Determining the hydroperiod during the dry season alone is not adequate.

Pollution Control Act (Chapter 90.48 RCW), the Shoreline Management Act, and the Growth Management Act. Conversion of a PCC wetland to non-agricultural use requires state approval.

Joint Guidance on Conducting Wetland Delineations for the Food Security Act of 1985 and Section 404 of the Clean Water Act

In 1994, the Departments of Agriculture, Interior, and Army and the EPA entered into a Memorandum of Agreement (MOA), *Guidance on Conducting Wetland Determinations for the Food Security Act (FSA) and Section 404 of the Clean Water Act (CWA)*. The MOA was developed to streamline the wetland delineation process on agricultural lands, to promote consistency between the CWA and the FSA, and to provide predictability and simplification for U.S. Department of Agriculture program participants.

In January 2005 both the Natural Resources Conservation Service (NRCS) and Department of the Army withdrew from the MOA. The MOA was replaced with the Corps and NRCS *Joint Guidance on Conducting Wetland Delineations for the Food Security Act of 1985 and Section 404 of the Clean Water Act*, issued February 25, 2005[9]. This guidance addresses the responsibility of NRCS for performing wetland delineations for the FSA and the Corps for delineations for CWA Section 404 purposes.

The 2005 MOA also states that the identification of prior converted croplands (PCC) made by NRCS remains valid as long as the area is devoted to an agricultural use. If the land changes to a non-agricultural use, the PCC determination is no longer applicable and a new wetland determination is required for Clean Water Act purposes. Specific guidance will be provided by the Corps in the near future addressing how the Corps will treat PCC designations for land that changes from agricultural to non-agricultural use.[10]

Landowners, who intend to develop their land or conduct an activity that precludes use of the land for continued agricultural production, should contact the Corps to determine if the land meets the criteria for jurisdictional wetlands under the CWA. See Appendix C, Agency Contacts.

> Important Note: The Corps of Engineers, not applicants or their consultants, has authority to determine whether or not a wetland is a water of the U.S. and thus regulated under the federal Clean Water Act (CWA). If the Corps determines that a wetland is not subject to regulation under the CWA, applicants should be aware that these wetlands are still regulated by Ecology as well as by local governments.

9 The joint guidance can be found on-line at http://www.nrcs.usda.gov/programs/compliance/pdf_files/COE_NRCS_wetland.pdf.

10 Check the following web page for updates http://www.ecy.wa.gov/programs/sea/pcc.html or via the Corps regulatory web page at http://www.nws.usace.army.mil/ (Regulatory, Waters & Wetlands Information).

3.4 What Regulations Apply?

Federal, state and local wetland regulations can vary in how they apply to different types of wetlands and different types of activities that can impact wetlands. Some types of wetlands or wetlands of a certain size are specifically exempted under some laws. Certain activities, such as forestry or agriculture, are exempted under some laws. It is important to determine whether and how a wetland is subject to each law that applies. The best way to do this is to consult with the appropriate agency. In general, the Corps is the agency to contact at the federal level; Ecology the agency to contact at the state level; and the city or county planning department at the local level. Tribes can also play an important role in wetland regulations when projects affect reservation land, *cultural resources*, traditional cultural properties, and tribal "usual and accustomed" areas[11] (see Section 3.4.3, *The Role of Other State Agencies*).

Regulatory authority regarding compensatory mitigation

Regulations (33 320-330 and 40 CFR 230) authorize the U.S. Army Corps of Engineers (Corps) and U.S. Environmental Protection Agency (EPA) to require compensatory mitigation for unavoidable impacts to wetlands and other jurisdictional waters of the U.S. The Corps and EPA have prepared policies and procedures to be used in determining the mitigation necessary to demonstrate compliance with the Clean Water Act 404 (b)(1) Guidelines (40 CFR 230). This information is set forth in the *Memorandum of Agreement (MOA) Between the Environmental Protection Agency and the Department of the Army Concerning the Determination of Mitigation under the Clean Water Act Section 404 (b)(1) Guidelines*, dated February 7th, 1990.

The Washington State Department of Ecology's (Ecology) authority rests with the state Water Pollution Control Act (Chapter 90.48 RCW) and associated water quality regulations (Chapter 173-201A WAC). Based on the antidegradation policy (Chapter 173-201A-300 WAC), with adequate mitigation that effectively offsets the impacts, Ecology can permit projects that would not otherwise comply with the regulations.

A description of the laws and rules that may apply to proposed activities in or near wetlands can be found in Appendix E. A table in the appendix summarizes pertinent federal, state, and local laws and rules. The appendix also includes key policy and guidance documents used by the agencies to implement wetland regulations. It is important to note that policies and guidance have evolved over time as more has been learned about compensatory mitigation. If there appear to be conflicts between documents, contact the agencies for clarification. For more information on each law contact the responsible agency (see Appendix C).

11 Tribes can also have a significant role in coordination and consultation under Section 106 of the National Historic Preservation Act of 1966 to determine how a project may affect recorded or undiscovered cultural resources (see Appendix E for a description of the National Historic Preservation Act).

What activities are regulated?

Because of the complexity of laws and regulations that may apply to a particular activity, it is best to contact each agency that might have jurisdiction to find out if a wetland or activity is regulated by that agency's laws and regulations. Though the definitive answer needs to come directly from the agencies, qualified wetland professionals that work locally and are familiar with the different laws and how they apply can help save an applicant time and money (see Appendix D, *Hiring a Qualified Wetland Professional*).

3.4.1 Applying for Permits

Once an applicant understands the laws that might apply to a wetland they may be impacting, they should find out what the requirements and timelines are for filing a permit application to get approval for impacts to a wetland. To make the process easier for applicants, Washington State developed the Joint Aquatic Resource Permit Application (JARPA). The JARPA streamlines the permit-application process for water-related projects.

The JARPA application covers the most frequently required federal and state authorizations relating to wetlands. These include the state Shoreline permits, state Hydraulic Project Approval (HPA), state 401 Water Quality Certification, and Corps Section 404 and Section 10 permits under the Federal Clean Water Act. Rather than completing several separate forms, the applicant fills out one standard permit application for all.

The review process begins when the standard application is completed and submitted to each agency at the same time. The standardization, however, does not reduce the number of authorizations/permits required; it only makes the application process easier. The application still needs to be reviewed by each agency. Also, each agency still issues separate authorizations under its authority. Some local governments use the JARPA, combining some or all of their wetland-related permits on the JARPA form. Check with the local government to determine whether they use the JARPA format. You can get the JARPA form at the Office of Regulatory Assistance web page: http://www.ecy.wa.gov/programs/sea/pac/jarpa.html.

Washington State Office of Regulatory Assistance (ORA)

ORA provides one-stop assistance in navigating the regulatory process and determining which agency permits and authorizations may be needed. ORA staff will help applicants develop a plan for meeting environmental and land-use requirements. Contact ORA at (360) 407-7037, 800-917-0043, ecypac@ecy.wa.gov, or visit their web page: http://www.ecy.wa.gov/programs/sea/pac. To go directly to ORA's on-line Project Questionnaire, developed to help applicants determine which Washington State and Federal environmental permits will be needed for a project, go to http://www.ecy.wa.gov/opas/index.asp.

If the proposed work will take place in or near wetlands or other waters, applicants should also contact the Corps, the appropriate regional wetland specialist for Ecology, and the local government (see Appendix C, *Agency Contacts*). Contacting the appropriate wetland regulatory staff early can save time and money.

3.4.2 The Role of Other State Agencies

The Washington Department of Natural Resources (WDNR) and the Washington Department of Fish and Wildlife (WDFW) also implement regulations that apply to wetlands and other aquatic resources. WDNR is the manager of state-owned aquatic lands. If activities, including mitigation projects, are proposed on state-owned aquatic lands, authorization to use the lands must be issued from the WDNR. For any projects authorized on state-owned aquatic lands, WDNR's administrative rules (WAC 352-30-107(6)) dictate that all substantial or irreversible impacts must be fully mitigated. WDNR's Aquatic Resources Division is currently working on guidance for mitigation related to management of state-owned aquatic lands. Go to http://www.dnr.wa.gov/htdocs/aqr/or http://www.dnr.wa.gov/htdocs/aqr/mitigation/index.html.

> Boundaries of state-owned aquatic lands
>
> A discussion on this topic can be found in a brochure prepared by WDNR. It can be found on-line at http://www.dnr.wa.gov/htdocs/aqr/pdfs/aqrland_bound.pdf.

WDNR is required by the Forest Practices Act (Chapter 76.09 RCW) to administer and enforce all rules adopted by the Forest Practices Board. The Forested Practices Act and its implementing rules (Chapter 222 WAC) apply the wetland provisions of the federal Clean Water Act and the State Water Pollution Control Act on state and private forest lands.

WDNR reviews applications for timber harvest and applies restrictions along streams and within wetlands and their buffers as detailed in the Forest Practices Manual (see the web page for the Forest Practices Division if you are proposing to impact wetlands in areas where WDNR has jurisdiction: http://www.dnr.wa.gov/forestpractices/index.html).

WDFW is responsible for preserving, protecting, and perpetuating all fish and shellfish resources of the state. To assist in achieving that goal, the state Legislature in 1949 passed a state law now known as the "Hydraulic Code" (Chapter 77.55 RCW). The law requires that any person, organization, or government agency wishing to conduct any construction activity that will use, divert, obstruct, or change the bed or flow of state waters must do so under the terms of a permit (called the Hydraulic Project Approval or HPA). This permit is issued by WDFW. State waters include all marine waters and fresh waters of the state (for more information if your activities may impact wetlands adjacent to, or in streams: http://wdfw.wa.gov/hab/hpapage.htm).

3.5 Can You Avoid Impacts to the Wetland?

Programs protecting wetlands on the federal, state, and local level generally require three basic actions for projects that are likely to affect wetlands:

1. Identify and describe potential impacts.
2. Follow the *mitigation sequencing* process (discussed below).
3. Provide compensatory mitigation for unavoidable impacts.

Before authorizing a project, the agencies require that the applicant demonstrate that impacts have been avoided and minimized to the greatest extent practicable (i.e., apply mitigation sequencing as described below). The applicant must determine the amount of unavoidable impacts and compensate for lost or degraded wetland area and/or function.

First, avoid and minimize impacts to wetlands

For most types of impacts, wetland laws require that applicants demonstrate a "need" for impacts to a wetland. The impacts must generally be "unavoidable." It is getting harder to find developable sites in areas that do not have wetlands or other types of natural resources (e.g., streams) or hazards (e.g., steep slopes). This can make it difficult to develop some properties in a pattern or at a density that is necessary or desired. However, many developers have found that they can save considerable time and money by completely avoiding wetland impacts and the associated mitigation requirements. In other cases, creative design and construction can significantly reduce impacts.

3.5.1 Mitigation Sequencing

The Washington State Environmental Policy Act (SEPA) (Chapter 43-21C RCW), administered by Ecology, and Section 404 of the federal Clean Water Act (CWA), administered by the Corps and EPA, both require that a sequence of actions be taken for proposals that will impact wetlands (mitigation sequence). The following are the steps in the mitigation sequence according to the implementing rules of SEPA (Chapter 197-11-768 WAC):

> *(1) Avoiding the impact altogether by not taking a certain action or parts of an action;*
>
> *(2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;*
>
> *(3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;*
>
> *(4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;*
>
> *(5) Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or*
>
> *(6) Monitoring the impact and taking appropriate corrective measures.*

At the federal level, activities requiring a CWA Section 404 permit are usually subject to similar sequencing requirements as found in the implementing rules of SEPA. In 1990, the EPA and Corps entered into a Memorandum of Agreement (MOA) (*The Determination of*

Mitigation Under the Clean Water Act Section 404(b)(1) Guidelines[12]) to clarify the type and level of mitigation required under Section 404 regulations. The agencies established a three-part process, also known as mitigation sequencing, to help guide mitigation decisions:

1. Avoid – In general, adverse impacts are to be avoided to the maximum extent practicable. (In most cases a proposed discharge may not be permitted if there is a practicable alternative to that discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences. However, the 404(b)(1) Guidelines provide flexibility in applying the sequencing process, such as in cases when the environmental impact would be insignificant.)

2. Minimize – Take appropriate and practicable steps to minimize those adverse impacts that cannot be avoided.

3. Compensate – Provide appropriate and practicable compensation for the remaining impacts that cannot be avoided or further minimized.

This sequencing process is therefore required to comply with both state and federal laws.

Projects that require CWA authorization by the Corps must also comply with the Section 404(b) (1) guidelines. These guidelines presume, unless clearly rebutted by the applicant, that less environmentally damaging alternatives to filling special aquatic sites, such as wetlands, are available for non-water-dependent activities. Whether a project is water dependent or not, the guidelines presume that all practicable alternatives that do not involve a discharge into a special aquatic site, which includes wetlands, have less adverse impact on the aquatic ecosystem.

The Section 404(b)(1) guidelines prohibit the Corps from authorizing a project under an individual permit unless that project would use the "least environmentally damaging practicable alternative" (as determined by the Corps and EPA). If a less environmentally damaging alternative is available and practicable, then a permit would be denied. In some cases, the least environmentally damaging practicable alternative is the one that would relocate the project away from special aquatic sites, possibly to another site altogether. In the case of nationwide permits (NWP) (a collection of general permits), the Corps has already performed an alternatives analysis and determined that projects which meet the conditions of the NWP meet the test of "least environmentally damaging practicable alternative." For more information on NWP go to the Corps' Regulatory Program web page ("Permit and Applicant Information") via http://www.nws.usace.army.mil.

When determining the least environmentally damaging practicable alternative, other ecosystems and habitats should be considered. For example, it may be preferable to authorize an impact to a low-functioning, highly degraded wetland rather than damage a mature, forested upland that provides a high level of function.

12 The MOA can be found via the Seattle District regulatory home page http://www.nws.usace.army.mil/ (Regulatory Permit Program, Regulations and Guidance) or directly at: http://www.usace.army.mil/inet/functions/cw/cecwo/reg/moafe90.htm. See Appendix E for a description.

Avoid wetlands that are hard to replace

For certain wetlands that are rare, sensitive, or hard to replace (e.g., bogs, fens, mature forested wetlands, eelgrass beds, and habitats for unique species or endangered plant populations) *avoidance* is usually the only step in the mitigation sequence. For more information and further guidance see the *Federal Guidance on Protection and Mitigation of Difficult to Replace Aquatic Resources Under Section 404 of the Clean Water Act*, which was developed as part of the National Wetlands Mitigation Action Plan (http://www.mitigationactionplan.gov).

3.6 What Type of Impacts Are You Proposing?

The loss of an entire wetland is not the only type of impact that requires compensatory mitigation. The area of wetland affected, the degree of alteration, and the effects on functions can vary widely. All of these factors affect the requirements for compensatory mitigation. If an entire wetland is filled, all functions are lost and generally will need to be replaced. If only a portion of a wetland is filled, there will be changes in the degree to which it provides functions. Some functions may be affected only slightly and others eliminated completely. Likewise, a wetland may be degraded without any loss of area, as when removal of vegetation results in a change in the level of functioning.

Some impacts result in a permanent loss of wetland area and function (e.g., filling for a permanent structure), while others may be temporary (e.g., installing a utility line through an emergent wetland). Permanent changes typically require compensation for the functions lost or reduced. Compensatory mitigation may also be required for temporary (short or long term) or indirect impacts. Four types of impacts are defined below:

Permanent impacts result in the permanent loss of wetlands or waters of the state/United States. For example, placement of fill in a wetland to construct a road would be considered a permanent impact. Permanent impacts typically require compensatory mitigation.

Long-term temporary impacts affect functions in such a way that they can be restored, or will eventually be restored over time, but not within a year or so. Long-term temporary impacts or alterations carry a risk of permanent loss, such as when soil is compacted by equipment, deep excavation is required, or pipeline trenches alter the water regime. Clearing a *forested wetland* for a temporary access road changes the plant community and degrades functions, such as song bird habitat provided by the tree canopy. It will take many years to grow back and re-establish the previous level of function. Long-term temporary impacts normally require compensatory mitigation but at a lower ratio than permanent impacts (see Section 6.5.6, *Mitigation Ratios for Temporary Impacts and Conversions*).

Short-term temporary impacts last for a limited time, and functions return to pre-impact performance fairly soon (about one year or within one growing season of the impact). For example, clearing emergent vegetation (e.g., cattails, rushes, sedges, grasses, etc.) for temporary construction impacts associated with a road (e.g., for a short-term staging area), changes the functions performed by the wetlands for a short time. Emergent vegetation may return within one growing season if the disturbance is not severe. Compensatory mitigation is often not required for short-term temporary impacts (see Section 6.5.6, *Mitigation Ratios for Temporary Impacts and Conversions*).

Indirect impacts can result from activities adjacent to or upslope from a wetland that affect how it functions. For example, constructing a road adjacent to or near a wetland may produce sediment that enters the wetland, burying vegetation, and altering functions.

Indirect impacts can also result from primary impacts within a wetland that have secondary (indirect) negative effects on functions. For example, placement of fill for a new road may cause indirect impacts within a wetland. The road crossing affects more than just the area of wetland under the road fill. The flow of water through the wetland changes, and the road forms a barrier to animal movement and causes ongoing disturbances from noise and light.

Another type of indirect impact occurs when so much of a wetland is filled that the remaining wetland area can't provide functions at its former levels. Some functions decline sharply as wetland size diminishes. In such cases, the agencies may consider the entire wetland to be adversely impacted, and compensatory mitigation will be required for both direct and indirect impacts to the wetland.

Avoid impacts to compensatory wetland mitigation sites

Impacts to sites containing compensatory wetland mitigation projects should be avoided whenever possible. If impacts are unavoidable, the agencies consider the following when calculating how much compensatory mitigation will be required (i.e., the mitigation ratio):

- If the project is still active (i.e., still under construction or being monitored) then the amount of required mitigation will be higher to address the additional *temporal loss* of the original wetland's functions and area. Specific mitigation ratios will depend on how the site is currently functioning, the level of impact, and how close the site is to meeting its goals.
- If the project has been completed (i.e., the monitoring period is over and the agencies have acknowledged that all permit requirements are fulfilled) then the compensation wetland will be viewed as any other natural wetland. The amount of required compensatory mitigation will be based on the existing wetland area, functions, type, and category, as well as the type and amount of impact.

3.7 How Much and What Type of Compensatory Mitigation Will Be Required?

Mitigation is typically required to compensate for the loss of wetland acreage and/or functions. Many factors, in addition to the type and degree of impact, determine the appropriate form and amount of compensation. Chapter 6 contains detailed information on what the agencies use to guide their determination.

When compensatory mitigation is required, a plan must be developed and presented to the agencies for approval as part of the permit process. A conceptual plan should first be developed and discussed with the agencies, followed by draft and final plans that are revised as the mitigation proposal progresses. See the next section for a general description of the factors to consider in developing a mitigation plan.

3.8 How Do You Develop a Mitigation Plan?

A mitigation plan is the document that explains how a wetland impact will be compensated for and provides enough detail for the agencies to determine if the mitigation project is likely to succeed. The plan should describe:

- The nature of the proposed impacts (i.e., acreage of wetlands and functions lost or degraded).
- The goals, objectives, and performance standards.
- The rationale for the mitigation site that was selected.
- How the compensation will be accomplished.
- How it will be monitored to assess progress toward the goals and objectives.

Other elements that are addressed and implemented through a compensatory mitigation plan are:

- Site maintenance.
- Financial assurances.
- Long-term protection.

Once a plan has been developed and the agencies have reviewed the plan and permit application, it may be subject to public review and comment. After the mitigation project is installed, it will be monitored for compliance by the agencies.

More details on some of the elements of a mitigation plan can be found in Section 3.9 (*What Are the Requirements for a Compensatory Mitigation Project?*). Part 2 of this document provides detailed information and guidance on developing a mitigation plan and includes a recommended outline.

Mitigation plans are typically prepared by qualified wetland professionals, usually consultants hired by the applicant. The agencies strongly encourage applicants to hire experienced consultants who have successfully developed and implemented mitigation projects. Having an experienced consultant can save time and money in developing and implementing mitigation (see Appendix D, *Hiring a Qualified Wetland Professional*).

The agencies also urge applicants and their consultants to work with agency staff early in the process of developing a mitigation plan. An applicant can save time and money by first developing a conceptual mitigation approach and getting feedback from agency staff before developing draft and final plans. The conceptual plan should include potential options for compensating for an impact. Many applicants have spent a lot of time and money on a detailed mitigation proposal, only to find that the location or design is not practicable or appropriate.

3.9 What Are the Requirements for a Compensatory Mitigation Project?

The detailed requirements for compensatory wetland mitigation tend to be site-specific and are handled on a case-by-case basis. Guidance provided in Chapters 4 through 6 addresses approaches to mitigation, types of wetland compensation, the location of the compensation project, the amount of compensation (mitigation ratios), and the widths of buffers needed to protect mitigation sites.

3.9.1 Goals, Objectives, and Performance Standards

A compensation project must formally identify its goals, the steps that will be taken to accomplish those goals (objectives), and measurable indicators to determine if the objectives have been achieved (performance standards). Goals, objectives, and performance standards are essential for determining the success and compliance of a project.

Goals should identify what the project is trying to accomplish – what the end product will be (e.g., what functions you want the project to provide). Objectives should identify specific elements of a goal that can be measured and that provide more detail on how that goal may be achieved. Performance standards, or success criteria, are specific conditions used to determine whether a mitigation project is achieving its objectives.

Every compensation project is unique and has its own site-specific considerations. Its goals, objectives, and performance standards should still include basic information like the amount of wetland acreage and the targeted functions. Part 2 of this document provides examples and more detailed information on goals, objectives, and performance standards.

3.9.2 Monitoring

Monitoring ensures that a mitigation project achieves its stated purpose and complies with permit obligations. It involves gathering and analyzing data about conditions at a mitigation site that is used to determine whether a project is achieving its performance standards. It also provides critical information about whether a site needs maintenance or whether contingency actions need to be taken.

A mitigation plan should include a monitoring plan. The duration, frequency, and methods of monitoring depend on a project's goals, objectives, and performance standards. In general, monitoring is required for at least five years. If a scrub-shrub or forested vegetation community is proposed, monitoring may be required for 10 years or more. Monitoring may be extended if interim performance standards are not being met.

3.9.3 Maintenance and Contingency Plans

Maintenance and *contingency plans* should be included in the overall plan for the compensatory mitigation project. Ideally, projects should be relatively maintenance free to be considered successful. However, mitigation sites often require maintenance to help ensure that performance standards are achieved. Maintenance plans outline the activities that are regularly scheduled that prevent minor issues from becoming big problems. Ongoing maintenance activities could include removal of unwanted plant species, the upkeep of short-term irrigation systems, weeding trees and shrubs to the drip line, mulching, and removal of litter.

Contingency plans should outline actions that would be taken if monitoring revealed a problem that would prevent the site from attaining its performance standards. Contingency plans should both anticipate problems and identify specific actions that would be implemented to rectify each problem. Actions may be identified for problems such as failed plantings, invasion of non-native species (e.g., reed canary grass, bull frogs), damaged or missing structures, insufficient water supply or inappropriate water regime, and vandalism.

3.9.4 Adaptive Management

Adaptive management is a systematic process in which modifications to a compensatory mitigation plan, including monitoring, maintenance, and contingency plans, are made based on what has or has not been effective. It is most often implemented when unforeseen circumstances result in problems that a compensatory mitigation plan has not addressed. For example, a hundred-year flood could destroy vegetation planted at the site or bury the mitigation area with sediment. Or contingency measures identified in the plan might fail to rectify problems. Through adaptive management, the applicant and agencies should discuss any problems and possible solutions and site management should be adjusted accordingly.

3.9.5 Financial Assurances

Financial assurances may be required by the agencies to ensure that the potential risks of mitigation failure are minimized. Financial assurances protect the environment by providing the agencies with the financial resources necessary to ensure the success of a mitigation project should the responsible party be unable or unwilling to do so. Such assurances may be needed for construction of the compensation site, short-term management, and long-term management. Some financial assurances are held until after construction of the site, while others are held until it is determined that the goals, objectives, and performance standards have been met (i.e., the site is fully compliant).

Financial assurances may take the form of performance bonds or letters of credit. Applicants should check with their local planning department to determine if the local government will require performance bonds or other forms of financial assurances. A bond should estimate all costs associated with the entire compensatory mitigation project, including site preparation, plant materials, construction materials, installation oversight, maintenance, monitoring and reporting, and contingency actions expected through the end of the required monitoring period.

Agencies usually require that applicants provide a source of funding for the long-term management of larger compensation projects and those entrusted to another entity for long-term maintenance. This often includes the establishment of an endowment which generates sufficient interest to fund ongoing management activities (e.g., weed control, repair of vandalism, monitoring).

3.9.6 Long-Term Protection

To ensure the successful compensation of wetland area and/or function lost to unavoidable impacts, applicants must provide a means of protecting the mitigation site for the long term. Wetland mitigation sites can be protected from future loss and degradation through the use of buffers, legal mechanisms, and other forms of physical protection.

3.9.6.1 Buffers

Buffers are a common and necessary element of compensatory mitigation. Buffers are protective vegetated areas along the perimeter of wetlands and other aquatic resources that reduce impacts from adjacent land uses through various physical, chemical, and biological processes.

The agencies require that compensation wetlands include a buffer of the minimum width necessary to protect the most sensitive functions performed by the wetland. The buffer width needed for the compensation site will be based on the projected level of functions. Surrounding land uses also help determine the width of the buffer. A mitigation site that is located next to land uses that have high impacts to adjacent wetlands, for example, is likely to need a larger buffer than one adjacent to land uses that have low impacts to adjacent wetlands. See Section 6.6, *Determining Adequate Buffers*, for detailed guidance on buffer requirements and determining appropriate buffer widths.

3.9.6.2 Legal Protection of the Site

Deed restrictions, *conservation easements*, or other legal mechanisms are generally required to protect compensatory mitigation projects from future development. This is especially true when existing wetlands are preserved to compensate for wetland losses. Such legal mechanisms are needed in addition to buffers to ensure that the wetlands will not be lost or degraded in the future. See Part 2 for more discussion of legal protection mechanisms.

For compensatory mitigation projects on state-owned aquatic lands, project proponents must apply for a use authorization from the Washington Department of Natural Resources (WDNR). Use authorizations can be issued for up to 50 years, depending on the land classification. WDNR is currently drafting its policy and guidelines for issuing use authorizations related to compensatory mitigation activities. (See Section 3.4.2, *The Role of Other State Agencies*.)

3.9.6.3 Physical Protection of the Site

Compensatory mitigation sites and their buffers may need physical protection from recreational vehicles, lawnmowers, cats and dogs, herbivores (e.g., geese, deer), and pedestrian traffic. The protection needed depends on the type of threat and the functions provided by the site. People can often be deterred by a split-rail fence or even signs indicating that the area is a wetland and should not be disturbed. Planting native thorny shrub species in the buffer can also deter people from entering the wetland. Placing large boulders at key points can deter off-road vehicles.

Protection against browsing animals may need to target particular species. An 11-ft fence that excludes deer probably won't stop geese from grazing. Protective tubes may be needed on each seedling to keep mice from girdling trees and shrubs. For further discussion, see Part 2, *Site Planning and Design – Vegetation*.

Fences

Fence specifications should be tailored to address what is needed to protect a particular compensation wetland, based on both the potential for human impacts and the desired functions of a site. If the mitigation is to support larger mammals, fencing is discouraged. If a fence is necessary, it should allow wildlife to get into and out of the mitigation site. Examples include split-rail and smooth-wire fences.

Instead of fences, consider natural barriers to keep people out of a mitigation site. A buffer dominated by spiny or thorny native plants such as rose, salmonberry, gooseberry, hawthorn, or stinging nettles could be planted. The barrier could also be complemented with signage.

Chain-link or barbed wire fences around mitigation sites are discouraged unless a specific need for such a fence is established. If the main habitat functions are for small mammals, birds, amphibians, and fish, a chain-link fence may be acceptable for some situations or periods of time (e.g., to fence out herbivores until plants get established). Where mitigation sites are next to grazing lands, smooth wire fencing may not provide adequate protection and the greater protection of barbed wire fences may be needed.

3.9.7 Public Review and Comment

After a permit application and compensatory mitigation plans have been submitted, reviewed, and determined to be complete, there is usually an opportunity for public comment. Through their public notice process for standard individual permits, the Corps gives the public a chance to review and comment on the proposed project's impacts and mitigation strategy. Usually, the public notice contains a synopsis and drawings of the proposed mitigation, with details available upon request. When a Section 401 Water Quality Certification from the state is necessary, Ecology normally issues a separate public notice.

These processes afford the public only a limited opportunity to comment on compensatory mitigation plans, since most permit actions fall under the Corps Nationwide Permit program. There is no formal opportunity for the public to review and comment on mitigation plans when a Nationwide Permit applies. For more information on nationwide permits go to the Corps' Regulatory Program web page ("Permit and Applicant Information") via http://www.nws.usace.army.mil/.

On the local level, the public may get to comment on permits and plans for compensatory mitigation as a part of the public review process through the State Environmental Policy

Act. Those interested should contact their local government's planning department or office of community development for more information (see Appendix C, *Agency Contacts*).

> Public notices are available on-line
>
> Public Notices for proposed projects being reviewed by the Seattle District of the Corps of Engineers are available on-line at its Regulatory Branch web page via http://www.nws.usace.army.mil/. You can email the Seattle District (regulatory.nws@nwso2.usace.army-mil) to request that your email address be added to its public notice mailing list.
>
> Ecology maintains a list of active Public Notices at the following web page: http://www.ecy.wa.gov/programs/sea/fed-permit.

3.9.8 Compliance and Enforcement

The agencies must ensure, to the best of their abilities, that compensatory mitigation is not only appropriate and adequate, but also successful. To accomplish this, their regulatory programs include compliance and enforcement elements.

The purpose of compliance is to ensure that permittees meet the terms and conditions of their permits. Under their responsibilities relative to compliance, the agencies typically inspect mitigation sites, review project status and monitoring reports, and determine whether mitigation projects have met their performance standards. Permittees should expect the Corps, Ecology, and other regulatory agencies to take an active role in ensuring compliance. Recent research by Ecology found that compensatory mitigation projects that are reviewed for their compliance by regulatory agencies tend to be more successful (Johnson et al. 2002). A project proponent who fails to comply with the terms and conditions of a permit may be subject to judicial action or a civil penalty.

In contrast to compliance, enforcement deals with activities that have occurred without proper authorization. In addition to protecting the environment, enforcement actions help preserve the integrity of a regulatory program by ensuring that everyone is treated fairly and consistently. An effective enforcement program also helps eliminate unfair advantages that might accrue to someone who does not abide by environmental laws and regulations.

Enforcement normally involves working cooperatively with a violator to resolve the violation and includes remediation of its adverse environmental impact. When necessary, enforcement actions include civil or criminal procedures that can result in substantial fines and/or imprisonment. The Clean Water Act authorizes fines for enforcement actions of up to $25,000 per violation per day (33 USC § 1319).

Chapter 4 - Approaches to Compensatory Mitigation

Mitigation can be provided for the impacts of a single project or in conjunction with the impacts of other projects. Many mitigation proposals however are individual or project specific; they aim to satisfy permit requirements for only one project. In most cases, an applicant is required to implement a *compensatory mitigation* project at the same time that wetland impacts occur (i.e., concurrently) or soon thereafter (see Section 6.2, *Determining When Mitigation Actions Should Occur*).

Because project-specific, *concurrent mitigation* is by far the most common approach to compensating for wetland losses at this time, discussion of other approaches in this document is limited. Other options to compensating for wetland impacts are being developed and encouraged, however. These include advance mitigation and other programmatic approaches, such as mitigation banking, which are briefly discussed in this chapter. Individuals interested in pursuing these approaches should contact the agencies to find out more (see Appendix C, *Agency Contacts*).

4.1 Advance Mitigation

Advance mitigation is compensatory mitigation in which the mitigation project is implemented before, and in anticipation of, future known impacts to wetlands. Advance mitigation has been used most for large mitigation projects that are constructed in distinct phases where the impacts to wetlands are known. Advance mitigation lets an applicant provide all of the compensation needed for the entire project affecting wetlands at one time. If the mitigation is successful, the approach will often result in lower mitigation ratios for later phases of the project. This is because the impacts have already been compensated for and the *temporal losses* and the risk of failure are reduced or eliminated (see Section 6.5, *Identifying the Amount of Compensation [Mitigation Ratios]*).

Although similar to mitigation banking (see Section 4.2.1), advance mitigation is different in several ways. Most important, advance mitigation is used only to compensate for a specific project (or projects) with pre-identified impacts to wetlands. In contrast, the use of a mitigation bank does not require that specific impacts or debit projects be determined in advance. Also, if the intended project is not built, advance mitigation is generally not transferable to other projects. In other words, advance mitigation is implemented at the applicant's own risk.

If the project (or projects) planning to use the advance mitigation do not occur, the project proponent in some limited cases may be able to gain certification for a mitigation bank, which would let agencies permit the use of this mitigation for other projects. In this case, pre-project baseline studies and post-construction monitoring are important to document initial conditions and subsequent development of the mitigation project. This type of documentation would be necessary for certification as a mitigation bank. However, the approval process for advance mitigation cannot substitute for the review and approval process for mitigation banking. Advance mitigation that is not for specific wetland impacts will need to follow the procedures and requirements for mitigation banking.

"Excess" Compensatory Mitigation

Sometimes permittees voluntarily or accidentally provide more mitigation than required. Permittees ask to apply this "excess" mitigation to another project affecting wetlands in the same vicinity. At times applicants have requested that excess mitigation be reserved or acknowledged for future projects. Since there are formal processes for mitigation banks and advance mitigation, the agencies generally do not support creating unofficial banks for excess mitigation. Allowing applicants to unofficially "bank credits" or perform advance mitigation circumvents the federal and state processes set up for these actions.

If applicants perform compensation beyond what is required in the hope of using it for future projects, they do so at their own risk. The agencies are under no obligation to accept it as compensation for the impacts of other projects, but they may consider it in certain situations. Baseline conditions at the mitigation site should be thoroughly documented in order for any excess mitigation to be considered for other projects.

Applicants should consider consolidating compensatory mitigation for projects beyond the one being authorized before starting the permit process. That way, the applicant and agencies can decide on the correct approach first, and the applicant can receive assurance that the proposed compensatory mitigation can be used for future projects.

4.2 Programmatic Mitigation

Programmatic mitigation generally involves combining compensatory mitigation for two or more projects affecting wetlands or other *aquatic resources*. Programmatic approaches include *mitigation banking*, *in-lieu fees*, programmatic mitigation areas at the local level, and "consolidated" mitigation. These approaches often involve compensatory mitigation projects designed to restore and maintain *environmental processes* in a larger landscape context. Some of these approaches however have not yet been widely used in the State of Washington.

4.2.1 Mitigation Banking

Although *mitigation banking* has been around since the 1970s, it has only recently become widely used. The 1995 federal guidance on mitigation banking[13] defines it as "wetland restoration, creation, enhancement, and in exceptional circumstances, preservation undertaken expressly for the purpose of compensating for unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be as environmentally beneficial." Typically a public agency, organization, or private entrepreneur establishes a large mitigation site. Credits (see Section 4.2.1.2. for definition) from a bank are then withdrawn to compensate for a number of smaller impacts to wetlands in the future. Public agencies such as transportation departments typically use the banks only for their projects, whereas private entrepreneurs

13 Federal Guidance for the Establishment, Use and Operation of Mitigation Banks (60 FR 58605-58614, November 28, 1995). (See Appendix E for a description.)

sell the bank credits to private developers or public agencies to use as mitigation for their projects.

Mitigation banks provide an opportunity to compensate for impacts at a regional scale and provide larger, better-connected blocks of habitat in advance of impacts. Mitigation banks generate “credits,” that can then be sold to permit applicants who need to offset the impacts of projects within a designated “service area” of the bank (see Section 4.2.1.2 for definitions).

Because mitigation banks are developed in advance of the majority of impacts for which they compensate, this ensures that the banks are ecologically successful before being used to offset such impacts. Properly developed mitigation banks offer improved functions, lower mitigation costs to permit applicants, and a more streamlined permit process for projects using the bank.

Bank sites are normally protected in perpetuity by a legally binding protective covenant such as a conservation easement that is held by a long-term manager. Bank sponsors must also provide one or more temporary financial assurances to ensure the successful ecological development of the bank and establishment of an endowment to fund long-term management of the bank site.

To date, few mitigation banks have been approved in Washington. The agencies however are developing and implementing a state process (see Section 4.2.1.3) for reviewing and approving banks. As they gain experience in evaluating proposals, mitigation banks are likely to become more common in Washington.

4.2.1.1 Washington’s Mitigation Banking Law

In 1998, the Washington State Legislature adopted Chapter 90.84 RCW, Wetlands Mitigation Banking (see Appendix E for a description). Through this law the state legislature recognized mitigation banking as an important tool for compensating for wetland impacts. The law notes that banking may provide benefits over concurrent mitigation such as reduction of temporal losses, consolidation of smaller individual projects, etc. The law however does not change the way wetlands are regulated, and *mitigation sequencing* (*avoidance*, *minimization*, and *compensation*) still applies (see Section 3.5.1, *Mitigation Sequencing*).

The law directs Ecology to develop and adopt rules for a statewide wetland banking certification program through a collaborative process involving the interested public and private entities. The rules are to focus on procedures for certifying banks as well as the process for implementing banks. The law also requires that the rules must be consistent with the 1995 federal guidance on wetland banking.

Ecology used a collaborative approach to develop a draft rule (Chapter 173-700 WAC). In 1999, an 18-member advisory team was formed to develop the rule. The team consisted of representatives from local, state, and federal agencies; environmental organizations; agriculture; business; and private bank developers. This team developed and published a draft rule for public review and comment in 2001, but it was withdrawn in 2001 due to budget shortfalls.

The 2004 and 2005 state budgets funded a pilot program to test the draft rule. The pilot program lets Ecology test the draft rule, make changes, improve it if necessary, and eventually adopt it. With input from the advisory committee and pilot program participants, improvements to the pilot rule may be made before it is formally adopted. If funds are allocated to finalize the banking rule, Ecology will refile a draft of the revised rule for public comment and then proceed to final adoption. For current information on the state Wetland Mitigation Banking Program go to http://www.ecy.wa.gov/programs/sea/wetmitig.

4.2.1.2 Terms Used in Mitigation Banking

- Mitigation Bank Instrument (MBI) and Memorandum of Agreement (MOA). These are legally binding documents that include all details of the bank development and operation, including credit generation, service area, monitoring, and long-term maintenance provisions.
- Bank site. The physical site where mitigation banks are constructed and operated.
- Bank sponsor (Banker). An organization or individual operating under the provisions of a mitigation banking instrument that: 1) markets and sells credits; 2) tracks available credits through a bank ledger; 3) monitors and reports on the development of the bank site; and 4) provides for perpetual protection, management, and other services for the bank site.
- Mitigation Bank Review Team (MBRT). An interagency oversight committee that reviews and approves the mitigation bank instrument and provides oversight of the bank's operation.
- Debit projects. Projects located within the service area of the bank that use bank credits to compensate for their unavoidable wetland impacts.
- Service area. The "market area" or the geographic area in which credits may be sold (if determined to be appropriate by the permitting agencies).

4.2.1.3 Planning a Mitigation Bank and Getting it Approved

The following steps must generally be completed while planning a mitigation bank and getting it approved and on the ground. The circumstances of a specific bank may require additional tasks or a slightly different sequence of activities.

- Determine if there is a market/demand for a proposed mitigation bank in a particular area.
- Identify the specific mitigation needs of the area in terms of aquatic resources and functions, and then locate sites where this could be accomplished effectively (economically and ecologically). In other words, determine the general categories of projects and types of impacts that may use a potential bank for compensation and identify potential bank sites that match the general activities expected to be compensated for.
- Contact local governments near the potential bank and see if there are any statutory barriers to using a compensatory wetland mitigation bank (e.g., wetland mitigation is limited to on-site or same *sub-basin*, provisions of critical areas ordinances, etc.).

- Develop a conceptual design and short proposal that, at a minimum identifies the location of the project and its goals and objectives for specific functions to be achieved at the bank site.
- Request that the MBRT convene a pre-application meeting to discuss the proposal, tour the project area, and determine whether further consideration of the bank proposal is appropriate.
- If further consideration of the proposal is warranted, prepare a “prospectus” for the bank as required by the draft state rule (Chapter 173-700 WAC) and the 1995 federal guidance.
- Once preliminary approval of the prospectus is granted, the agencies will issue a public notice that includes the prospectus and requests comments from the public and other interested parties on the proposed bank.
- Work with the MBRT to refine the bank design, service area, crediting issues, long-term management, and other items that make up the banking instrument as outlined in the draft state rule (Chapter 173-700 WAC) and 1995 federal guidance.
- With the agencies, develop and finalize a negotiated mitigation banking instrument (MBI), which details the legal and physical characteristics of the bank and describes how it would be established and operated.
- The Corps and Ecology develop a legal memorandum of agreement (MOA) for the bank.
- The agencies complete their review and issue a permit that authorizes construction of the bank and requires full implementation of the provisions of the MBI and MOA.
- After completing baseline studies construct the bank site and monitor it for success.
- The agencies and the MBRT monitor the operation and ecological success of the bank, and approve the release of credits for sale or use.

For detailed guidance on the planning and approval process and requirements for a mitigation bank, see the federal guidance on mitigation banking and the state’s draft mitigation banking rules (see Appendix E for a description).

4.2.1.4 Using Banks for Mitigation

Once released for use or sale, bank credits are used to compensate for impacts that generally occur within the service area of the bank. As credits are used, bankers debit them from the bank’s ledger. Once all credits in a bank have been used, the bank is closed.

After a permit applicant has taken all necessary steps to avoid and minimize a project’s likely impacts on the aquatic environment, the agencies will then determine whether buying credits from a particular bank would provide appropriate and practicable compensation for a proposed impact. The agencies will consider:

- Whether any other opportunity for mitigation is available and environmentally preferable.
- How closely a bank’s credits match the functions affected by a proposed action.

- Whether using a bank to compensate for the impacts would be in the best interest of the aquatic environment, particularly in light of the needs of the watershed.

4.2.2 In-Lieu Fees

In-lieu fees (ILFs) are gradually being recognized as a viable option for consolidating compensatory mitigation projects. In this approach to mitigation, a permittee pays a fee to a third party in lieu of conducting project-specific mitigation or buying credits from a mitigation bank. ILF mitigation is used mainly to compensate for minor impacts to wetlands when better approaches to compensation are not available, practicable, or when the use of an ILF is in the best interest of the environment. Compensation for larger impacts is usually provided by project-specific mitigation or a mitigation bank.

In 2000, federal guidance on the use of in-lieu fee arrangements[14] clarified how in-lieu fee mitigation "may serve as an effective and useful approach to satisfy compensatory mitigation requirements and meet the Administration's goal of no overall net loss of wetlands." It elaborated on the previous discussion of in-lieu fees found in the 1995 federal guidance on mitigation banks[15].

An ILF represents the expected costs to a third party of replacing the wetland functions lost or degraded as a result of the permittee's project. ILFs are typically held in trust until they can be combined with other ILFs to finance a mitigation project. The entity operating the trust is typically a nonprofit organization such as a local land trust, private conservation group, or government agency with demonstrated competence in natural resource management.

4.2.2.1 Establishing an In-Lieu Fee Program in Washington State

The agencies are discussing a framework for an ILF program in Washington. Such a framework would not by itself establish any local or regional ILF trust fund. Rather it would establish a process for managing collected fees, procedures for evaluating, approving, and funding ILF activities, and rules for coordinating among program participants. Once a framework is established, a wide variety of individual ILF trust funds could be developed as the need arises throughout the state. The basic goals of a Washington ILF program would be: 1) to increase the overall quality of mitigation for projects with minor impacts; and 2) to give permit applicants another way to compensate for the impacts of their projects when better approaches are unavailable.

Though there currently is no specific framework for the use of ILFs, ILF mitigation may be considered appropriate when:

- The impacts of a project are too small to justify the cost of designing and implementing project-specific mitigation.

14 Federal Guidance on the Use of In-Lieu-Fee Arrangements for Compensatory Mitigation Under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act (65 FR 66914-66917, November 7, 2000). (See description in Appendix E.)

15 Federal Guidance for the Establishment, Use and Operation of Mitigation Banks (60 FR 58605-58614, November 28, 1995). (See description in Appendix E.)

- Opportunities to do project-specific mitigation or to buy credits from an approved mitigation bank are not available.
- Project-specific mitigation that could be implemented would likely result in a low-performing system, have a high risk of failure, be incompatible with adjacent land uses, or fail to address the needs of the watershed.
- A minor amount of additional mitigation is needed to supplement project-specific mitigation that does not fully compensate for a project's impact.

In Washington, the agencies have approved case-by-case use of ILF mitigation, generally when other forms of compensation are not available, practicable, or appropriate. In such situations, a third-party recipient of the fee must be identified and the agencies enter in to a contract with them. The contract generally should identify how fees will be collected and when the fees will be used, and include specific mitigation plans that describe how the ILF-funded mitigation will compensate for impacts.

The following criteria must usually be met before the agencies will approve an ILF arrangement:

1. The fees will be used to fund a clearly defined mitigation project.
2. The entity responsible for spending the money has a proven track record in such matters.
3. The project being funded would result in an increase in acreage and function that adequately compensates for the permitted impacts.
4. There is a clear timeline for completing the mitigation project.
5. The permitted impacts for which the ILF compensates are small (generally less than ½ acre) and minor, unless the ILF is a portion of a compensatory mitigation package (mitigation requirements are met by combining several different approaches).
6. There are provisions for long-term protection and management (including mechanisms such as conservation easements) and funding for long-term management of the site.
7. No approved mitigation bank or other form of compensatory mitigation is available and environmentally preferable.
8. The ILF-funded mitigation project is within the same watershed as the impact.

Comparing in-lieu fees and mitigation banks

ILF mitigation and mitigation banking share many features. Both allow permittees to meet mitigation requirements by paying a fee to a third party who accepts responsibility for successfully implementing the required compensatory mitigation. Both must also comply fully with federal mitigation guidance and policy, including a requirement for a written implementing agreement. The agreement normally includes construction plans, performance standards, monitoring and reporting provisions, a long-term management plan, financial assurances, a protective real-estate agreement (e.g., conservation easement), and other measures to ensure the ecological success of a project.

The main differences between mitigation banking and ILF mitigation are: 1) the timing of the mitigation activities that compensate for project impacts; and 2) determining the amount of ecological benefit and the appropriate fee. With mitigation banks, mitigation is done in advance of the impacts; ILF mitigation is normally conducted afterwards. With banks, the ecological benefits and the financial costs of mitigation are known, so an appropriate fee for credits is easily established. With ILF projects, the ecological benefits and financial costs often must be estimated, so determining appropriate fees is more difficult. While specific ILF-funded mitigation projects may not always be identified in advance of project impacts, spending ILFs quickly to fund mitigation projects is generally a high priority. The agencies may adjust the amount of the ILF to compensate for expected delays in spending them. Because of their advantages over ILFs, the agencies generally prefer the use of mitigation banks.

4.2.3 Programmatic Mitigation Areas at the Local Level

A programmatic mitigation area is one or more sites identified, by a local government or a state or federal agency, as a preferred location for wetland mitigation. The regulatory entity then directs applicants to mitigate for projects affecting wetlands at the programmatic mitigation area. Mitigation projects are constructed separately on the site, but all are part of a common design. Using a programmatic mitigation area is like doing an individual concurrent mitigation project except that the site location and design have already been identified. The programmatic mitigation sites are subject to the same minimum requirements as other mitigation sites, such as long-term protection and monitoring.

Programmatic mitigation allows the restoration of larger wetland areas that are important to the functioning of a stream basin or watershed because of where they are. Many projects require relatively small mitigation areas, and a programmatic mitigation area allows their consolidation into a larger area.

A programmatic mitigation area works as follows:

1. The lead regulatory entity (e.g., city, county, or state or federal agency) identifies one or more priority restoration areas.

2. The regulatory entity develops a mitigation plan for the entire site and either buys the land or buys an easement on the property.

3. As projects needing compensatory mitigation arise, applicants are directed to perform actions that contribute to the overall site plan.

This approach has rarely been used in Washington, but the agencies support programmatic mitigation areas that are integrated with watershed planning and focus on high-priority sites. One example is along Clear Creek in Kitsap County, where several adjacent mitigation projects have been completed. The county has actively directed mitigation projects to this area. Another example is along Mill Creek in Auburn, where the Emerald Downs Race Track and Washington State Department of Transportation (WSDOT) located their mitigation sites in an area identified in the draft Mill Creek Special Area Management Plan. A third example can be seen in the lower Snohomish River estuary, which has elements of a programmatic mitigation area supported by the inventory and restoration priorities identified in the Snohomish Estuary Wetland Integration Plan (SEWIP). Several compensation wetlands lie adjacent to the river and sloughs within the SEWIP area. Together, these sites are expected to provide significant benefits to the watershed and its wildlife. WSDOT has also developed a programmatic mitigation agreement with Ecology to provide consolidated compensation for small, ongoing impacts to wetlands in the Willapa Bay watershed.

4.2.4 "Consolidated" Mitigation

The programmatic approaches already mentioned in this chapter could all be considered consolidated mitigation in that they involve combining (or consolidating) compensatory mitigation for two or more individual projects affecting wetlands or other aquatic resources. Another scenario where mitigation can be consolidated is as follows: There are two or more proposed projects, by the same or different entity, which have identified wetland impacts. The projects will be permitted separately and both will require mitigation. The mitigation for the two projects can be combined and developed together as one project or phased in at different times on a single site either concurrently with, or in advance of project impacts. This approach can be done by a single entity, such as a public works department with multiple projects affecting wetlands in a general area, or by two or more entities that cooperate to share costs and resources.

This approach therefore can provide some of the economic and environmental benefits of mitigation banking such as economies of scale and resulting larger blocks of wetland area than can benefit wildlife. Timing and coordination between projects using the consolidated site however can be difficult. This option has not yet been widely used in Washington.

If considering this approach or any other approach mentioned in this chapter, it is important to contact the agencies early to determine if it will be considered appropriate given the specific circumstances (see Appendix C for agency contacts).

Chapter 5 - Types of Compensatory Mitigation

This chapter describes the types of *compensatory mitigation* (e.g., re-establishment, rehabilitation) and discusses the agencies' preferences for each type.

5.1 The Different Types of Compensatory Mitigation

Compensatory mitigation entails one or more of the following basic actions:

- *Restoring* wetland acreage and functions to an area where those functions formerly occurred.
- Creating new wetland area and functions in an area where they did not previously occur.
- *Enhancing* functions at an existing wetland.
- *Preserving* an existing high-quality wetland to protect it from future loss or degradation.

> Compensatory mitigation is not evaluated until appropriate and practicable *avoidance* and *minimization* has been accomplished (see Section 3.5.1, *Mitigation Sequencing*).

Until recently, compensatory mitigation has been divided into four categories: restoration, creation, enhancement, and preservation. In 2002, in Regulatory Guidance Letter (RGL) 02-02, the Corps of Engineers redefined the types of compensatory mitigation based on the mitigation activity and whether it offers the potential for a net gain in acres and/or functions. The terms used by the Corps are: *restoration* (divided into two categories - *re-establishment* and *rehabilitation*), *establishment*, *enhancement*, and *protection/maintenance*. See Figure 1 for a comparison of old and new terms.

For consistency, the agencies are using the Corps's terminology and definitions. However, the terms "creation" and "preservation" are used throughout this document in lieu of "establishment" and "protection/maintenance," respectively, since the former terms are widely understood and used in wetland compensatory mitigation. The terms for compensatory activities are defined in RGL 02-02 as follows (text added for this document is within [brackets]):

> Restoration: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into:
>
> > Re-establishment: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former wetland. Re-establishment results in rebuilding a former wetland and results in a gain in wetland acres [and functions]. [Activities could include removing fill, plugging ditches, or breaking drain tiles.]

Rehabilitation: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic functions [and processes] of a degraded wetland. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres. [Activities could involve breaching a dike to reconnect wetlands to a floodplain or returning tidal influence to a wetland.]

Creation (called "Establishment" in the guidance letter): The manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland or deepwater site, where a wetland did not previously exist. Establishment results in a gain in wetland acreage [and function]. [A typical action is the excavation of upland soils to elevations that will produce a wetland *hydroperiod* and hydric soils, and support the growth of hydrophytic plant species (Gwin et al. 1999).]

Enhancement: The manipulation of the physical, chemical, or biological characteristics of a wetland to heighten, intensify or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for specified purposes such as water quality improvement, flood water retention, or wildlife habitat. Enhancement results in a change in wetland function(s) and can lead to a decline in other wetland functions, but does not result in a gain in wetland acres. [Examples are planting vegetation, controlling non-native or *invasive species*, and modifying site elevations to alter hydroperiods.]

Preservation (called "Protection/Maintenance" in the guidance letter): The removal of a threat to, or preventing the decline of, wetland conditions by an action in or near a wetland. This term includes the purchase of land or easements, repairing water control structures or fences, or structural protection. Preservation does not result in a gain of wetland acres [but may result in a gain in functions over the long term].

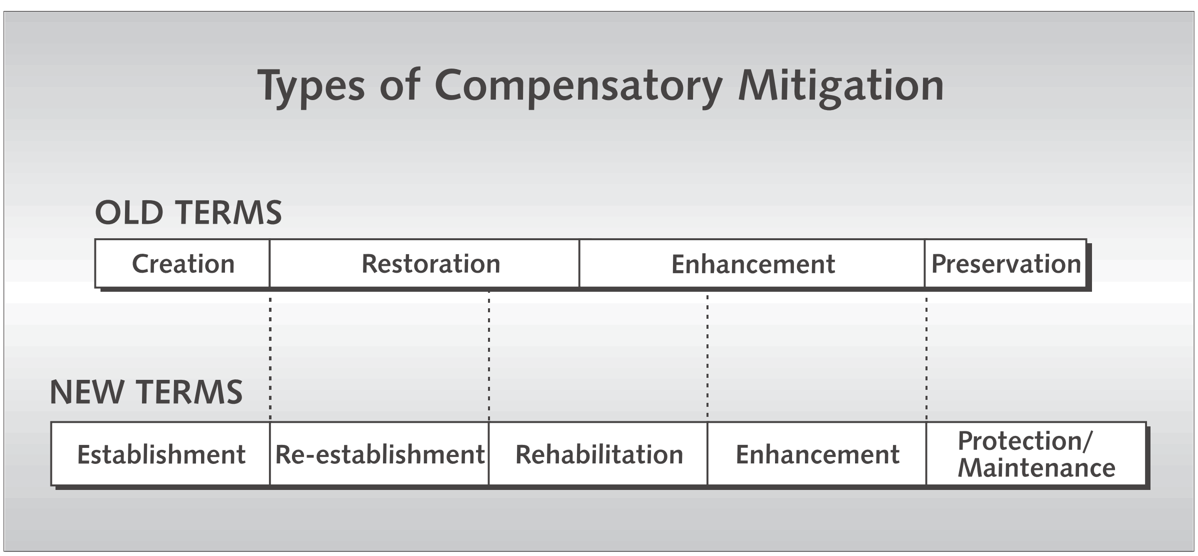

Figure 1. Old and new terms for types of compensatory mitigation.

5.1.1 The Difference between Rehabilitation and Enhancement

Rehabilitation and enhancement are similar in that they both involve existing wetlands and, when used to compensate for filling wetlands, result in a net loss of wetland acreage. Some activities that were called enhancement in the past are now considered rehabilitation (a form of restoration), and may generate a more favorable (lower) mitigation ratio. The distinction between rehabilitation and enhancement as defined above is not clear-cut and can be hard to understand. Actions that rehabilitate or enhance wetlands span a continuum and cannot be strictly defined as one or the other.

Rehabilitation ◄————————► Enhancement

In general, rehabilitation involves actions that are more sustainable and that reinstate *environmental processes*, at both the site and landscape scales (e.g., reinstating hydrologic processes in a floodplain by breaching dikes). Such actions often restore environmental processes that have been disturbed or altered by human activity. The agencies further define rehabilitation as actions that restore the original *hydrogeomorphic (HGM) class*, or subclass, to a wetland whose current HGM class, or subclass, has been changed by human activities.

Enhancement typically involves gains in only one or a few functions and can lead to a decline in other functions. Enhancement actions often focus on structural improvements to a site and generally do <u>not</u> address larger-scale environmental processes or even processes at the site scale.

Take a former forested, riverine wetland that was changed to an emergent, *depressional wetland* by diking and grazing. Rehabilitating the wetland would involve breaching the dike and ending the grazing. In this case the hydrologic processes are reinstated so the wetland becomes a riverine wetland again. Reforesting the wetland without reconnecting it to the riverine system would be considered enhancement because this change is structural and does not reinstate environmental processes.

Because of the range that the two terms span, rehabilitation and enhancement activities may overlap. Both rehabilitation and enhancement can provide ecological benefits that compensate for project impacts, depending on specific circumstances. When the distinction between rehabilitation and enhancement is not clear-cut, the agencies are responsible for determining what term to use for a proposal's compensatory mitigation. See Appendix H for more information.

5.2 Agency Preferences for Each Type of Compensatory Mitigation

This section describes the advantages and disadvantages of different types of compensation and the reasons why some are preferred by the agencies. Which type is best depends on the circumstances of a given project (see Chapter 6, *Determining Appropriate and Adequate Compensatory Mitigation*).

The general order of preference for the types of wetland compensation is:

1. Restoration (re-establishment or rehabilitation).
2. Creation (establishment).
3. Enhancement.
4. Preservation (protection/maintenance).

5.2.1 Restoration

Restoration, including both re-establishment and rehabilitation, is generally the agencies' first choice for compensation. The *Operational Guidelines for Creating or Restoring Self-Sustaining Wetlands* (Chapter 7 in National Research Council 2001) state that restoration "has been observed to be more feasible and sustainable than creation of wetlands. In restored sites the proper substrate may be present, seed sources may be on-site or nearby, and the appropriate hydrological conditions may exist or may be easily restored." A 1990 Memorandum of Agreement[16] between the Corps and EPA declares, "Because the likelihood of success is greater and the impacts to potentially valuable uplands are reduced, restoration should be the first option considered."

In reality, restoration of freshwater wetlands has not been used as much as creation in Washington. This may be because many wetland impacts are relatively small (generally <1/2 acre) and it is more difficult to find cost-effective restoration opportunities for small sites. Restoration is typically most feasible and cost effective when done over a large area. In addition, previous regulatory requirements directed applicants to provide compensation on-site, which often excluded opportunities for restoration (Sheldon et al. 2005).

There may be more opportunities for rehabilitation than re-establishment. Re-establishment involves restoring processes and functions to an area that was formerly a wetland. Rehabilitation involves improving or repairing the performance of processes and functions in an existing wetland, usually highly degraded because one or more environmental processes supporting it have been disrupted. Rehabilitation often involves actions that substantially improve the hydrologic processes (i.e., previous patterns of water flow) that have been altered by human activities. Rehabilitation might involve breaking drain tiles and plugging ditches to stop the rapid removal of water from a degraded wetland and to restore wetland functions such as groundwater recharge. Although re-establishment and rehabilitation both provide a gain in functions, only re-establishment will provide a gain in acreage as well.

16 Memorandum of Agreement between the Environmental Protection Agency and the Department of the Army Concerning the Determination of Mitigation Under the Clean Water Act Section 404 (b)(1) Guidelines, issued February 6, 1990. (See Appendix E for a description.)

5.2.2 Creation (Establishment)

Landscape position and proximity to a reliable water source are critical for the successful creation of wetlands. This cannot be over emphasized.

Creation, like re-establishment, results in a gain in both wetland area and function but not in areas that were once wetland. Creation is less likely to succeed than restoration and, thus, is less preferred by the agencies than restoration. But this applies only when the created wetland is in an appropriate position in the landscape and would not be established at the cost of another high functioning habitat.

In Washington State, a recent study found that wetlands created from uplands were relatively successful. Sixty percent of created wetlands were either fully or moderately successful, while only 11% of enhanced wetlands were moderately successful, and none were fully successful (Johnson et al. 2002). Many created wetlands resulted in significant gains in water quality and quantity functions (Johnson et al. 2002).

The National Research Council made recommendations to increase the success of wetland creation (National Research Council 2001). Two of them are:

1. "Avoid over-engineered structures in the wetland design." These include water-control structures such as berms and weirs that will require repairs and intensive maintenance. Bioengineered structures of logs or rocks that create contours and mimic natural structures along rivers and shorelines are better than highly engineered structures like walls of riprap or bulkheads. To be successful, creation projects need to be self-sustaining and relatively maintenance free.

2. "Restore or develop naturally variable hydrological conditions." Water inputs for compensation wetlands should take advantage of natural patterns of water flow, such as overbank flooding in a riverine setting or groundwater discharge in a slope or depressional setting.

5.2.3 Enhancement

The enhancement of existing wetlands has been widely used in compensatory mitigation. It is less preferred than restoration (re-establishment and rehabilitation) or creation (establishment). Enhancement activities usually attempt to change plant communities from non-native emergent to native scrub-shrub or forested communities. Frequently, it includes attempts to remove and control undesirable *invasive species* such as reed canarygrass (*Phalaris arundinacea*), blackberry (*Rubus discolor* [= *R. procerus*]), and purple loosestrife (*Lythrum salicaria*) and the planting of native woody species. Occasionally, enhancement includes changing the site's water regime through excavation, construction of weirs, or removal of ditches and drains. Enhancement has historically focused on habitat, but other wetland functions can also be enhanced.

Using enhancement alone to compensate for wetland loss and degradation is cause for concern because it results in a net loss of wetland area. A recent study of mitigation in Washington State (Johnson et al. 2002) raised concerns about the value of enhancement:

- Most enhancement actions focus on improving vegetation structure and ignore improving environmental processes that support wetland systems and functions.
- There is a net loss of water quality and quantity functions and only modest gains in habitat functions.
- The use of enhancement as a primary means of compensatory mitigation contributes to a loss of wetland acreage.

A range of activities with widely varying ecological benefits have been lumped under the heading of enhancement. It is important to differentiate between different kinds of enhancement and determine the level of benefit from each. Enhancement could be more effective if it were geared to improve functions that are limiting in a region or *watershed*. It is important to identify whether enhancement activities will result in any tradeoffs in functions. If any tradeoffs will occur the net ecological benefits should be identified. Enhancement has a place in the mitigation toolbox, but the agencies generally prefer to see it used in combination with re-establishment or creation.

> The agencies prefer that enhancement be used in combination with re-establishment or creation, not alone.

5.2.4 Preservation

Preservation of wetlands to compensate for impacts to wetlands is appropriate only in limited circumstances. The practice can be controversial because it always results in a net loss of wetland area and is perceived as trading one wetland for another one that is already protected. The reality is that some wetland types are not adequately protected and can benefit from being placed in public ownership or protected by a *conservation easement*.

Many *forested wetlands* can be logged under current state laws, and wetlands with significant habitat value are very difficult to protect without large *buffers* and *corridors* to connect them to other habitats. Preservation of large tracts of wetlands and uplands can provide benefits that are impossible to achieve using typical regulatory approaches. One way to think about net loss with respect to preservation is that some wetlands are going to experience unmitigated impacts unless they are protected. Preservation can therefore provide a net gain in functions over what would otherwise occur. For example, preventing trees from being logged provides a potential net gain in forested wetland functions in the future.

Preservation has the following advantages as a compensatory mitigation tool:

- Preservation can ensure protection for high-quality, high-functioning aquatic systems that are critical for the health of the watershed.
- Preservation does not involve the uncertainty of success inherent in restoration, creation, or enhancement.

- Larger mitigation areas can be set aside due to the higher mitigation ratios required for preservation.

As with other forms of mitigation, preserving wetlands as compensation is allowed only after following the standard mitigation sequence of avoiding and minimizing impacts first. Preservation projects are also subject to the same requirements as other types of wetland mitigation (e.g., monitoring and long-term protection; see Section 3.9). Generally significantly higher ratios are required to offset impacts than for wetland restoration (re-establishment and rehabilitation) or creation (establishment) because there is a net loss of wetland area and limited gains in wetland functions (see Section 6.5, *Identifying the Amount of Compensation (Mitigation Ratios)*).

For more criteria and guidance on using wetland preservation for compensatory mitigation see Section 6.4, *Using Preservation*.

Chapter 6 - Determining Appropriate and Adequate Compensatory Mitigation

The agencies normally authorize wetland impacts only if the permit applicant compensates for lost wetland acreage, functions, or both. Compensatory mitigation should be customized for the specific impacts of a project and the qualities of the mitigation site. This document cannot offer detailed guidance for specific projects, which must be handled case by case. However, this chapter will help applicants understand what makes a compensatory mitigation plan appropriate and proportionate to the expected loss of wetland acreage and function – and ecologically successful.

To determine the compensatory mitigation needed, you must answer the following questions:

- What are the types and extent of wetlands (area and function) affected by the project?
- How will the proposed mitigation compensate for the impacts (i.e., how will the project contribute to the goal of no net loss of wetland area, functions, or both)?
- Will the proposed mitigation be successful and sustainable?

To help answer these questions, this chapter discusses:

- When and where compensatory mitigation should occur.
- What type of compensatory mitigation should be used.
- How much mitigation is required compared to what has been lost (mitigation ratio).
- What buffer widths are needed to protect the mitigation site.

Compensatory mitigation should be proportionate to the impact

The agencies must determine the mitigation requirements for specific wetland impacts to ensure that they are proportionate to the proposed loss or degradation of wetland area, functions, or both. This is consistent with the opinion of the U.S. Supreme Court that government permit requirements must have "rough proportionality" with development impacts (*Dolan v. City of Tigard,* 512 U.S. 374, 114 S.Ct. 2309, 129 L.Ed.2d 304 [1994]).

6.1 Compensating for Wetland Losses

6.1.1 No Net Loss

In 1988 the National Wetlands Policy Forum published recommendations on how wetland policies could be improved to better protect and manage the country's wetland resources (Conservation Foundation 1988). The principal recommendation was to establish a national wetlands protection goal, specifically, to "establish a national wetlands protection policy to achieve no overall net loss of the nation's remaining wetlands base, as defined by acreage and function, and to restore and create wetlands, where feasible, to increase the quality and quantity of the nation's wetland resource base."

This goal did not necessarily need to be applied on every permit decision; no net loss is a programmatic rather than a permit-specific goal. Compensatory mitigation must replace area, functions, or both to achieve this goal, but not on every individual project. The forum also recommended that the ultimate goal should be to increase both the quantity and quality of the nation's wetland resource base, rather than just compensate for wetland losses. Non-regulatory restoration should contribute to overall wetland gains. Though "no-net-loss" was never formally adopted as federal policy, it remains a national goal, established by President George H.W. Bush in 1989. Governor Booth Gardner formally adopted this goal for Washington State with Executive Order 89-10 (see Appendix E for a description), and it remains in effect.

6.1.2 Compensating for Lost or Degraded Area

Compensatory mitigation has traditionally focused on the wetland acreage needed to offset the loss or degradation of wetland area and/or functions. A report by the National Research Council (2001) recommended that both wetland functions and area be considered. The Corps' Regulatory Guidance Letter 02-02 also emphasizes the replacement of area, functions, or both.

Area has been used to account for authorized impacts and compensation for several reasons:

- It is fairly easy to determine the area of a wetland.
- Methods for assessing functions have limited use in accounting for the amount of loss and the amount of compensation necessary.
- Measuring wetland functions can be time consuming and expensive, and not always warranted for minor impacts.

The amount of compensation required is determined case by case, often using a replacement or mitigation ratio (see Section 6.5, *Identifying the Amount of Compensation [Mitigation Ratios]*).

6.1.3 Compensating for Lost or Degraded Functions

Since 1989 numerous studies have evaluated whether no net loss of acreage is being achieved, but determining whether a net loss of functions is occurring has been more difficult (see Section 2.1, *Wetlands and Their Functions*). A study of compensation projects in Washington State (Johnson et al. 2002) found that many projects did not adequately compensate for functions lost from authorized impacts. The National Research Council (2001) concluded that a net loss of functions has been occurring nationally. Based on the National Research Council (2001) recommendations, the Corps' Regulatory Guidance Letter 02-2 re-emphasizes the idea that wetland impacts be addressed with "at a minimum, one-to-one functional replacement, i.e., no net loss of functions." Therefore, the agencies will increasingly focus on compensating for wetland functions.

Examples of Wetland Functions

Improving Water Quality

- Removing Sediment
- Removing Nutrients (Phosphorous and Nitrogen)
- Removing Metals and Toxic Organic Compounds
- Removing Pathogens

Maintaining the Water Regime in a Watershed (Hydrologic Functions)

- Reducing Peak Flows
- Decreasing Erosion
- Recharging Groundwater

Maintaining Habitat

- Providing General Habitat
- Providing Habitat for Invertebrates
- Providing Habitat for Amphibians
- Providing Habitat for Anadromous Fish
- Providing Habitat for Resident Fish
- Providing Habitat for Wetland-Associated Birds
- Providing Habitat for Wetland-Associated Mammals
- Richness of Native Plants
- Supporting Food Webs

From Freshwater Wetlands in Washington State Volume 1: A Synthesis of the Science (Sheldon et al. 2005).

6.1.3.1 Analyzing Wetland Functions

When an applicant proposes to alter a wetland, it is important to know what wetland functions will be lost or reduced and their importance in the landscape (see Section 2.3, *Wetlands as Part of the Landscape*). This information helps the applicant and agencies understand what may be lost and lets them make more informed decisions about mitigation.

To make informed decisions about wetland impacts and replacement of lost functions, wetland functions must be analyzed at both the wetland impact site and the compensation site, both before and after the project is completed. The same analysis of the proposed mitigation site, pre- and post-mitigation, provides an estimate of the expected gain in functions, or "functional lift," that is expected. This lift must then be compared to the functions to be lost at the impact site. The mitigation would be sufficient, in most cases, only if the expected "lift" at the mitigation site equals or exceeds the loss at the impact site. Trade-offs in functions may be allowed, but this may affect the amount of compensation (i.e., mitigation ratios) required (see Section 6.5, *Identifying the Amount of Compensation* [Mitigation Ratios]).

A number of tools to analyze wetland functions are reviewed in Appendix G. The appendix also includes guidance on which tools are recommended for use with compensatory mitigation.

Using Analyses of Functions

- When a project involves impacts to wetlands, a description of the functions provided by the wetlands is required.
- The level of analysis depends on the type and scale of the proposed impacts. If wetland impacts would be significant, the agencies may ask an applicant to use the Methods for Assessing Wetland Functions (also known as the Washington State wetland function assessment methods, or WFAM; Hruby et al. 1999, Hruby et al. 2000) (see Appendix G).
- If Ecology is involved in a project, the agencies usually require the applicant to use the Washington State wetland rating system (Hruby 2004a, 2004b) to determine the category of the wetland and how well it performs three general categories of functions.
- Functions should be analyzed both before designing any mitigation and during the monitoring period after the mitigation has been installed. The agencies will use these analyses to help determine whether a project provides the proposed level of functions.

6.2 Determining When Mitigation Actions Should Occur

Mitigation can occur at the same time as or before project impacts. *Concurrent mitigation* refers to compensation that occurs at about the same time as the impact. *Advance mitigation* refers to compensation that is implemented before the impact. While the agencies prefer advance compensation, in reality, many compensation projects are implemented as much as one to two years after the impact occurs.

The amount of compensation required may be influenced by the timing of compensatory mitigation. If a compensation project is completed before wetland impacts, the *temporal loss* of functions is less. If a compensation project is implemented far enough in advance of wetland impacts, the agencies can determine if it has met all of the goals, objectives, and performance standards. Therefore, the risk of failure and temporal loss is reduced, and mitigation ratios will be lower.

Activities to implement a compensation project can be scheduled before, during, and after site construction begins. However, a baseline assessment of the compensation site must precede any such work. This baseline information is essential for comparisons with later site performance.

Completion schedules may vary, depending on the goals of the project and the types of activities to be performed. If the goal of a project is to create a new wetland with a specific *hydroperiod* (or water regime) and a variety of plant communities, it may help to wait a year after the site is graded to make sure that the water regime is appropriate before planting. This can help avoid plant mortality from too much or too little water.

Phased planting may be appropriate in establishing a forested wetland. Deciduous species can be planted initially to provide a canopy, and shade-tolerant conifers can be underplanted after the deciduous trees are established.

Notify the agencies before starting construction at compensation sites

Most permits and approvals require applicants to notify the agencies before starting construction. For large projects, the applicant should plan an on-site, preconstruction meeting with the agencies and the contractor implementing the compensatory mitigation plan. This helps to ensure that the contractor understands the site goals and design, the permit conditions, and the expectations of the regulatory agencies.

6.3 Choosing the Location and Type of Compensatory Mitigation

Selecting the location for the compensation action and deciding the type of wetland that will be restored, created, etc. are two of the most critical aspects in determining appropriate and adequate wetland compensation. The type and location of wetland compensation should provide sustainable ecological benefits that are important to the functioning of the *watershed*.

6.3.1 Choosing the Location

6.3.1.1 Background

The location of a compensation wetland is one of the first issues that a project proponent faces. The location of a wetland affects its structure (or morphology), the types of functions it provides, and the relative value of those functions. For example, a *depressional wetland* in the upper portion of a watershed can reduce flooding downstream by detaining surface waters and delaying the runoff from storm events into streams. The same wetland located in the lower portion of a watershed would not do as much to reduce flooding.

The Corps, EPA, and Ecology consider multiple factors when reviewing and approving proposals for the location of compensation projects. These factors include the surrounding land uses and ecological conditions. The landscape and land uses surrounding and upgradient from a compensation site affect how well it functions and whether the performance of functions is likely to be degraded over time. The agencies encourage applicants and local governments to use available information on the landscape and large-scale environmental processes when selecting and designing mitigation sites (see Section 2.3, *Wetlands as Part of the Landscape,* as well as Section 3.3 in Part 2 on site selection).

Questions the agencies consider when evaluating on- vs. off-site and in- vs. out-of-kind options

The agencies consider the following questions when evaluating the location and type of compensatory mitigation proposals. These criteria are consistent with Washington State's *Alternative Mitigation Policy Guidance Interagency Implementation Agreement* (Ecology 2000; see Appendix E).

- What are the functions, habitat types, and species that would be adversely affected?
- Is replacement or reintroduction of the functions, habitat type, or species vital to the health of the watershed? If so, do they need to be replaced on site to maintain the necessary functions?
- If on-site, in-kind replacement is not necessary, are there priority areas for restoring species, habitat types, or functions that are important or limited in the watershed? Are the affected wetland type and its functions fairly common in the watershed, while other types and functions are relatively rare or limited due to historic losses?
- If both on- and off-site mitigation is available, will the functions, habitat type, or species proposed as off-site compensatory mitigation provide greater value to the landscape than those proposed as on-site?
- How will the proposed mitigation maintain, protect, or enhance impaired functions or *environmental processes* that are critical or limiting in the watershed?
- Does the proposed mitigation have a high likelihood of success?
- Will the proposed mitigation be sustainable in light of expected future land uses?

Historically, applicants were directed to locate compensation wetlands on or near the impact site. A 1990 Memorandum of Agreement (MOA) (*The Determination of Mitigation Under the Clean Water Act Section 404 (b) (1) Guidelines*) between the Corps and EPA on wetland mitigation documented a strong preference for compensation wetlands that were *on-site* and *in-kind*. On-site means the compensation site is near the wetland to be lost or degraded (i.e., normally on the same property). In-kind means compensating with the same type of wetland or aquatic resource that is impacted (see Section 6.3.2 for more on in-kind compensation). Many city and county wetland regulations still embody a preference for locating wetland compensation on-site.

Formerly, it was widely held that locating the compensation on the same site as the lost wetland would provide the greatest opportunity to replace the functions. Since then, studies on compensatory mitigation (National Research Council 2001, Johnson et al. 2002) and observations by the agencies have shown that these policies often result in atypical, low-quality wetlands in locations without an appropriate water regime, some of which are incompatible with the surrounding landscape.

In its 2001 compensatory wetland mitigation study, the National Research Council found that many mitigation areas were not sustainable because they were incorrectly positioned in the landscape. The authors determined that this occurred, in part, because of the preference for on-site mitigation. The National Research Council also found that some sites, although in appropriate landscape positions, were threatened by future development in the watershed.

> **Federal guidance on implementing a watershed approach to compensatory mitigation**
>
> The federal agencies working on the National Mitigation Plan are working on guidance to address compensatory mitigation in a watershed context. For updated information go to http://www.mitigationactionplan.gov/watershed_context.html.

Other research has shown that the location of a wetland can affect it in variable ways. King (1997) found that fish and wildlife habitats generally benefit from being surrounded by healthy ecological landscapes that are relatively inaccessible to humans. Other wetland functions such as sediment and nutrient trapping often provide more benefit when located in or near disturbed landscapes. In other words, wetlands in disturbed areas often have a greater opportunity to provide certain functions. Some of the *values* (social functions) that wetlands provide, such as aesthetics, recreation, education, and flood protection, do not occur in the absence of people. (For a detailed discussion of wetland functions and the difference between the potential and opportunity for a wetland to perform specific functions see *Methods for Assessing Wetland Functions* [Hruby et al. 1999 and 2000].)

Based on regulatory experience and scientific research, the agencies are allowing more flexibility in determining the best locations for mitigation. The agencies will use multiple factors to evaluate the appropriate location for each proposed compensation project. Landscape position, proximity to disturbance, availability of appropriate hydrology, and the needs of the watershed and larger landscape are the primary considerations.

> **Local requirements for the location of compensatory mitigation sites**
>
> Some local governments have requirements for the location of mitigation sites in their regulations. Applicants should contact the local planning department to see if there are any restrictions on off-site compensation.
>
> **Authorizations for use of state-owned aquatic lands**
>
> Whether on- or off-site, if activities, including mitigation projects, are proposed on state-owned aquatic lands, authorization to use the lands must be issued from the WDNR (see Section 3.4.2, *The Role of Other State Agencies*).

6.3.1.2 Considerations for Choosing a Location

Applicants are encouraged to seek compensation sites as close to the impact area as practicable, but not necessarily on the same site. To maximize the replacement of lost functions, compensatory wetlands should be located in a similar hydrogeomorphic position in the landscape as the affected wetlands. The order of preference starts in the immediate drainage basin as the impact, then the next higher level basin, then other *sub-basins* in the watershed with similar geology, and finally, the river basin (i.e., the upper, middle, and lower portions, which are also referred to as the source, transport, and receiving portions of a river basin). Compensation should occur in a location where the targeted functions can reasonably be performed and sustained and should not be atypical for that location (refer to the shaded box in Section 6.5.2, *Defining Atypical Wetlands*). (Also see Section 3.3 in Part 2 for a discussion of site selection.)

Defining watershed

The term *watershed* can be confusing because it can be defined and interpreted at a variety of scales. Generally, a watershed is defined as a geographic area of land bounded by topographic high points in which water drains to a common destination. A watershed can be as large as that of a large river (Columbia River), a Water Resource Inventory Area (WRIA), or a major Hydrologic Unit (as classified by a U.S. Geological Survey Hydrologic Unit Code, or HUC), or as small as a river basin or reach.

A *sub-basin* is part of a larger drainage basin or watershed. For example, the watershed of a large river may be composed of several sub-basins, one for each of the river's tributaries.

For the purposes of mitigation, the "boundaries" of the watershed will depend upon the resource, functions, and landscape conditions. Off-site mitigation is generally not authorized beyond the WRIA. When mitigation is required to occur in an area smaller than a WRIA, the terms basin and sub-basin are used.

The agencies are likely to require on-site compensation when:

- The location is critical for replacing location-dependent functions (e.g., water quality and quantity functions and certain habitats).
- The location plays a critical role in watershed-scale processes and functions (e.g., the site provides a connection to other habitat areas and open spaces, or the site is located along a stream).
- The location has a high probability of success and is sufficiently protected from off-site pressures (e.g., the site has an adequate buffer).

The agencies may prefer off-site compensation when:

- The adversely affected functions are of low-quality and the project proponent can demonstrate that compensatory mitigation at an off-site location will provide functions that are critical or limiting in the watershed.
- On-site compensation is not feasible or unlikely to succeed due to adjacent land uses, excessive site disturbances, or the presence of highly invasive plant species.
- The off-site option is an approved wetland mitigation bank, *advance mitigation* site, programmatic mitigation area, or *in-lieu fee* program, and on-site compensatory

mitigation is not environmentally preferable (see Chapter 4, *Approaches to Compensatory Mitigation*).

Off-site compensation must usually be located in the same watershed as the site experiencing the impact. However, occasionally the agencies may agree to compensation outside of the watershed for minor impacts. Considerations include:

- Whether the impact site is located near the boundary of the watershed and suitable sites for compensation are not located in the watershed.
- Whether the geology, topography, plant communities, and climate are similar between watersheds.

Acceptable compensation (whether on-site or off-site) should be a part of a network or *corridor* connecting significant habitat areas or other open space areas whenever possible. When evaluating proposals, agencies keep in mind the natural patterns and corridors in the watershed. As described earlier, rivers and streams function as freeways for the movement of wildlife, water, sediments, and nutrients. Where applicable, compensatory mitigation should contribute to and preserve these corridors to support and maintain the functions of the watershed.

In some cases, as in urbanized areas, connections to other habitat areas are not feasible. However, small wetlands may provide the only available habitat in an area, even though they are surrounded by large paved areas, buildings or lawns. Loss of these wetlands could further isolate the plant and animal communities of other small wetlands in the area by limiting the amount of habitat available for them to expand into (i.e., limiting the possibilities for dispersal and genetic exchange).

In addition, these small wetlands and their buffers may provide the only open, natural area. As these areas become increasingly rare their ecological importance tends to increase. In such cases, the most ecologically preferable alternative for compensation may be to permanently protect other small, on-site urban wetlands that are susceptible to loss and further degradation (rather than compensating for the unavoidable wetland impacts off-site) (see Section 6.4, *Using Preservation*). Decisions on alternative mitigation proposals are made on a case-by-case basis and are at the discretion of the agencies.

Consider the Federal Aviation Administration (FAA) rules when choosing a location

Compensatory mitigation projects located near airports, that have the potential to attract waterfowl and other bird species which might pose a threat to aircraft, require a location that is consistent with current FAA guidance. In a 1997 Memorandum or Agreement (MOA) and Advisory Circular (AC), the FAA provided guidance on locating certain land uses, including wetlands, having the potential to attract hazardous wildlife to or in the vicinity of public-use airports. One of the three major activities of most concern is "development of conservation/mitigation habitats or other land uses that could attract hazardous wildlife to airports or nearby areas." When determining the location of compensation sites the criteria in the FAA AC 150/5200-33 should be considered. If you choose a site that is affected by FAA rules this may result in design constraints, including limiting wildlife habitat and use of the site. The MOA can be accessed at: http://wildlife-mitigation.tc.faa.gov/public_html/moa.pdf.

6.3.2 Providing In-Kind Versus Out-of-kind Compensation

Another important issue that must be resolved early when planning a wetland compensation project is whether the compensation will be in-kind or out-of-kind. *In-kind mitigation* is compensatory mitigation that involves the same wetland type and functions as the lost or degraded wetland, for example, the same *hydrogeomorphic (HGM)* subclass (e.g., riverine flow-through, depressional outflow, *flats*, etc.), plant community, and *Cowardin class* (e.g., palustrine emergent, palustrine forested or *estuarine wetlands*). *Out-of-kind mitigation* therefore refers to compensatory mitigation that involves wetland types and functions which are different from the lost or degraded wetland.

In the February 6, 1990 Memorandum of Agreement between the Corps and EPA[17], in-kind compensatory mitigation is generally preferable to out-of-kind compensatory mitigation. The preference was based on the assumption that similar wetland types provide similar functions. When compensation is out-of-kind, the compensation wetland and wetland that was lost or degraded may perform different functions, therefore net losses of some functions can occur. If, however, compensatory mitigation projects are designed to replace the same type of wetland and functions that are lost, potential net losses of functions are minimized.

As previously discussed, different wetlands perform different functions and at different levels. This is reflected in the wetland class under the HGM classification system (e.g., depressional, riverine, slope, etc.). This classification groups wetlands with similar hydrogeomorphic characteristics. The hydrogeomorphology of a wetland determines, in part, which functions a wetland will perform and the level at which those functions are performed. Therefore, *riverine wetlands* provide different functions from, and perform functions differently than, depressional closed wetlands. For example, a depressional closed wetland may retain all sediments that enter it, while a riverine flow through wetland

17 *The Determination of Mitigation under the Clean Water Act Section 404(b)(1) Guidelines.* See Appendix E for a description.

may only detain sediment temporarily because annual flooding moves sediment downstream. If a riverine wetland is used to compensate for impacts to a depressional wetland, then a loss of some of the functions provided by depressional wetlands would be expected.

With a greater awareness of the role that wetlands play in watersheds and larger landscapes, the agencies are now more likely to approve out-of-kind wetland mitigation projects when it provides an overall net gain in functions that are critical or limited in a watershed. The agencies strongly consider what will provide the greatest ecological benefits for the landscape when making a decision about in- or out-of-kind compensation. The following sections describe how the agencies determine whether in- or out-of-kind compensation is appropriate.

6.3.2.1 In-kind Compensatory Mitigation

In-kind compensatory mitigation is required when the greatest ecological benefits for the watershed can be obtained by replacing adversely affected functions. The following are some circumstances when in-kind compensation is environmentally preferable:

- The affected wetlands and functions are limited or rare within a watershed and are critical for replacement.
- Replacement of the affected functions is important to the maintenance of environmental processes that affect the larger landscape.
- The wetlands affected are high quality or rare (refer to Section 6.4.2[#4] for characteristics of high-quality wetlands).
- Replacement of the same wetland type and functions is needed to satisfy requirements for sensitive or listed species.

In-kind compensation is usually required for impacts to estuarine wetlands

Impacts to *estuarine wetlands* are usually compensated in-kind (i.e., with another estuarine wetland). Freshwater wetlands are rarely acceptable as compensation for impacts to estuarine systems. Estuarine wetlands are important because of their rarity, their landscape position, and the functions they provide.

Other considerations include:

- The extensive, historic loss and conversion of estuarine wetlands in Washington.
- The important habitat they provide for some threatened and endangered species.

6.3.2.2 Out-of-kind Compensatory Mitigation

Out-of-kind compensatory mitigation may provide far greater environmental benefits to the watershed than in-kind replacement, if it is appropriate for its landscape location and connects into a system of natural areas and aquatic corridors. Generally, small impacts to degraded wetland systems may be offset using out-of-kind mitigation. The agencies also accept out-of-kind mitigation when the affected wetlands are dominated by reed canary grass and other *invasive species*. In these cases, the agencies prefer to replace the lost wetlands with ones that are appropriate for their landscape setting, support native communities, and maintain environmental processes.

Out-of-kind mitigation may also be acceptable if the functions or habitats lost are relatively abundant in the area and the compensation project will provide functions and habitats that are limited in the watershed. For instance, while estuarine wetlands provide critical habitat areas for fish and wildlife, much of the original estuarine wetlands in Washington have been lost. As a result, estuarine habitat and shoreline functions are very limited in some river basins, particularly in the Puget Sound area. Because restoration of these habitats is a priority to the agencies, it may be determined that the loss of reed canary grass pastureland in the lower watershed can be adequately offset through the removal of dikes to restore tidal flows and estuarine wetlands habitats.

Out-of-kind compensation may be considered when:

- The lost or degraded wetland provides minimal functions and is not considered limited in the landscape or critical for a special species.
- It is demonstrated that the proposed out-of-kind compensation will provide an overall net gain in functions or habitats that are critical, rare, or limited in a watershed.
- It is not possible to replace the wetland type in-kind. For example, coastal lagoons and *bogs* are considered irreplaceable wetlands because they perform some special functions that have not been proven to be successfully replaced through compensatory mitigation. Impacts to such wetlands would therefore result in a net loss of some functions no matter what kind of compensation is proposed. In general, impacts to irreplaceable wetland types are strongly opposed by the agencies. When it is unavoidable, it is recommended that compensation involve rehabilitation of degraded wetlands of a similar type. Where rehabilitation is not an available option, out-of-kind compensation may be considered.

Federal guidance on off-site and out-of-kind compensatory mitigation

For more information and further guidance on off-site and out-of-kind compensatory mitigation please refer to the *Federal Guidance on the Use of Off-Site and Out-of-Kind Compensatory Mitigation Under Section 404 of the Clean Water Act*, which was developed as part of the National Mitigation Action Plan (http://www.mitigationactionplan.gov).

6.3.2.3 Out-of-Kind Resource Trade-Offs

Out-of-kind resource trade-offs involve replacing an affected wetland with habitats or ecosystems other than wetlands. This could include upland riparian restoration; stream rehabilitation; enhancement or protection of stream or wetland buffers; or preservation of mature forest lands, dune systems, or shrub/steppe communities.

As described above, mitigation requirements for wetland impacts generally involve the restoration, creation, etc. of wetland functions similar to those that are lost or degraded. In some limited cases, however, the agencies have allowed applicants to meet some of their compensatory requirements with non-wetland resources, such as riparian restoration. The agencies may consider tradeoffs if the functions provided by non-wetland resources are limited in the watershed or are critical for restoring the health and functioning of key environmental processes. When agencies allow resource trade-offs, wetland compensation is generally required on a 1 to 1 basis, and then the non-wetland resources are used to make up the difference in the mitigation ratios (see Section 6.5, *Identifying the Amount of Compensation [Mitigation Ratios]*). For example, a one-acre wetland fill may require the creation or re-establishment of two acres of wetland. However, in some circumstances it may be appropriate to create or restore one acre of wetland, along with five acres of riparian restoration. Each request for compensation with non-wetland resources is evaluated on a case-by-case basis (see also Section 6.5.7, *Uplands Used as Compensation*).

Out-of-kind resource tradeoffs may be allowed when:

- Wetland impacts occur to a highly degraded wetland which provides low levels of wetland functions.
- It can be demonstrated that the greatest environmental benefits in a basin can be achieved by restoring, rehabilitating, or preserving non-wetland resources. Options for meaningful wetland compensation are limited or non-existent.
- The non-wetland resource contributes to and enhances the overall functioning of the wetland system. For example, stream and riparian rehabilitation adjacent to a riverine wetland.
- When the non-wetland habitats contribute to the restoration of habitats for sensitive or endangered species.

To make reasonable and appropriate decisions on resource trade-offs for wetland compensation, agencies need to have information on the condition and functioning of the watershed or basin in order to determine if the net effect of the trade-off will be positive. In areas where watershed planning is underway, some of the information may already be available. Some of that information includes:

- Identification of limiting resources or functions in the area.
- The degree of permanent disruptions to environmental processes such as the way water moves through the landscape.
- Key areas identified for restoration.
- Key areas identified for protection and preservation.

No matter what type of compensatory mitigation being proposed, whether it is in- or out-of-kind, on- or off-site, or a proposed resource trade-off, it is important to contact the agencies early to determine whether it will be appropriate and adequate compensation for the lost or degraded wetland and its functions (see Appendix C, *Agency Contacts*).

6.4 Using Preservation

6.4.1 Why is Preservation Acceptable for Mitigation?

The preservation of a high-quality wetland, such as a mature forested wetland, native sedge community, or *vernal pool*, can provide significant ecological benefits. Preserving high quality and well-functioning wetlands protects the functions being performed by those wetlands from being lost in the future. Native species disperse from mature wetland areas into adjacent habitats, particularly restored and created wetlands. Seeds dispersed from a preserved site can colonize adjacent created wetlands and animals may move on to the site from the preservation area. When preservation is part of a compensatory mitigation project, the preserved wetland can help to increase the quality of the created wetland and reduce the time for the compensation wetland to start to provide functions. In urban areas where wetlands are under considerable threat of loss and degradation, the preservation of wetlands and riparian areas can protect travel corridors for wildlife and provide natural areas.

The agencies have accepted mature forested wetlands, mature scrub/shrub systems and open native meadows for preservation credit[18]. Under existing federal and state laws, trees can be legally harvested from forested wetlands. While the harvest does not result in a loss of wetland area, it does result in a loss of wetland functions. Vernal pool complexes in Eastern Washington may also be suitable for preservation, particularly if they are small enough to meet the exemption criteria in local wetland ordinances. In the case of vernal pools, the applicant would need to preserve the adjacent uplands as part of the mitigation package to protect their habitat and hydrologic functions.

When evaluating preservation sites, it is important to consider the anticipated future land uses around the preservation site to ensure that the preserved wetland won't be degraded over time. Things that can degrade the preservation site and its ability to function include:

- Storm water runoff – water level fluctuations and pollution.
- Lack of *connectivity* – isolation from other habitat areas.
- Clearing.
- Dumping.

Preservation proposals need to include adequate buffer areas. Buffer width must be sufficient to protect the wetland and its functions from encroachment and degradation. Future land use dictates the size and composition necessary for a buffer that is adequate to protect the wetland and its functions (refer to Section 6.6, *Determining Adequate Buffers*). The following section provides criteria to help determine when preservation is an acceptable form of compensatory mitigation.

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18 See the 1998 *Guidelines for Implementation of Compensatory Mitigation Requirements for Conversion of Wetlands to Cranberry Bogs* (Washington State Department of Ecology, U.S. Environmental Protection Agency Region 10, U.S. Army Corps of Engineers Seattle District, and U.S. Fish and Wildlife Service. 1998. Special Public Notice), which can be found at the Seattle District regulatory home page http://www.nws.usace.army.mil (Regulatory, Waters & Wetland Information, Mitigation) or directly at: http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/ACF101C.pdf .

6.4.2 Acceptable Uses of Preservation

The agencies evaluate proposals to use preservation as part of a compensation package on a case-by-case basis. Preservation is an acceptable form of compensatory mitigation when used in combination with other forms of compensation such as re-establishment or creation (establishment). In limited cases, preservation may also be used by itself, but more restrictions will apply. Areas which provide important habitats and functions as well as those areas contributing to the wetland functions, may be included as part of a preservation package (see also Section 6.5.7, *Uplands Used as Compensation*).

Preserving at-risk, high-quality wetlands and habitat may be an acceptable part of a mitigation plan when the following criteria are met:

1. Preservation is used for compensation only after the standard sequencing of mitigation (i.e., avoid and minimize impacts first and then compensate). Refer to *Mitigation Sequencing* (Section 3.1.1).
2. Restoration (re-establishment and rehabilitation), creation (establishment), and enhancement opportunities have also been considered, and preservation is approved by the permitting agencies as the environmentally preferable option.
3. The preservation site is determined to be under demonstrable threat[19] of destruction or substantive degradation; that is, the site is likely to suffer serious negative impacts from on-site or off-site activities that are not regulated (e.g., logging of forested wetlands).
4. The area proposed for preservation is of high quality or critical for the health of the watershed or sub-basin. Some of the following features may indicate high-quality sites:
    a. Category I or II wetland rating (using the wetland rating system for eastern or western WA [Hruby2004a and 2004b]).
    b. Rare or irreplaceable wetland type (e.g., bogs, mature forested wetlands, estuaries) or aquatic habitat that is rare or a limited resource in the area.
    c. Habitat for threatened or endangered species.
    d. Provides biological and/or hydrologic connectivity[20].
    e. High regional or watershed importance (e.g., listed as priority site in a watershed or basin plan).

19 Demonstrable threat: Clear evidence of destructive land use changes that are consistent with local and regional land use trends, and that are not the consequence of actions under the permit applicant's control.

20 Sites isolated from other habitat areas are generally not good candidates for preservation. However, in some cases agencies may support preservation of sites in urban areas in order to protect open space and habitat if the area is under demonstrable threat.

f. Large size with high species diversity (plants and/or animals) and/or high abundance of native species.

g. A site that is continuous with the head of a watershed, or with a lake or pond in an upper watershed that significantly improves outflow hydrology and water quality.

High-quality wetlands

In general a high-quality wetland is important to the ecosystem or landscape, supports an appropriate native community, and performs important functions.

Features of high-quality wetlands are listed in Section 6.4.2[#4]. Not all of the features are required for a wetland to be considered high quality. For instance, you may have a forested riparian wetland system that may not be rare or irreplaceable, but it may still be worth preserving if it contributes to the maintenance of environmental processes such as over-bank flooding, movement of sediments, and recruitment of large woody debris.

6.4.2.1 Preservation in Combination With Other Forms of Compensation

Using preservation as compensation is generally acceptable when done in combination with restoration, creation, or enhancement, provided that a minimum of 1:1 acreage replacement is provided by re-establishment or creation and the criteria below are met:

1. All criteria listed in Section 6.4.2 are met.
2. The impact area is small (generally < ½ acre) and/or impacts are occurring to a low- functioning system (Category III or IV wetland).
3. Preservation of a high-quality system occurs in the same watershed or basin as the wetland impact.
4. Preservation sites include buffer areas adequate to protect the habitat and its functions from encroachment and degradation.
5. Mitigation ratios for preservation in combination with other forms of mitigation will generally range from 10:1 to 20:1, as determined on a case-by-case basis, depending on the quality of the wetlands being lost or degraded and the quality of the wetlands being preserved.

6.4.2.2 Preservation as the Sole Means of Compensation for Wetland Impacts

Preservation alone should only be used as compensatory mitigation in exceptional circumstances. Preservation alone should not apply if impacts are occurring to functions that must be replaced on site, such as flood storage or water quality treatment that need to be replicated by water quality measures implemented within the project limits. Preservation of at-risk, high-quality wetlands and habitat (as defined in Section 6.4.2 [#4]) may be considered as the sole means of compensation for wetland impacts when the following criteria are met:

1. All criteria listed in Section 6.4.2.1 are met.
2. The wetland impacts will not have a significant adverse impact on habitat for listed fish, or other ESA listed species.
3. There is no net loss of habitat functions within the watershed or basin.
4. Higher mitigation ratios are applied. Mitigation ratios for preservation as the sole means of mitigation shall generally start at 20:1. Specific ratios should depend upon the significance of the preservation project and the quality of the wetland resources lost (see Section 6.5*, Identifying the Amount of Compensation [Mitigation Ratios]*).

Federal guidance on the use of preservation as compensatory mitigation

For more information and further guidance on preservation see the *Federal Guidance on the Use of Preservation as Compensatory Mitigation Under Section 404 of the Clean Water Act*, which is being developed as part of the National Mitigation Action Plan (http://www.mitigationactionplan.gov).

6.5 Identifying the Amount of Compensation (Mitigation Ratios)

A key issue in achieving the goal of no net loss is the amount of compensation (square feet or acres) that is required compared to what has been lost. When the acreage required for compensatory mitigation is divided by the acreage of impact, the result is a number known variously as a “replacement,” “compensation,” or “mitigation” ratio.

The mitigation ratio reflects the area of a particular type of compensatory mitigation (e.g., creation, restoration, enhancement, or preservation) needed to make up for the loss of one unit of area of wetland (King et al. 1993). For example, a permitted loss of a one-acre wetland that requires six acres of enhancement in order to adequately compensate for the loss of functions is said to have a 6:1 mitigation ratio.

Mitigation ratios are used to help ensure that compensatory mitigation actions are adequate to offset unavoidable wetland impacts. A greater area of mitigation than the area of impact is almost always required. The greater area of mitigation helps offset (or “to balance”) the risk that compensatory mitigation will fail (completely or partially or be “less than fully successful”) and the temporal loss of functions that may occur. Many studies have documented that it can take anywhere from 5 to 100 years to achieve a fully-functioning restored or created wetland (see Chapter 6 of *Wetlands in Washington State – Volume 2* [Granger et. al 2005]).

In addition to the risk of failure and the temporal loss, a higher or lower mitigation ratio may be required based on the nature and effectiveness of the mitigation itself and tradeoffs associated with out-of-kind and off-site mitigation.

Definition of temporal loss

Temporal loss is the loss of functions between the time an impact occurs and the time the functions are re-established. In the context of wetland mitigation, it is the loss of functions that occurs between the time functions are lost at an impact site and the time those functions are fully replaced at a mitigation site.

The agencies determine the amount of compensation necessary to mitigate wetland impacts on a case-by-case basis to ensure that the loss of wetland acreage and functions is adequately addressed. In general, compensatory mitigation proposals should:

- Replace wetland impacts with the same or higher category of wetland.
- Provide equal or greater area of wetlands through re-establishment or creation.
- Be located in areas where the compensation can contribute to ecosystem functioning at a large scale (e.g., part of river corridors and green space networks).
- Clearly identify how the compensation actions will replace the functions lost or provide measurable gains in other functions important in the area (refer to Appendix H, for more information on different compensation actions).

Section 6.5.1 describes the rationale for using mitigation ratios. Section 6.5.2 provides a set of mitigation ratios that approximates the amount of compensatory mitigation which is likely to be required for a particular impact. It also provides guidelines for using the ratios.

6.5.1 Rationale for Mitigation Ratios Greater Than 1:1

When compensatory wetland mitigation was first required, the loss of one unit of area (acre) of wetland generally would require one unit of area (acre) of compensation (a 1:1 ratio). However, a 1:1 mitigation ratio is generally no longer considered sufficient (Castelle et al. 1992, King et al. 1993, National Research Council 2001, Granger et al. 2005) due to the risk of failure and temporal loss:

- Risk of failure. It is possible that compensation sites will not perform as proposed (King and Bohlen 1994) and therefore may fail to compensate for wetland loss and degradation (Castelle et al. 1992, Johnson et al. 2002, Sheldon et al. 2005).
- Temporal loss. It may take many years for a compensation site to achieve the "ecological equivalency" (National Research Council 2001) and develop the proposed/required wetland structures and/or functions (Castelle et al. 1992, Johnson et al. 2002, Sheldon et al. 2005).

Other factors that support the case for mitigation ratios greater than 1:1 include:

- Some types of compensation result in a net loss. Some types of compensation result in a net loss of wetland acreage and/or function (e.g., enhancement, preservation). One way to minimize this loss is to require larger amounts of compensation. For example, the use of enhancement results in a net loss of wetland area and may result in a very limited increase in wetland functions or a trade-off in functions (Johnson et al. 2002). Therefore, in order to compensate for the loss of functions, wetland functions would need to be increased (improved , enhanced) over a larger area. Thus, enhancement typically requires higher mitigation ratios than re-establishment or creation (establishment).

- Type of wetlands and their functions. There are many types of wetlands with varying functions. Mitigation ratios must take into account the type of wetland and the functions that would be lost or degraded. For example, the loss of a high-functioning forested wetland would require a higher mitigation ratio than the loss of a highly degraded, low-functioning wet pasture (Breaux and Serefiddin 1999). This is because of the much higher risk of failing to replace the forested wetland and the greater time needed to establish a forested wetland as compensation.
- The location and kind of compensation. Additional wetland area may be required to offset losses if out-of-kind compensation is proposed or the replacement wetland is located quite a distance from the impact area.
- Permanence or degree of impact or alteration. In some cases a wetland may only be temporarily disturbed (see Section 3.6, *What Type of Impact Are You Proposing?*). For example, when a new pipeline crosses through a wetland the vegetation, soil, and hydroperiod are usually only temporarily altered. Impacts that are relatively short in duration generally require lower mitigation ratios than permanent impacts. In some cases an alteration may be a conversion from one wetland type to another, such as converting a forested or scrub-shrub wetland to an emergent wetland for overhead utility lines or buried pipelines. Such conversions may require lower ratios than permanent wetland losses (refer to Section 6.5.6, *Mitigation Ratios for Temporary Impacts and Conversions*).

(For more discussion about the rationale for ratios refer to Appendix 8-F, *Rationale for Guidance on Ratios*, in Granger et. al 2005.)

6.5.2 Typical Mitigation Ratios for Compensatory Mitigation

This section contains tables that provide typical ratios for compensatory mitigation. The ratios provide a starting point for discussion. They are based on evaluations of mitigation success and risk at a programmatic level, and do not represent the specific risk of any individual project.

Typical mitigation ratios for projects in western Washington are shown in Table1a, and mitigation ratios for projects in eastern Washington are shown in Table 1b. Refer to Section 6.5.2.1 (*Background and Basic Assumptions for Using the Mitigation Ratios in Tables 1a and 1b*) before reading the tables. Note that preservation is not included in the tables and is discussed separately in Section 6.5.5.

One basic assumption for using the ratios is that the hydrogeomorphic (HGM) classification and category of the affected

> The ratios are partly based on the rating (category) of the affected wetland
>
> The ratios found in Tables 1a and 1b are based on the category of the wetland or special characteristics. You must rate the affected wetland using the rating systems for eastern or western Washington (Hruby 2004a and 2004b) before using the tables (refer to Section 3.3, *What Type and Size of Wetlands Are Present?*).

wetland will be the same as the compensation wetland. The category is determined by the wetland rating systems for eastern or western Washington (Hruby2004a and 2004b).

The proposed HGM classification, category, and functions of the compensation site can be compared to those of the impact site and this information may be used as a basis for determining mitigation ratios. On a case-by-case basis, it is possible to use the scores from the wetland rating systems to compare functions between the compensation wetland and the affected wetland. This information may be used to adjust mitigation ratios. For example, ratios may be lower if impacts to a Category IV wetland are to be mitigated by creating a Category II wetland. The same is true for impacts to wetlands that currently would be considered *atypical* (see definition below).

Scores from the *Methods for Assessing Wetlands* (Hruby et al. 1999 or 2000) may also be used if the impact site and the site used for compensation will be the same HGM class and subclass. The ratios may be adjusted either up or down if the category or HGM class or subclass of the wetland proposed for compensation is different. Scores from the methods for assessing wetland functions (Hruby et al. 1999) provide another option to establish whether the functions lost will be replaced if both the affected wetland and the wetland used for compensation are of the same HGM class and subclass.

Defining atypical wetlands

Compensatory mitigation should not result in the creation, restoration, or enhancement of an *atypical wetland*. An atypical wetland is defined as a wetland whose "design" does not match the type of wetland that would normally be found in the geomorphic setting of the proposed site (i.e., the water source and hydroperiod proposed for the mitigation site are not typical for the geomorphic setting). In addition, any designs that provide exaggerated morphology or require a berm or other engineered structures to hold back water would be considered atypical.

Creating a depressional wetland by excavating a depression in a riverine overflow channel or creating a depression in an existing slope wetland using an engineered berm to hold water, would both produce atypical wetlands. These would be considered atypical HGM locations for depressional wetlands and, as such, they would be less likely to provide the same functions. Excavating a permanently inundated pond in an existing seasonally saturated or inundated wetland would also result in an atypical wetland.

Note: This is different than the "atypical wetland" defined in the Corps 1987 wetland delineation manual.

6.5.2.1 Background and Basic Assumptions for Using the Ratios in Tables 1a and 1b.

This following list provides important background information and assumptions for the use of the ratios in the tables. Read these prior to using Tables 1a and 1b.

- Each column in Tables 1a and 1b is a different type of compensatory mitigation (restoration, creation, and enhancement). The types of compensation are defined in Section 5.1.
- Separate tables are provided for eastern and western Washington because these areas vary substantially in landscape setting, geology, climate, and wetland types and functions.
- The ratios shown represent a compensatory mitigation project that is constructed concurrent with wetland impacts. If mitigation is constructed well after the impacts (i.e., a year or more of delay) the ratios will increase due to added temporal loss.
- If impacts are to be mitigated by using an approved and established mitigation bank, the rules and ratios applicable to the individual bank should be used.
- The ratios are based on the assumption that the category and hydrogeomorphic (HGM) class or subclass of the compensation wetland and affected wetland are the same (e.g., impacts to a Category II riverine wetland are compensated by creating, restoring, or enhancing a Category II riverine wetland).
- Ratios for projects in which the category and HGM class or subclass of wetlands proposed as compensation are not the same as that of the wetland affected will be determined on a case-by-case basis using the ratios in the tables as a starting point. The ratios could be higher in such cases.
- The ratio for using rehabilitation as compensation is 2 times that for using re-establishment or creation (R/C) (2 acres of rehabilitation are equivalent to 1 acre of R/C). The ratio for using enhancement as compensation is 4 times that for using R/C (4 acres of enhancement are equivalent to 1 acre of R/C).
- Re-establishment or creation can be used in combination with rehabilitation or enhancement. For example, 1 acre of impact to a Category III wetland would require 2 acres of R/C. If an applicant provides 1 acre of R/C (i.e., replacing the lost acreage at a 1:1 ratio), the remaining 1 acre of R/C necessary to compensate for the impact could be substituted with 2 acres of rehabilitation or 4 acres of enhancement.
- Generally the use of enhancement alone as compensation is discouraged. Using enhancement in combination with the replacement of wetland area at a minimum of 1:1 through re-establishment or creation is preferred.

The fourth and fifth columns in Tables 1a and 1b list two sets of ratios when different types of compensation are used as part of a mitigation package, specifically “re-establishment or creation and rehabilitation” or “re-establishment or creation and enhancement.” See the footnote to the table as well as the discussion in Section 6.5.4, *Combining Different Types of Compensation*, for an explanation.

The mitigation ratios provided in this section are guidance

The ratios provided as guidance in this document represent what a permit applicant should expect as requirements for compensation, thereby providing some predictability for applicants. However, regulatory agencies may deviate from the guidance. They must make an individual determination on the mitigation ratios required for specific wetland impacts to ensure that the compensation is proportionate to the proposed loss or degradation of wetland area and/or functions. In other words, the required compensation represents a roughly proportional exchange for the proposed impacts (Dolan v. City of Tigard, 512 U.s. 374, 114 S. Ct. 2309, 129 L.Ed.2d 304 (1994)) to provide and ensure the adequate compensation of wetland area and functions.

Table 1a. Mitigation ratios for western Washington.

Category and Type of Wetland Impacts	Re-establishment or Creation	Rehabilitation Only[21]	Re-establishment or Creation (R/C) and Rehabilitation (RH)[21]	Re-establishment or Creation (R/C) and Enhancement (E)[21]	Enhancement Only[21]
All Category IV	1.5:1	3:1	1:1 R/C and 1:1RH	1:1 R/C and 2:1 E	6:1
All Category III	2:1	4:1	1:1 R/C and 2:1 RH	1:1 R/C and 4:1 E	8:1
Category II Estuarine	Case-by-case	4:1 Rehabilitation of an estuarine wetland	Case-by-case	Case-by-case	Case-by-case
Category II Interdunal	2:1 Compensation must be interdunal wetland	4:1 Compensation must be interdunal wetland	1:1 R/C and 2:1 RH Compensation must be interdunal wetland	Not considered an option[22]	Not considered an option[22]
All other Category II	3:1	6:1	1:1 R/C and 4:1 RH	1:1 R/C and 8:1 E	12:1
Category I Forested	6:1	12:1	1:1 R/C and 10:1 RH	1:1 R/C and 20:1 E	24:1
Category I - based on score for functions	4:1	8:1	1:1 R/C and 6:1 RH	1:1 R/C and 12:1 E	16:1
Category I Natural Heritage site	Not considered possible[23]	6:1 Rehabilitation of a Natural Heritage site	R/C Not considered possible[23]	R/C Not considered possible[23]	Case-by-case
Category I Coastal Lagoon	Not considered possible[23]	6:1 Rehabilitation of a coastal lagoon	R/C not considered possible[23]	R/C not considered possible[23]	Case-by-case
Category I Bog	Not considered possible[23]	6:1 Rehabilitation of a bog	R/C Not considered possible[23]	R/C Not considered possible[23]	Case-by-case
Category I Estuarine	Case-by-case	6:1 Rehabilitation of an estuarine wetland	Case-by-case	Case-by-case	Case-by-case
NOTE: Typical ratios for preservation are discussed in Section 6.5.5.					

21 These ratios are based on the assumption that the rehabilitation or enhancement actions implemented represent the average degree of improvement possible for the site. Proposals to implement more effective rehabilitation or enhancement actions may result in a lower ratio, while less effective actions may result in a higher ratio. The distinction between rehabilitation and enhancement is not clear-cut. Instead, rehabilitation and enhancement actions span a continuum. Proposals that fall within the gray area between rehabilitation and enhancement will result in a ratio that lies between the ratios for rehabilitation and the ratios for enhancement (see Appendix H for further discussion).

22 Due to the dynamic nature of interdunal systems, enhancement is not considered an ecologically appropriate action.

23 Natural Heritage sites, coastal lagoons, and bogs are considered irreplaceable wetlands because they perform some functions that cannot be replaced through compensatory mitigation. Impacts to such wetlands would therefore result in a net loss of some functions no matter what kind of compensation is proposed.

Table 1b: Mitigation ratios for eastern Washington.

Category and Type of Wetland Impacts	Re-establishment or Creation	Rehabilitation Only[24]	Re-establishment or Creation (R/C) and Rehabilitation (RH) [24]	Re-establishment or Creation (R/C) and Enhancement (E)[24]	Enhancement Only[24]
All Category IV	1.5:1	3:1	1:1 R/C and 1:1 RH	1:1 R/C and 2:1 E	6:1
All Category III	2:1	4:1	1:1 R/C and 2:1 RH	1:1 R/C and 4:1 E	8:1
Category II Forested	4:1	8:1	1:1 R/C and 4:1 RH	1:1 R/C and 6:1 E	16:1
Category II Vernal pool	2:1 Compensation must be seasonally ponded wetland	4:1 Compensation must be seasonally ponded wetland	1:1 R/C and 2:1 RH	Case-by-case	Case-by-case
All other Category II	3:1	6:1	1:1 R/C and 4:1 RH	1:1 R/C and 8:1 E	12:1
Category I Forested	6:1	12:1	1:1 R/C and 10:1 RH	1:1 R/C and 20:1 E	24:1
Category I based on score for functions	4:1	8:1	1:1 R/C and 6:1 RH	1:1 R/C and 12:1 E	16:1
Category I Natural Heritage site	Not considered possible[25]	6:1 Rehabilitation of a Natural Heritage site	R/C Not considered possible[25]	R/C Not considered possible[25]	Case-by-case
Category I Alkali	Not considered possible[25]	6:1 rehabilitation of an alkali wetland	R/C Not considered possible[25]	R/C Not considered possible[25]	Case-by-case
Category I Bog	Not considered possible[25]	6:1 Rehabilitation of a bog	R/C Not considered possible[25]	R/C Not considered possible[25]	Case-by-case
NOTE: Ratios for preservation are discussed in Section 6.5.5.					

24 These ratios are based on the assumption that the rehabilitation or enhancement actions implemented represent the average degree of improvement possible for the site. Proposals to implement more effective rehabilitation or enhancement actions may result in a lower ratio, while less effective actions may result in a higher ratio. The distinction between rehabilitation and enhancement is not clear-cut. Instead, rehabilitation and enhancement actions span a continuum. Proposals that fall within the gray area between rehabilitation and enhancement will result in a ratio that lies between the ratios for rehabilitation and the ratios for enhancement (see Appendix H for further discussion).

25 Natural Heritage sites, alkali wetland, and bogs are considered irreplaceable wetlands because they perform some functions that cannot be replaced through compensatory mitigation. Impacts to such wetlands would therefore result in a net loss of some functions no matter what kind of compensation is proposed.

6.5.3 Guidelines on Using Mitigation Ratios

6.5.3.1 Increasing or Reducing Ratios

The preceding tables provided typical ratios for permanent impacts to particular wetland types and categories. As noted earlier, they are based on programmatic evaluations of mitigation and are not intended to reflect individual site conditions. Therefore, the following guidance is provided to assist the agencies in deciding whether a project requires an increase (provide more compensation) or a decrease (provide less compensation) in mitigation ratios.

Increases in mitigation ratios are appropriate under the following circumstances:

- Success of the proposed compensation project is uncertain.
- A long time will elapse between the loss of wetland functions at the impact site and establishment of wetland functions at the mitigation site.
- Proposed compensatory mitigation will result in a lower category wetland or reduced functions relative to the wetland being impacted.
- The impact was unauthorized.

Reductions in mitigation ratios are appropriate under the following circumstances:

- Documentation by a qualified wetland professional (see Appendix D) demonstrates that the proposed mitigation actions have a very high likelihood of success based on prior experience.
- Documentation by a qualified wetland professional demonstrates that the proposed actions for compensation will provide functions and values that are significantly greater than the wetland being affected.
- The proposed actions for compensation are conducted in advance of the impact and are shown to be successful.

Determining ratios for impacts to wetlands that have multiple hydrogeomorphic (HGM) classes

In wetlands where several HGM classes are found within one delineated boundary, the areas of the wetlands within each HGM class can be scored and rated separately and the ratios adjusted accordingly (e.g., a Category II slope wetland and a Category III depressional wetland), if all of the following apply:

- The wetland does not meet any of the criteria for wetlands with "Special Characteristics" as defined in the rating system (Hruby 2004a and 2004b).
- The rating and score for the entire wetland is provided along with the scores and ratings for each area with a different HGM class.
- All wetland impacts are within an area that has a different HGM class from the one used to establish the initial category.
- The proponents provide adequate hydrologic and geomorphic data to establish that the boundary between HGM classes lies at least 50 feet outside of the footprint of the impacts.

For more information on classifying and rating wetlands refer to the rating systems for eastern and western Washington (Hruby 2004a and b).

6.5.4 Combining Different Types of Compensation

Establishing a mitigation ratio is straightforward when compensation projects involve one type of compensation and replace the wetland area lost (e.g., re-establishment, creation). However, when a proposal for compensation includes re-establishment or creation along with enhancement, two ratios are used to determine the total amount of compensation required. The fourth and fifth column in both Tables 1a and 1b list the ratios required when these types of compensation are used in conjunction. Ratios are provided for each wetland category and type. When using these ratios, both the re-establishment/creation and the enhancement ratios listed are per area (acre) of impact. For example, when the column lists the ratios as “1:1 R/C and 6:1 E” it means that for every acre of impact an applicant would be required to provide 1 acre of re-establishment or creation and 6 acres of enhancement. Thus, for a 3-acre impact to a Category II forested wetland in eastern Washington, the amount of compensation necessary would be 3 acres of creation/re-establishment plus 18 acres of enhanced wetland for a total area of 21 acres. Alternatively, in this scenario, the applicant could provide 12 acres of re-establishment or creation (4:1 from Table 1b) to offset the three-acre loss.

When rehabilitation is used with creation or re-establishment, the ratio for rehabilitated area will be determined based on the projected level of improvement of functions or degree of restoration of ecological processes. In most cases, the ratios for rehabilitation will be less than those for enhancement (see Appendix H for further discussion).

6.5.5 Mitigation Ratios for Preservation

In some cases, preservation of existing wetlands may be acceptable as compensation for wetland losses and degradation. Acceptable sites for preservation include those that:

- Are important due to their landscape position.
- Are rare or limited wetland types.
- Provide high levels of functions.

Preservation is sometimes combined with other forms of compensation to form a mitigation package. In exceptional circumstances it is used by itself. The use of preservation as the sole means of compensating for loss of a wetland is generally not allowed because of the net loss in wetland area.

Ratios for preservation in combination with other forms of mitigation generally range from 10:1 to 20:1. Specific ratios will be determined on a case-by-case basis, depending on the quality of the lost or degraded wetlands and the quality of the wetlands being preserved. Ratios for preservation as the sole means of mitigation generally start at 20:1. Specific ratios will depend upon the significance of the preservation project and the quality of the wetland resources lost.

See Sections 5.2.4 and 6.4 for more information on preservation and the criteria for its use as compensation.

6.5.6 Mitigation Ratios for Temporary Impacts and Conversions

When impacts to wetlands are not permanent, the agencies often require some compensation for the temporal loss of wetland functions. Long-term temporary impacts refer to impacts to functions that will eventually be replaced, but which will take a long time. As opposed to short-term temporary impacts in which functions are replaced quickly; usually within a growing season or two (see Section 3.6, *What Type of Impact Are You Proposing?*).

For long-term temporary impacts, agencies typically require some compensation to account for the risk and temporal loss of wetland functions, in addition to restoring the affected wetland to its previous condition. Generally, the ratios for long-term temporary impacts to forested and scrub-shrub wetlands are one-quarter of the typical ratios for permanent impacts (refer to Tables 1a and 1b), provided that the following measures are satisfied:

- An explanation is provided on how hydric soil, especially deep organic soil, is stored and handled in the areas where the soil profile will be severely disturbed for a fairly significant depth or length of time.
- Surface and groundwater flow patterns are maintained or can be restored immediately following construction.
- A 10-year monitoring and maintenance plan is developed and implemented for the restored forest and scrub-shrub wetlands.
- Disturbed buffers are re-vegetated and monitored.

- Where appropriate, the hydroseed mix to be applied on re-establishment areas is identified.

For long-term temporary impacts that last for greater than two years, the Corps considers the impacts to be of a more permanent nature even if the area will eventually be restored. The ratios therefore would be closer to those found in Tables 1a and 1b. Ecology will also review these case-by- case and the amount of mitigation will be commensurate with the expected length of impacts.

When impacts are to a native emergent community and there is a potential risk that its re-establishment will be unsuccessful (generally due to invasive species), compensation for temporal loss and the potential risk may be required in addition to restoring the affected wetland and monitoring the site. If the impacts are to wetlands dominated by non-native vegetation (e.g., blackberry, reed canarygrass, or pasture grasses), restoration of the affected wetland with native species and monitoring after construction is generally all that is required.

Loss of functions due to the permanent conversion of wetlands from one type to another also requires compensation. For example, when a forested wetland is permanently converted to an emergent or shrub wetland (e.g., for a utility right-of-way) some functions are permanently lost or reduced.

The ratios for conversion of wetlands from one type to another will vary based on the type and degree of the alteration, but they are generally one-half of the typical ratios for permanent impacts (refer to Tables 1a and 1b).

Mitigation guidance for the conversion of wetlands to cranberry bogs

Specific guidance has been developed for conversions of wetlands to cranberry bogs. Please refer to the 1998 *Guidelines for Implementation of Compensatory Mitigation Requirements for Conversion of Wetlands to Cranberry Bogs* for information on ratios associated with this activity (Washington State Department of Ecology, U.S. Environmental Protection Agency Region 10, U.S. Army Corps of Engineers Seattle District, and U.S. Fish and Wildlife Service. 1998. Special Public Notice: http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/ACF101C.pdf).

6.5.7 Uplands Used as Compensation

Uplands may be used for compensatory mitigation in certain situations providing they are protected from future uses that are incompatible with the compensation project goals. Normally, approval for using upland areas will only be granted after a minimum of 1:1 replacement of wetland area is provided.

The ratio used for uplands that are part of a compensation package is in the range of 10:1 to 20:1 and will be determined based on the following criteria:

- Degree to which the upland provides connectivity through corridors or adjacency to other habitat areas.

- Quality of the upland area.
- Ability to increase the performance of aquatic resource functions.
- Ability to provide additional ecological functions.

6.6 Determining Adequate Buffers

Generally, buffers are vegetated areas adjacent to an aquatic resource that can, through various physical, chemical, and/or biological processes, reduce impacts from adjacent land uses. The scientific literature recognizes that buffers provide important functions that protect wetlands and provide essential habitat for many species that depend on wetlands (refer to Chapter 5 in *Wetlands in Washington State - Volume 1* (Sheldon et. al 2005)). Buffers protect and maintain the wide variety of functions provided by wetlands. The physical characteristics of buffers-slope, soils, vegetation, and width-determine how well buffers reduce the adverse impacts of adjacent land uses and provide the habitat needed by wildlife species that use wetlands and habitats adjacent to them. For wildlife that use wetlands, but also require uplands to meet their life-history needs, buffers provide necessary terrestrial habitats.

Compensation wetlands generally need a buffer in order to protect the wetland from the impacts of adjacent land uses and, in most cases, to provide habitat necessary for the survival of wetland-dependent wildlife species. The necessary physical characteristics (e.g., width, vegetation type and density) of the required buffer will depend to a large degree on the functions that the compensation site and the buffer itself are intended to provide. Protecting wildlife habitat functions of wetlands generally requires larger buffers than protecting the water-quality functions of wetlands. However, the width necessary to protect a compensation site from adjacent impacts is contingent upon a number of other criteria, such as:

- The functions and sensitivity of the compensatory wetland to be protected by the buffer.
- The characteristics of the watershed contributing to the compensatory wetland.
- The characteristics of the buffer itself.
- The nature of the adjacent land use (or proposed land use) and the expected impacts from the land use.
- The specific functions that the buffer is intended to provide.[26]

In the past, the agencies did not consistently require buffers around compensatory mitigation sites. In fact, in some cases, agencies allowed buffer area to count toward the fulfillment of compensation area requirements, thereby giving credit for the protection of buffers. However, new federal guidance (RGL 02-02), Ecology's evaluation of wetland mitigation sites in Washington (Johnson et. al 2000 and 2001), and the recent state review

26 The above section was adapted from *Wetlands in Washington State Volume 1: A Synthesis of the Science* (Sheldon et al. 2005). The text has been modified slightly to apply to compensatory mitigation.

of the best available science on wetlands (Sheldon et al. 2005), have led the agencies to revise their views on the necessity of buffers around compensation sites.

The agencies now require that most compensatory wetlands have a buffer based on the minimum width necessary to protect the most sensitive functions being performed. In most cases, the acreage provided by the buffer will not contribute toward compensation acreage, because the buffer is necessary to protect the functions of the compensatory wetland.

Buffers around compensation wetlands should be well marked with signs and/or fencing to help protect the buffer. This is a particular concern when wetlands are adjacent to residential areas or other lands with "active" uses. These types of land uses can result in reductions in buffer width and quality over time (refer to *Wetlands in Washington State - Volume 1* (Sheldon et. al 2005), Section 5.5.5, *Buffer Maintenance and Effectiveness Over Time*). These impacts can result from several causes, including:

- Removal of native vegetation and conversion to lawn or non-native plantings.
- Use of the buffer as a dumping ground for lawn and yard waste and garbage.
- Human and pet intrusions.
- Filling to extend uplands into wetlands.

Use of semi-permanent boundary markers (e.g., signs, large rocks, wildlife friendly fencing[27]) can help reduce intrusions into the buffer (see Section 3.9.5, *Long-term Protection*, for more information).

6.6.1 Buffer Widths for Compensation Sites

The width and character of buffers needed around compensation sites will be determined on a case-by-case basis depending on project and site-specific factors. The primary factors that will be considered in determining what type and width of buffer is necessary include:

- The goals and objectives of the proposed compensation site.
- The functions or special characteristics the proposed compensation site is expected to provide.
- The current and expected future land uses adjacent to the compensation site.
- The presence of connecting corridors between the compensation site and other habitats important to species expected to use the compensation site.

In order to give applicants some predictability regarding buffers that may be required for a compensation site, the agencies have outlined more specific guidance below.

The buffer widths in the following tables were developed based on the review of scientific information done for *Wetlands in Washington State Volume 1: A Synthesis of the Science* (Sheldon et al. 2005) and are adapted from *Volume 2: Guidance for Protecting and Managing Wetlands* (Granger et. al. 2005). The tables represent a synthesis of the

27 Chain link fences are not recommended due to their disruptions to wildlife movement (see note on fencing in Chapter 3).

information about the type and size of buffers needed to protect functions and specific wetland characteristics of concern. For detailed rationale for the buffer widths refer to Appendix 8-E of Volume 2 (Granger et. al 2005).

The fact that not all land uses have the same level of impact has been incorporated into the buffer widths in Tables 3-6b. For example, a compensation wetland established adjacent to a single family residence on 5 acres is expected to experience a smaller impact than a compensation wetland next to 20 houses on the same 5 acres. Three categories of impacts are outlined - changes to land-uses that create high impacts, moderate impacts, and low impacts. Categories for impacts and definitions of land-uses are provided in Table 2, which follows.

Basic Assumptions for Recommended Buffer Widths

Recommendations for buffer widths assume that:

- A proposed category for the compensatory wetland has been identified using the wetland rating system for eastern or western Washington (Hruby 2004a or 2004b).
- The buffer is vegetated with native plant communities that are appropriate for the ecoregion or with a plant community that provides similar functions [28]. *Ecoregions* denote areas with similar ecosystems and types, quality, and quantity of environmental resources. The classification is hierarchical and Level III ecoregion subdivisions currently mapped for Washington are: Coast Range, Puget Lowland, Cascades, Eastern Cascades Slopes and Foothills, North Cascades, Columbia Plateau, Blue Mountains, and Northern Rockies. The U.S. Environmental Protection Agency maintains updated maps of ecoregions that are available at http://www.epa.gov/naaujydh/pages/models/ecoregions.htm.
- If the buffer vegetation is disturbed (grazed, mowed, etc.), it needs to be revegetated with native plant communities that are appropriate for the ecoregion, or with a plant community that provides similar functions (see footnote 28, next page).
- The width of the buffer is measured in horizontal distance (see drawing below) for determining appropriate widths on slopes.

- The buffer will remain relatively undisturbed in the future.

A compensatory wetland may fall into more than one category. For example, if the proposed compensatory wetland is intended to be a forested, riparian wetland it may be rated a Category II wetland because it is a riparian forest, but it may be rated a Category I wetland based on its anticipated score for functions. If a wetland meets more than one of the characteristics listed in Tables 3 through 6b, the buffer recommended to protect the compensatory wetland is the widest one.

28 Generally this means planting native plant species. Many buffers, however, have been disturbed and will be vegetated with non-native species. The agencies understand that it may be difficult or undesirable to try to control all non-native species and, therefore, will consider the condition of the buffer on a case-by case basis. The emphasis will be on providing vegetation in the buffer that will meet the needed buffer functions

Table 2. Types of land uses that can result in high, moderate, and low levels of impact to adjacent wetlands.

Level of Impact from Proposed Change in Land Use	Types of Land Use Based on Common Zoning Designations
High	• Commercial • Urban • Industrial • Institutional • Retail sales • Residential (more than 1 unit/acre) • Conversion to high-intensity agriculture (dairies, nurseries, greenhouses, growing and harvesting crops requiring annual tilling and raising and maintaining animals, etc.) • High-intensity recreation (golf courses, ball fields, etc.) • Hobby farms
Moderate	• Residential (1 unit/acre or less) • Moderate-intensity open space (parks with biking, jogging, etc.) • Conversion to moderate-intensity agriculture (orchards, hay fields, etc.) • Paved trails • Building of logging roads • Utility corridor or right-of-way shared by several utilities and including access/maintenance road
Low	• Forestry (cutting of trees only) • Low-intensity open space (hiking, bird-watching, preservation of natural resources, etc.) • Unpaved trails • Utility corridor without a maintenance road and little or no vegetation management

Table 3. Width of buffers needed to protect Category IV wetlands.

(For wetlands scoring less than 30 points for all functions using the rating system [Hruby 2004a and b])

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use	Other Measures Recommended for Protection
Score for all 3 basic functions is less than 30 points	Low - 25 ft Moderate – 40 ft High – 50 ft	No recommendations at this time.*

Table 4. Width of buffers needed to protect Category III wetlands.

(For wetlands scoring 30 – 50 points for all functions using the rating system [Hruby 2004a and b])

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use	Other Measures Recommended for Protection
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time.*
Not meeting above characteristic	Low - 40 ft Moderate – 60 ft High – 80 ft	No recommendations at this time.*

* No information on other measures for protection was available at the time this document was written. The Washington State Department of Ecology will continue to collect new information for future updates to this document. This applies to Tables 4 through 6b as well.

Table 5a. Width of buffers needed to protect Category II wetlands in eastern Washington

(For wetlands scoring 51-69 points for all functions or having the "Special Characteristics" identified in the rating system [Hruby 2004a])

Wetland Characteristics	**Buffer Widths by Impact of Proposed Land Use** (apply most protective if more than one criterion is met)	**Other Measures Recommended for Protection**
High level of function for habitat (score for habitat 29 - 36 points)	Low – 100 ft Moderate – 150 ft High – 200 ft	Maintain connections to other habitat areas
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time *
High level of function for water quality improvement and low for habitat (score for water quality 24 - 32 points; habitat less than 20 points)	Low - 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Vernal pool	Low - 100 ft Moderate – 150 ft High – 200 ft OR Develop a regional plan to protect the most important vernal pool complexes – buffers of vernal pools outside protection zones can then be reduced to: Low - 40 ft Moderate – 60 ft High – 80 ft	No intensive grazing or tilling in the wetland
Riparian forest	Buffer width to be based on score for habitat functions or water quality functions	Riparian forest wetlands need to be protected at a watershed or sub-basin scale (protection of the water regime in the watershed) Other protection based on needs to protect habitat and/or water quality functions
Not meeting above characteristics	Low - 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time *

* No information on other measures for protection was available at the time this document was written. The Washington State Department of Ecology will continue to collect new information for future updates to this document. This applies to Tables 4 through 6b as well.

Table 5b. Width of buffers needed to protect Category II wetlands in western Washington.

(For wetlands scoring 51-69 points for all functions or having the "Special Characteristics" identified in the rating system [Hruby 2004b])

Wetland Characteristics	**Buffer Widths by Impact of Proposed Land Use** (Apply most protective if more than one criterion is met.)	**Other Measures Recommended for Protection**
High level of function for habitat (score for habitat 29 - 36 points)	Low - 150 ft Moderate – 225 ft High – 300 ft	Maintain connections to other habitat areas
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time *
High level of function for water quality improvement and low for habitat (score for water quality 24 - 32 points; habitat less than 20 points)	Low - 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Estuarine	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time *
Interdunal	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time *
Not meeting above characteristics	Low - 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time *

* No information on other measures for protection was available at the time this document was written. The Washington State Department of Ecology will continue to collect new information for future updates to this document. This applies to Tables 4 through 6b as well.

Table 6a. Width of buffers needed to protect Category I wetlands in eastern Washington.

(For wetlands scoring 70 points or more for all functions or having the "Special Characteristics" identified in the rating system [Hruby 2004a])

Wetland Characteristics	**Buffer Widths by Impact of Proposed Land Use** (apply most protective if more than one criterion is met)	**Other Measures Recommended for Protection**
Natural Heritage Wetlands	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries No septic systems within 300 ft Restore degraded parts of buffer
Bogs	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries Restore degraded parts of buffer
Forested	Buffer size to be based on score for habitat functions or water quality functions	If forested wetland scores high for habitat, need to maintain connectivity to other natural areas Restore degraded parts of buffer
Alkali	Low – 100 ft Moderate – 150 ft High – 200 ft	No additional surface discharges to wetland or its tributaries Restore degraded parts of buffer
High level of function for habitat (score for habitat 29 - 36 points)	Low – 100 ft Moderate – 150 ft High – 200 ft	Maintain connections to other habitat areas Restore degraded parts of buffer
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low – 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time *
High level of function for water quality improvement (24 – 32 points) and low for habitat (less than 20 points)	Low – 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Not meeting any of the above characteristics	Low – 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time *

* No information on other measures for protection was available at the time this document was written. The Washington State Department of Ecology will continue to collect new information for future updates to this document. This applies to Tables 4 through 6b as well.

Table 6b. Width of buffers needed to protect Category I wetlands in western Washington

(For wetlands scoring 70 points or more for all functions or having the "Special Characteristics" identified in the rating system [Hruby 2004b])

Wetland Characteristics	**Buffer Widths by Impact of Proposed Land Use** (Apply most protective if more than one criterion is met)	**Other Measures Recommended for Protection**
Natural Heritage Wetlands	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries No septic systems within 300 ft of wetland Restore degraded parts of buffer
Bogs	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries Restore degraded parts of buffer
Forested	Buffer width to be based on score for habitat functions or water quality functions	If forested wetland scores high for habitat, need to maintain connections to other habitat areas Restore degraded parts of buffer
Estuarine	Low - 100 ft Moderate – 150 ft High – 200 ft	No recommendations at this time *
Wetlands in Coastal Lagoons	Low - 100 ft Moderate – 150 ft High – 200 ft	No recommendations at this time *
High level of function for habitat (score for habitat 29 - 36 points)	Low – 150 ft Moderate – 225 ft High – 300 ft	Maintain connections to other habitat areas Restore degraded parts of buffer
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low – 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time *
High level of function for water quality improvement (24 – 32 points) and low for habitat (less than 20 points)	Low – 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Not meeting any of the above characteristics	Low – 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time *

* No information on other measures for protection was available at the time this document was written. The Washington State Department of Ecology will continue to collect new information for future updates to this document. This applies to Tables 4 through 6b as well.

6.6.1.1 Reducing Buffer Widths

In the following situations, buffer widths for compensatory wetlands will generally be smaller than the recommended width. A narrower buffer may be acceptable when it will not result in reduced functions in the compensatory wetland. Buffer reductions are also appropriate when the intensity of impacts from adjacent land uses are reduced, or when there is a natural barrier to providing a full buffer.

Reduction in Buffer Width Based on Reducing the Intensity of Impacts from Existing or Proposed Adjacent Land Uses

The buffer widths recommended for land uses with high-intensity impacts can be reduced to those recommended for moderate-intensity impacts under the following conditions:

- For compensatory wetlands that are intended to score moderate or high for habitat in the wetland rating system or other *function assessment*, the width of the buffer around the compensatory wetland can be reduced if both of the following are met:

  1) A relatively undisturbed, vegetated corridor[29] at least 100 feet wide is protected between the compensatory wetland and any other Priority Habitats as defined by the Washington State Department of Fish and Wildlife. Priority Habitats in Washington include (for current definitions of Priority Habitats see http://wdfw.wa.gov/hab/phshabs.htm):

     - Wetlands
     - Riparian zones
     - Aspen stands
     - Cliffs
     - Prairies
     - Caves
     - Stands of Oregon White Oak
     - Old-growth forests
     - Estuary/estuary-like
     - Marine/estuarine shorelines
     - Eelgrass meadows
     - Talus slopes
     - Urban natural open space

     The corridor must be protected for the entire distance between the compensatory wetland and the Priority Habitat by some type of legal protection such as a conservation easement.

  2) Measures to minimize the impacts of different land uses on wetlands, such as the examples summarized in Table 7, are applied.

- For compensatory wetlands that will score low for habitat (less than 20 points for habitat in the rating system), the buffer width can be reduced to that required for moderate land-use impacts by applying measures to minimize the impacts of the proposed land uses (see examples in Table 7).

29 "Relatively undisturbed" and "vegetated corridor" are defined in questions H 2.1 and H 2.2.1 of the wetland rating system for eastern and western Washington (Hruby 2004a, 2004b).

Table 7. Measures to minimize high-impact land use on wetlands[30].

Examples of Disturbance	Activities and Uses that Cause Disturbances	Examples of Measures to Minimize Impacts
Lights	• Parking lots • Warehouses • Manufacturing • Residential	• Direct lights away from wetland
Noise	• Manufacturing • Residential	• Locate activity that generates noise away from wetland
Toxic runoff*	• Parking lots • Roads • Manufacturing • Residential areas • Application of agricultural pesticides • Landscaping	• Route all new, untreated runoff away from wetland while ensuring wetland is not dewatered • Establish covenants limiting use of pesticides within 150 ft of wetland • Apply integrated pest management
Stormwater runoff	• Parking lots • Roads • Manufacturing • Residential areas • Commercial • Landscaping	• Retrofit stormwater detention and treatment for roads and existing adjacent development • Prevent channelized flow from lawns that directly enters the buffer
Change in water regime	• Impermeable surfaces • Lawns • Tilling	• Infiltrate or treat, detain, and disperse into buffer new runoff from impervious surfaces and new lawns
Pets and human disturbance	• Residential areas	• Use privacy fencing; plant dense vegetation appropriate for the ecoregion to delineate buffer edge and to discourage disturbance; place wetland and its buffer in a separate land ownership tract
Dust	• Tilled fields	• Use *best management practices* to control dust
* These examples are not necessarily adequate for minimizing toxic runoff if threatened or endangered species are present at the site.		

30 This is not a complete list of measures. Other measures may be proposed by an applicant or be determined to be relevant to a specific site.

Reduction in Buffer Widths For a Site Adjacent to a Parcel with an Individual Rural Stewardship Plan

When a compensation wetland is proposed in a location adjacent to a parcel where a Rural Stewardship Plan (RSP) is in place, the buffer around the compensation wetland can be reduced to a width appropriate for a low-impact land use. A Rural Stewardship Plan is the product of a collaborative effort between rural property owners and a local government to tailor a management plan specific for a rural parcel of land. The goal of a RSP is better management of wetlands than would be achieved through strict adherence to regulations. In exchange, the landowner gains flexibility in the widths of buffers required, in clearing limits, and in other requirements found in the regulations. For example, dense development in rural residential areas can be treated as having a low level of impact when the development of the site is managed through a locally approved RSP. The voluntary agreement includes provisions for restoration, maintenance, and long-term monitoring and specifies the widths of buffers needed to protect each wetland within the RSP.

Reduction in Buffer Widths Where Natural Limits Exist

Cliffs and very steep slopes are one example of site-specific conditions that may allow reduced buffers. If a compensation site is situated at the base of a 100-ft bluff, the bluff itself may provide a buffer for the portion of the wetland that is adjacent to it, and agencies are not likely to require additional buffer area at the top of the bluff. Similarly, wetlands adjacent to open water areas generally won't need buffers on the open water side.

6.6.1.2 Increasing the Width of, or Enhancing, the Buffer

If necessary, agencies may require a wider buffer than those listed in Tables 3 through 6b to ensure that the compensatory wetland and its functions are adequately protected. The agencies may also require that a buffer area be enhanced to further protect the compensatory wetland.

Buffer is Not Vegetated with Plants Appropriate for the Region

The recommended buffer widths are based on the assumption that the buffer is vegetated with a native plant community appropriate for the ecoregion or with one that performs similar functions [31]. If the existing buffer is unvegetated, sparsely vegetated, or vegetated with invasive species that do not perform needed functions, the buffer should either be planted to create the appropriate plant community or widened to ensure it provides adequate functions. Generally, improving the vegetation will be more effective than widening the buffer.

31 Generally this means planting native plant species. Many buffers, however, have been disturbed and will be vegetated with non-native species. The agencies understand that it may be difficult or undesirable to try to control all non-native species and, therefore, will consider the condition of the buffer on a case-by case basis. The emphasis will be on providing vegetation in the buffer that will meet the needed buffer functions.

Buffer Has a Steep Slope

The effectiveness of buffers at removing pollutants before they enter a wetland decreases as the slope increases (refer to Chapter 5 in *Wetlands in Washington State - Volume 1* (Sheldon et. al 2005)). If a buffer is to be based on the score for its ability to improve water quality (see Tables 5a through 6b) rather than habitat or other criteria, then the buffer should be increased by 50% if the slope is greater than 30% (a 3-foot rise for every 10 feet of horizontal distance).

Buffer Is Used by Species Sensitive to Disturbance

If the compensatory wetland is intended to provide habitat for a plant or animal species that is particularly sensitive to disturbance (such as a threatened or endangered species), the width of the buffer should be increased to provide adequate protection for the species based on its particular, life-history needs. Some buffer requirements for priority species are available on the Washington State Department of Fish and Wildlife web page (http://wdfw.wa.gov/hab/phsrecs.htm). The list of priority vertebrate species is located at http://wdfw.wa.gov/hab/phsvert.htm; and invertebrates listed at http://wdfw.wa.gov/hab/phsinvrt.htm. (Information on the buffer widths needed by some threatened, endangered, and sensitive species of wildlife is provided in Appendix 8-H of *Wetlands in Washington State - Volume 2* [Granger et. al 2005].)

6.6.2 Buffer Averaging

Buffer averaging means having a wider buffer in some areas and a narrower buffer in others based on differences in adjacent land-uses and wetlands on the site and site-specific physical limitations. The total buffer area after averaging must be equal to the buffer area provided by uniform buffer widths. The widths of buffers may be averaged if this will improve the protection of wetland functions, or if it is the only way to allow for reasonable use of a parcel. Averaging may not be used in conjunction with any of the other provisions for reductions in buffers listed above.

- Averaging to <u>improve wetland protection</u> may be permitted when all of the following conditions are met:
  - The compensatory wetland will have significant differences in characteristics in different parts of the wetlands that affect its habitat functions, such as a compensatory wetland with a forested component adjacent to a degraded emergent component or a "dual-rated" wetland with a Category I area adjacent to a lower rated area (thus the buffer around the more degraded portion could be narrower through averaging whereas the higher rated area would have larger buffers)
  - The buffer is increased adjacent to the proposed higher-functioning habitat or more sensitive portion of the wetland, and decreased adjacent to the lower-functioning or less sensitive portion.
  - The total area of the buffer after averaging is at least equal to the area required without averaging.
  - The buffer at its narrowest point is never less than 75% of the required width.

- Averaging to allow reasonable use of a parcel may be permitted when all of the following are met:
  - There are no feasible alternatives to the site design that could be accomplished without buffer averaging.
  - The averaged buffer will not result in degradation of the compensatory wetland's functions and values as demonstrated by a report from a qualified wetland professional (see Appendix D, *Hiring a Qualified Wetland Professional*).
  - The total buffer area after averaging is equal to the area required without averaging.
  - The buffer at its narrowest point is never less than 75% of the required width.

6.6.3 Wetlands as Buffers

In cases where area for an upland buffer is limited or nonexistent, wetland area on the edge of the compensation wetland can be considered a buffer for the rest of the compensatory wetland. However, the acreage of wetland which is acting as a buffer would not count toward compensation requirements for wetland acreage. It is not acceptable to fill wetlands to "create" an upland buffer for the wetland.

In these situations, the outer portion of the wetland (often referred to as a "paper" buffer) is performing similar functions as an upland buffer (filtering out pollutants and screening noise, light, and intrusions), thus, protecting the inner portion of the wetland. In most cases, however, the "paper" buffer is not able to perform the additional buffer function of providing adjacent upland habitat needed for many wetland dependent species. Thus, the width of "paper" buffers generally will be based on the need for providing the water quality and screening functions.

6.6.4 Credit for Buffers

There are two situations where some compensation credit for buffers can be generated. These are described below.

Additional buffer acreage provided beyond the required minimum buffer can count as part of the compensation acreage, provided that certain conditions are met (see Section 6.5.7, *Uplands Used as Compensation*). For example, if a Category III compensatory wetland with a moderate habitat score is surrounded by moderate intensity land-uses, the agencies may determine that a minimum 110-foot buffer is needed to protect its functions (see Table 4). However, if the compensation proposal includes a 200-foot buffer for the wetland, the additional 90 feet may be used to meet requirements for compensation area if the buffer provides additional habitat and connections to other habitats, and supports appropriate native plant communities.

In some limited cases, mitigation credit may be given for enhancing buffers around a compensation site. The most likely scenario is one where the impact wetland has no buffer (or a minimal buffer) and the compensation site has no buffer (or a minimal or degraded buffer). In this situation, an applicant may receive some credit for enhancing/restoring the buffer around the compensation site. Applicants are encouraged to consult with the appropriate agency staff to determine if such a situation exists and warrants consideration of credit.

Federal Guidance on the use of vegetated buffers as compensatory mitigation

For more information and further guidance on vegetated buffers please refer to the Federal Guidance on the Use of Vegetated Buffers as Compensatory Mitigation Under Section 404 of the Clean Water Act, which is being developed as part of the National Mitigation Action Plan (http://www.mitigationactionplan.gov/index.html).

6.6.5 Buffers in Urban Areas

The agencies recognize that providing adequate buffers around compensation sites located in urban and urbanizing areas is a challenge. Higher land values increase the cost of providing buffers. In many urban settings it may be difficult to find a location for a compensation site that includes enough area to provide needed buffers.

However, in many instances, compensation wetlands located in urban areas will not be expected to provide significant wildlife habitat and, thus, will not need the wider buffers necessary to protect this function. In most urban locations, the compensation site will primarily provide water quality and quantity-related functions and will need buffers at the smaller end of the range.

In situations where moderate or high-quality wildlife habitat is provided by the compensation site, larger buffers may be necessary. However, the protection of a connecting corridor between the compensation site and other habitats or providing a large buffer on one side of the site may be sufficient to maintain the habitat functions. In most cases buffer averaging can be employed to address unique site constraints.

In other instances, the agencies may decide that it is critical to locate the compensation site in an urban area near the impact site where adequate buffers are precluded. This may mean that the expectations for the level of functions provided by the compensation site will be lowered and the credit given for the wetland compensation area may be lowered as well.

Chapter 7 - Other Mitigation Considerations

7.1 Compensatory Mitigation and Other Aquatic Resources

This document is not intended to address mitigation requirements and policies for resources other than freshwater wetlands although many of the basic principles in this guidance apply to other aquatic resources. Compensation may be required for impacts to other aquatic resources and specific mitigation requirement for impacts to them should be discussed with the appropriate permitting agencies.

Various information sources that address mitigation in other aquatic systems exist: The Washington State Department of Fish and Wildlife's (WDFW) *Integrated Streambank Protection Guidelines* (WDFW et al. 2003) provides guidance for addressing impacts to riverine systems. The Washington State Department of Natural Resources (WDNR) is developing a mitigation policy for state-owned aquatic lands. If a project will potentially impact a river, stream, or state-owned aquatic lands, applicants should work closely with the agencies, including WDFW and WDNR, for specific permitting and mitigation requirements.

Draft guidance on stream assessment methods appropriate for impact assessment and mitigation

In accordance with the National Mitigation Action Plan, the Federal Interagency Mitigation Workgroup (FIMW) commissioned the preparation of a technical resource document to assist with stream mitigation entitled: *Physical Stream Assessment: A Review of Selected Protocols for use in the Clean Water Act (CWA) Section 404 Program (Stream Mitigation Compendium)*. The Stream Mitigation Compendium is intended as a reference that can be consulted by regulatory agencies, resource managers, and restoration ecologists in order to select, adapt, or devise stream assessment methods appropriate for impact assessment and mitigation of fluvial resources in the CWA Section 404 Program.

The draft of this document can be found on-line at http://www.mitigationactionplan.gov/actionitem.html.

7.2 Invasive Species - An Evolving Policy

By now, most regulators and consultants are well aware of the challenges that *invasive species* can pose for successful *compensatory mitigation*. Some of the most common invasive species encountered in the Pacific Northwest include reed canary grass *(Phalaris arundinacea)*, and Himalayan and evergreen blackberries *(Rubus discolor (procerus) and R. laciniatus)*. The invasive purple loosestrife *(Lythrum salicaria)*, is being diligently watched for on mitigation sites to attempt to stave off potential infestations in the Pacific Northwest. However, the more common and prolific invasive species that are currently encountered pale in comparison to the potential foothold and problems that knotweeds pose for mitigation sites, particularly stream and riparian restoration projects.

7.2.1 Knotweed

Japanese, Himalayan, giant, and hybrid knotweeds *(Polygonum cuspidatum, P. polystachyum, P Sachalinense, and P. bohemicum)* spread quickly to form dense tall thickets that shade other species and preclude natural regeneration of the normally diverse native species assemblage. Knotweeds can have profound impacts on salmonid habitat, because they prevent tree establishment along stream banks, disrupt timing, decay rate and quality of detritus in aquatic food webs, and sequester nitrogen in fall, reducing the amount of nitrogen that would be provided by normal leaf-drop in streams. Knotweed therefore has significant impacts on riparian ecosystems and biological diversity.

Knotweed is a creeping perennial. It dies back to the ground with the first hard frost, and returns each year from the same roots. Knotweed has an extensive network of rhizomes spreading at least 23 feet from the parent plant and penetrating more than 7 feet into the soil, making it extremely difficult to control once it is established. Knotweed survives severe floods. In fact, floodwaters merely serve to disperse knotweed fragments throughout the floodplains and cobble bars of rivers. Small fragments can regenerate into whole new stands, and rhizome fragments can be buried up to a meter and still regenerate. Because it grows faster than native species, it quickly shades them out.

Many methods of control have been attempted including, hand cutting, mowing, digging, pulling, covering, herbicides, and a combination of the above. With proper timing these methods can effectively eliminate stands of knotweed; however, all treatment approaches must be tenacious and thorough to be successful.

Because knotweed is so rapidly infesting certain areas of Washington State, the agencies have adopted a "zero tolerance" policy to help control this noxious, invasive species. Knotweed is also beginning to appear on many state and county noxious weed lists. Therefore, if there are no existing non-native knotweed plants on a mitigation site, but knotweed is later found during a monitoring event, a *contingency plan* should be implemented to immediately eradicate it.

For mitigation sites that have established stands of knotweed on them, the agencies will require that efforts be made to reduce the population, with the ultimate goal of eradication over time. Reed canarygrass will allow co-existence of established trees and shrubs, so it is often possible to “live with” a certain percentage on-site. Allowing knotweed to exist is much more problematic. Given time, knotweed will totally overrun a site, and once vigorously established it is more difficult to eradicate. However, one encouraging factor is that, unlike reed canarygrass, clumps of knotweed are likely to be less numerous and much more visible. This makes it much easier to locate populations and ensure treatment of the entire infestation.

7.2.2 Reed Canarygrass

In the Pacific Northwest, reed canary grass *(Phalaris arundinacea)* is one of the most difficult species to eradicate. It is a perennial, typically found in wetlands, that spreads by both seeds and rhizomes and creates dense, tall monocultures that crowd out low-growing species. If reed canary grass is present it is difficult to establish native plants because of the competitive advantage of the reed canary grass.

There is promising on-going research which indicates certain treatments can be effective in controlling reed canarygrass. These include aggressive, repeated mowing at the right time of the year and applying herbicides over a two-year period; rolling up the reed canarygrass mats, including the rhizomes, using them for microtopography or as berms/*buffers* on the mitigation site, covering the rolled-up mats with soil and planting with native species; thick plantings of willows for dense shade establishment (lesser degree of success), and planting a quick growing and spreading native seed mix (must be arduously maintained to be successful). Even with these methods, if adjacent sites have reed canarygrass as a dominant species, then keeping aerial coverage to a 10% maximum has been difficult, at best, to achieve.

An important lesson has been learned from reed canarygrass control and standards. The agencies' previous policy regarding performance standards for reed canarygrass was generally a 10% maximum aerial coverage for all monitoring years. However, many mitigation sites "failed" because they could not achieve the 10% standard, mainly because of widespread coverage of reed canarygrass on adjacent properties or within upstream *corridors*. The intent of invasive species performance standards in mitigation plans is to prevent the establishment of monocultures of invasive species that out-compete native species and compromise and degrade wetland and ecosystem functions. It is not the agencies intent to require unrealistic or unattainable performance standards for compensatory mitigation success.

The agencies have therefore implemented a more flexible policy for reed canarygrass coverage on mitigation sites. The agencies acknowledge that reed canarygrass does provide some important wetland functions, such as water-quality filtering and food-chain support. However, if a native plant community is desired, the most effective and efficient way to manage and maintain a site is to prevent new infestations and eradicate small populations of reed canarygrass as soon as possible. Therefore, for creation or restoration sites that currently have little or no reed canarygrass coverage, limiting reed canary grass to 10% may still be appropriate. The agencies however have adopted a policy of case-by-case determination so that standards make sense, are realistic, and are achievable.

7.3 Compensatory Mitigation And The Endangered Species Act

Many of the activities that destroy or degrade wetlands and their functions also adversely impact species listed as threatened or endangered under the Endangered Species Act (ESA) (33 USC §§ 1531 et seq., see Appendix E for a description). As a result, the regulatory agencies often give special consideration to the specific needs of these federally protected species when determining what compensatory mitigation will be required. Even before considering compensatory mitigation, the regulatory agencies often apply more stringent standards for avoiding and minimizing impacts to the aquatic environment and ESA-listed species, especially when the activity would degrade or destroy habitat that is difficult or impossible to replace. Typically, requirements for compensatory mitigation for projects involving ESA-listed species simultaneously address impacts to both wetland functions and endangered species and their habitat.

Section 7 of the ESA requires federal agencies and departments to consult with the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) and/or the U.S. Fish and Wildlife Service (USFWS) prior to taking any action that could potentially affect a species listed (or proposed for listing) as treatened or endangered. Consultation is also mandated if the action would destroy or adversely modify designated critical habitat for a listed species. This requirement applies to the Corps when it issues a Clean Water Act Section 404 or Section 10 permit. In a process somewhat analogous to *mitigation sequencing* (refer to section 3.5.1, *Mitigation Sequencing*), Section 7 consultations usually result in the identification of measures that would minimize the impacts of a proposed action on ESA-protected species and their critical habitat. As a result, the consultation process often gives the NOAA Fisheries and/or USFWS considerable influence over the nature and extent of compensatory mitigation required by the Corps in cases where federally listed species are involved.

Protecting habitat, as a component of compensatory mitigation, can benefit ESA-listed species. As such, larger consolidated mitigation projects, such as conservation and mitigation banks, may aid in the recovery of ESA-listed species. They may provide effective compensation for projects that impact ESA-listed species, their designated critical habitat, or both (see Section 4.2, *Programmatic Compensatory Mitigation*). Recognizing this, the USFWS, in 2003, issued a set of comprehensive federal guidelines intended to promote and guide the development of conservation banks (*Guidance for the Establishment, Use, and Operation of Conservation Banks,* see Appendix E for a description). Similar in many ways to wetland mitigation banks, conservation banks are lands (usually large tracts) with existing habitat that are acquired or protected[32] by third parties to be managed specifically for listed species and protected in perpetuity by *conservation easement*.[33] Like mitigation banks, conservation banks may develop and sell credits to offset adverse impacts to endangered species or their habitats that occur elsewhere. As of this writing, no conservation banks have been approved in Washington. The USFWS and NMFS are not currently engaged in banking in this region.

7.4 Stormwater and Wetland Mitigation

It can be difficult to separate wetland and stormwater issues when addressing compensatory mitigation in urban areas. In many cases existing wetlands receive all or part of their water from stormwater. However, stormwater facilities have not generally been considered acceptable compensation for the loss of wetland area. The agencies rarely allow the use of constructed stormwater facilities to be used for compensatory wetland mitigation for several reasons:

1. The stormwater facilities are generally designed to mitigate for impacts to water quality and quantity from additional impervious surfaces and changes to patterns of water flow (primarily conversions from infiltration of precipitation to surface runoff) that result from the proposed land-use change. They are generally not designed to also mitigate for the water quality and quantity functions lost when wetlands are lost.

32 Conservation banks can also be created by restoring or enhancing disturbed habitat, creating new habitat in some situations, and prescriptively managing a site for specified biological characteristics.

33 Use authorizations from WDNR (for state-owned aquatic lands) or other traditional conservation easements could be used to secure land for use as a conservation or mitigation bank.

2. Typical stormwater facilities such as detention basins and vaults do not provide the same types of functions as wetlands provide because they have water regimes which are very different in depth, timing and duration from natural wetlands.
3. Most stormwater facilities are so intensively managed that they cannot provide the range of functions needed to mitigate impacts to wetlands.
4. Stormwater facilities are not regulated as *waters of the state* whereas compensatory mitigation wetlands are afforded the same levels of protection as natural wetlands. This means that the long-term protection of wetland functions cannot be guaranteed if constructed stormwater facilities are used as compensation for lost wetlands.

Federal regulation of stormwater facilities

The Corps regulates some stormwater facilities as a result of the "Talent" decision (Ninth Circuit's decision on March 12, 2001, in *Headwaters, Inc. v. Talent Irrigation District*). Maintenance of stormwater facilities is an exempt activity. If however, the stormwater ponds are connected to a water of the U.S., impacts to the ponds are a regulated activity even if the ponds were dug from uplands. Stormwater ponds are often not maintained on a regular basis and therefore have some habitat functions which may need to be mitigated if lost.

However, there has been a growing interest on the part of project applicants to incorporate stormwater facilities as part of their wetland compensation package. The agencies have allowed some clean storm water[34] to be used as a water source for compensation sites. In this case, extensive modeling is needed to determine the appropriate size and topography for the compensation site. The use of clean stormwater can be beneficial to the water cycle in the basin if there is an attenuation of the flows leaving the wetland after storm events and/or some of the flows infiltrate into the soil profile.

The agencies are currently working on guidance and requirements for when stormwater facilities and wetland compensatory mitigation can be combined. When that guidance is developed, it will be added to this document. Check the following web site for updates: http://www.ecy.wa.gov/programs/sea/wet-updatedocs.htm.

Ecology has published a manual to provide local governments, land developers, development engineers, and businesses with technical standards and guidance on stormwater management based on the current state of the science and the best technical information available. The 2005 revision to the *Stormwater Management Manual for Western Washington* includes practices to minimize stormwater impacts on receiving

34 Clean storm water is runoff that does not flow over areas where it could pick up contaminants such as parking lots or lawn areas. Roof runoff from buildings is generally considered clean provided that the roofing materials do not release pollutants. Galvanized or copper-treated, asphalt-shingle roofs are examples of non-suitable roofs, since rain on the roof can pick up zinc or copper contamination from the roof materials.

waters, including wetlands, in areas west of the crest of the Cascade Mountains and addresses the effects of changes in water quality and water quantity on those waters.

Ecology also published a stormwater management manual for eastern Washington in 2004. The manual is more limited in scope than the western Washington manual with respect to management guidelines for wetlands and stormwater.

How to obtain Ecology's stormwater management manuals

Details about changes to and requirements of the stormwater manual for western Washington are available on the internet at: http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

The manual for eastern Washington is available at: http://www.ecy.wa.gov/programs/wq/stormwater/eastern_manual/index.html

7.5 Talent Decision: Ditches as Waters of the U.S.

In 2001, the United States Court of Appeals for the 9th Circuit decided on the case *Headwaters, Inc. v. Talent Irrigation Distric*t (commonly known as the Talent Decision, 243 F.3d 526). Prior to the Talent Decision, ditches dug in wetlands or hydric soils were always regulated as waters of the U.S. provided they connected to other waters of the U.S. In addition, ditches that were straightened or channelized natural drainages or streams were, and still are, regulated as waters of the U.S.

In the Talent Decision the court held that irrigation canals that receive water from natural streams, and lakes and divert water to streams and creeks, are connected as "tributaries." The 9th Circuit further held that a "stream which contributes its flow to a larger stream or other body of water is a tributary...As tributaries, the canals are 'waters of the U.S'', and are subject to the Clean Water Act and its permit requirement." This decision supercedes any contrary conclusion from previous Corps of Engineers policy statements regarding ditches.

Corps districts are awaiting official guidance from their HQ office on making jurisdictional calls related to ditches. A Regulatory Guidance Letter (RGL) will also be developed to address exemptions for construction or maintenance of irrigations ditches and maintenance of drainage ditches. WSDOT has a website devoted to the Talent Decision: http://www.wsdot.wa.gov/environment/Talent/default.htm.

7.5.1 Compensatory Mitigation and Ditches

Most impacts to ditches will be self-mitigating since most roadside ditches that are impacted by construction projects are replaced in-kind. Mitigation may be required for impacts to ditches that have valuable habitat components (a small subset of ditches that are not routinely maintained). Applicants must assess the functions the ditch is providing (e.g., water quality, water conveyance, habitat) and which of those functions will be replaced with a new ditch or if the ditch is being tightlined, which functions may not be replaced. Compensatory mitigation requirements for ditch impacts will be determined on a case-by-case basis.

Glossary

Adaptive management. A systematic process for improving management policies and practices by learning from the outcomes of previous policies and practices. Related to compensatory mitigation, it involves the permittee and the agencies discussing the problems occurring on a compensation site and coming to agreement on possible solutions or alternative approaches necessary to bring the site into compliance.

Advance mitigation. Compensatory mitigation in which the mitigation project is implemented before, and in anticipation of, future known impacts to wetlands. Compare to *concurrent mitigation* and mitigation banking.

Aquatic resources. Refers to ecological systems where the regular or occasional presence of water is the dominant factor in determining the characteristics of the site. Aquatic resources include wetlands, rivers, streams, and lakes and other deepwater habitats.

Assessment. See *function assessment*.

Atypical wetland. A wetland whose “design” does not match the type of wetland that would be normally be found in the geomorphic setting of the proposed site (i.e., the water source and hydroperiod proposed for the mitigation site are not typical for the geomorphic setting). Designs that provide exaggerated morphology or require a berm or other engineered structures to hold back water would also be considered atypical.

Avoidance. The first step of *mitigation sequencing*.

Beneficial uses. The term used in the federal and state Clean Water Acts to represent societal values of aquatic resources such as water supply; surface and groundwater treatment; stormwater attenuation; fish and shellfish migration, rearing, spawning, and harvesting; wildlife habitat; recreation; support of biotic diversity; and aesthetics. See *wetland values.*

Best management practices (BMPs). Schedules of activities, prohibitions of practices, maintenance procedures, managerial practices, or structural features that prevent or reduce adverse impacts to waters of Washington State.

Bog. A unique type of wetland dominated by mosses at the surface and that form peat soils. Bogs form in areas where the climate allows the accumulation of peat. The water regime in bogs is dominated by precipitation rather than surface inflow. The plant community is specialized to survive in the nutrient-poor and highly acidic conditions typical of bog systems.

Buffers or buffer areas. Vegetated areas adjacent to wetlands, or other aquatic resources, that can reduce impacts from adjacent land uses through various physical, chemical, and/or biological processes.

Characterizations. A method that groups wetlands based on their distinguishing traits or qualities (Hruby 1999). For example, Ecology's wetland rating systems for eastern and western WA assign wetlands to Category I, II, III, or IV based on their distinguishing traits or qualities. See *wetland rating*.

Class. A grouping based on shared characteristics in a classification scheme. In the Cowardin classification (Cowardin et al. 1979) of wetlands a class is the third level in the 'taxonomy' of wetlands whereas in the *hydrogeomorphic classificatio*n (Brinson 1993) it is the highest taxonomic unit.

Compensation. Same as *compensatory mitigation.*

Compensatory mitigation. The stage of the mitigation sequence, where impacts to wetland functions are offset (i.e., compensated for) through creation (establishment), restoration (re-establishment, rehabilitation), or enhancement of other wetlands. Because regulatory requirements and policies tend to focus on compensatory mitigation, the term "mitigation" is often used to refer to compensation, which is just one part of the overall mitigation sequence. See *mitigation sequencing.*

Concurrent mitigation. Compensatory mitigation that is implemented at approximately the same time as the authorized activities that result in wetland impacts. See *compensatory mitigation.*

Connectivity. The degree to which structures found across the landscape facilitate movement of living organisms between patches or their habitat. The movement can occur either within the lifetime of an organism or over a period of generations. The purpose of facilitating movement is to maintain viable populations that allow species and communities of species to persist in time. Connectivity can be achieved via a continuous and linear habitat feature (as in a corridor) or discrete habitat patches comprised but not limited to individual forests, wetlands, shrub lands, and shorelines.

Conservation easement. A legal restriction placed on a piece of property to protect the resources (natural or man-made) associated with the parcel. It restricts the type and amount of activities that can take place on a parcel of land. Easements are recorded on the property deed and are held in trust by a conservation easement "holder" such as a land trust or government agency. The holder polices the terms of the easement for the duration of its existence, which is usually into perpetuity. Compare to *deed restriction.*

Contingency plan. A plan outlining actions that would be taken if monitoring revealed a problem that would prevent the site from attaining its performance standards. Contingency plans should both anticipate problems and identify specific actions that would be implemented to rectify each problem.

Corridor. Areas that contain relatively undisturbed habitat and/or vegetation that maintain connections for wildlife throughout the landscape. Corridors usually represent linear habitats with the range of environmental functions necessary to permit the movement of animals between larger and more fully functioning habitats. Corridors can include but are not limited to, annual or seasonal migration corridors that connect wintering and breeding habitat, or intra-seasonal corridors that connect foraging and nesting habitat or breeding and dispersal habitat. See *connectivity.*

Cowardin classification. The first commonly used classification system for wetlands. It was developed in 1979 by the U.S. Fish and Wildlife Service. The Cowardin system classifies wetlands based on water flow, substrate types, vegetation types, and dominant plant species. See *class*.

Creation. See *establishment*.

Critical areas. Defined by the State of Washington to "Include the following areas and ecosystems: (a) Wetlands; (b) areas with a critical recharging effect on aquifers used for potable water; (c) fish and wildlife habitat conservation areas; (d) frequently flooded areas; and (e) geologically hazardous areas" (Growth Management Act RCW 36.70A.030). Basically, critical areas are those areas that should have some development limitations due to the benefits that those areas provide to society or to the dangers that those areas present to society if developed.

Cultural resources. Any archaeological, historical, or cultural (e.g., religious significance) areas of concern. This term is a catch-all term that is not defined in any federal statute or regulation.

Deed restriction. Clauses in a deed limiting the future uses of the property. Deed restrictions may impose a vast variety of limitations and conditions. For example, for a compensatory mitigation site, a deed restriction may limit the allowed activities on the site based on the goals and objectives of the site. If the site is primarily for wildlife habitat human access may be restricted. Compare to *conservation easement*.

Depressional wetland. A class of wetlands in the *hydrogeomorphic classification*. These are wetlands that occur in topographic depressions that exhibit closed contour interval(s) on three sides and elevations that are lower than the surrounding landscape.

Dredge/dredged. Any excavation of the substrate of a water body. Dredging can be conducted by mechanical or hydraulic means and is performed to maintain navigation channels, remove contaminated sediments, and other purposes.

Enhancement. The manipulation of the physical, chemical, or biological characteristics of a wetland site to heighten, intensify or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for specified purposes such as water quality improvement, flood water retention or wildlife habitat. Activities typically consist of planting vegetation, controlling non-native or invasive species, modifying site elevations or the proportion of open water to influence hydroperiods, or some combination of these. Enhancement results in a change in some wetland functions and can lead to a decline in other wetland functions, but does not result in a gain in wetland acres. Compare to *establishment* and *restoration* (*re-establishment* and *rehabilitation*).

Environmental Processes. Environmental factors that occur at larger geographic scales, such as basins, sub-basins, and watersheds. Processes are dynamic and usually represent the movement of a basic environmental characteristic, such as water, sediment, nutrients and chemicals, energy, or animals and plants. The interaction of landscape processes with the physical environment creates specific geographic locations where groundwater is recharged, flood waters are stored, stream water is oxygenated, pollutants are removed, and wetlands are created.

Establishment (creation). The manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland or deepwater site, where a wetland did not previously exist. Establishment results in a gain in wetland acreage [and function]. (Note: The U.S. Army Corps of Engineers' Regulatory Guidance Letter 02-02 uses the term "establishment" rather than the previously accepted term "creation." Federal agencies, as well as the Department of Ecology, have started using the term "establishment.") Compare to *enhancement* and *restoration*.

Estuarine wetland. Wetlands where salt tolerant plant species are dominant and the water regime is influenced by tidal action. The wetlands are usually partially enclosed by land with open, or partially obstructed access to open saline water. In areas where freshwater wetlands grade into estuarine areas, the boundary of the latter extends to an area where the salinity is less than 5 ppt (parts per thousand) during the period of average annual low flow.

Federal undertaking. For the purposes of this document, federal undertaking means issuing a Department of the Army permit by the Corps.

Flat. A class of wetlands in the *hydrogeomorphic classification*. These are wetlands that occur in topographically flat areas that are hydrologically isolated from surrounding ground or surface water. They are primarily maintained by precipitation.

Forested wetland. A wetland *class* in the *Cowardin classification* where woody plants taller than 20 feet form the dominant cover (> 30% aerial cover). Shrubs often form a second layer beneath the forest canopy, with a layer of herbaceous plants growing beneath the shrubs.

Functions. The physical, biological, chemical, and geologic interactions among different components of the environment. See *wetland functions*.

Function assessment. The process by which the capacity (i.e., potential) of a wetland to perform a function is measured or characterized. This approach analyzes the capacity to perform a function often using a numeric model. Assessments are methods that generate a number that represents an estimate of the performance of a wetland function. The number generated is relative to a predetermined standard (e.g., level of function provided by *reference wetlands*). Numbers do not reflect an actual level of function performance (Hruby 1999). Examples include the Washington State methods for assessing wetland functions (also known as WFAM) (Hruby et al. 1999 and 2000) and a Hydrogeomorphic wetland function assessment method (Brinson et al. 1995). See *functions*.

Historic property. Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on the National Register of Historic Places, including artifacts, records, and material remains related to such a property or resource. Historic properties are protected by the National Historic Preservation Act and other laws.

Hydrogeomorphic (HGM) classification. A system used to classify wetlands based on the position of the wetland in the landscape (geomorphic setting), the water source for the wetland, and the flow and fluctuation of the water once in the wetland. An HGM wetland *class* is the highest level in the hydrogeomorphic classification of wetlands. There are six basic hydrogeomorphic wetland classes including depressional, tidal fringe, slope, riverine, lake fringe, and flat. See class.

Hydroperiod (or water regime). The pattern of water level fluctuations in a wetland. Includes the depth, frequency, duration, and timing of inundation or flooding. Patterns can be daily, monthly, seasonal, annual or longer term.

In-kind mitigation. *Compensatory mitigation* that is the same physical and functional type as that of the impact area (e.g., same Cowardin class or hydrogeomorphic type) (RGL 02-02).

In-lieu fees (ILFs). An approach to compensatory mitigation that allows permit applicants to pay a fee to a third party such as a government agency or conservation organization. The fees are then used to restore, create, enhance, or preserve wetlands. Generally, in-lieu fee contributions are collected in advance of wetland losses. These funds are accumulated until they are sufficient to design and implement a wetland compensation project.

Interdunal wetlands. Wetlands that form in the "deflation plains" and "swales" that are geomorphic features in areas of coastal dunes. These dune forms are the result of the interaction between sand, wind, water, and plants. The dune system immediately behind the ocean beach (i.e., the primary dune system) is very dynamic and can change from storm to storm. These wetlands provide critical habitat in this ecosystem.

Invasive Species. Defined by the National Invasive Species Council (NISC) as "(1) a non-native (alien) to the ecosystem under consideration and (2) a species whose introduction is likely to cause economic or environmental harm, or harm to human health" (Executive Order 13112).

Lacustrine (lake) fringe wetlands. A wetland *class* under the *hydrogeomorphic classification*. These are wetlands that occur at the margins of topographic depressions in which surface water is greater than 8 hectares (20 acres) and greater than 2 meters deep in western Washington and 3 meters in eastern Washington.

Minimization. The second step of mitigation sequencing, in which actions are taken to reduce the extent of wetland impacts (e.g., a project is redesigned to lessen wetland alteration). It does not however eliminate the direct or indirect loss of area and/or functions. See *mitigation sequencing*.

Mitigation banking. As defined by the 1995 federal guidance on wetland mitigation banking and state law (Chapter 90.84 RCW), mitigation banking is "wetland restoration, creation, enhancement, and in exceptional circumstances, preservation undertaken expressly for the purpose of compensating for unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be as environmentally beneficial."

Mitigation sequencing. A prescribed order of steps taken to reduce the impacts of activities on wetlands. Mitigation sequencing involves: 1. Avoiding the impact altogether by not taking a certain action or parts of an action; 2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps, such as project redesign, relocation, or timing, to avoid or reduce impacts; 3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment; 4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; 5. Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and 6. Monitoring the impact and taking appropriate corrective measures (WAC 197.11.768). See *compensatory mitigation.*

Navigable waters. Those waters that are subject to the ebb and flow of the tide shoreward to the mean high water mark and/or are presently used, or have been used in the past or may be susceptible to use to transport interstate or foreign commerce (33 CFR 329).

Off-site mitigation. Compensatory mitigation that is not located at or near the project that is affecting wetlands. Off-site mitigation is generally only allowed when on-site mitigation is not practicable and environmentally preferable.

On-site mitigation. *Compensatory mitigation* that occurs within project boundaries and/or areas adjacent or contiguous to impact area (RGL 02-02).

Out-of-kind mitigation. Compensatory mitigation in which the wetland and its associated functions used to compensate for the impacts are of a different kind than those impacted.

Performance standards. Observable or measurable attributes used to determine whether a compensatory mitigation project meets its objectives. Standards are written in a mitigation plan and are enforceable conditions.

Preservation. *See protection/maintenance.*

Programmatic mitigation area. A site (or series of sites) that has been identified by a local government or a state or federal agency as a preferred area for wetland compensation. Mitigation for multiple impacts is directed to these areas to produce larger more ecologically significant systems.

Protection/maintenance (preservation). Removing a threat to, or preventing the decline of, wetland conditions by an action in or near a wetland. This includes the purchase of land or easements, repairing water control structures or fences, or structural protection such as repairing a barrier island. This term also includes activities commonly associated with the term preservation (in a regulatory context). Under regulatory actions preservation does not result in a gain of wetland acres, but may result in a gain in functions over the long term, and is used only in exceptional circumstances.

Rating. A method that groups wetlands according to a qualitative scaling of function performance, such as high, medium, or low (Hruby 1999). The wetland evaluation technique (WET) (Adamus et al. 1987) is an example of a wetland rating method. The semi-quantitative assessment methodology (SAM) (Cooke 2000) is an example of a wetland rating method for the Puget lowlands of western Washington.

Re-establishment. The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former wetland. Activities could include removing fill material, plugging ditches or breaking drain tiles. Re-establishment results in a gain in wetland acres and functions. Compare to *rehabilitation*. See also *restoration.*

Reference wetland. In the context of compensatory mitigation, a wetland chosen to represent the functions and characteristics that are being created, restored, or enhanced at the "mitigation" site. A reference wetland can be used for monitoring the success of the mitigation project. Reference wetlands, in the context of methods for assessing wetland functions, mean the sites chosen to represent the full range of functioning in a region or hydrogeomorphic class. Data collected at these sites are used to calibrate the methods.

Rehabilitation. The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic functions and processes of a degraded wetland. Activities could involve breaching a dike to reconnect wetlands to a floodplain, restoring tidal influence to a wetland, or breaking drain tiles and plugging drainage ditches. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres. Compare to *establishment (creation), re-establishment* and *enhancement*. See also *restoration.*

Restoration. The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into *re-establishment* and *rehabilitation*. Re-establishment represents a net gain in acres while rehabilitation does not.

Riverine wetlands. A *class* of wetlands in the *hydrogeomorphic classification*. Wetlands that occur in floodplains and riparian corridors in association with stream or river channels where there is frequent overbank flooding.

Slope wetlands. A class of wetlands in the *hydrogeomorphic classification.* These are wetlands that occur on the slopes of hills or valleys. The principal water source is usually seepage from groundwater.

State Historic Preservation Officer (SHPO). Administers the national historic preservation program at the State level, review National Register of Historic Places nominations, maintain data on historic properties that have been identified but not yet nominated, and consult with Federal agencies during Section 106 review. SHPOs are designated by the governor of their respective State or territory. Federal agencies seek the views of the appropriate SHPO when identifying historic properties and assessing effects of an undertaking on historic properties. SHPO work for the Washington State Office of Archaeology and Historic Preservation.

Stormwater. Stormwater is the water coming from rain or snow that runs off surfaces such as rooftops, paved streets, highways, and parking lots. It can also come from hard grassy surfaces like lawns, play fields, and from graveled roads and parking lots.

Sub-basin. A smaller drainage basin that is part of a larger drainage basin or watershed. For example, the watershed of a large river may be composed of several sub-basins, one for each of the river's tributaries.

Temporal loss (of functions). Temporal loss is the loss of functions between the time an impact occurs and the time the functions are re-established. In the context of wetland mitigation, it is the loss of functions that occurs between the time functions are lost at an impact site and the time those functions are fully replaced at a mitigation site.

Tidal fringe wetlands. A class of wetlands in the *hydrogeomorphic classification.* Wetlands that occur on continental margins where marine waters are greater than 2 meters deep and more than 8 hectares (20 acres) in size.

Tribal Historic Preservation Officer (THPO). A representative of a tribe that assumes any or all of the functions of a State Historic Preservation Officer (see above) with respect to *tribal land.* The decision to participate or not participate in the program rests with the tribe. In Washington there are currently 5 tribes with a THPO: the Makah Tribe; the Skokomish Indian Tribe; the Confederated Tribes of the Colville; the Squaxin Island Tribe; and the Spokane Tribe.

Tribal lands. All lands within the boundaries of an Indian Reservation, whether they are tribally or independently owned.

Values. See *wetland values.*

Vernal pool. Small depressions in the scabrock or in shallow soils of eastern Washington that fill with snowmelt or spring rains. They retain water until the late spring when reduced precipitation and increased evapotranspiration lead to a complete drying out. The wetlands hold water long enough throughout the year to allow some strictly aquatic organisms to flourish, but not long enough for the development of a typical wetland environment.

Waters of the state. Include lakes, rivers, ponds, streams, inland waters, underground waters, salt waters and all other surface waters and watercourses within the jurisdiction of the state of Washington (RCW Chapter 90.48.020).

Waters of the United States. Generally include navigable waters, tributaries of navigable waters, interstate waters, and all other waters such as intrastate lakes, rivers, streams, and wetlands. See 33 CFR 328.3 for a detailed definition.

Watershed. A geographic area of land bounded by topographic high points in which water drains to a common destination.

Wetland functions. The physical, biological, chemical, and geologic interactions among different components of the environment that occur within a wetland. Wetlands perform many valuable functions and these can be grouped into three categories: functions that improve water quality, functions that change the water regime in a watershed such as flood storage, and functions that provide habitat for plants and animals. See *functions.*

Wetland rating. Also called a wetland rating system, is a tool for dividing or grouping wetlands into groups that have similar needs for protection. One method used in Washington is the Washington State wetland rating systems (Hruby 2004a,b), which places wetlands in categories based on their rarity, sensitivity, our inability to replace them, and their functions. See *characterization.*

Wetland values. Wetland processes, characteristics, or attributes that are considered to benefit society. See *beneficial uses.*

Wetlands. As defined by the *Washington State Wetlands Delineation Manual* (Ecology 1997), "The Corps of Engineers (CE) (Federal Register 1982), the Environmental Protection Agency (EPA) (Federal Register 1985), Washington's Water Quality Standards, the Shoreline Management Act (SMA) and the Growth Management Act (GMA) all define wetlands as: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. In addition, Washington's Water Quality Standards, the SMA and GMA definitions add: "Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands."

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Washington Department of Fish and Wildlife's Hydraulic Project Approval page http://wdfw.wa.gov/hab/hpapage.htm.

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Washington State Office of Regulatory Assistance (ORA) http://www.ecy.wa.gov/programs/sea/pac/ or go to http://apps.ecy.wa.gov/opas/index.asp for ORA's on-line Project Questionnaire, developed to help applicants determine which Washington State and Federal environmental permits will be needed for a project.

Appendix A - Reviewers of the Document

Individuals and organizations that provided written comments, suggestions, and materials during the public review period (Name and affiliation at time of comment)

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Appendix B - National Research Council's Mitigation Guidelines

In 2001 the National Academy of Science's National Research Council published a report entitled, *Compensating for Wetland Losses Under The Clean Water Act*, which provided recommendations for improving mitigation. In response, the U.S. Army Corps of Engineers (Corps) provided implementation clarification so that a minimum level of standards for compensatory mitigation could be set for all Corps districts. The clarifying guidance is provided in this appendix. This information has been incorporated throughout this document and the agencies mitigation policies and guidance are consistent with it.

The full report (National Academy of Sciences 2001) can be found on-line at http://www.nap.edu/books/0309074320/html.

Incorporating the National Research Council's Mitigation Guidelines Into the Clean Water Act Section 404 Program

BACKGROUND

In its comprehensive report entitled "*Compensating for Wetland Losses Under the Clean Water Act*," the National Research Council (NRC) provided ten guidelines to aid in planning and implementing successful mitigation projects ("Operational Guidelines for Creating or Restoring Wetlands that are Ecologically Self-Sustaining"; NRC, 2001). Please note that these guidelines also pertain to restoration and enhancement of other aquatic resource systems, such as streams. Each of the ten guidelines can generally be described as A) basic requirement for mitigation success, or B) guide for mitigation site selection. The following sections include both the original text of the NRC guidelines, in italics, as well as a discussion of how applicants and field staff can incorporate these guidelines into the development and review of mitigation projects.

A. Basic Requirements for Success

When considering mitigation sites it is important to note that wetland mitigation is not a precise, exact science and predictable results are not always obtainable. Having an adaptive management attitude is a necessity. One should incorporate experimentation into the mitigation plan when possible. This may mean using experimental plots within a mitigation site with different controls, replication, different treatments, inputs, etc., to determine if specific mitigation efforts are effectively meeting the desired goals. This requires detailed planning, effective implementation of the mitigation project, close monitoring (both short and long term) of the implemented plans and finally adjusting to intermediate results with an adaptive attitude and additional modifications to obtain long range wetland and watershed goals. In addition, researchers have found that restoration is the most likely type of mitigation to result in successful and sustainable aquatic resource replacement. Moreover, numerous studies in a variety of landscapes and watershed types have shown that of all factors contributing to mitigation success, attaining and maintaining appropriate hydrological conditions is the most important. The following NRC guidelines should be considered basic requirements for mitigation success.

A.1. Whenever possible, choose wetland restoration over creation.

Select sites where wetlands previously existed or where nearby wetlands still exist. Restoration of wetlands has been observed to be more feasible and sustainable than creation of wetlands. In restored sites the proper substrate may be present, seed sources may be on-site or nearby, and the appropriate hydrological conditions may exist or may be more easily restored.

The U.S. Army Corps of Engineers (Corps) and Environmental Protection Agency (EPA) Mitigation Memorandum of Agreement states that, "because the likelihood of success is greater and the impacts to potentially valuable uplands are reduced, restoration should be the first option considered" (Fed. Regist. 60(Nov. 28):58605). The Florida Department of Environmental Regulation (FDER 1991a) recommends an emphasis on restoration first, then enhancement, and, finally, creation as a last resort. Morgan and Roberts (1999) recommend encouraging the use of more restoration and less creation.

The applicant proposes the type of mitigation. However, the Corps and other agencies will evaluate proposals based on the ease of completion and the likelihood of success. Therefore, pure wetland creation will be evaluated using very stringent criteria before being approved for use as compensatory mitigation for project impacts. Some projects may include creation as part of an overall mitigation effort that involves restoration, enhancement, and/or preservation (e.g., as in a proposed mitigation bank). In these cases, evaluation will be based on the entire proposal and its location in the watershed.

A.2. Avoid over-engineered structures in the wetland's design

Design the system for minimal maintenance. Set initial conditions and let the system develop. Natural systems should be planned to accommodate biological systems. The system of plants, animals, microbes, substrate, and water flows should be developed for self-maintenance and self-design. Whenever possible, avoid manipulating wetland processes using approaches that require continual maintenance. Avoid hydraulic control structures and other engineered structures that are vulnerable to chronic failure and require maintenance and replacement. If necessary to design in structures, such as to prevent erosion until the wetland has developed soil stability, do so using natural features, such as large woody debris. Be aware that more specific habitat designs and planting will be required where rare and endangered species are among the specific restoration targets.

Whenever feasible, use natural recruitment sources for more resilient vegetation establishment. Some systems, especially estuarine wetlands, are rapidly colonized, and natural recruitment is often equivalent or superior to plantings (Dawe et al. 2000). Try to take advantage of native seed banks, and use soil and plant material salvage whenever possible. Consider planting mature plants as supplemental rather than required, with the decision depending on early results from natural recruitment and invasive species occurrence. Evaluate on-site and nearby seed banks to ascertain their viability and response to hydrological conditions. When plant introduction is necessary to promote soil stability and prevent invasive species, the vegetation selected must be appropriate to the site *rather than forced to fit external pressures for an ancillary purpose (e.g., preferred wildlife food source or habitat).*

The use of over-engineered structures and maintenance intensive plans for mitigation is not recommended and will be evaluated using very stringent criteria. If these types of plans are ultimately approved, they must include a comprehensive remedial plan and financial assurances [note that all mitigation projects should have remedial plans and financial assurances], along with a non-wasting endowment to insure that proper maintenance occurs.

It should also be noted that aggressive soil and planting plans using introduced plants and soil from outside sources must be closely monitored to prevent invasive plant takeovers and monotypic plant communities. Such failures can be minimized by undertaking both short-term and long-term monitoring, and having contingency plans in place.

A. 3. Restore or develop naturally variable hydrological conditions.

Promote naturally variable hydrology, with emphasis on enabling fluctuations in water flow and level, and duration and frequency of change, representative of other comparable wetlands in the same landscape setting. Preferably, natural hydrology should be allowed to become reestablished rather than finessed through active engineering devices to mimic a natural hydroperiod. When restoration is not an option, favor the use of passive devices that have a higher likelihood to sustain the desired hydroperiod over long term. Try to avoid designing a system dependent on water-control structures or other artificial infrastructure that must be maintained in perpetuity in order for wetland hydrology to meet the specified design. In situations where direct (in-kind) replacement is desired, candidate mitigation sites should have the same basic hydrological attributes as the impacted site.

Hydrology should be inspected during flood seasons and heavy rains, and the annual and extreme-event flooding histories of the site should be reviewed as closely as possible. For larger mitigation projects, a detailed hydrological study of the site should be undertaken, including a determination of the potential interaction of groundwater with the proposed wetland. Without flooding or saturated soils, for at least part of the growing season, a wetland will not develop. Similarly, a site that is too wet will not support the desired biodiversity. The tidal cycle and stages are important to the hydrology of coastal wetlands.

Natural hydrology is the most important factor in the development of successful mitigation. Wetlands and other waters are very dynamic, and dependent on natural seasonal and yearly variations that are unlikely to be sustainable in a controlled hydrologic environment. Artificial structures and mechanisms should be used only temporarily. Complex engineering and solely artificial mechanisms to maintain water flow normally will not be acceptable in a mitigation proposal. In those sites where an artificial water source (irrigation) has been used to attempt to simulate natural hydrology there are several problems that lead to reduced likelihood of success. First, artificial irrigation does not provide the dynamic and variable nature of water flow normally found in wetlands or riparian systems. Second, the lack of seasonal flows limits the transport of organic matter into and out of the wetland or riparian system. Without any inflow, the net result of artificial irrigation is transport of organic material out of the system. Third, depending on the timing, the use of flood or sprinkler systems on newly created or restoration sites often promotes the germination and growth of exotic plant species.

Note that this changes the Corps' past policy of accepting artificial irrigation as the sole source of hydrology for mitigation projects. If permitted at all, these projects will require substantial financial assurances and a higher mitigation ratio to offset their risk of failure. Applicants must weigh the potential investment costs of acquiring land suitable for restoration versus creation projects in upland environments that will likely involve higher long-term costs and greater risks of mitigation site failure.

The Corps may approve exceptions dealing with hydrologic manipulations, on a case-by-case basis in highly unusual circumstances. It should be noted, however, that even minor engineering or hydraulic manipulation requiring long-term maintenance will only be approved after the applicant posts a non-wasting endowment, performance bond, or other financial assurance.

A.4. Consider complications associated with creation or restoration in seriously degraded or disturbed sites

> *A seriously degraded wetland, surrounded by an extensively developed landscape, may achieve its maximal function only as an impaired system that requires active management to support natural processes and native species (NRC 1992). It should be recognized, however, that the functional performance of some degraded sites may be optimized by mitigation, and these considerations should be included if the goal of the mitigation is water- or sediment-quality improvement, promotion of rare or endangered species, or other objectives best served by locating a wetland in a disturbed landscape position. Disturbance that is intense, unnatural, or rare can promote extensive invasion by exotic species or at least delay the natural rates of redevelopment. Reintroducing natural hydrology with minimal excavation of soils often promotes alternative pathways of wetland development. It is often advantageous to preserve the integrity of native soils and to avoid deep grading of substrates that may destroy natural belowground processes and facilitate exotic species colonization (Zedler 1996).*

When considering restoration options it is necessary to determine the spatial and temporal scale of the damage: is the damage limited to the water body itself, or is it a predominant characteristic of the watershed or the surrounding landscape? On-site damage may be restorable, whereas regional-scale damage may be more difficult, or impossible, to reverse or obtain historic conditions. Alternate goals may be necessary in order to determine specific goals of the restoration project. Those desired wetland mitigation goals will depend on the resources needed, the level of degradation and realistic mitigation targets as reflected by the watershed and surrounding landscape. This issue points to the importance of evaluating mitigation plans from a broader watershed perspective.

A.5. Conduct early monitoring as part of adaptive management

Develop a thorough monitoring plan as part of an adaptive management program that provides early indication of potential problems and direction for correction actions. The monitoring of wetland structure, processes, and function from the onset of wetland restoration or creation can indicate potential problems. Process monitoring (e.g., water-level fluctuations, sediment accretion and erosion, plant flowering, and bird nesting) is particularly important because it will likely identify the source of a problem and how it can be remedied. Monitoring and control of nonindigenous species should be a part of any effective adaptive management program. Assessment of wetland performance must be integrated with adaptive management. Both require understanding the processes that drive the structure and characteristics of a developing wetland. Simply documenting the structure (vegetation, sediments, fauna, and nutrients) will not provide the knowledge and guidance required to make adaptive "corrections" when adverse conditions are discovered. Although wetland development may take years to decades, process-based monitoring might provide more sensitive early indicators of whether a mitigation site is proceeding along an appropriate trajectory.

There are many factors that may positively or negatively influence aquatic resources and the functions they provide, such as urbanization, farming or grazing. Wetlands and other aquatic resources are often subject to a wide range and frequency of events such as floods, fires and ice storms. As with all natural systems, some things are beyond control. Well-crafted mitigation plans, however, recognize the likelihood of these events and attempt to plan for them, primarily through monitoring and adaptive management. In addition, it is important to realize the mobile nature of wetlands and streams. They change over time and over the landscape in response to internal and external forces.

Monitoring and adaptive management should be used to evaluate and adjust maintenance (e.g., predator control, irrigation), and design remedial actions. Adaptive management should consider changes in ecological patterns and processes, including biodiversity of the mitigation project as it evolves or goes through successional stages. Trends in the surrounding area must also be taken into account (i.e., landscape/watershed context). Being proactive helps ensure the ultimate success of the mitigation, and improvement of the greater landscape. One proactive methodology is incorporation of experimentation into the mitigation plan when possible, such as using experimental plots within a mitigation site with different controls, replication, different treatments, inputs, etc., to determine if specific mitigation efforts are meeting the desired goals.

B. Mitigation Site Selection

The selection of an appropriate site to construct a mitigation project is one of the most important, yet often under-evaluated, aspects of mitigation planning. In many instances, the choice of the mitigation site has been completed by the applicant based solely on economic considerations with minimal concern for the underlying physical and ecological characteristics of the site. While economic factors are important in determining the practicability of site selection, current technology and the following NRC guidelines should also factor into the selection of a mitigation site.

B.1. Consider the hydrogeomorphic and ecological landscape and climate

Whenever possible, locate the mitigation site in a setting of comparable landscape position and hydrogeomorphic class. Do not generate atypical "hydrogeomorphic hybrids"; instead, duplicate the features of reference wetlands or enhance connectivity with natural upland landscape elements (Gwin et al. 1999).

Regulatory agency personnel should provide a landscape setting characterization of both the wetland to be developed and, using comparable descriptors, the proposed mitigation site. Consider conducting a cumulative impact analysis at the landscape level based on templates for wetland development (Bedford 1999). Landscapes have natural patterns that maximize the value and function of individual habitats. For example, isolated wetlands function in ways that are quite different from wetlands adjacent to rivers. A forested wetland island, created in an otherwise grassy or agricultural landscape, will support species that are different from those in a forested wetland in a large forest tract. For wildlife and fisheries enhancement, determine if the wetland site is along ecological corridors such as migratory flyways or spawning runs. Constraints also include landscape factors. Shoreline and coastal wetlands adjacent to heavy wave action have historically high erosion rates or highly erodible soils, and often-heavy boat wakes. Placement of wetlands in these locations may require shoreline armoring and other protective engineered structures that are contrary to the mitigation goals and at cross-purposes to the desired functions

Even though catastrophic events cannot be prevented, a fundamental factor in mitigation plan design should be how well the site will respond to natural disturbances that are likely to occur. Floods, droughts, muskrats, geese, and storms are expected natural disturbances and should be accommodated in mitigation designs rather than feared. Natural ecosystems generally recover rapidly from natural disturbances to which they are adapted. The design should aim to restore a series of natural processes at the mitigation sites to ensure that resilience will have been achieved.

Watershed management requires thinking in terms of multiple spatial scales: the specific wetland or stream itself, the watershed that influences the wetland/stream, and the greater landscape. The landscape in which a wetland or water exists, defines its hydrogeologic setting. The hydrogeologic setting in turn controls surface and sub-surface flows of water, while a variety of hydrogeologic settings results in biological and functional diversity of aquatic resources.

There are three aspects of watershed management that the applicant must address in a mitigation plan: hydrogeomorphic considerations, the ecological landscape, and climate. It should be noted that the overall goal of compensatory mitigation is to replace the functions being lost (functional equivalency) due to a permitted Section 404 activity. By evaluating the hydrogeomorphic setting, ecological landscape and climate, one can determine which attributes can be manipulated (i.e. hydrology, topography, soil, vegetation or fauna) to restore, create or enhance viable aquatic functions.

Hydrogeomorphic considerations refers to the source of water and the geomorphic setting of the area. For example, a riverine wetland receives water from upstream sources in a linear manner, whereas vernal pools exist as relatively closed depressions underlain by an impermeable layer that allows rainfall runoff from a small watershed to fill the pool during specific times of year. Applicants should strive to replicate the hydrogeomorphic regime of the impacted water to increase the potential that the mitigation site mimics the functions lost. Only as a last resort, should applicants prepare plans for constructing wetlands using artificial water sources or placing wetlands into non-appropriate areas of the landscape. In such cases, there should be a contingency plan to prepare for unanticipated events or failures.

Ecological landscape describes the location and setting of the wetland/water in the surrounding landscape. For example, attempting to place mitigation in a dissimilar ecological complex than that of the impacted water is expected to result in a wetland/water unlikely to replicate the functions of the wetland/water that was lost. In all cases, the applicant should evaluate the historical ecological landscape of the mitigation site; for example, if there had been large areas of forested wetland in an agricultural area, then replacement of a forested wetland may be appropriate given other factors that should be considered. In most cases, applicants should plan for a mitigation area that fits best within the ecological landscape of the watershed or region of the mitigation site. Applicants should also consider constructing mitigation sites with more than one type of wetland/water regime, if appropriate, to provide for landscape diversity.

Climate also affects mitigation and is clearly beyond the control of the applicant. Therefore, the mitigation site should be sited in an area supported by the normal rainfall, subsurface and/or groundwater in the region. Climate considerations also can impact other hydrologic issues, sediment transport factors and other factors affecting attainment of desired functions. While climate cannot be manipulated, applicants need to account for it in mitigation plans, including local and regional variability and extremes.

B. 2. Adopt a dynamic landscape perspective

Consider both current and future watershed hydrology and wetland location. Take into account surrounding land use and future plans for the land. Select sites that are, and will continue to be, resistant to disturbance from the surrounding landscape, such as preserving large buffers and connectivity to other wetlands. Build on existing wetland and upland systems. If possible, locate the mitigation site to take advantage of refuges, buffers, green spaces, and other preserved elements of the landscape. Design a system that utilizes natural processes and energies, such as the potential energy of streams as natural subsidies to the system. Flooding rivers and tides transport great quantities of water, nutrients, and organic matter in relatively short time periods, subsidizing the wetlands open to these flows as well as the adjacent rivers, lakes, and estuaries.

Applicants should consider both current and expected future hydrology (including effects of any proposed manipulations), sediment transport, locations of water resources, and overall watershed functional goals before choosing a mitigation site. This is extremely critical in watersheds that are rapidly urbanizing; changing infiltration rates can modify runoff profiles substantially, with associated changes in sediment transport, flooding frequency, and water quality. More importantly, this factor encourages applicants to plan for long-term survival by placing mitigation in areas that will remain as open space and not be severely impacted by clearly predictable development. Consideration of the landscape perspective requires evaluation of buffers and connectivity (both hydrologic- and habitat-related). Buffers are particularly important to insure that changing conditions are ameliorated, especially in watersheds that have been, or are in the process of being, heavily developed. In addition, because wetlands are so dynamic, adequate buffers and open space upland areas are vital to allowing for wetlands to "breath" (expand and/or decrease in size and function) and migrate within the landscape, particularly in watersheds under natural and/or man-made pressures.

B.3. Pay attention to subsurface conditions, including soil and sediment geochemistry and physics, groundwater quantity and quality, and infaunal communities.

> *Inspect and characterize the soils in some detail to determine their permeability, texture, and stratigraphy. Highly permeable soils are not likely to support a wetland unless water inflow rates or water tables are high. Characterize the general chemical structure and variability of soils, surface water, groundwater, and tides. Even if the wetland is being created or restored primarily for wildlife enhancement, chemicals in the soil and water may be significant, either for wetland productivity or bioaccumulation of toxic materials. At a minimum, these should include chemical attributes that control critical geochemical or biological processes, such as pH, redox, nutrients (nitrogen and phosphorus species), organic content and suspended matter.*

Knowledge of the physical and chemical properties of the soil and water at the mitigation site is also critical to choice of location. For example, to mitigate for a saline wetland, without knowing the properties of the soil and water sources at the mitigation site, it is unlikely that such a wetland is restorable or creatable. Certain plants are capable of tolerating some chemicals and actually thrive in those environments, while others plants have low tolerances and quickly diminish when subjected to water containing certain chemicals, promoting monotypic plant communities. Planning for outside influences that may negatively affect the mitigation project can make a big difference as to the success of the mitigation efforts and meeting watershed objectives.

B.4 Pay particular attention to appropriate planting elevation, depth, soil type, and seasonal timing

> *When the introduction of species is necessary, select appropriate genotypes. Genetic differences within species can affect wetland restoration outcomes, as found by Seliskar (1995), who planted cordgrass (Spartina alterniflora) from Georgia, Delaware, and Massachusetts into a tidal wetland restoration site in Delaware. Different genotypes displayed differences in stem density, stem height, belowground biomass, rooting depth, decomposition rate, and carbohydrate allocation. Beneath the plantings, there were differences in edaphic chlorophyll and invertebrates.*

> *Many sites are deemed compliant once the vegetation community becomes established. If a site is still being irrigated or recently stopped being irrigated, the vegetation might not survive. In other cases, plants that are dependent on surface-water input might not have developed deep root systems. When the surface-water input is stopped, the plants decline and eventually die, leaving the mitigation site in poor condition after the Corps has certified the project as compliant.*

A successful mitigation plan needs to consider soil type and source, base elevation and water depth, plant adaptability and tolerances, and the timing of water input. When possible: a) use local plant stock already genetically adapted to the local environment; b) use stock known to be generally free from invasive or non-native species; c) use soil banks predetermined to have desirable seed sources; d) choose soil with desirable characteristics (e.g., high clay composition and low silt and sand composition for compaction purposes); e) determine final bottom elevations to insure that targeted water regimes are met and the planned plant community can tolerate the water depth, frequency of inundation and quality of water sources.

It is particularly helpful to examine reference wetlands and/or waters near the mitigation area, in order to identify typical characteristics of sustainable waters in a particular watershed or region. This allows one to determine the likelihood of certain attributes developing in a proposed mitigation site. It should be emphasized that wetland restoration is much more likely to achieve desired results than wetland creation, as evidence of a previously existing wetland or other aquatic resource is a strong indicator of what will return, given the proper circumstances Historical data for a particular site, if available, can also help establish management goals and monitoring objectives. Creating wetlands from uplands has proven to be difficult and often requires extensive maintenance.

B.5. Provide appropriately heterogeneous topography

> *The need to promote specific hydroperiods to support specific wetland plants and animals means that appropriate elevations and topographic variations must be present in restoration and creation sites. Slight differences in topography (e.g., micro- and meso-scale variations and presence and absence of drainage connections) can alter the timing, frequency, amplitude, and duration of inundation. In the case of some less-studied, restored wetland types, there is little scientific or technical information on natural microtopography (e.g., what causes strings and flarks in patterned fens or how hummocks in fens control local nutrient dynamics and species assemblages and subsurface hydrology are poorly known). In all cases, but especially those with minimal scientific and technical background, the proposed development wetland or appropriate example(s) of the target wetland type should provide a model template for incorporating microtopography.*
>
> *Plan for elevations that are appropriate to plant and animal communities that are reflected in adjacent or close-by natural systems. In tidal systems, be aware of local variations in tidal flooding regime (e.g., due to freshwater flow and local controls on circulation) that might affect flooding duration and frequency.*

While manipulations of natural water supply may not be possible or desirable, changes in topography are possible and should be incorporated in the design of a restored or created wetland/water when needed. Varying the depths of the substrate of the mitigation area ensures a heterogeneous topography, decreasing the likelihood of homogenous plant communities. Rather than plan on one water level or one elevation of the substrate, in hopes of establishing a specific plant community, it is best to vary the depth of the bottom stratum. This will increase the likelihood of success for a more diverse targeted plant community and desired functions.

Appendix C - Agency Contacts

U.S. Army Corps of Engineers (Corps) - Seattle District

The Seattle District administers the Corps' Regulatory Program throughout the state of Washington except that the activities of Ports located on the Washington side of the Lower Columbia River are regulated by the Portland District.

Within the Corps, staff responsibility is generally divided up by county, but the county responsibilities sometimes shift. Staff are also assigned to special topics (e.g., endangered species, transportation projects, etc.). For information contact the headquarters or regional offices (see below). Also, check the following website for the most current list of staff: http://www.nws.usace.army.mil/ (Regulatory, "Contact Our Staff").

Seattle District Headquarters and Regional Contacts

Mailing address	Agency staff	Counties
Seattle District Headquarters Seattle District Corps of Engineers Regulatory Branch, CENWS-OD-RG ATTN: "person's name/file number" Post Office Box 3755 Seattle, Washington 98124-3755 Telephone: (206)764-3495 Fax: (206)764-6602 **Physical Address** Federal Center South 4735 E. Marginal Way South Seattle, Washington	Please contact the Seattle District Headquarters for current county staff assignments. There are also staff assigned to special topics (e.g., endangered species, mitigation banking, etc.). Check the regulatory web page for a list of special topics and associated staff assignments: http://www.nws.usace.army.mil/ (Regulatory, "Contact Our Staff")	Clallam, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Snohomish, Thurston, Whatcom
Eastern Washington Field Office U.S. Army Corps of Engineers Eastern Washington Field Office Post Office Box 273 Chattaroy, Washington 99003-0273	Tim Erkel tim.r.erkel@nws02.usace.army.mil (509)238-4570 Fax: (509)238-4561	Adams, Asotin, Benton, Columbia, Ferry, Franklin, Garfield, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, and Whitman
Southwest Washington Field Office U.S. Army Corps of Engineers Southwest Washington Field Office 2108 Grand Boulevard Vancouver, WA 98661-4624 Fax: (360)750-9307	Ron Klump ron.klump@nws02.usace.army.mil (360)750-9046 Vacant (360)694-1171 Brad Murphy bradley.j.murphy@nws02.usace.army.mil (360)906-7274	Clark, Cowlitz, Klickitat, Pacific (enforcement only), Skamania, and Wahkiakum

Mailing address	Agency staff	Counties
Central Washington Field Office U.S. Army Corps of Engineers Central Washington Field Office Post Office Box 2829 Chelan, Washington 98816	Debbie Knaub deborah.j.knaub@nws02.usace.army.mil (509)682-7010 Fax: (509)682-7710	Chelan, Douglas, Grant, and Okanogan
Seattle District Corps of Engineers Regulatory Branch, CENWS-OD-RG ATTN: Jason Lehto Post Office Box 3755 Seattle, Washington 98124	Jason Lehto jason.a.lehto@nws02.usace.army.mil (206)764-3495 Fax: (206)764-6602	Kittitas and Yakima

U.S. Environmental Protection Agency (EPA) - Region 10

The EPA provides oversight of the Corps Regulatory Program and Clean Water Act Section 401 Water Quality Certifications for activities on *tribal lands* and in national parks. EPA Region 10 has a main office in Seattle, and small offices in Olympia WA; Portland, Eugene and La Grande OR; Boise, Prosser, and Pocatello ID; and Anchorage, Juneau, and Kenai AK. Within EPA, staff responsibility is generally divided up by county, but the county responsibilities sometimes shift. For information contact the Regional Office at:

U.S. EPA, Region 10
1200 Sixth Avenue
Seattle WA 98101
(206)553-1200 or 1-800-424-4EPA (toll free number)

The following table provides a list of staff that can answer questions regarding wetland mitigation proposals. For more general wetlands information you can contact the EPA Wetlands Helpline (see shaded box below).

EPA Region 10 Wetland Contacts

Agency staff	Contact information	Subject areas
Joan Cabreza	(206)553-7369 cabreza.joan@epa.gov	mitigation/restoration, mitigation banking, invasive species
Richard Clark	(206)553-6522 clark.richard@epa.gov	regulatory/permit processes, 401 certifications, enforcement
Krista Rave-Perkins	(206)553-6686 rave-perkins.krista@epa.gov	regulatory/permit processes, 401 certifications
Ralph Rogers	(206)553-4012 rogers.ralph@epa.gov	regional ecologist, mitigation/restoration, monitoring
Linda Storm	(206)553-6384 storm.linda@epa.gov	regulatory/permit processes, restoration, monitoring, cultural resources

EPA Wetlands Helpline

For more general wetlands information you can contact the EPA Wetlands Helpline. The helpline is a national resource and may be useful for obtaining national publications, federal registers, general wetland information, etc.

Who We Are

The EPA Wetlands Helpline is a contractor-operated information and referral service which handles requests for information on wetlands regulation, legislation and policy pursuant to Section 404 of the Clean Water Act, wetlands values and functions, and wetlands agricultural issues. The Helpline acts as a first point of contact for EPA's Wetlands Division, which is part of the Office of Wetlands, Oceans and Watersheds (OWOW). As of January 1, 2002, the Helpline has been co-located within the EPA's Water Resource Center allowing both Helpline and Resource Center customers access to the full spectrum of water-related public information available from EPA.

What We Do

The Helpline is staffed by librarians providing in-depth, EPA-approved information, documents, and referrals addressing Federal and State regulatory programs, wetlands science, and educational outreach. Librarians can respond to specialized research requests using the Helpline's extensive reference library, as well as other pertinent sources including the Internet. Librarians also maintain an extensive list of contacts at regulatory agencies and other organizations to provide the most appropriate and accurate referrals.

Our Documents

For more general wetlands information you can contact the EPA Wetlands Helpline, which is a contractor-operated information and referral service. The helpline is a national resource and may be useful for obtaining national publications, federal registers, general wetland information, etc. The Helpline acts as a first point of contact for EPA's Wetlands Division, which is part of the Office of Wetlands, Oceans and Watersheds (OWOW).

Contact Us

Hours: Monday through Friday, excluding Federal Holidays, 8:30am to 5:30pm Eastern Standard Time. Telephone: 1-800-832-7828

Fax: (202)566-1736.
Email: wetlands.helpline@epa.gov
Website: http://www.epa.gov/OWOW/wetlands/wetline.html
Helpline Publications List: http://www.epa.gov/owow/wetlands/wetpubs.html

Watershed Academy (web-based interactive courses)

The EPA Office of Water also maintains a series of web-based interactive courses called the Watershed Academy. The Academy provides dozens of on-line courses on everything from wetlands and watersheds to invasive species, and includes courses from other federal agencies as well. To see a catalogue of courses go to http://www.epa.gov/owow/watershed/waacademy/catolog.html.

Washington State Department of Ecology

Wetland staff at the Washington State Department of Ecology are located at the headquarters office in Lacey, Washington and in four regional offices: Central region (Yakima), Eastern region (Spokane), Northwest region (Bellevue), and Southwest region (Lacey). Regional staff responsibility is divided by county, but the county responsibilities sometimes shift. For information contact the headquarters or regional offices (see below). Also, check the following website for the most current list of staff: http://www.ecy.wa.gov/programs/sea/wetlandcontacts.htm.

Mailing address	Agency staff	County or Subject Area
Ecology Headquarters PO Box 47600 Olympia, WA 98504 Telephone: (360)407-6000 Fax: (360) 407-6902 **Physical Address** 300 Desmond Drive SE Lacey, WA 98503	Andy McMillan (360) 407-7272, anmc461@ecy.wa.gov	Wetland Science & Policy Manager
	Lauren Driscoll (360)407-7045, ldri461@ecy.wa.gov	Wetland mitigation policy and mitigation banking
	Christina Merten@NWRO (425)649-7007, chme461@ecy.wa.gov	Wetland mitigation banking
	Dana L. Mock (360)407-6947, dmoc461@ecy.wa.gov	Various wetland projects, including mitigation guidance updates
	Donna Bunten (360)407-7172, dbun461@ecy.wa.gov	Critical area ordinance review coordinator and other projects
	Jeanne Koenings (360)407-7258, jkoe461@ecy.wa.gov	Wetland stewardship
	Patricia Johnson 360)407-6140, pjoh461@ecy.wa.gov	Forested wetland projects (WETSAG) and other projects
	Susan Grigsby (360)407-7546, sgri461@ecy.wa.gov	Landscape planning and geographic information systems (GIS)
	Stephen Stanley @NWRO (425)649-4210, ssta461@ecy.wa.gov	Restoration and landscape planning
	Teri Granger (360)407-6857, tgra461@ecy.wa.gov	Various wetland grant projects, including best available science
	Tom Hruby (360)407-7274, thru461@ecy.wa.gov	Senior Ecologist

Central regional office 15 West Yakima Avenue, Suite 200 Yakima, WA 98902-3401 Fax: (509)575-2809 	Cathy Reed (509) 575-2616, craj461@ecy.wa.gov	Benton, Kittitas, Klickitat and Yakima counties
	Gary Graff (509) 454-4260, gagr461@ecy.wa.gov	Chelan, Douglas and Okanogan counties
Eastern regional office N. 4601 Monroe Spokane, WA 99205-1295 	Chris Merker (509) 329-3528, Fax: (509)329-3529 cmer461@ecy.wa.gov	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, and Whitman counties
Northwest regional office Mail Stop NB-81 3190 – 160th Avenue SE Bellevue, WA 98008-5452 Fax: (206)649-7098 	Erik Stockdale (425)649-7061, esto461@ecy.wa.gov	Watershed planning and technical assistance
	Kim Harper (425)649-7004, khar461@ecy.wa.gov	Transportation projects, Multi-agency Permitting Team (MAPT)
	Laura Casey (425)649-7148, cala461@ecy.wa.gov	San Juan, Skagit, and Snohomish counties
	Richard Robohm (425) 649-4447, riro461@ecy.wa.gov	King and Kitsap counties
	Susan Meyer (425) 649-7168, sume461@ecy.wa.gov	Whatcom and Island counties
Southwest regional office P.O. Box 47775 Olympia, WA 98504-7775 Fax: (360)407-6305 	Gretchen Lux (360) 407-6221, glux461@ecy.wa.gov	Clallam, Jefferson, and Mason counties
	Mark Cline (360) 407-7273, mcli461@ecy.wa.gov	Wahkiakum, Skamania, Lewis, Clark, and Cowlitz counties
	Perry Lund (360) 407-7260, plun461@ecy.wa.gov	Unit Supervisor, Grays Harbor and Pacific counties
	Karen Rogers (360)407-6294, krog461@ecy.wa.gov	Pierce and Thurston counties

Office of Regulatory Assistance (ORA) - Help with Environmental Permitting

ORA staff provide information regarding environmental permits issued by the State departments of Ecology, Fish and Wildlife, Health, and Natural Resources, and the local air authorities. Regional staff are available to coordinate permit applications for large, complex projects, and to work with applicants, agencies and regulatory authorities to develop a plan for meeting environmental and land-use requirements.

The Office is located in the Ecology Building at 300 Desmond Dr. SE, Lacey, WA. Staff are available Monday through Friday from 9 a.m. to 4 p.m. Although you can drop in anytime during those hours, it is recommended that you make an appointment. You can call the Office at 360-407-7037 or 800-917-0043, or e-mail them at ecypac@ecy.wa.gov or go to the website at http://www.ecy.wa.gov/programs/sea/pac/.

Local Governments

Most local governments (cites and counties) maintain web sites with current contact information. The Municipal Research & Services Center of Washington maintains a current list of local government web sites (for cities and towns go to http://www.mrsc.org/byndmrsc/cities.aspx and for counties go to http://www.mrsc.org/byndmrsc/counties.aspx). This information is also accessible on the Access Washington web site, which provides Washington State Government information and services http://access.wa.gov/). You can call the Municipal Research & Services Center of Washington to get the phone number for your local government planner at (206) 625-1300.

The state Department of Community, Trade and Economic Development's (CTED) Local Government Division provides technical assistance to local governments, including growth management services. Go to http://www.cted.wa.gov/growth/ or call (360) 725-3000 for general information and to get connected with the appropriate planner who can answer specific questions.

Appendix D - Hiring a Qualified Wetland Professional

This appendix contains recommendations to help locate and select a professional who is qualified to assist with wetland issues. Wetland professionals are usually hired to identify and delineate wetlands, rate them, assess functions and values, and provide assistance with wetland regulations and permits. They often complete the necessary application forms and studies needed to meet regulations. They also provide advice about designing and implementing compensatory mitigation projects that are needed to replace wetlands if they will be lost or degraded.

Wetland professionals are generally hired by landowners or developers who want to do something on their property that may affect a wetland. In addition, many local governments hire professionals to provide review as a third party. Some professionals are self-employed; others work for larger environmental or engineering consulting firms.

What is a Qualified Wetland Professional?

There is no government sanctioned program for certifying someone as a “qualified wetland professional” or “qualified wetland specialist.” Generally, the term means a person with professional experience and comprehensive training in wetland issues, including experience performing wetland delineations, assessing wetland functions and values, analyzing wetland impacts, and recommending and designing wetland mitigation projects.

The Society of Wetland Scientists administers a professional certification program for wetland scientists that has two levels of certification: Professional Wetland Scientist (PWS) and Wetland Professional In-Training (WPIT). A person certified as a PWS would be considered a qualified wetland scientist. This program is discussed further in the shaded box at the end of this appendix.

If the person is not a certified PWS, there is no simple means of determining if they are adequately qualified to undertake the tasks listed above. However, the following criteria are indicators of someone who may be qualified to perform the wide range of tasks typically required of a wetland professional:

- At a minimum, a Bachelor of Science or Bachelor of Arts or equivalent degree in hydrology, soil science, botany, ecology, resource management, or related field. A graduate degree in one of these fields is usually an indication of more advanced expertise.
- At least two years of full-time work experience as a wetland professional; including delineating wetlands using the state or federal manuals, preparing wetland reports, conducting function assessments, and developing and implementing mitigation plans. Generally, the more years of experience, the greater the expertise.
- Completion of additional wetland-specific training programs. This could include a more comprehensive program such as the University of Washington Wetland Science and Management Certificate Program or individual workshops on wetland delineation, function assessment, mitigation design, hydrophytic plant or hydric soil identification, etc.

Keep in mind that most people engaged in professional wetland work have greater expertise in some aspects of the field than others. A person may have in-depth training in plant ecology or soils or hydrology, but few people have all three. A person may have extensive experience in wetland delineation or function assessment and have little experience in designing and implementing mitigation projects. Thus, it is important to be clear what specific tasks need to be completed and make sure the person or firm being hired has the specific expertise needed. Generally, more complex projects require multiple individuals that provide collective expertise to address all aspects of the project.

How to Find a Qualified Wetland Professional

There are a number of ways to find the names of wetland professionals. Finding a qualified one, however, can be difficult since this group of professionals is not required to be certified, licensed, or bonded in the State of Washington. One approach is to look in the Yellow Pages under *Environmental and Ecological Services*. You can also contact the local government planning office and ask for a list of professionals that work in its jurisdiction. Some local governments maintain lists of wetland professionals they consider to be well qualified.

Wetland professionals may also be found by requesting the advice of associations or businesses that commonly encounter wetlands in their work, such as the Building Industry Association and Association of Washington Business. Finally, state and federal resource agencies can be asked for referrals. Be aware, however, that most agencies will not be able to provide recommendations because of questions of fairness.

Finally, the Society of Wetland Scientists maintains a searchable database of “professional wetland scientists.” See the shaded box at the end of this appendix.

How to Select a Qualified Wetland Professional

A number of factors should be considered before hiring a wetlands professional. When interviewing professionals, their qualifications should be carefully considered (see above for the minimum recommended). Be sure to ask the following questions before making a selection:

- Does the professional have training or experience in the use of the 1987 federal or 1997 Washington State wetland delineation manuals? The selected professional should have the ability to apply the methods for identifying wetlands used by state and federal agencies. Make sure that the professional can identify wetlands and their boundaries consistent with regulating agencies.
- Has the professional had additional training or expertise in related fields such as hydrology, soil science, botany, or ecology?
- Is the professional familiar with local, state, and federal wetland regulations?
- How long has the professional been doing wetlands work? How much experience do they have delineating wetlands in the field, assessing wetlands functions and values, or working with wetland regulations? Has the person worked in the part of the state where you propose to develop? Ask the professional for examples of previous

work similar to the services being requested. Can the professional take you to a successful wetland mitigation project they designed and/or implemented?

- Does the professional have experience working with regulatory agencies? Ask the professional to describe their working relationship with the agencies that will be reviewing and/or permitting your project.
- Does the professional have experience working on a team? Given the complexity of some projects, it is expected that a wetland professional will team up with others who have experience in related fields such as water quality, wildlife, stormwater management, and hydrogeology. Ask the professional for a list of people with whom they have worked on a team in the past.
- Who were some of the professional's past clients? Request referrals and ask clients if they were satisfied with the professional's work. Ask whether there were any problems that occurred during or after the project, how the professional handled those problems, and what they charged for their work. Find out what type of track record the company has with local, state, and federal agencies. Be sure to ask for references that include clients who have had projects reviewed and approved by the regulatory agencies (Corps, Ecology, and local government).
- Talk with colleagues and other businesses, such as real estate, land development, homebuilding, etc. that are routinely involved in wetland concerns. Ask them about their experiences and knowledge regarding the professional being considered.
- If you are considering a consulting firm, find out exactly who will be working on your project. Will it be the principal professional with the years of experience, or someone with less experience who works for them?
- Get an estimate of how much the professional will charge. Compare rates but do not let cost be the sole criterion. Be sure to consider training, experience, and the other factors as well. A good professional who charges more may end up saving money by reducing permit processing delays.

Society of Wetland Scientists Professional Certification Program

The Society of Wetland Scientists keeps a list of those who have qualified for their professional certification program for wetland scientists. The certification program website http://www.wetlandcert.org allows you to search by name, city, and/or state. As explained in the Professional Wetland Scientist program overview:

> *Certification is not required by any agency and has no official or legal standing. However, certification signifies that the academic and work experience of a Professional Wetland Scientist (PWS) meets the standards expected by his or her peers of a practicing wetland professional and provides acknowledgment to his or her peers of adherence to standards of professional ethics with regard to the conduct and practice of wetland science.*
>
> *Wetland Professional in Training (WPIT) is considered a preliminary step for persons who meet the requirements for either (but not both) education and experience. Professional Wetland Scientist (PWS) certification is awarded for those meeting both educational and experience requirements.*
>
> *Minimum degree requirements for WPIT and PWS are the BA or BS degrees, with course distribution of 15 semester hours each in biological and physical sciences and 6 hours in quantitative areas. For certification as a PWS, an additional 15 semester hours in wetland-related courses are required. In addition to comprehensive training in wetland science, a PWS is expected to have professional experience of at least 5 years as a wetland scientist, demonstrating the application of current technical knowledge dealing with wetland resources and activities.*

Appendix E - Laws, Rules, Policies, and Guidance

This appendix provides a brief summary of each of the laws, rules, policies, and guidance most pertinent to wetlands and mitigation for impacts to wetlands. Table E-1 on the following page summarizes laws/permits commonly applicable to activities in or near wetlands. Those laws and additional laws, rules, policies, and guidance are then described in further detail. This appendix is not meant to be a comprehensive list. In order to determine if any laws, rules, policies, or guidance apply to a particular situation, contact the agencies (see Appendix C, *Agency Contacts*).

On-line access to laws and rules

The following web pages can be used to access many of the laws and rules described in this appendix. To find the Rivers and Harbors Act of 1899 (33 USC § 403), for example, you would go to either of the web pages listed below for the USC and search by Title (33 in this example) and Section (403 in this example).

United States Code (USC) – Legal Information Institute
http://www4.law.cornell.edu/uscode.

United States Code (USC) – Office of the Law Revision Counsel
http://uscode.house.gov/lawrevisioncounsel.shtml.

Code of Federal Regulations (CFR) http://www.gpoaccess.gov/cfr/index.html.

Federal Register (FR) http://www.gpoaccess.gov/fr/.

Revised Code of Washington (RCW) http://www.leg.wa.gov/rcw/index.cfm..

The Library of Congress, THOMAS, Legislative Information on the Internet. Find recent amendments to laws by searching this web site. http://thomas.loc.gov/.

Washington Administrative Codes (WAC's) http://www.leg.wa.gov/wac/.

Table E-1. Laws/permits commonly applicable to activities in or near wetlands

Law	Implementation	Jurisdiction	Application to Wetlands	Implementing Agency
Federal Laws/Permits				
Clean Water Act Section 404	Permit required for discharge of *dredged* or fill material into waters of the United States, including wetlands	*Waters of the United States[36]*	Includes all wetlands (with some exceptions)	*United States Army Corps of Engineers/ Environmental Protection Agency*
Clean Water Act Section 401	Certification that the proposed project will meet state water quality standards is a condition of federal permits approval	Federal permits affecting waters of the U.S., including wetlands	Includes all wetlands that may be affected by a federally permitted activity	*Washington Department of Ecology/ EPA on Tribal lands and National Parks*
Rivers and Harbors Act of 1899 Section 10	Permit required for structures and/or work in or affecting navigable waters of the United States	Navigable waters to the mean high water mark of tidal waters and the ordinary high water mark (OHWM) of non-tidal waters	Wetlands within the limits of navigable waters	*United States Army Corps of Engineers*
National Environment al Policy Act (NEPA)	Federal analysis and decision-making procedures that require full disclosure of potential impacts associated with proposed actions	All federal actions[37] not specifically exempted	All wetlands	*Varies (usually the federal agency issuing the permit)*
Federal Coastal Zone Management Act	A notice of consistency with the state coastal zone management plan is a condition of federal activities, federal license and permit approval, and federal support of local activities	Applies to Washington's 15 coastal counties[38]	Wetlands within the 15 coastal counties of Washington	*Washington Department of Ecology*

36 The Corps of Engineers, not applicants or their consultants, has authority to determine whether or not a wetland is a water of the U.S. and thus regulated under the federal Clean Water Act (CWA). If the Corps determines that a wetland is not subject to regulation under the CWA, applicants should be aware that these wetlands are still subject to regulation by Ecology under the State's Water Pollution Control Act as well as by local jurisdictions.

37 "Actions" includes permits, authorizations, and projects with federal funding.

38 Washington's 15 coastal counties are: Clallam, Grays Harbor, Island, Jefferson, King, Kitsap, Mason, Pacific, Pierce, San Juan, Skagit, Snohomish, Thurston, Wahkiakum, and Whatcom.

State Laws/Permits				
Law	**Implementation**	**Jurisdiction**	**Application to Wetlands**	**Implementing Agency**
State Water Pollution Control Act	Permits, orders, certifications or compliance with water quality standards	Any pollution of waters of the state	All waters of the state including wetlands	*Washington Department of Ecology*
State Growth Management Act	Consistency with local comprehensive plans and development regulations. Various permits may be required.	All cities and counties in Washington State	Requires protection of all wetlands designated as critical areas	*Local government/ Washington Department of Community Trade & Economic Development*
State Shoreline Management Act	Permits required to ensure that proposed activity complies with local shoreline master plan and the Shoreline Management Act	Shorelines of the state including streams with flows greater than 20 cfs or lakes 20 acres or larger and landward area within 200 feet from OHWM or floodway; associated wetlands, river deltas and certain floodplains	Includes all land within 200 feet of the OHWM of a state shoreline. Jurisdiction may be extended to include the entirety of an associated wetland and/or floodplains	*Local government/ Washington Department of Ecology*
State Hydraulic Code	Permit (Hydraulic Project Approval) required for all work	Activities affecting waters of the state	All wetlands within OHWM of fresh or estuarine waters and those wetlands above OHWM[39] whose alteration could affect the bed or flow.	*Washington Department of Fish & Wildlife*
Forest Practices Act	Permit required for tree harvest	State-owned and private timberlands	Restricts harvest activities in and around wetlands	*Washington Department of Natural Resources*
Aquatic Lands Act	Authorization required for use of state-owned aquatic lands for a variety of activities	State-owned aquatic lands	Wetland impacts or compensation projects proposed on, or affecting, state-owned aquatic lands	*Washington Department of Natural Resources*
Local Laws/Permits				
Local Laws	Consistency with local comprehensive plans, zoning, ordinances, shoreline master programs. Various permits may be required	As defined by local plans, ordinances, and regulations	May identify specific wetlands and performance standards	Local government

39 Note: In marine waters, the OHWM is most often a higher elevation than Mean Higher High Water (MHHW) which is the average of the higher daily high tide. Clean Water Act jurisdiction is limited at MHHW but critical fish habitat for surf smelt spawning and some herring spawning occurs above MHHW to the OHWM.

Federal Laws and Rules

Rivers and Harbors Act of 1899 (33 USC § 403)

Section 10 of the Rivers and Harbors Act requires the Department of the Army authorization for structures and/or work in or affecting navigable waters of the United States. Section 10 regulates structures and work outside of navigable waters of the United States that would affect the course, location, or condition of a waterbody in such a manner as to impact its navigable capacity. Discharging dredged or fill material into navigable waters of the United States, including wetlands, may require authorization under both Section 10 and Section 404 of the CWA.

National Environmental Policy Act of 1969 (42 USC § 4321 et seq.)

The National Environmental Policy Act (NEPA) is the national charter for protecting and enhancing the quality of the nation's environment. NEPA directs the federal government to assess the likely impact of its proposed actions on the environment. Under NEPA, the Corps, before issuing and individual Section 404 permit must conduct an alternatives analysis and document that no reasonable alternative to the proposed action exists and that sufficient efforts have been made to minimize damage to wetlands and other aquatic resources[40].

The federal agencies are responsible for ensuring compliance with the following federal laws and rules which are described below:

- Fish and Wildlife Coordination Act.
- Coastal Zone Management Act.
- Endangered Species Act.
- Magnuson-Stevens Act and the National Historic Preservation Act.

The agencies will coordinate with applicants and/or their consultants to ensure that compliance with these laws and rules occurs.

Clean Water Act (33 USC § 1251 et seq.)

The Clean Water Act (CWA), formerly known as the Federal Water Pollution Control Act. The primary goal of the Clean Water Act (CWA) is to "restore the chemical, physical, and biological integrity of the Nation's waters." Two sections (404 and 401) of the CWA as they relate to wetlands and mitigation are described below.

40 Under the Corps' §404 Nationwide Permit (NWP) Program, this alternatives analysis has already been completed so applicants for nationwide permits are not required to conduct a project-specific alternatives analysis. They are, however, still required to avoid and minimize impacts. More information on the NWP Program can be found via the Corps' Regulatory Program web page ("Permit and Applicant Information").

Section 404. Under Section (§) 404 of the CWA, the Secretary of the Army, acting through the U.S. Army Corps of Engineers (Corps), regulates the discharge of *dredged or fill material into waters of the United States*, including wetlands, through a permit program. The Corps' Regulatory Program is the primary federal tool for protecting wetlands and other aquatic resources of the United States. Anyone proposing to discharge dredged or fill material into waters of the United States must first obtain authorization from the Corps.

The Corps has the responsibility and authority (33 CFR 320-331) to require permit applicants to implement all appropriate and practicable measures to minimize the adverse impacts of their activities on wetlands, ensure that those activities are not contrary to the public interest, and satisfy legal requirements such as the §404(b)(1) guidelines (see 404(b)(1) guidelines and the National Environmental Policy Act).

The Environmental Protection Agency (EPA) is also responsible for implementing and enforcing §404 (40 CFR Part 230). The EPA oversees the Corps Regulatory Program and is responsible for application of the 404(b)(1) guidelines for CWA permits.

Section 401. Under §401 of the CWA, activities involving a discharge of dredged or fill material to navigable waters authorized by a federal permit or license, such as a §404 permit, must receive certification from the state that the activity complies with the water quality standards of that state and any established effluent limitations (such as those under a water clean up plan[41]). The §401 certification signifies that the state has reasonable assurance that the project as proposed and conditioned will comply with applicable water quality standards and other appropriate requirements of state law.

Ecology is the state agency responsible for §401 water quality certifications (401 certification) in Washington (see State Water Pollution Control Act). A 401 certification must be obtained from Ecology before the federal permit can be issued. The EPA is responsible for issuing 401 certifications on most[42] *Tribal lands* (land within the boundaries of an Indian Reservation) and within all national parks where the state has not been given jurisdiction for water quality certification. In Washington, national parks where the state does not have 401 jurisdiction include Olympic, Mount Rainier and North Cascades National Parks.

41 Water clean up plans or TMDLs (Total Maximum Daily Load plans) are developed for waters which are impaired (i.e. not meeting water quality standards) due to various pollutants. These water clean up plans may set limits on the amount of specific pollutants that can be discharged into a water body. The limits are referred to as "effluent limitations".

42 Some tribes have been given exclusive jurisdiction for activities occurring on their lands (they have their own water quality standards that have been approved by EPA and therefore they can write their own 401 certifications). Check with the EPA for a current list of approved tribes.

Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 USC § 661 et seq.)

The Fish and Wildlife Coordination Act, authorizes the Secretary of the Interior, through the U.S. Fish and Wildlife Service (USFWS), to assist and cooperate with federal, state, and public or private agencies and organizations in the conservation and rehabilitation of wildlife whenever the waters of a stream or other waterbody would be impounded, diverted, deepened, or otherwise controlled or modified. The act requires proponents to also consult with the state wildlife resources agency and, when appropriate, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS). This coordination helps to conserve our wildlife resources by preventing or reducing the loss of those resources and, whenever possible, improving those resources.

Coastal Zone Management Act (16 USC §1451 et seq.)

The Coastal Zone Management Act (CZMA) requires states to review all federal projects, permits, and licenses that may affect any land or water use or natural resources of the coastal zone for consistency with the state's coastal management program. In Washington, CZM review applies to Washington's 15 coastal counties[43], and Ecology is the state agency responsible for this review. Activities and development affecting coastal resources which involve federal activities, federal licenses or permits, and federal assistance programs (funding) require a written CZM decision by Ecology. A CZM notice of consistency determination must be submitted stating whether the project is consistent with Washington's Coastal Zone Management Program (WCZMP).

For projects located within the 15 coastal counties, the project must comply with the enforceable policies within the following six laws: 1) Shoreline Management Act (SMA), 2) State Environmental Policy Act (SEPA), 3) Clean Water Act (CWA), 4) Clean Air Act, 5) Energy Facility Site Evaluation Council (EFSEC), and 6) Ocean Resource Management Act (ORMA). Ecology must issue a CZM consistency determination for projects if they have complied with the enforceable policies. For more information on coastal zone management in Washington go to http://www.ecy.wa.gov/programs/sea/czm/index.html.

Endangered Species Act (16 USC 1531 et seq.)

The Endangered Species Act (ESA) establishes a federal program to conserve the ecosystems upon which endangered and threatened species depend. It also establishes a policy that federal agencies and departments seek to conserve endangered and threatened species. Section 7 of the ESA requires federal departments and agencies to consult with NMFS and/or the USFWS to ensure that the actions they authorize, fund, or carry out do not jeopardize the continued existence of an endangered or threatened species or result in the destruction or adverse modification of designated critical habitat for those species. Federal agencies are responsible for ensuring compliance with the requirements of Section 7 of the ESA. Section 9 of the ESA, prohibits all individuals, governments, and other entities from "taking" listed species of fish and wildlife except as exempted under Section 10 of the ESA (see Section 7.3, *Compensatory Mitigation and the Endangered Species Act)*.

43 Washington's 15 coastal counties include, Clallam, Grays Harbor, Island, Jefferson, King, Kitsap, Mason, Pacific, Pierce, San Juan, Skagit, Snohomish, Thurston, Wahkiakum, and Whatcom.

Magnuson-Stevens Act (16 USC § 1801 et seq.)

The Magnuson-Stevens Act (MSA) is the federal law that governs marine fisheries management in the United States. Among its provisions, the MSA mandates the identification of essential fish habitat (EFH) for federally managed species as well as the development of measures to conserve and enhance the habitat necessary for fish to carry out their life cycles. The MSA requires federal agencies to consult with NMFS before they authorize, fund or conduct an activity that may adversely affect EFH. When consulted, NMFS provides guidance, in the form of conservation recommendations, to help federal agencies minimize the impact of their actions on EFH.

National Historic Preservation Act of 1966 (16 USC 470 et seq.)

Section 106 (16 USC § 470f) of the National Historic Preservation Act of 1966 (NHPA) requires federal agencies, including the Corps to make a determination on how a project may affect recorded or undiscovered *cultural resources* and/or *historic properties* within the permit area. Section 106 of the NHPA states, in part, a Federal agency "having direct or indirect jurisdiction" over a proposed *federal undertaking* shall, prior to approval of the undertaking, take into account the effect of the undertaking on any historic property "in or eligible for inclusion in the National Register of Historic Places." A cultural resource/historic property survey, conducted by a professional archaeologist, may be required for the specific project impact area and compensation areas. The federal agencies involved in the project make the determination on whether a survey needs to be done[44]. Based on the results of the survey, the applicable federal agency will take the lead on conducting the appropriate Section 106 consultation with the *State Historic Preservation Officers or Tribal Historic Preservation Officers*. Applicants should be aware that Section 106 coordination and/or consultation may add substantial time to the application and mitigation review process.

Federal Policies and Guidance

Executive Order 11990, Protection of Wetlands (May 24, 1977)

Executive Order(EO) 11990 requires federal agencies to "avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative." In carrying out these directives, federal agencies must avoid undertaking or providing assistance for new construction located in wetlands unless there is no practicable alternative to such construction and the proposed action includes all practicable measures to minimize harm to wetlands, taking into account factors relevant to the proposal's effect on the survival and quality of wetlands. These factors include: 1) public health, safety, and welfare, including water supply, quality, recharge and discharge; pollution; flood and storm hazards; and sediment and erosion; 2) maintenance of natural systems, including conservation and long term productivity of existing flora and fauna,

44 One criterion for determining if a survey needs to be done is whether the project location is listed on the National Register of Historic Places or the project has raised concerns with the local Native American Tribes with knowledge of the area.

species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and food and fiber resources; and 3) other uses of wetlands in the public interest, including recreational, scientific, and cultural uses. EO 11990 can be found at http://www.ecy.wa.gov/programs/sea/czm/index.html.

Executive Order 11988, Protection of Floodplains (May 24, 1977)

Since wetlands can often be found in floodplains and losses of those wetlands can adversely affect the functions of the floodplain, some projects may need to be evaluated in the context of floodplain management.

Executive Order 11988 requires federal agencies to "avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains" and "avoid direct or indirect support of floodplain development wherever there is a practicable alternative." In carrying out these directives, the Corps must consider "alternatives to avoid adverse effects and incompatible development in the floodplains" during its permit application evaluation process. Those activities that the Corps finds could not practicably avoid impacting floodplains must be designed or modified as necessary to minimize their potential harm to the floodplain. EO 11988 can be found at http://www.epa.gov/owow/wetlands/regs/eo11988.html.

Guidelines for Specification of Disposal Sites for Dredged or Fill Material (also known as the 404 (b)(1) guidelines)[45] (45 FR 85336-85357, December 24th, 1980)

Prior to issuing a permit under §404 of the CWA, the Corps must determine that the proposed discharge of dredged or fill material into *waters of the United States* would not be contrary to the public interest and would comply with the *Guidelines for Specification of Disposal Sites for Dredged or Fill Material* (40 CFR Part 230), more popularly known as the 404(b)(1) guidelines. Mitigation sequencing (see Section 3.5.1) is an important consideration in both the 404(b)(1) guidelines and the public interest review process.

The 404(b)(1) guidelines, which provide criteria to be used by the Corps to evaluate a proposed discharge, generally prohibit the Corps from authorizing a discharge of dredged or fill material into waters of the United States if: 1) there is a practicable alternative to the proposed discharge that would have less environmental impact, 2) the discharge would violate any applicable state water quality standard or CWA toxic effluent standard or would jeopardize the continued existence of species listed as threatened or endangered under the ESA, 3) the discharge would cause or contribute to significant degradation of the waters of the United States, or 4) appropriate and practicable steps have not been taken to minimize adverse impacts of the discharge on the aquatic ecosystem.

45 The following two Memorandums to the Field, issued by the EPA and the Corps, provide guidance on the flexibility that the Corps should be utilizing when making determinations of compliance with the Section 404(b)(1) Guidelines, particularly with regard to the alternatives analysis: *Appropriate level of Analysis Required for Evaluating Compliance With the Section 404(b)(1) Guidelines Alternatives Requirements*, RGL 93-02, August 23, 1993 (); and, *Individual Permit Flexibility for Small Landowners*, RGL 95-01, March 6, 1995 (). RGLs can be found via the Seattle District Corps home page (Regulatory, Regulatory Permit Program, Regulations and Guidance).

Memorandum of Agreement Between the Environmental Protection Agency and Department of the Army Concerning the Determination of Mitigation Under the Clean Water Act Section 404(b)(1) Guidelines (February 6, 1990)

The Department of the Army and the EPA signed a memorandum of agreement (MOA) that provides guidance for determining the type and level of mitigation necessary to comply with the 404(b)(1) guidelines in the case of standard individual permit applications. The MOA describes mitigation as a sequential process of avoiding adverse impacts, taking appropriate and practicable steps to minimize adverse impacts, and providing appropriate and practicable compensation for adverse impacts that remain after all appropriate and practicable minimization has been required. The MOA also instituted a preference for on-site, in-kind mitigation and recognized that "no net loss" of wetland functions and values may not be achieved with every permit action. The MOA noted, without providing further guidance, that mitigation banking may be an acceptable form of compensatory mitigation under certain conditions. The MOA can be found at http://www.epa.gov/owow/wetlands/regs/mitigate.html..

Federal Guidance for the Establishment, Use and Operation of Mitigation Banks (60 FR 58605-58614, November 28, 1995)

This multi-agency guidance establishes federal policy on establishing, using, and operating mitigation banks to provide compensatory mitigation for adverse impacts to wetlands and other aquatic resources. This guidance is intended to assist federal agencies, bank sponsors, and others in meeting the requirements of Section 404 of the CWA and other federal statutes and regulations. The banking guidance establishes a process to evaluate mitigation bank proposals, criteria for using a mitigation bank, and requirements for long-term management, monitoring, and remediation of mitigation banks. In addition, this guidance discusses a number of important planning and policy issues, such as the role of preservation, the relationship between mitigation banks and in-lieu fee mitigation arrangements, the approval process, and considerations for bank site development and operation. The guidance can be found at http://www.epa.gov/owow/wetlands/guidance/mitbankn.html.

Memorandum of Agreement Between the Federal Aviation Administration, the U.S. Air Force, the U.S. Army, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the U.S. Department of Agriculture to Address Aircraft-Wildlife Strikes (and attached Advisory Circular on Hazardous Wildlife Attractants on or Near Airports (150/5200-33, May 1, 1997)

The listed agencies signed a memorandum of agreement (MOA) with the goal to more effectively address existing and future environmental conditions that contribute to aircraft-wildlife strikes. The signatory agencies agreed that one of the major activities of concern was the development of conservation/mitigation habitats or other land uses that could attract hazardous wildlife to airports or nearby areas. In addition, the Advisory Circular provides guidance on locating certain land uses that have the potential to attract hazardous wildlife. Wetlands are considered a land use that is incompatible with safe airport operations and the FAA recommends that wetland mitigation sites be located at least 10,000 feet (for airports serving turbine-powered aircraft) from aircraft movement areas. The Corps RGL 02-02 agrees and states that "Compensatory mitigation projects that have the potential to attract waterfowl and other bird species that might pose a threat to aircraft will be sited consistent with the Federal Aviation Administration Advisory Circular on Hazardous Wildlife Attractants on or near Airports." The MOA can be found at http://wildlife-mitigation.tc.faa.gov/public_html/moa.pdf.

Guidelines for Implementation of Compensatory Mitigation Requirements for Conversion of Wetlands to Cranberry Bogs (1998)

The Corps, Ecology, EPA, and USFWS published this special public notice, which is still in effect. The Corps and Ecology regulate the expansion of existing, and creation of new, cranberry operations in wetlands under §404 and §401, respectively, of the CWA. In 1992, the Corps created a special Nationwide Permit (NWP 34) for expansion of existing cranberry bogs of up to 10 acres; new operations must be processed under the Corps Individual Permit Process. The 1998 guidance was developed as a result of questions arising from agencies concerning the need for additional mitigation requirements in terms of avoidance, minimization, and compensation for unavoidable impacts to wetlands due to cranberry projects. Guidance concerning compensatory mitigation ratios, used to implement mitigation requirements, was identified as a need for cranberry expansion and new operations in Washington State. This guidance provides a table of compensation ratios for impacts/conversion of wetland to cranberry bog as well as the statement «Mitigation ratios would be doubled if an after-the fact Corps permit is issued for unauthorized work in waters of the U.S., including wetlands.» The ratios are, on average, lower than for other types of wetland impacts because it is acknowledged that cranberry bogs, in most circumstances, are wetlands themselves which may provide some important wetland functions. As with other types of projects, ratios are determined on a case-by-case basis using best professional judgment.

In addition to restoration (preferred), creation (very low priority), and enhancement (low priority), the cranberry guidance views the preservation of threatened, high-quality wetlands as a high priority for compensation for the conversion of bogs to cranberry production. The agencies allowed a more flexible approach to preservation because 1) cranberry bogs are still wetlands, although their habitat and water quality functions are lower; 2) mitigation opportunities in Pacific and Grays Harbor County are very limited; and 3) mature forested and scrub shrub wetlands are very much at risk in the cranberry producing counties. This policy is consistent with the February 6th, 1990 MOA. The guidelines can be found at http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/ACF101C.pdf.

Executive Order 13112, Invasive Species (February 3, 1999)

Executive Order 13112 requires each federal agency whose actions may affect the status of invasive species to take a number of proactive steps. These include: identifying such actions; using relevant programs and authorities to prevent invasive species introductions; detecting and responding rapidly to control populations of such species in a cost-effective and environmentally sound manner; monitoring invasive species populations accurately and reliably; providing for restoration of native species and habitat conditions in invaded ecosystems; conducting research on invasive species; developing technologies to prevent introduction and provide for environmentally sound control of invasive species; and promoting public education on invasive species. In addition, the Order instructs agencies not to authorize, fund, or carry out actions that it believes are likely to cause the introduction or spread of invasive species. In carrying out this Order, the Corps and other federal agencies must ensure that compensatory mitigation activities do not establish new populations of invasive species or facilitate the spread of existing populations. EO 13112 can be found at http://www.invasivespeciesinfo.gov/laws/execorder.shtml

Federal Guidance on the Use of In-Lieu-Fee Arrangements for Compensatory Mitigation Under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899 (65 FR 66914-66917, November 7, 2000)

This multi-agency (Corps, EPA, USFWS, and NMFS) guidance establishes federal policy on the use of in-lieu fee (ILF) arrangements for compensatory mitigation for adverse impacts to wetlands and other aquatic resources. The goal of the guidance is to clarify the manner in which in-lieu fee mitigation may be used to serve as an effective and useful approach for satisfying compensatory mitigation requirements and in helping to meet federal government's goal of no overall net loss of wetlands. This guidance continues a discussion started in the 1995 federal mitigation banking guidance (see above) by outlining the circumstances under which ILF mitigation can be used and remain consistent with existing federal regulations and policy. This guidance also establishes federal policy on planning, establishing, and using ILF arrangements. This policy is very similar to that applied to mitigation banking. The guidance can be found at http://www.epa.gov/owow/wetlands/pdf/inlieufee.pdf.

US Army Corps of Engineers/EPA Memorandum to the Field: Guidance on Compensatory Mitigation Projects for Aquatic Resource Impacts Under the Corps Regulatory Program Pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899 (Regulatory Guidance Letter 02-02, December 24, 2002)

Regulatory Guidance Letter (RGL) 02-02 was developed to improve the success of compensatory mitigation and help meet the national goal of "no net loss" of wetlands. The RGL also responded to the 2001 National Research Council/National Academy of Sciences report on mitigation in the Corps Regulatory Program. RGL 02-02 provides guidance intended to improve the planning, construction, monitoring, and enforcement of mitigation projects. The RGL will help the Corps' meet its goal of no overall net loss of wetlands by improving the quality of wetland mitigation required as conditions of Corps permits. The RGL focuses on using a landscape-scale approach, requiring wetland mitigation that addresses the ecological needs of watersheds, and ensuring the protection of wetlands and other aquatic areas established as compensatory mitigation. RGL 02-02 can be found at http://www.usace.army.mil/inet/functions/cw/hot_topics/RGL_02-2.pdf.

National Wetlands Mitigation Action Plan (December 24, 2002)

In conjunction with the release of Regulatory Guidance Letter 02-02, the Corps and other federal agencies jointly issued the National Wetlands Mitigation Action Plan (NWMAP) on December 24, 2002. The NWMAP is a comprehensive set of actions that federal agencies are undertaking to improve the ecological success of compensatory mitigation under the Clean Water Act and related programs, and to help ensure the effective restoration and protection of our nation's wetlands.

The NWMAP was developed in response to studies by the National Academy of Sciences and General Accounting Office that concluded that the national goal of no net loss of wetlands was not being met for wetland functions through compensatory mitigation. Action items in the NWMAP include clarifying current mitigation policy on such issues as the use of in-kind vs. out-of-kind mitigation, the use of on-site vs. off-site mitigation, and the use of preservation and vegetated buffers as mitigation; integrating compensatory mitigation into a landscape context; improving data collection and availability; building a national database to more effectively track the success of mitigation projects; and developing performance standards that better measure the success of mitigation at replacing lost aquatic functions. Go to the following website for more information: http://www.mitigationactionplan.gov.

Guidance for the Establishment, Use, and Operation of Conservation Banks (May 2, 2003)

In a memorandum the U.S. Department of the Interior's Fish and Wildlife Service issued guidance on establishing, using, and operating conservation banks. This federal guidance, which closely parallels the 1995 federal mitigation banking guidance, discusses the relationship between mitigation and conservation banking and establishes criteria for developing and using a conservation bank, including provisions for long-term management, monitoring, and a detailed conservation bank agreement. In essence, conservation banking transfers the mitigation banking concept to endangered and threatened species conservation.

In contrast to mitigation banks, which typically offset adverse impacts to wetlands and other aquatic resources, conservation banks, also known as habitat banks, offset adverse impacts to natural resources that are typically associated with species listed under the Endangered Species Act. The natural resources associated with conservation banks are not necessarily aquatic in nature. Like mitigation banks, conservation banks represent a market-based approach to implementing high-quality, larger-scale, mitigation projects that are permanently protected. The memorandum can be found at http://www.fws.gov/endangered/policies/conservation-banking.pdf.

State Laws and Rules

State Water Pollution Control Act (Chapter 90.48 RCW)

The State Water Pollution Control Act directs Ecology to protect state water quality by controlling and preventing the pollution or degradation of streams, lakes, rivers, ponds, inland waters, salt waters, water courses, and other surface and underground *waters of the state of Washington*. The law directs Ecology to establish water quality standards that will uphold the state's water quality. A certification issued under § 401 of the Clean Water Act reflects the state's determination that a project approved by the Corps complies with state water quality standards and other appropriate requirements of state law (see Clean Water Act).

The state utilizes its authority under the Water Pollution Control Act to review and authorize projects that will result in the alteration or loss of isolated wetlands and other waters of the state that are not within Corps jurisdiction (see Section 3.3, *What Type and*

Size of Wetlands Are Present?). Also, refer to Ecology's focus sheet on isolated wetlands found in Appendix F.

Ecology's regulation of wetlands, including isolated wetlands, ensures that projects are in compliance with the State Water Quality Standards (Chapter 173.201A WAC). The State Water Quality Standards consist of three main elements:

1. Characteristic uses of surface waters;
2. Numerical criteria for conventional water quality parameters that are not to be exceeded (Chapter 173-201A-130 WAC); and
3. An antidegradation policy (Chapter 173.201A.260[3]h WAC).

As discussed in the Ecology publication, *Water Quality Guidelines for Wetlands: Using the Surface Water Quality Standards for Activities Involving Wetlands* (Ecology publication # 96-06, http://www.ecy.wa.gov/pubs/9606.pdf), the antidegradation section of the water quality standards is the primary means used to protect water quality in wetlands. Specific numeric criteria for wetland water quality are difficult to establish, hence they are not generally used.

Antidegradation Policy (Chapter 173.201A.300 WAC)

The implementing rules for the state Water Pollution Control Act (Chapter 90.48 RCW) contain an antidegradation policy (Chapter 173-201A-300 WAC) that applies to human activities which may impact state water quality. The purpose of the antidegradation policy is to restore and maintain the quality of the surface waters of Washington and ensure that all human activities which may degrade the water quality "at a minimum, apply all known, available, and reasonable methods of prevention, control, and treatment." The policy calls for three levels of protection for surface waters:

- Tier I is used to ensure existing and designated uses are maintained and protected and applies to all waters and all sources of pollution. "No degradation may be allowed that would interfere with, or become injurious to, existing or designated uses, except as provided for in this chapter" (Chapter 173-201A-310 WAC).
- Tier II is used to ensure that waters of a higher quality than the criteria assigned in this chapter are not degraded unless such lowering of water quality is necessary and in the overriding public interest. Tier II applies only to a specific list of polluting activities.
- Tier III is used to prevent the degradation of waters formally listed in this chapter as "outstanding resource waters," and applies to all sources of pollution.

The antidegradation policy establishes the bottom line for water quality protection in the state: "Existing beneficial uses shall be maintained and protected and no further degradation which would interfere with or become injurious to existing beneficial uses shall be allowed." Beneficial uses are more or less equivalent to wetland "functions and values" and therefore include: water supply; surface and groundwater treatment; stormwater attenuation; fish and shellfish migration, rearing, spawning, and harvesting; wildlife habitat; recreation; support of biotic diversity; and aesthetics.

Applying the water quality standards to wetlands means that all existing beneficial uses (or functions and values) of wetlands cannot be lost, and if wetland impacts are unavoidable, the loss of beneficial uses must be adequately replaced (compensated).

Shoreline Management Act (Chapter 90.58 RCW)

The Shoreline Management Act (SMA) of 1971 was enacted to protect the State's shorelines and the reasonable uses of those shorelines. The Shoreline Management Act states that the intent of the act is to "provide for the management of the shorelines of the state by planning for and fostering all reasonable and appropriate uses" of those shorelines (Chapter 90.58.020 RCW). Uses identified in the SMA include state interests, preserving the natural character of the shoreline, protecting the resources and ecology of the shoreline and public access. State shorelines include shorelines of lakes over 20 acres in size and rivers and streams with flows greater than 20.0 cubic feet per second (cfs). State wetland jurisdiction under the SMA is limited to uplands and wetlands within 200 feet of the shoreline and wetlands that are associated with regulated water bodies. Associated wetlands can be located beyond the 200-foot zone if they influence or are influenced by the SMA-regulated water body. The SMA also requires local governments to adopt shoreline master programs to protect the state's shorelines (see Shoreline Master Program).

Growth Management Act (Chapter 36.70A RCW)

The Growth Management Act (GMA) adopted in 1990 and amended in 1991 requires local governments to designate and protect *critical areas*, which include wetlands. Local governments must use best available science (BAS) when reviewing and revising policies and regulations for critical areas (Chapter 36.70A.172 RCW). Ecology provides technical assistance to local governments under GMA. Requirements for wetland protection standards, buffers, and wetland mitigation vary from jurisdiction to jurisdiction, so you need to contact your local planning and development services department to get information on local requirements for projects involving wetlands. The Department of Community, Trade and Economic Development (CTED), a state agency, is another resource for information on local rules affecting wetlands (see Appendix C, *Agency Contacts*).

Hydraulic Code (Chapter 77.55.100 RCW)

This law, passed in 1949, is intended to protect fish from harm in all marine and fresh waters of the state. This law is implemented through a permit called the Hydraulic Project Approval (HPA) and administered by the Washington Department of Fish and Wildlife. The permit is required for any project that will "use, divert, obstruct or change the natural flow or bed of any of the salt or fresh waters of the state." While not directly intended to protect wetlands, the HPA is required for any work that affects the bed or flow of state waters including all work within the mean higher high water line in salt water or within the ordinary high water line in fresh water, which often includes wetlands. For more information on the HPA go to http://wdfw.wa.gov/hab/hpapage.htm..

Forest Practices Act (Chapter 76.09 RCW)

This law and its implementing regulations (Chapter 222 WAC) apply the wetland provisions of the federal Clean Water Act and Washington State Water Pollution Control Act (Chapter 90.48.425 RCW) to state and private forest lands. Section 8 of the Forest Practices Manual

(Chapter 222 WAC) contains an abbreviated wetland delineation manual. Prohibitions or restrictions for timber harvest along streams and within wetlands and their buffers are detailed in the Forest Practices Manual. For more information on forest practices go to http://www.dnr.wa.gov/forestpractices/index.html.

Aquatic Lands Act (commonly referred to as such) (Chapter 79.90-79.96 RCW)

These statutes define the Washington Department of Natural Resources (WDNR) responsibility to manage state-owned aquatic lands and include authorizing the use of these lands for a variety of activities, which can include wetland mitigation projects. Projects proposed on state aquatic land may require separate authorization from WDNR. Chapters 79.90 – 79.96 RCW were not passed under the term "Aquatic Lands Act." However, the sections all relate to the management of state-owned aquatic lands and have become commonly referred to as such.

State Environmental Policy Act (Chapter 43.21C RCW)

The Washington State Environmental Policy Act (SEPA) provides a way to identify environmental impacts that might result from state and local government decisions, such as issuing permits for private projects, constructing public facilities, or adopting regulations, policies, or plans. Information provided for the SEPA review process helps state and local government decision-makers, applicants, and the public understand how a proposal would affect the environment. This information can be used to revise a proposal to reduce likely environmental impacts, to condition the proposal so that impacts are mitigated, or to deny a proposal when adverse environmental impacts cannot be mitigated.

Wetlands Mitigation Banking Act (Chapter 90.84 RCW)

This law articulates the state's policy to support wetland mitigation banks as an important tool for compensating for wetland losses. The law directs Ecology to develop rules for a statewide certification process to ensure that approved wetland banks are environmentally sound and the process is predictable for applicants. Ecology has completed a draft bank certification rule, which currently provides guidance on developing wetland banks in Washington (see DRAFT State Wetland Banking Rule). For more information on the status of the rule go to the Ecology Wetland Mitigation Banking Home Page at http://www.ecy.wa.gov/programs/sea/wetmitig/index.html.

Wetland Delineation Manual (Chapter 36.70A.175 RCW, Chapter 90.58.380 RCW, Chapter 173.22.080 WAC)

The state legislature passed a law in 1995 directing Ecology to "adopt a manual for the delineation of wetlands under this chapter that implements and is consistent with the 1987 manual in use on January 1, 1995, by the Corps of Engineers and the Environmental Protection Agency" (Chapter 90.58.380 RCW). Ecology has adopted a Washington State Wetland Identification and Delineation Manual (Chapter 173.22.080 WAC), which includes clarifying guidance from the Corps and EPA. This state manual is required to be used by all state agencies in the application of any state laws and regulations. Cities and counties must also use the state manual in the implementation of any regulations under the Growth Management Act (Chapter 36.70A.175 RCW). See GMA above. See also Section 3.2, *Do*

You Have a Wetland Present? The wetland delineation manual can be found at http://www.ecy.wa.gov/biblio/9694.html (Ecology 1997).

Aquatic Resources Mitigation Act (Chapter 90.74 RCW)

The Aquatic Resources Mitigation Act articulates the state's policy related to the mitigation of wetlands and aquatic habitat for infrastructure development. The law states "The practice of considering traditional on-site, in-kind mitigation may provide fewer environmental benefits when compared to innovative mitigation proposals that provide benefits in advance of a project's planned impacts and that restore functions or habitat other than those impacted at a project site; and regulatory decisions on development proposals that attempt to incorporate innovative mitigation measures take an unreasonable long period of time and are subject to a great deal of uncertainty and additional expenses." Therefore, the law directs state regulatory agencies to authorize innovative mitigation measures for infrastructure projects (i.e., Ecology and the Washington Department of Fish and Wildlife should consider mitigation proposals that are "timed, designed, and located in a manner to provide equal or better biological functions and values compared to traditional on-site, in-kind mitigation proposals"). The state's Alternative Mitigation Policy is consistent with the above-mentioned directives of this law.

State Policies and Guidance

Governor's Executive Order 89-10, Protection of Wetlands (December 1989)

This executive order, signed by Governor Booth Gardner, established an interim goal "to achieve no overall net loss in acreage and function of Washington's remaining wetlands base," and a long-term goal of increasing acreage and function of the state's wetland resources. Further, the order directed Ecology to develop guidance that would "lessen the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands" (see Section 6.1.1, *No Net Loss*). http://www.governor.wa.gov/actions/orders/eoarchive/eo89-10.htm

Governor's Executive Order 90-04, Protection of Wetlands (April 1990)

This executive order, signed by Governor Booth Gardner, directed all state agencies to use their existing authorities to protect wetlands. In particular, the order directed state agencies to use their SEPA authorities "to the extent legally permissible, to require mitigation of wetland impacts for all agency actions affecting wetlands." Executive Order 90-04 also defines mitigation and directs state agencies to implement the process of mitigation in sequential order (see Section 3.5.1, *Mitigation Sequencing*). http://www.governor.wa.gov/actions/orders/eoarchive/eo90-04.htm

Alternative Mitigation Policy Guidance for Aquatic Permitting Resources (February 2000)

Washington State's Alternative Mitigation Policy Guidance describes how the Departments of Ecology and Fish and Wildlife implement their policies regarding mitigation for aquatic resources. The policy guidance was developed through a cooperative effort between the Washington departments of Community Trade and Economic Development, Ecology, Transportation, and Fish and Wildlife, and interested Tribes as directed under the Salmon

Recovery Act, Chapter 75.46 RCW. The Alternative Mitigation Policy provides guidance on the factors and preferences used by each agency in determining when alternative mitigation options are preferable to on-site and in-kind compensation. The Alternative Mitigation Policy Guidance is consistent with the requirements under the state's Aquatic Resources Mitigation Act (Ch. 90.74 RCW). This guidance can be found at http://www.ecy.wa.gov/biblio/0306007.html.

DRAFT State Wetland Banking Rule (January 2001)

Ecology published its draft rule for a certification program for wetland mitigation banks pursuant to the Wetlands Mitigation Banking Act (Ch. 90.84 RCW). Although the rule was withdrawn prior to its adoption, Ecology uses it as its primary guidance for the review of wetland bank proposals. The draft rule outlines the review and approval process for mitigation banks, and provides technical guidance on designing and constructing a wetland mitigation bank. The draft state rule is consistent with the 1995 federal guidance for wetland mitigation banks.

In July 2004, the department started implementation of a pilot rule project to test the implementation of the draft bank certification rule. Check the Ecology Wetland Banking Home Page for the most recent information on the status of the bank certification rule. http://www.ecy.wa.gov/programs/sea/wetmitig/index.html.

Local Laws and Rules

Local governments also play an important role in protecting and managing wetlands. They are responsible for administering certain state laws as well as their own wetland protection programs and requirements. As always contact your local government for specific information on local requirements and standards prior to conducting any work in wetlands, streams, or other water bodies.

Critical Area Ordinance

Under the Growth Management Act, local governments (cities, towns, and counties) are required to identify *critical areas,* including wetlands and adopt ordinances protecting those areas. A Critical Area Ordinance (CAO), which is adopted by a local government, specifies the permit requirements and standards for wetland protection that will be employed in that particular jurisdiction.

Shoreline Master Program

The Shoreline Management Act (SMA, Chapter 90.58 RCW) directs local governments to develop shoreline master programs in order to protect the state's shorelines. Shoreline jurisdiction extends a minimum of 200 feet from the ordinary high water mark (OHWM) of a state shoreline. Under the SMA, wetlands that are associated with a shoreline area are regulated, even when they extend beyond 200 feet from the OHWM. Most shoreline master programs require the protection of a buffer in addition to protecting the wetland itself. Projects proposed in the shoreline zone must be consistent with the approved master plan or the applicant must apply for a variance. Consult with the local shoreline administrator for specific situations.

Appendix F - Isolated Wetlands - Changes in the Regulatory Process

This appendix includes a Focus Sheet developed by Ecology to help clarify the regulatory process for isolated wetlands. This document was published in 2001 (Ecology Publication #01-06-020). Some of the information provided in the Focus Sheet has since become out-of-date. The text has been modified to provide up-to-date information (edits are shown in *italics* and ~~strikethrough~~).

Focus

Isolated Wetlands   Changes in the Regulatory Process

Supreme Court Decision

A U.S. 2001 Supreme Court decision ~~last January~~ regarding how wetlands are regulated has generated a lot of questions by landowners and developers.

The court ruled that the federal Clean Water Act does not apply to those "isolated" wetlands where the only interstate commerce connection is use by migratory birds. This ruling overturned 15 years of regulation of isolated wetlands by the U.S. Army Corps of Engineers. While the court did not define the term "isolated," the Corps ~~has previously considered~~ *generally considers* isolated wetlands to be those that are not adjacent to or ~~connected via surface water~~ *do not have a sufficient hydrologic connection* to a navigable water body, such as a river, lake or marine waters.

Changes in Regulatory Process

Based on the Supreme Court's ruling, federal agencies no longer have regulatory oversight of these important environmental resources. More specifically, landowners no longer need a permit from the U.S. Army Corps of Engineers to fill in most isolated wetlands - although a Corps permit is still required for isolated wetlands with other interstate commerce use (recreation, industrial, etc.) as well as wetlands that are connected to a navigable water body. *Corps policy regarding the definition and regulation of isolated wetlands is currently in flux, and future court or administrative decisions may further change how isolated wetlands are regulated by the federal government.*[46]

However, the Supreme Court ruling did not change Washington state laws on wetlands. The state Clean Water Act (90.48 RCW) makes no distinction between types of wetlands. Rather, all "waters of the state" are covered by the law, and isolated wetlands are considered waters of the state.

It's not always easy to tell if a wetland is isolated. Landowners who want to develop an isolated wetland should contact the Corps of Engineers and request a formal jurisdictional determination to avoid any future legal problems and fines.

Why Regulate Isolated Wetlands?

Isolated wetlands in Washington perform many of the same important environmental functions as other wetlands, including recharging streams and aquifers, storing flood waters, filtering pollutants from water, and providing habitat for a host of plants and

46 Check the following web pages for updates http://www.ecy.wa.gov/programs/sea/pac/iso-wetlands.html or via the Corps regulatory web page at http://www.nws.usace.army.mil/ (Regulatory, WAters & Wetlands Information).

animals. Many wildlife species, including amphibians and waterfowl, are particularly dependent on isolated wetlands for breeding and foraging.

tate o ess

- Any project that calls for filling or altering a wetland determined by the Corps to be isolated will still be subject to regulation by the state. The state's process for reviewing projects that involve isolated wetlands will be different from the 401 Water Quality Certification process that is triggered by the Corps' 404 permit. Rather, Ecology will use administrative orders to regulate projects that will have impacts to isolated wetlands. The standards of review will remain the same as under 401 water-quality certifications - that is, the state water-quality standards for surface waters (WAC 173-201A). Anyone who wants more information about the review standards should obtain the following two publications: Water Quality Guidelines for Wetlands, Publication # 96-06, ~~and How Ecology Regulates Wetlands, Publication #97-112~~. This can be obtained by contacting Jean Witt at 360-407-7472.

  To seek an administrative order for a project that involves isolated wetlands, landowners should contact the ~~Permit Assistance Center~~ *Office of Regulatory Assistance* at the Department of Ecology, where our staff will guide you through the regulatory process. The phone number is 800-917-0043 or 360-407-7037, and the e-mail address is ecypac@ecy.wa.gov.

GMA Regulations

Additionally, applicants should be aware that isolated wetlands in Washington also are regulated under the state's Growth Management Act. Thus, projects with impacts to isolated wetlands typically will require approval from the applicable city or county.

Appendix G - Analyzing the Functions of Wetlands: An Overview of Methods

Wetland "assessment" methods are used to identify, characterize, or measure wetland functions, and in some cases, social values (Bartoldus 1999). An assessment of the functions performed by a wetland is often required when impacts to that wetland will result from a change in land use. The level of analysis depends upon the type, severity, and extent of the proposed impacts such that the detail necessary will be commensurate with the impacts.

A number of methods have been developed to assess wetland functions in Washington and across the U.S. A list of the methods for analyzing functions that were either specifically developed to analyze wetlands in Washington or are commonly used in the state can be found below. A brief description of each method, its advantages, limitations, and recommended uses are provided. For a list of tools developed to assist with analyses of wetlands at a landscape scale, refer to Appendix 5-b, *Wetlands in Washington State: Volume 2* (Granger et al. 2005).

Overview of Methods that Analyze Functions

The types of methods that analyze wetland functions include those that provide:

- Semi-quantitative results (for example, WFAM).
- Qualitative results (for example, Rating System, WSDOT Linear Method, SAM).

In general, more rapid methods produce more qualitative results.

Methods are more appropriate when developed or adapted for:

- The specific geographic area (for example, the Pacific Northwest).
- The appropriate domain or region (for example, the Columbia Basin of eastern Washington).
- The appropriate wetland type (for example, depressional vs. riverine wetlands).

The following is a list of methods that were developed for Washington wetlands or are commonly used in the state.

- Washington wetland function assessment methods (WFAM).
- Wetland rating systems for eastern and western Washington (Hruby 2004a and 2004b).
- Wetland Functions Characterization Tool for Linear Projects (Null 2000).
- Semi-Quantitative Assessment Methodology (SAM) (Cooke 2000).
- Wetland Evaluation Technique (WET) (Adamus et al. 1987).

- Wetland Values: Concepts and Methods for Wetlands Evaluation (Reppert).
- Proper Functioning Condition for Lentic Areas (PFC) (Pritchard 1999).
- Best Professional Judgment (BPJ).

A description of the hydrogeomorphic approach (HGM) is also provided at the end of this appendix.

Which Method Should I Use to Analyze Functions?

Most projects involving impacts to wetlands will, at some level, be required to describe the functions provided by that wetland. As a minimum, the agencies usually require that an analysis of functions be performed using a rating system. An applicant will generally be requested to apply the wetlands rating system for western or eastern Washington (see description below) to determine the category of the wetland and how well it performs three basic functions (improving water quality, reducing flooding and erosion, and the potential to provide habitat for many species). The rating system also helps determine if particular features or situations of concern exist at the site, such as the presence of a mature forest. However, a more thorough assessment of functions may be needed when wetland impacts will be significant. In such cases the agencies may request that an applicant complete an assessment using the wetland function assessment methods for Washington State, if the wetland is in one of the classes for which a method has been developed (see description of WFAM below).

Best professional judgment (BPJ) is recommended for use on relatively small (generally < 1/4 acre) wetland impacts where more intensive analysis is not warranted. When used, it is necessary to provide written documentation of the rationale used to decide the level of function provided by the wetland. For projects with minimal impacts the applicant may not be required to assess functions[47].

The agencies will also usually request some assessment of level of function performed by compensation wetlands. This is particularly true in the case of enhancement. When an applicant proposes to enhance wetlands, a baseline function assessment is required. In order to determine how much of an increase in functions has been attained, the level of functions provided by the wetlands being enhanced must be assessed prior to any enhancement activities taking place. An assessment of functions may be required as part of the project's performance standards to determine whether a compensation project has provided the required increase in the performance of functions.

47 Impacts which do not require pre-notification to the Corps are not likely to require assessments of wetland function. Applicants are advised to contact the Corps if you have any questions.

Brief Description of Methods and their Recommended Uses

Washington State Wetland Function Assessment Methods (WFAM)

Hruby, T, S. Stanley, T. Granger, T. Duebendorfer, R. Friesz, B. Lang, B. Leonard, K. March, and A. Wald. 2000. Methods for Assessing Wetland Functions, Volume II: Depressional Wetlands in the Columbia Basin of Eastern Washington. Parts I and II. Washington State Department of Ecology Publication #00-06-47 and#00-06-48. Olympia, WA.

Hruby, T., T. Granger, K. Brunner, S. Cooke, K. Dublanica, R. Gersib, L. Reinelt, K. Richter, D. Sheldon, E. Teachout, A. Wald, and F. Weinmann. 1999. Methods for Assessing Wetland Functions, Volume I: Riverine and Depressional Wetlands in the Lowlands of Western Washington. Parts I and II. Washington State Department of Ecology Publication #99-115 and #99-116. Olympia, WA.

The methods can be found at http://www.ecy.wa.gov/programs/sea/wfap

*Methods for Assessing Wetland Function*s, commonly called the Washington State Wetland Function Assessment Methods (WFAM), are a collection of *assessment* methods developed by interdisciplinary teams of experts and published by Ecology. Unlike rating systems which categorize wetlands using information about basic functions, the assessments provide a score for the degree to which several functions (up to 15) are performed by a wetland. The methods are based on the hydrogeomorphic (HGM) classification for wetlands.

Advantages

- Relatively rapid for the scientific rigor of the assessments that are needed.
- Provides a numeric expression of the level of performance of wetlands in regard to their potential to perform and their opportunity to perform numerous functions.
- Developed for specific areas in Washington and for specific wetland types.
- Peer reviewed and field tested in the area for which they were developed.
- Results are reproducible to <u>+10%</u>, especially with training.

Limitations

- Large, structurally complex sites may require a few days to complete an assessment.
- Site visits at different times of the year may be necessary to accurately determine the water regime (e.g., the length and extent of inundation).
- Specific training in the application of WFAM is required before one uses it for regulatory purposes.
- WFAM are lacking for specific wetland types. Methods do not exist for riverine wetlands in eastern Washington, any montane areas, or any slope, tidal, or interdunal wetlands.

- Numeric results may be misused to assume scores are continuous functions rather than discrete integers.
- It is not possible to make a direct quantitative comparison between the levels of wetland functions at sites with different HGM subclasses.

Recommended Uses

- Projects involving significant wetland impacts in terms of size (e.g., >2 acres) or estimated level of performance of the wetland.
- Determine if functions lost to impacts have been adequately replaced in compensatory mitigation. (Note: It is not recommended to detect small changes in functions.)

Washington State Wetlands Rating Systems

Hruby, T. 2004. Washington State Wetland Rating System for Eastern Washington – Revised. Washington State Department of Ecology Publication #04-06-015. Olympia, WA. http://www.ecy.wa.gov/biblio/0406015.html

Hruby, T. 2004. Washington State Wetland Rating System for Western Washington – Revised. Washington State Department of Ecology Publication #04-06-025. Olympia, WA. http://www.ecy.wa.gov/biblio/0406025.html

The wetland rating systems for eastern and western Washington are technically characterizations that group wetlands based on sensitivity, rarity, functions, and other criteria including the performance of basic functions.

Advantages

- Designed to categorize wetlands into one of four groups which allow agencies/local governments to determine how the wetlands should be protected and managed.
- Rapid and relatively easy to perform; the vast majority of sites can be rated within 1 to 2 hours in the field.

Limitations

- Not a quantitative assessment of functions, but a characterization.
- May oversimplify the performance of functions by lumping groups of functions in the scoring. This means that the information provided may not be adequate to protect individual functions.

Recommended Uses

- Determine into which category a wetland is grouped, often for regulatory purposes to determine buffer widths and ratios for compensatory mitigation.
- May provide sufficient characterization of potential functions for impacts to small (e.g., <1 acre), degraded wetlands when determining needs for compensation.

Wetland Functions Characterization Tool for Linear Projects

Null, W., G. Skinner, and W. Leonard. 2000. Wetland Functions Characterization Tool for Linear Projects. Washington State Department of Transportation Environmental Affairs Office, Olympia, WA. http://www.wsdot.wa.gov/environment/biology/docs/bpjtool.pdf.

This method is also a characterization. Washington State Department of Transportation adapted this method for Washington to meet their specific needs for assessing wetland impacts along linear projects. It uses a list of criteria for each function to guide decision-making. It relies on professional judgment regarding the likelihood that the function is being performed.

Advantages

- Provides documentation of the criteria and rationale used when applying best professional judgment to analyze functions.
- Can be very rapid when used by trained wetland professionals.
- Can also be used to characterize a portion of a larger wetland when a wetland exists on multiple properties and access to all parts of the wetland is restricted.
- Based on WFAM, which corresponds to “best available science.”

Limitations

- Cannot determine the level at which a function may be performed to plan compensatory mitigation.
- This method should not be used to measure change over time or as the result of alterations (e.g., impacts or mitigation).
- Method is subjective and results may vary significantly based on the experience and expertise of the user.

Recommended Uses

- Rapid screening of many wetlands to determine best areas for development or roads.

Semi-Quantitative Assessment Methodology (SAM)

Cooke Scientific Services Inc. 2000. Wetland and Buffer Functions Semi-quantitative Assessment Methodology (SAM). Final Working Draft User’s Manual. Cooke Scientific Services Inc. Seattle, WA. This method has not been published but is available on the web at http://www.cookescientific.com/sam.htm

Although SAM is in wide use, better tools have been developed more recently. The WFAM method is much more accurate in its ability to characterize the functions and their performance in wetlands and should be used in its place, especially for larger (> 1 acre) wetlands.

SAM provides a rapid method for *rating* various wetland attributes, including functions, with high, medium, and low rating.

Advantages

- Easy to use and requires no specific training (some knowledge of wetland ecology would obviously be beneficial).
- Reproducible between users.
- Developed for western Washington.

Limitations

- Provides very general information.
- "Low" ratings miss many site-specific details that are important for protection and management.
- Allocates high ratings to large, rural, undisturbed wetlands, while smaller wetlands in urban areas rate lower.
- Should not be used for wetlands east of the crest of the Cascade Mountains.

Wetland Evaluation Technique (WET)

Adamus, P.R., E.J. Clairain, Jr., R.D. Smith, and R.E. Young. 1987. Wetland evaluation technique (WET), Volume II: Methodology. Department of the Army, Waterways Experiment Station, Vicksburg, MS. NTIS No. ADA 189968.

WET is a rating method that was developed in the late 1980s by the U.S. Army Corps of Engineers in cooperation with Paul Adamus. WET was designed to be applicable to all wetland types throughout the contiguous U.S. For this reason it is not specific to wetland conditions in Washington and therefore provides only general information about functions. WET is no longer recommended for use in Washington's wetlands. Better tools have been developed more recently.

Wetland Values: Concepts and Methods for Wetlands Evaluation (often called the Reppert method after the author)

Reppert, R.T., W. Sigleo, E. Stakhiv, L. Messman and C. Beyers. 1979. Wetland Values: Concepts and Methods for Wetland Evaluation. U.S. Army Corps of Engineers, Institute for Water Resources. Fort Belvoir, Virginia.

Published in 1979, this was one of the first methods developed to help determine how wetlands function. It is a *rating* that groups wetlands into high, medium, or low based on "functional values." This method is no longer recommended for use in Washington's wetlands. Better tools have been developed more recently.

Proper Functioning Condition for Lentic Areas (PFC)

Prichard, D., C. Bridges, R. Krapf, S. Leonard, and W. Hagenbuck. 1999. Riparian Area Management: Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas. TR 1737-11. Bureau of Land Management, BLM/SC/ST-94/008+1737, Service Center, CO. 37 pp.

PFC is a qualitative method to *characterize* streams, riparian areas, and riparian wetlands. It was developed by the Bureau of Land Management to assess how well the physical processes in these areas are functioning.

Advantages

- Provides good information for designing restoration of riparian wetlands.

Limitations

- Correct application of this method requires an interdisciplinary team of experts.
- Does not separate wetlands from the rest of the riparian resources.
- Primarily for riparian wetlands.
- Not an assessment that can be used independently to rate, characterize, or assess wetlands and their functions.

Recommended Uses

- Could be useful in combination with other assessment methods.
- For wetlands that are “functional - at risk” or “non-functional” the methods can help to identify what is lacking (vegetation, soil, water) and may provide guidance on the likelihood of improving the condition and what actions could be taken to improve the condition.

Best Professional Judgment (BPJ)

Application of BPJ is the most common method used to determine the functions that a wetland provides. Application of this method requires that a wetland professional decide how well a wetland performs functions based on his/her own experience or knowledge.

Most methods are based to some degree on the best professional judgment of the individuals or the teams of individuals who developed them.

Advantages

- Can be very rapid.
- If the expert has local knowledge, the information on functions may be very specific to the region and wetland type.

Limitations

- Not reproducible. Reliability of results varies greatly with expertise.
- Can't track the criteria used to base the judgment unless they are carefully recorded.
- Easier to be biased in regard to functions for which the expert has more knowledge.

Recommended Uses

BPJ may be used in analyzing functions for small impacts where more intensive analysis is not warranted. BPJ should also be used in concert with other methods to help define and clarify the functional performance of wetlands, based on specific site conditions of the wetland and adjacent watersheds.

Hydrogeomorphic Approach (HGM)

Smith, D. R., Ammann, A., Bartoldus, C., and Brinson, M. M. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Technical Report WRP-DE-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. NTIS No. AD A307 121.

The HGM approach is not a method to assess, characterize, or rate wetlands. This approach has been developed by the U.S. Army Corps of Engineers to provide guidance on how to develop regional methods for analyzing functions. It was put forth by the Corps for use in Section 404 permitting. WFAM is based on many concepts in this approach. Other documents associated with this approach are available at: http://www.wes.army.mil/el/wetlands/hgmhp.html.

Appendix H - Examples of Compensation Actions and Their Relative Effectiveness

The amount of compensatory mitigation (mitigation ratio) that will be required is partially contingent upon the type of compensation being provided (see Section 6.5.2, Typical Ratios for *Compensatory Mitigation*). As discussed in Section 5.1.1, the distinction between rehabilitation and enhancement is not clear-cut and can be hard to understand. Actions that rehabilitate or enhance wetlands span a continuum of activities that cannot be defined by specific criteria and may overlap. Proposals that fall within the gray area between rehabilitation and enhancement will result in a mitigation ratio that lies between the ratios for rehabilitation and the ratios for enhancement. The ratios will be based on the ecological effectiveness of the proposed activities. Generally, more effective actions require lower ratios to adequately offset authorized impacts.

Applicants proposing to rehabilitate or enhance an existing wetland will therefore need to identify the specific actions to be performed and how they will improve wetland functions, environmental processes, or both. It is therefore more important for applicants to focus on the ecological effectiveness of the proposed mitigation activities (e.g., will processes be restored, or how much of a gain in functions will result) and put less emphasis on what the compensation action may be called.

Table H-1 below describes some of the actions that may be proposed for compensation. The table identifies how effective those actions may be in terms of gain in functions. The table was developed based on the best professional judgment of agency wetland staff that review and approve compensatory mitigation proposals.

Table H-2 provides some examples of actions that could be implemented on a proposed compensation site to address alterations or disturbances that have occurred in the past. Some of the actions are considered more effective while others are considered less effective. As with Table H-1, more effective actions would generally provide greater gains in the performance of functions and are more likely to be sustainable in the long term. In most cases, the more effective actions should be used.

Table H-1. Examples of compensation actions and their relative effectiveness

More Effective Actions (Greater performance of functions & sustainable)	**Less Effective Actions (Lesser gain in function & may not be sustainable)**
Restore water processes by reinstating subsurface/return flow for depressional & slope wetlands; tidal waters for estuarine wetlands; overbank flooding or flow-through from riverine source for riverine wetland.	Partially restore or incorrectly restore water flow and/or focus on enhancing the structure of the wetland area which may not be supported by the existing water regime (e.g., underplanting in existing scrub-shrub area).
Restore to hydrogeomorphic (HGM) class appropriate for landscape setting.	Create an atypical wetland or incorrect wetland class for landscape setting.
Remove stressors, such as water diversions, intensive agriculture, logging, clearing and grading, urban uses, and discharges from non-point sources.	No change to the stressors.
Design wetland mitigation in accordance with upslope or upstream processes present. In other words, don't design a wetland for amphibian habitat in a flashy urban hydrologic regime.	Design wetland mitigation based solely on the type of habitat or physical structure desired/proposed without consideration of the existing landform, HGM setting, or hydrologic processes.

Table H-2. Examples of alterations and the relative effectiveness of compensation actions to correct those alterations.

Site Alterations Due to Past Activities	**Actions to Address Alterations or Disturbances on Areas Proposed as Compensation Sites**	
Hydrologic alterations	More Effective	Less Effective
Diking	Remove dikes *(generally considered rehabilitation)*	Partial or no removal of dikes (may result in fish stranding)
Tiling	Break all tiles *(generally considered rehabilitation)*	Partial or no removal of tiles
Ditching	Plug all ditches *(generally considered rehabilitation)*	Partial or no removal of ditches
Channelization	Re-grade stream channel to proper curve amplitude and frequency and ensure that stream will flood over the bank (at approx 1.5 yr frequency) into adjoining floodplain (i.e. stream or river is not incised)	Stream or river remains incised and/or no overbank flooding occurs with redesign of channel
Stormwater Inputs	Treat and introduce as subsurface flow (i.e. infiltration through buffer)	Stormwater is treated but introduced as unregulated point source.
Weirs/Tide Gates	Remove	Lower outlet height without achieving natural hydroperiod of wetland (for tidal wetland fish stranding and flushing problems result; for riverine wetlands overbank flooding is limited)

Utilities - Pipelines, Sewers, Waterlines	Remove abandoned utilities or relocate active lines	Try to restore natural water regime by installing collars on subsurface utilities to prevent draining of water along utility line; or install subsurface permeable corridors to allow passage of water perpendicular to utility line (eliminates ponding on one side and less water out on the other) (reduced impact). No remediation
Soil alterations	**More Effective**	**Less Effective**
Tilling/Plowing	Stop tilling/plowing	Continue tilling and plowing (greatest impact)
Compaction of the Soil	Scarification and addition of organic material (mulch)	No measures except planting and grading (greatest impact)
Contamination of the Soil	Remove existing soils and replace with hydric soils	Contamination is not removed either through remediation or replacement of soils
Alteration of Soil/Surficial Geology	Maintain or restore natural soil and surficial geologic structure (e.g. impermeable layers, organic soils, recharge layers)	Puncture impermeable layers, excavate organic soils, put in impermeable layer (pond liner) in recharge area)
Vegetation alterations	**More Effective**	**Less Effective**
Removal of All Vegetation/Clearing	Revegetate and install necessary erosion control measures (hydroseed, natural materials mulching, natural matting - no plastics) and control invasives preferably without herbicides.	Revegetate without control of invasive species. Under planting alone, insufficient maintenance of planted site
Grazing	Remove grazing/mowing and control invasives. May need to replant areas to "jump-start" succession process (evaluate site by site.)	Continue grazing, use controls and create buffer strips and fencing to limit erosion/sedimentation and access to flowing and open water (reduced impacts); or continue grazing with no restrictions (greatest impacts)
Mowing	Stop mowing, control invasive plants - same measures as above	Continue mowing but impose Best Mamagement Practices and other restrictions including buffer strips on stream/river edges and open water areas (reduced impacts); Continue mowing with no controls (greatest impacts).
Logging	Revegetate with scrub shrub & appropriate pioneer forest species (e.g. willow and cottonwood planted first followed with subsequent plantings of cedars and other conifers)	Revegetate with inappropriate species or inappropriate timing (plant later successional species immediately) (reduced impacts). No planting (greatest impacts but evaluate each site for best approach)

Appendix 8-F
Rationale for the Draft Guidance on Ratios for Compensatory Mitigation to be Used with the Wetland Rating System

The acreage of creation, restoration, or enhancement that is required by regulatory agencies to compensate for impacts to wetlands is usually greater than the acreage of impact. This difference is expressed as a ratio (the mitigation ratio) of the area required for compensation vs. the area of impact. Ecology and Fish and Wildlife are providing guidance on ratios to use for compensatory mitigation that is linked to the *Washington State Wetlands Rating System* (see Appendices 8-C and 8-D). This appendix provides the rationale behind this guidance.

There are two major reasons why the ratios are greater than 1:1. The first is based on risk of mitigation failure and the second on temporal loss of functions. All of the studies done on compensatory mitigation (see Sheldon et al. 2003, Chapter 6) indicate that some percentage of mitigation projects fail to replace the functions lost. Overall, there continues to be a net loss of wetlands and their functions. Thus, more wetlands need to be created or restored than are impacted at a programmatic level to ensure that wetland functions and area are adequately replaced. The second factor is temporal loss. The studies reviewed in Volume 1 also indicate that functions in wetlands may take decades, if not centuries, to develop fully. By requiring a ratio larger than 1:1, we provide for more acreage of mitigation wetland that may not be functioning as well as the impacted wetland during the decades required for functions to fully develop at the mitigation site.

Thus, mitigation ratios are established based on risk of failure and temporal loss of functions. If mitigation is done in advance of impacts and can be demonstrated to be fully successful, it is reasonable to require ratios as low as 1:1. However, higher ratios should be set if there is an increasing risk of not adequately compensating for the functions lost, and as the time needed to establish the lost functions increases. Kusler (2003) has summarized some of the factors that should be considered in establishing the risk of unsuccessful mitigation:

1. **The functions present in the impacted wetland and those proposed for the "replacement" wetlands.** Larger ratios are justified where a replacement wetland will have fewer functions and values or perform the functions at a lower level. The net loss of function per acre of wetland has to be compensated by increasing the area of mitigation required.

2. **The overall ecological conditions of the impacted wetland and the "replacement" wetland.** Larger ratios are justified where a "replacement" wetland will be less persistent, diverse, or have less ecosystem integrity than the

original wetlands. The risk of losing ecological integrity has to be compensated by increasing the area of mitigation required.

3. **The probable success for wetlands of the type proposed as "replacement."** Larger ratios are justified for wetland types that have proven difficult to restore or create, thereby increasing the risk of failure.

4. **The expertise and experience of the agency or consultant proposing to carry out the project.** Larger ratios are justified for proponents who are less expert and less experienced. Lack of experience increases the risk that the project will not be successful.

5. **Threats to the "replacement" site.** Larger ratios are justified where there are threats to the site such as possible changes to the water regime, sedimentation, or pollution. These threats increase the risk that functions will be impaired in the future (see Chapters 3 and 4 in Volume 1).

6. **Whether the site will be susceptible to "mid-course" corrections**. Larger ratios are justified where the site has little capability for correcting problems as they develop, and smaller ratios are justified where that capability exists. Projects where problems have been corrected tend to be more successful than those that have not (Johnson et al. 2002).

The ratios discussed in this appendix were developed to provide a starting point for further discussions with each proponent of compensatory mitigation. The rationale for the ratios is based on the factors listed above and described in more detail below. **These ratios are based on averaging the observations of mitigation success and risk at a programmatic level and do not represent the specific risk of any individual project.**

Premises Used in Establishing Ratios

Baseline Ratios

The study by Johnson et al. (2002) summarized in Volume 1, Chapter 6, found that projects for compensatory mitigation in Washington State that created or restored wetlands were "moderately successful" or "successful" at replacing the functions lost only about half of the time. This means that overall there is about a 50% risk of failure. Other studies of the success of mitigation projects (summarized in Chapter 6 of Volume 1) suggest the risk of failure is even higher. These data would suggest that a minimum ratio of 2:1 is needed to ensure "no net loss of functions" at a programmatic level.

This ratio also needs to be adjusted to account for the temporal loss of functions described above. There are no scientific studies that have tried to quantify the temporal loss in terms of how many acres of additional wetlands this represents. Trying to quantify this experimentally is not possible because the data are not compatible: One cannot equate time with area. As a result, the additional area required to compensate for the temporal loss of functions is a value judgment. How highly do we value the loss of some functions for 5 to 10 years, some for 30 years, and others for 100 years or more? As a starting point for discussion, Ecology and Fish and Wildlife suggests that the compensation for the temporal loss of functions be equal to the area of impact**. Thus, the basic 2:1 ratio proposed to compensate for the risk of mitigation failure should be increased to 3:1 to account for the temporal loss of functions.**

If enhancement is used as the only form of compensation, there will always be a net loss of wetland area. Furthermore, only about 10% of the enhancement projects analyzed in Washington State were even moderately successful at replacing the functions lost (Johnson et al. 2002). This means that the risk is significantly higher than for creation or restoration, justifying a higher ratio for enhancement. **The ratios recommended for enhancement are twice that needed for creation or restoration** because the risks of not replacing the functions are much higher using enhancement, and there is a net loss of wetland area.

The basic ratios for creation/restoration and enhancement may be modified if the conditions for the proposed mitigation are different from the "average" condition. The *Washington State Wetlands Rating System* categorizes wetlands, and this information can also be used to increase or reduce the ratio. This information was used to develop the expanded recommendations for mitigation ratios presented in Appendices 8-C and 8-D. The following discussion summarizes the logic that was used to develop the ratios.

Incorporating Wetland Categories into Ratios

The basic mitigation ratio for creation and reestablishment is 3:1 as described above. This ratio is based on the assumption that the impacts are to a Category II wetland and the created or restored site will also become a Category II wetland and provide for full replacement of functions and integrity over time. The ratio for Category I wetlands is higher because it is assumed that it is much more difficult to create or restore a wetland to the high level of function represented by a Category I wetland, and there will be a net loss of function on a per acre basis.

Ratios for impacts to Category III wetlands, on the other hand, are lower because it is assumed that the risks are lower. It is assumed that there is a better chance for a successful creation or restoration of a Category III wetland than a Category II wetland. The ratio for a Category IV wetland is even lower because it is assumed that the replacement wetland will be a Category III wetland with higher levels of functions.

Ratios for Forested Wetlands

Studies of mitigation projects have shown that forested wetlands may take over 100 years to become established. The ratio recommended is designed to compensate for the additional temporal loss of the functions of a forested wetland during the long time it takes to establish this type of wetland.

Ratios for Wetlands that are Difficult to Create (Natural Heritage, Bogs, Alkali Wetlands, Estuarine Wetlands, Wetlands in Coastal Lagoons)

Ecology and Fish and Wildlife assumes that it is not possible to create Natural Heritage wetlands, bogs, alkali wetlands, estuarine wetlands, or wetlands in coastal lagoons from uplands or to enhance other wetlands to reproduce their characteristics.

No data are available for mitigation projects that involved creating Natural Heritage wetlands, alkali wetlands, estuarine wetlands, or wetlands in coastal lagoons from uplands. Bogs are the only type of wetland for which such information exists, and this information indicates that it is not possible to recreate the necessary physical, hydrologic, and chemical conditions needed to replace a bog through compensatory mitigation (see Chapter 6 in Volume 1). As a result, Ecology and Fish and Wildlife recommends that compensation for impacts to these types of wetlands should involve the rehabilitation of degraded wetlands of a similar type, rather than creation or enhancement.

Although estuarine wetlands are the only type that has been successfully rehabilitated, it is assumed that rehabilitation of the other types is also feasible. It is more feasible, at least, than if the compensation involves creating such a wetland or enhancing a wetland of another type to recreate the necessary ecological conditions. In the absence of any definitive information on the success of such rehabilitation, the ratio for compensation is set at 6:1 to be consistent with the other ratios. Projects that propose enhancement as compensation for impacts to these sensitive wetlands will have to be evaluated on a case-by-case basis. Enhancement would involve a net loss of acreage as well as an extremely high risk that the functions represented by the sensitive wetland types will not be replaced.

References

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Wetland Mitigation in the United States:

Assessing the Success of Mitigation Policies

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Abstract

Over most of the past 200 years, wetlands were viewed as useless or worse and about 50% of the original wetlands in the United States were destroyed. Over the past few decades, as the ecological and economic values of wetland habitats have become increasingly recognized, a variety of laws and policies (most notably Section 404 of the Clean Water Act) have been adopted to protect wetland resources. *Mitigation* is a cornerstone of these policies, whereby wetland losses are compensated by wetland restoration, creation or enhancement. Recent surveys show that mitigation policies have reduced the rate of wetland losses, but they have not achieved the goal of "no net loss." Most of these surveys have relied on permit files or simple field visits. These studies show that the area of wetland proposed for mitigation often does not even meet the area impacted. In addition, few mitigation projects are in compliance with all of their permit conditions. The picture is even worse when one considers the ability of restored wetlands to replace natural wetland functions. Several qualitative assessments of wetland mitigation projects in California indicate that some projects produce high quality habitat, but most are moderate quality and some are very low quality. A quantitative functional assessment of riparian mitigation projects in Orange County, California showed that **none** of the mitigation projects were successful from a functional perspective. To prevent continued wetland losses, permit conditions must focus on wetland functions, mitigation ratios (the area of mitigation required compared to the area lost) must be larger, permit conditions must be enforced, and monitoring and remediation must be improved.

Introduction

Throughout most of history, wetlands have been viewed by most of society as undesirable, the source of mosquitoes and disease and noxious odors. Consequently, it is not surprising that a great deal of the original wetland habitat in the United States, as elsewhere, has been destroyed. A comprehensive analysis of wetlands in the United States provides a good estimate of wetland losses (but not degradation) by analyzing aerial photographs of a stratified random sample of 3,629 plots throughout the U.S., each 2,560 acres[1] in size (Dahl and Johnson 1991). In the 1780's, the conterminous United States contained 221 million acres of wetlands (Dahl 1990); by the 1980's, only 103 million acres remained (Dahl and Johnson 1991). Over the past 200 years, 22 states have lost more than 50% of their wetland habitat (Dahl 1990). California has the distinction of having lost the largest fraction of its wetlands, 91%.

Over the past few decades, the value of wetlands has become more apparent. Wetland functions have been catalogued, and wetland values identified (Sather and Smith 1984; Mitsch and Gosselink 1993; National Research Council 1995). For example, wetland functions can include control of surface water storage, maintenance of high water table, the transformation and cycling of elements, the retention and removal of dissolved substances, the maintenance of characteristic plant communities, and food chain support (National Research Council 1995). Wetlands provide important habitat for a variety of fish and wildlife populations, including habitat for about one-third of the plant and animal species federally listed as threatened or endangered and important habitat for migratory birds (Dahl and Johnson 1991). Wetlands also provide many services to humans, including flood control, water quality improvements, and opportunities for hunting, recreation, bird-watching, education and scientific research (Mitsch and Gosselink 1993).

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[1] Areas are reported in acres throughout this paper because that is unit used in permits and reports. To convert acres to hectares, multiply by 0.4047.

Development of Wetland Mitigation Policies

The past destruction of wetlands seems shortsighted in light of our current knowledge of wetland functions and values. As society's understanding of wetland values increased, a variety of policies were established to protect existing wetland habitats. Foremost among these policies has been the concept of wetland mitigation. In this paper, I discuss how wetland mitigation has been applied in the United States. My view is nation-wide, but with a focus on California and the western United States.

The protection of wetland resources has its roots in the concept of mitigation. Mitigation was developed as a way to allow necessary development while protecting natural resources. The concept of mitigation was introduced in the Fish and Wildlife Coordination Act of 1958 (Blomberg 1987). The use of mitigation in natural resource impacts did not become firmly established until the late 1960s, notably with the National Environmental Policy Act (NEPA), which applies to all federal agencies and all activities involving federal monies. NEPA established the procedure for incorporating mitigation analyses into Environmental Impact Statements. NEPA does not require that effective mitigation occurs, but it does require an explanation of mitigation decisions as part of the planning process (Ashe 1982).

One of the early problems with mitigation was inconsistent definitions and applications. If they used mitigation at all, individual agencies applied it according to their own mandates and political environment. The first step towards a consistent national definition came with the Council on Environmental Quality regulations for implementing NEPA, which defined mitigation as: (1) avoiding the impact; (2) minimizing the impact; (3) rectifying the impact; (4) reducing or eliminating the impact over time; and (5) compensating for impacts. This definition includes components of *avoidance* so that an impact does not occur, and *compensating* for impacts that do occur. In general use, and for the most part throughout this paper, "mitigation" usually refers to compensatory mitigation, though it is important to keep the full definition in mind.

At the same time mitigation policy was being developed, the U.S. government moved to restrict development of wetlands by passing the Federal Water Pollution Control Act of 1972 (later the Clean Water

Act). This legislation gave wetlands special protection not afforded other habitat types. Section 404 of the Clean Water Act regulates the placement of dredge and fill materials in the "Waters of the United States," which has been interpreted to include a broad range of wetlands. The U.S. Army Corps of Engineers, in cooperation with the U.S. Environmental Protection Agency, is responsible for implementing the Section 404 program (USACE (United States Army Corps of Engineers) 1986). Mitigation is an important part of the permitting process under Section 404 (Kruczynski 1990), not because it is explicitly required under the Clean Water Act but because the issuance of a Section 404 permit triggers NEPA and its mitigation requirement (Berry and Dennison 1993). The Corps administers a similar permitting program under Section 10 of the Rivers and Harbors Act of 1899.

During the 1980s, the concept of mitigation began to mature. The U.S. Fish and Wildlife Service (Federal Register, v. 46, No. 15 at 7644) adopted the first comprehensive mitigation policy in 1981. The Corps of Engineers adopted its own mitigation policies in 1985. In 1990, the U.S. Congress instructed the Corps to pursue the goal of "no overall net loss" of the nation's remaining wetlands (Section 307 of the Water Resources Development Act). President Bush's administration adopted this "no net loss" goal, as has President Clinton's administration. There is some issue about the interpretation of "no net loss." It is clear that there is a desire that there be no further loss of wetland acres. But if acres alone were the criteria, low-function mitigation wetlands could replace highly functioning natural wetlands, and this would be contrary to the overall goal of protection wetland functions and values. Therefore, the current interpretation is there should also be no net loss of wetland functions and values. This could mean a highly functioning mitigation wetland could replace a low-function natural wetland using a smaller area. On a case-by-case basis, this does occur, but if widely implemented it would mean an overall loss of wetland acreage. Some mitigation policies address these issues explicitly. For example, the U.S. Fish and Wildlife Service mitigation policy for wetlands in the western United States is no net loss of in-kind habitat value or acreage, whichever is greater (Habitat Resources II, Wetland Policy, Region 1, October 22, 1985, cited in DeWeese [1994]).

An important aspect of the refinement of mitigation policy was the development of priorities for evaluating mitigation alternatives. Mitigation that avoids or minimizes impacts is the preferred approach; compensatory mitigation should be used only to mitigate for unavoidable impacts. These priorities are implemented in Section 404 permitting through a process of “sequencing,” initiated through a 1990 Memorandum of Agreement between the Corps and EPA (Berry and Dennison 1993). First, an applicant must show that a project is “water dependent” and must therefore be completed in or near a wetland, and that the project is the least damaging, practicable alternative that meets the specific project purpose. The applicant is also required to attempt to avoid impacts, then minimize them. Finally, if the applicant can show that the proposed project has no alternative sites and the impacts have been minimized but there are remaining impacts to wetlands and “waters,” the permitee may be required to provide compensatory mitigation, such as wetland creation or restoration.

These national efforts have been mirrored by a variety of state policies. For example, the California Coastal Act of 1976 regulates coastal development, with specific guidelines for impacts to wetland habitats. Unlike Section 404, where often an applicant is not required to notify the Corps for impacts less than 1/3 acre and the commonly applied Nationwide Permit 26 allows impacts up to 3 acres, there is no acreage threshold below which a proposed project is categorically exempt from Coastal Commission review. To permit a project, the Commission must find that (1) there is no feasible less environmentally damaging alternative, (2) feasible mitigation measures have been provided to minimize adverse environmental effects, and (3) the functional capacity of an existing wetland or estuary is maintained or enhanced. In evaluating feasible restoration alternatives, availability of potential restoration sites is considered but the sites do not need to be owned by the project proponent. The governor of California has also adopted a no-net loss policy for the state. The states of Oregon and Washington also have specific and complex mitigation policies (Blomberg 1987). Another example is the Freshwater Wetlands Protection Act (FWPA) adopted by New Jersey specifically for protection of freshwater wetlands, considered to be the strongest wetland law in the United States (Torok et al. 1996). The FWPA regulates more activities than Section 404 and requires permits for activities impacting one acre and less of man-made drainage ditches, natural swales or isolated wetlands.

Thus, the current attitude about wetland protection is vastly different from the attitudes of the past. Federal and state policies have been adopted that protect wetland habitats. Although these policies universally favor wetland conservation and protection, they also provide for mitigation of the wetland impacts that are inevitable with continuing public and private development. In the next section, I consider how well these policies are being implemented.

Implementation

There are many different ways to evaluate the implementation of wetland protection and mitigation policies. The simplest is to rely on information contained in permit files. Permit files contain information about the nature of the impacts to natural wetlands, including type of wetland and nature and size of the impact, and the type of compensatory mitigation required, including size and type of wetland to be created or restored. Permits also contain special conditions that establish the goals for the mitigation wetlands. Special conditions are established by regulatory personnel, though frequently with input from the permittee, on a project-by-project basis. As a result, there can be differences between regions and even individuals in what conditions are attached to a permit. On the other hand, there are some general policies that apply broadly. For example, the 1990 Memorandum of Agreement between the Corps and EPA (Berry and Dennison 1993) establishes policy for the location of a mitigation project: the highest priority is given to on-site mitigation, but if off-site, the mitigation should be in close proximity to the impact area, such in the same watershed.

Permit files provide insight into the intent of regulators when they issue permits for wetland projects. Of course, intentions are not always realized, so another approach for evaluating how mitigation policies are being implemented is to assess how well actual mitigation projects meet their permit conditions. From this perspective, compliance with permit conditions would mean successful implementation of permit objectives.

Successful achievement of permit conditions does not necessarily mean that wetland mitigation goals have been achieved, however, because the permit conditions may have been inadequate. Since an underlying goal of mitigation policy is to protect wetland functions and values, a final approach to evaluating the success of mitigation policy is to assess how well mitigation wetlands attain the functions of natural wetlands.

These three approaches are discussed in the following sections.

Acreage Required

When the US Army Corps of Engineers was required by the US Congress to report on its implementation of Section 404, it based its evaluation on the area of wetland impacted and required for mitigation. According to the Corps, Section 404 implementation is resulting in more acres of wetland being required as mitigation than are being allowed to be destroyed (Studt 1994). In 1993, 11,600 acres of wetlands were impacted under Section 404 permits with mitigation requirements for 15,200; in 1994, 17,200 acres were impacted with requirements for 38,000 acres of mitigation (Table 1). Thus, by the simple metric of acreage, overall the Section 404 program appears to be protecting wetland resources in the United States and, in fact, achieving the policy goal of "no net loss."

The Corps data represent data aggregated across the entire United States. Several studies have focused on individual states or regions. Kentula and her colleagues have examined 404 permits for a number of southern and Pacific coast states (Kentula et al. 1992; Sifneos et al. 1992a; Sifneos et al. 1992b). In every case, fewer acres were required as compensatory mitigation than were allowed to be impacted under 404 permits (Table 1). In some cases, such as Arkansas, the number of permits was quite low (only 7) and the difference between impacts and compensatory mitigation was small (only 10.7 acres, or 1.5% of the impacts). In other cases, though, many acres were impacted or the difference between impacts and mitigation were substantial. For example, 2,945 acres were impacted in Texas, but 917 fewer acres were required as mitigation, for a loss of 31%. In Oregon, fewer acres were involved but the loss was 43%.

Several studies have assessed wetland mitigation in California (Table 1). Holland and Kentula (1992) summarized statistics for the entire state. In contrast to other states, there was a net gain of wetland acreage, although the gain was very small (0.06%). McEnespy and Hymanson (1997) reviewed 13 permits given by the California Coastal Commission for wetland mitigation in coastal California. The total acreage was small (12.7 acres of impacts), but acres of mitigation required exceeded impacts by 32%; most (13.0 acres) of the compensatory mitigation was enhancement of existing wetland rather than restoration or creation. This pattern of more acres of mitigation than impacts has also been found in studies of California subregions. (DeWeese 1994) examined Section 404 permits for the San Francisco Bay-Delta region issued between 1983 and 1993. A subset of 30 projects was evaluated from a total of 168 permits for the area. For these 30 projects, 415 acres of impacts were to be mitigated by the 599 acres of mitigation, for a gain of 184 acres (Table 1). Allen and Feddema (1996) reviewed 75 projects in southern California in which 276 acres of mitigation were required for 199 acres of impacts. Sudol (1996) examined Corps permits (both Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act) issued in Orange County from 1979 to 1993. The 70 permits requiring mitigation permitted 335 acres of impacts while requiring 376 acres of mitigation, for a gain of 41 acres (Table 1). In San Diego County, impacts to 253 acres of wetlands were compensated by requiring 382 acres of mitigation, a 51% increase in area (Fenner 1991). Thus, it appears that the imposition of compensatory mitigation requirements for wetland impacts in California may have been more in line with national mitigation policy than in other states, at least in terms of increasing acreage.

The preceding analyses focused on permits requiring compensatory mitigation. Only a subset of all Section 404 permits require compensatory mitigation. In Louisiana, 41% of the 404 permits required compensatory mitigation (Sifneos et al. 1992a), whereas only 3% of the permits in Oregon required mitigation (Kentula et al. 1992). By including only permits requiring compensatory mitigation, these studies may have overlooked some cases of uncompensated loss. For example, 13% of the 535 Corps permits for Orange County required compensatory mitigation (Sudol 1996). The remaining 465 permits allowed 54 acres of impact without compensatory mitigation. Most of these permits were issued under Section 10 for work in bays and harbors that was considered to have minimal impacts on the aquatic environment. Nonetheless, if the 54 acres of impacts is added to the 335 acres of impacts allowed by permits requiring compensatory mitigation, then overall Orange County has experienced a net loss of 13 acres (3.3%) rather than an increase of 41 acres.

Aside from the issue of inadequate acreage being required, other problems with the implementation of Section 404 have been uncovered by analyzing permit files. In Oregon and Washington, impacts and compensatory mitigation were not balanced for some types of wetlands (Kentula et al. 1992). In Oregon, freshwater marshes had the greatest loss, with additional uncompensated losses of forested wetlands and lower riverine bottom habitat. In contrast, 18 freshwater ponds constituting 19% of the area were created, even though no freshwater ponds were impacted. For estuarine wetlands, there was a large loss of subtidal flats but a gain in salt marsh. Similar patterns were seen in Washington. In southern California, riparian woodlands accounted for 20% of the impacts but 35% of the required mitigation, whereas freshwater wetlands accounted for 29% of the impacts but only 19% of the required mitigation (Allen and Feddema 1996). In addition, compensatory mitigation under Section 404 can include projects that do not create or restore wetland habitat. For example, the planned mitigation projects in Orange County included 24 acres of enhancement of existing wetlands and 31 acres of passive revegetation (Sudol 1996). Although enhancement can improve wetland functions, it does not increase wetland area, and including this acreage in mitigation summaries as if it is a “gain” in area (which must usually be done because of the nature of permit records) overestimates the actual gain in wetland area.

Analyses based on area of wetlands impacted and required as compensatory mitigation rely on reviews of permit files. Each of the studies cited above has noted the difficulties associated with such reviews because of poor data quality, incomplete files, and poor accessibility. In spite of these problems, file reviews provide a useful picture of the *intent* of regulators when they issue permits for wetland projects, an important aspect of the implementation of wetlands policy. However, permit reviews provide only a limited view of compensatory mitigation. On the one hand, they only consider the final permit actions, not the avoidance and minimization of impacts that result from the permitting process. Allen and Feddema (1996) report that 14 permits were withdrawn from 1987-89, and that withdrawn permits are sometimes resubmitted with reduced wetland impacts. On the other hand, permit reviews cannot determine whether the required mitigation was actually undertaken, whether it actually complied with the terms of the permit, and whether it fully compensated for the wetland functions and values lost by the permitted project. Actual implementation and compliance of mitigation projects are discussed in the next section, while the function of mitigation wetlands is discussed in the following section.

Compliance with Permit Conditions

An assessment of how well wetland mitigation projects actually meet their permit requirements cannot be based on an office review of permit files. In theory, permittees provide the Corps with a signed certificate of compliance after completion of the project stating that they fully complied with the permit's terms and conditions. In practice, the Corps cannot keep track of whether these certificates have been filed, and in any case it is unlikely that a permittee would certify that the permit conditions were not met! Thus, an assessment of permit compliance necessitates an on-site review of mitigation sites. During a site visit, the conditions at the mitigation site can be compared to the permit requirements. Surprisingly few assessments of actual permit compliance have been completed in the United States. Results of early surveys in San Francisco Bay ranged from a low of 3% success (Eliot 1985) to 33% (Demgen 1988) or 43% (BCDC (Bay Conservation and Development Commission) 1988) success. (Note that some of these early studies often confounded *compliance success*, how well the projects met their permit requirements, with *ecological success*, how well they replace the functions of natural wetlands.) Recently, three different studies were completed in California, and these examples are discussed below.

DeWeese (1994) reviewed 30 projects in the San Francisco Bay-Delta region given Section 404 permits by the Army Corps of Engineers. Each project was given a Compliance Rating from 0-10, with 10 indicating full compliance, 9 indicating 85-99% compliance, and so forth. Only 3 projects complied with 100% of their permit requirements (Figure 1A). Six projects complied with 85-99% of their permit conditions, and another six projects complied with 75-84%. Twelve projects complied with 45-74% of their permit conditions. Finally, one project complied with only 1-14% of its permit conditions, and two projects had zero compliance. In terms of compliance, then, there were a few projects that fully complied with their permits, a few more that were nearly in compliance, the majority in the middle range, being out of compliance for a substantial number of permit conditions, and a few with very poor compliance.

DeWeese's summary of mitigation compliance indicates a number of problem areas regarding permit conditions. For example, the notes for one project (PN 9957) indicate a number of problems with plant survival and concerns about adequate irrigation, in part because the planting sites were high on a levee and might be too far from the water table. There are also questions about the maintenance and removal of vegetation planted as mitigation. These problems raise serious questions about the long-term sustainability of this site. Nonetheless, the site was given a perfect score (10) for compliance. DeWeese notes "the permit does not require that the plants have vigorous growth, only that they be alive."

DeWeese's study also illustrates an additional problem with using permit file summaries to evaluate the implementation of mitigation policies. Although 599.4 acres of mitigation were required by the Section 404 permits, only 537.2 acres were actually created. This still exceeds the 415.3 acres of impacts allowed by the permits, but reduces the excess acreage from 184.1 acres to 121.9 acres.

McEnespy and Hymanson (1997) conducted a similar survey of wetland mitigation projects, this time based on compliance with conditions established in California Coastal Commission permits. Half of these projects met 90-100% of their permit conditions (Figure 1B; compliance was not reported with finer resolution). Four projects (22%) met fewer than 32% of their permit conditions.

Sudol (1996) evaluated permit compliance at the Section 404 and Section 10 permits issued in Orange County from 1979 to 1993. Thirty of the 70 sites (43%) met all of their permit conditions and were considered successful; these projects comprised 195 acres. Six sites (9%) comprising 52 acres did not meet any of their permit conditions and were considered failures. In addition to the six failures, mitigation was never attempted at two sites where it was required. Finally, the permitted project was never completed for some reason at 13 sites, and so no compensatory mitigation was needed, even though these permits are included in summaries based on permit files. Excluding these "no project" sites, there were 315 acres of impacts; only 195 acres of mitigation met all permit conditions, for a success rate of 62%. Looking just at riparian sites (discussed further below), there were 40 projects allowing 240 acres of impacts and requiring 256 acres of mitigation. Twenty of the projects covering 143 acres successfully met all of their permit conditions, for a success rate of 60% by acres; 7 projects covering 41 acres were failures (17% by acres).

Achievement of Mitigation Goals: Replacement of Wetland Functions

The assessments reviewed thus far have not assessed the ecological trade-offs in mitigation, yet these are the most controversial. The basic goal for mitigating impacts to natural wetlands is to replace wetland functions (and values). In Oregon and Washington, functional replacement was listed as the goal for >65% of Section 404 permits requiring compensatory mitigation (Kentula et al. 1992). Unfortunately, few studies have assessed whether this goal is being accomplished.

Shortly after wetland mitigation became widespread, questions about its appropriateness were raised (Race and Christie 1982; Quammen 1986). One of the first critiques of wetland mitigation concluded that few, if any, wetland restoration projects in San Francisco Bay were successful (Race 1985). A review of 14 wetland mitigation projects in San Francisco Bay found that 43% of the projects were successful, in that they met their permit conditions and created valuable Bay resources (BCDC (Bay Conservation and Development Commission) 1988). Zentner (1987) examined 63 coastal wetland restoration projects throughout California and found that 65% of them were successful (defined as exhibiting roughly typical wetland values as similar, unrestored wetlands and meeting the goals of the project).

One problem with these early studies is that they relied on non-quantitative, subjective evaluations. In recent years, many studies have provided a quantitative comparison between restored and natural wetlands (e.g., Craft et al. 1988; Moy and Levin 1991; Rulifson 1991; Chamberlain and Barnhart 1993; Sacco et al. 1994; Havens et al. 1995; Streever et al. 1996; Minello and Webb 1997; Zedler et al. 1997). However, few of these studies have taken a broad look at mitigation *per se*, and concerns about whether constructed or restored wetlands can successfully replace natural wetland functions remain. A recent special feature in the journal *Ecological Applications* highlighted some of the concerns (Zedler 1996).

After 10 years, Race notes that, in spite of progress in some areas, compensatory mitigation continues to have a poor record of performance (Race and Fonseca 1996).

In perhaps the most detailed study of the functional equivalence of a mitigation wetland, Zedler and her coworkers have developed an extensive body of information about two mitigation projects in San Diego, California (Pacific Estuarine Research Laboratory (PERL) 1990; Zedler 1996; Haltiner et al. 1997). The mitigation marshes were constructed on dredge spoils with substantially different sediment characteristics than natural marsh sediments, including coarser grain size and lower organic and nutrient contents. This fundamental difference has led to lower cordgrass (*Spartina foliosa*) heights than at a nearby reference natural wetland (Langis et al. 1991; Gibson et al. 1994; Boyer and Zedler 1999), and the consequent absence of the endangered species, the Light-Footed Clapper Rail, for which the mitigation was required (Zedler 1993). Five years after construction, the mitigation marsh did not reach the level of the natural marsh reference site for 10 of 11 ecosystem functions (Zedler and Langis 1991). Although the sediment may eventually become similar to the reference site, even after 12 years there is little evidence of a clear trajectory to convergence (Zedler and Callaway 1999). However, the mitigation site was not deficient in all functions: the fish assemblage was comparable to the reference site (Zedler et al. 1997).

Although Zedler's detailed studies of the San Diego mitigation salt marshes provide strong evidence that restored wetlands may not fully replace the functions of natural wetlands, they do not provide insight into the frequency and severity of this problem. Several recent studies that have surveyed a number of different mitigation projects can provide this broader perspective. Not surprisingly, there is a trade-off between the level of detailed information that can be obtained at one or two sites versus many different sites. As a result, these survey studies have less detailed information about each site, and frequently depend on qualitative assessments involving "best professional judgement." In spite of the limitations of this subjective approach, these surveys yield provide useful information about the general success of wetland mitigation projects.

DeWeese (1994)used a qualitative assessment of wetland value to evaluate the success of Section 404 projects in the San Francisco Bay-Delta region. Each project was given a Value Rating from 0-10, with

10 indicating extremely high value (among the best examples of this habitat type in the region) and 0 indicating no value; this rating system is similar to the ratings given for compliance (see above). The ratings were determined by each evaluator's best professional judgement. Most of the projects evaluated (53%) were more than five years old (the period most frequently specified in Corps permits for monitoring).

Of the 29 mitigation projects evaluated, only one was judged to have very high value (Figure 2A). Thirteen projects were judged average or slightly above or below average. Six projects were judged well below average, two were judged to have low value, and two projects were judged to have no habitat value. Although the goal of "no net loss of acreage" was being met in the Bay-Delta region, the mitigation projects were not replacing in-kind habitat values. The average value rating was only 4.66 for the 30 projects studied.

Compliance ratings were correlated with value ratings for different wetland types. For example, the two wetland types with the lowest compliance ratings, riparian and vernal pools, also had the lowest value ratings. This correlation also holds for all projects considered individually, with $r=0.69$ ($P<0.01$, $N=29$ because value was not rated at one site). These results suggest that mitigation projects that met their permit conditions were most likely to provide high habitat value.

DeWeese emphasized the importance of permit compliance for ensuring a successful project. One particular shortcoming highlighted was the frequent omission of monitoring reports. DeWeese considered the primary objective of the monitoring report to be requiring the permittee to evaluate interim project success and take remedial actions when necessary; absence of a monitoring report, therefore, may reflect a lack of attention to the mitigation site. DeWeese also noted that permits commonly included inadequate success criteria. Success criteria were stated as vague goals or a single criterion (e.g., percent vegetation survival) with no reference site designated as a control.

McEnespy and Hymanson (1997) examined sites permitted under the California Coastal Act. Using a methodology similar to DeWeese's, sites were evaluated during field visits and assigned a subjective score based on the perceived habitat quality. Six of the 23 projects were given the highest grade of “A,” six were given B’s, and six were given C’s (Figure 2B). There were four projects given the barely passing score of D, and one project was given an F. Although the middle-to-lower distribution of scores appears similar to DeWeese’s, relatively more projects were judged to have higher value. Because of the subjective nature of the assessments, it’s not possible to know whether the Coastal Commission projects were actually resulting in higher habitat quality (perhaps because of better oversight or planning), or whether the apparent differences are due to differences in scoring.

Allen and Feddema (1996) used a different approach when they examined 75 southern California wetland sites. They used a subjective methodology that evaluated project completion/compliance and three condition criteria: vegetation status, ground cover, and invasion by weeds. They “discounted” mitigation acreage according to the status of the project. For example, for projects that were completed and generally complied with Corps permit requirements but exhibited significant problems in one of the three condition criteria, the project area was multiplied by 0.75; if two of the condition criteria were not met, the project area was multiplied by 0.50. If mitigation was incomplete or unsuccessful, the project area was multiplied by 0.0. Overall, Allen and Feddema found a 69% success rate, so that 191 acres served as mitigation for 199 acres of impacts. Successful mitigation was substantially lower than the 276 acres required by the permits, so that instead of the apparent 38.7% increase in acreage in the permits (Table 1), there was a slight decrease in acreage. Allen and Feddema found a difference in mitigation success between Orange County (75%) and Riverside County (40%), as well as a slightly higher success rate for large projects (>8.6 acres) compared to small (73% versus 66%).

Although not related to compensatory mitigation under Section 404, Josselyn et al. (1993) evaluated restoration projects conducted under the California State Coastal Conservancy’s program. Twenty-two projects at 19 sites were selected for evaluation; as a result of these projects 1652 acres of coastal wetland were acquired or enhanced. The success of each project in enhancing specific wetland functions was evaluated subjectively using best professional judgement. At 36% of the sites, all of the evaluated wetland functions were improved by the restoration. At 48% of the sites, at least one wetland function was not improved by the restoration project, and one site (5%) failed in all functions evaluated.

Using criteria established by the National Research Council (1992) for judging project effectiveness, Josselyn et al. (1993) found that 59% of the projects were effective at achieving their goals, 45% were effective at producing a self-sustaining ecosystem, 61% were effective at restoring critical functions, and 55% were effective at producing habitat benefits. For each of these categories except producing a self-sustaining ecosystem, only 5% of the projects were ineffective. The majority of restoration projects did not produce a self-sustaining ecosystem, and 31% were judged ineffective in this category.

Qualitative assessment approaches such as those just described are used because they are quick and easy to implement, but they have many significant shortcomings. For example, comparisons among studies are complicated by the subjective nature of the assessments, as mentioned above. Qualitative assessments also have tended to focus on vegetation and other easily reviewed aspects of a site, overlooking important wetland functions. As an alternative to qualitative assessments, the Hydrogeomorphic (HGM) assessment methodology has been developed to provide a function-based assessment approach appropriate for regional wetland types (Smith et al. 1995; Brinson et al. 1997). HGM is appropriate for planning and assessment of wetlands in a regulatory context. It is particularly well suited for questions concerning the mitigation of wetland impacts from the standpoint of the replacement of wetland functions (Rheinhardt et al. 1997; Hauer and Smith 1998), and has recently been used for impact assessment and mitigation planning (Ainslie and Sparks 1999). HGM classifies wetlands by hydrologic and geomorphic properties and uses information on other wetland sites from the region in the same HGM class to develop and calibrate standards for assessment. The number of functions included in the assessment depends on the wetland class, but are included in the general functional categories of hydrology, biogeochemistry, and maintenance of characteristic plant and animal communities. HGM models are developed for specific wetland classes (e.g., estuarine fringe wetlands), which allows them to be tailored to the specific functions performed by that wetland class in a specific region, but precludes comparison between different types of wetlands. HGM results provide an indication of the potential for a wetland to perform various functions, but does not directly measure the functions or the actual “value” of the site.

As part of his evaluation of all mitigation projects required by the Corps of Engineers in Orange County, CA as compensation for impacts to riparian habitats under Section 404, Sudol (1996) used HGM to provide a quantitative indication of wetland functions at a variety of mitigation sites. I have already discussed Sudol's survey of permit compliance at 70 mitigation sites in Orange County. The HGM assessment was conducted at all of those sites classified as lower perennial riverine habitat. Forty projects were included, representing 240 acres of impacts with 256 acres of proposed mitigation. The 15 habitat functions included in the HGM model were assessed for all 40 projects, and compared to the values at 7 reference sites representing the best attainable conditions in the region. The functions were combined into three subgroup scores, for hydrology, biogeochemistry, and habitat. Criteria for success were based on the functional capacity scores of the reference sites. Since none of the reference sites had subgroup functional capacity scores less than 83% (most were much higher, with a mean of 95%), the criterion for successful achievement of a subgroup function at a mitigation site was set at 80%. This criterion is quite low compared to the functioning at the reference sites in order to avoid judging the mitigation sites too harshly. Any site that scored less than 50% on two of the three function subgroups was judged a failure.

The results are striking. Not a single mitigation site was found to be successful. Five sites (16.5 acres of impacts and 24.0 acres of mitigation) were complete failures without applying an HGM assessment based on a lack of vegetation and hydrology. The remaining 35 projects were located at 20 sites. Of these, only two sites were judged successful for even one subgroup (hydrology) (Figure 2C), and many of the sites achieved less than 50% functional capacity in all three subgroups. Except for the two hydrology subgroup scores, the functional capacities of the mitigation sites were not even in the range of the reference sites. The distribution of the mitigation site subgroup functional capacities seemed to be bimodal, with one mode at 60% functional capacity and the other at 20%. These results indicate that most of the functions were being performed at a low level at most of the mitigation sites.

The major reason for the failure of these sites was the lack of proper hydrology, specifically stream channels. Most of the mitigation sites were planted and irrigated upland sites. There is no overbank flooding at these sites, so hydrological functions such as dynamic surface water storage and energy dissipation are low. The habitat scores were higher because of the ease of establishing vegetation on irrigated sites. However, even HGM does not measure an aspect of habitat function that is undoubtedly lacking at these sites: sustainability. Without the proper hydrologic regime, the riparian vegetation cannot be sustained at these sites even if irrigation can support planted riparian vegetation.

Sudol's results demonstrate the importance of judging the success of mitigation based on quantitative assessment of wetland functions. Comparing only acres of impacts with acres of mitigation, the riparian habitat losses caused by 40 projects in Orange County were more than compensated for, with 256 acres of mitigation required for 240 acres of impacts. Based on acres alone, all 256 acres of required mitigation are considered successful (Figure 2). Based on permit conditions, only 143 acres successfully met their permit conditions, and 41 acres failed to comply with any of the permit conditions. The HGM assessment, however, shows that even the sites that achieved compliance success did not attain ecological success. From a functional perspective, 0 acres were successful, 15 acres were partially successful, and 241 acres were a failure.

Sudol's results also highlight the difference between qualitative and quantitative assessments of ecological success, because he made independent assessments using each approach. Sudol's qualitative assessment, based on the type of field review using best professional judgement, indicated that 9 projects, accounting for 104 acres of impacts and 63 acres of mitigation, were successful, and 14 projects accounting for 51 acres of impacts and 84 acres of mitigation were failures. As with most qualitative assessments, Sudol's assessment was heavily influenced by the vegetation at the site. For example, success was defined as habitat with "similar spatial and species diversity as minimally disturbed habitat," while failure was assigned to sites with mostly upland plant species or less that 10% cover of vegetation. The HGM assessment provided a much broader framework for assessing functions. Ultimately, this broader framework was responsible for identifying fundamental flaws in the functioning of the mitigation sites. The difference in conclusions is dramatic: from 63 acres of successful mitigation and 84 acres of failed mitigation to 0 acres of success and 241 acres of failure. Thus, Sudol's work suggests that the ecological success rate found in other studies using "best professional judgement" may, in fact, be higher than warranted by a broader view of wetland functions.

Conclusion

The United States has some powerful laws and policies aimed at conserving wetland habitats. They are the result of the relatively recent realization of the magnitude of wetland loss in the United States coupled with a recent recognition of the ecological importance of wetland functions and the societal value of wetland habitats. However, there are problems with nearly every aspect of the implementation of these policies. As a result, wetland losses continue, albeit at a lower rate.

The problems described here do not mean that there is no value to mitigation policies. The policies have been evolving to protect wetlands better, and some of the studies discussed here have only recently identified remaining problem areas. In the United States, there is little point in considering the elimination of mitigation; outlawing any development in any wetland would raise serious issues of private property rights and legal "takings." Instead, we must focus on ways to improve the actual practice of mitigation. Several other authors have offered recommendations for ways to improve the success of wetland mitigation (BCDC (Bay Conservation and Development Commission) 1988; National Research Council 1992; Allen and Feddema 1996; Race and Fonseca 1996).

One reason for continued wetland losses is that too many wetland impacts are allowed to go unmitigated. Some of these losses occur because the regulatory protection of wetlands is not broad enough. For example, one of the largest sources of wetland loss, conversion of wetlands to agriculture, is not even regulated under Section 404 of the Clean Water Act (Holland and Kentula 1992). Even for impacts that are regulated, substantial losses still occur. Some 404 permits allow wetland losses without requiring mitigation; in Orange County, this amounted to 16% of the permitted impacts (Sudol 1996). Some are the result of nationwide permits, which allow impacts that are presumed to be non-significant. It is clear, however, that the cumulative effect of hundreds or thousands of small impacts can be significant (Stein and

Ambrose 1998). Finally, an unknown number of acres are impacted due to illegal activities; I will come back to enforcement issues later.

Even for those wetland impacts for which mitigation is required under a permitting program such as Section 10 or Section 404, implementation of the mitigation policy is insufficient. For most states that have been studied, even based on acreage the wetland impacts are not fully compensated. And too much emphasis has been placed on acreage. From both a compliance standpoint and a function standpoint, many (or sometimes all) wetland mitigation projects are not fully successful.

Several steps could be taken to improve the record of wetland protection under existing regulatory programs.

All studies that reviewed permit files have noted substantial problems with record-keeping. Holland and Kentula (1992) note that acreage data were lacking for 40% of impacted and compensatory wetlands. There have also been problems with permit follow-up. For example, Holland and Kentula (1992) found completion dates specified in only 2.2% of compensatory wetlands in California. Holland and Kentula (1992) recommend improved documentation, regular reporting, and increased monitoring.

Although improved record-keeping is essential for evaluating the effectiveness of the 404 Program, in itself it does not ensure that the appropriate compensatory mitigation is completed. Race and Fonseca (1996) have argued that the key to improving the effectiveness of mitigation is "getting to compliance." They recommend a stronger emphasis on compliance and enforcement. Moreover, they contend that noncompliance will likely continue as the norm unless enforcement and monitoring are emphasized. Although recognizing the importance of improved scientific understanding of restoration and creation efforts, they argue that additional scientific information will not be sufficient to resolve the current problems with compensatory mitigation.

One of the most important steps towards improving mitigation would be to improve the special conditions attached to permits requiring mitigation. To a large degree, permit conditions will determine how well compensatory mitigation replaces natural wetland functions and values – at least they establish what is expected. A major shortcoming of most permits is the failure to require replacement of wetland functions and processes; instead, performance standards are based on simple measures such as plant survivorship or cover. Part of the reason that mitigation wetlands do not replace natural wetland functions is undoubtedly the difficulty of reproducing natural functions and processes. But part of the problem is also the non-rigorous expectations established in permit conditions. Permittees and their consultants can be very good at providing the conditions required in permits. In Orange County, for example, permit conditions generally focused on survival of planted riparian trees, so consultants became quite good at producing "tree farms." Because the permits did not require the replacement of natural hydrologic or biogeochemical functions, it is perhaps not surprising that these functions were not present at mitigation sites. Requiring that these functions be replaced, as a permit condition, will challenge the consultants to find methods for replacing them.

Monitoring requirements must also be improved for mitigation projects. Lax monitoring requirements may send the wrong message to a permittee, suggesting that there is little interest in whether or not a mitigation project is successful. For example, monitoring by even one follow-up visit was required for less than one-third of compensatory mitigation sites in California (Holland and Kentula 1992), and for only 10% of the projects in Louisiana (Sifneos et al. 1992a). Most monitoring requirements are too short. The longest monitoring period typically required in Section 404 permits is five years, although monitoring can be longer if the mitigation involves a unique habitat type or is not successful. Recent studies have indicated that the long-term functioning and sustainability of a restoration site may not be apparent until 10 to 40 years after the project is completed. Finally, the permittee is responsible for monitoring. Although the permit conditions can specify what needs to be monitored and the permittee may be required to hire a biological monitor (i.e., someone trained to do this work), this does not remove the potential conflict of interest in which a permittee decides whether they have complied with permit conditions. Independent monitoring, where the monitor answers to the permitting agency rather than the permittee, might provide a more accurate accounting of restoration success.

Monitoring is also necessary to evaluate whether or not remediation is needed. Typically, there is no explicit provision for remediation if ecological functions are not replaced by a mitigation wetland. A permittee's responsibilities end with the satisfaction of permit conditions, but the simple, non-function basis and short time frame for most performance standards (3-5 years) means that there is little assurance that natural wetland functions will be produced and sustained. To compensate fully for impacts to a wetland, a mitigation wetland must provide the same wetland functions for as long as the impacted wetland would have provided those functions. Success in the short term (3-5 years) does not mean that the mitigation wetland will be as resilient to environmental perturbations as a natural wetland. Thus, mitigation wetlands must be monitored for an extended period of time, and appropriate remediation undertaken if the wetland ceases to provide replacement of the lost wetland functions.

Good mitigation policies do little good if there is no enforcement. The present lack of enforcement allows inadequate efforts to be considered successful, and illegal actions (e.g., failing to construct a required mitigation project) go undetected. Although there is widespread concern about the lack of enforcement, Sudol (1996) found relatively few cases where wetland impacts were permitted but the required mitigation was not undertaken. Still, there is little question that unpermitted activities are illegally impacted wetlands (although the magnitude of the impacts are not well known), and increased enforcement could help stem these losses.

Finally, it is clear that even the best implementation of mitigation policies, with appropriate permit conditions and monitoring, will not ensure successful mitigation. Experience to date suggests that even projects that have been carefully designed to replace natural wetland functions do not always do so. There is just too much we still don't know about how to restore or create wetland habitats. The history of mitigation failures argues for extreme caution. The greatest precaution is to avoid destruction of natural wetlands whenever possible. If this is not possible, we need to take the precautions mentioned above, and in addition higher mitigation ratios may be necessary in order to end up with no net loss of wetland functions in a region. We need to consider wetland restoration or creation as experimental. Adaptive management (see Zedler 1996) provides a framework to improving our understanding of wetland mitigation over the long term, so that eventually we may actually be able to realize the goal of no net loss of wetland functions.

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Table 1. Summary of wetland losses and required mitigation. Except for McEnespy and Hymanson (1997), all projects summarize Section 404 permits; permits not requiring mitigation were excluded from the analyses.

Location	Date	No. of permits	Impacts (acres)	Mitigation (acres)	Change (acres)	Change (%)	Comments	Reference
United States	1993 1994	NA NA	11,600 17,200	15,200 38,000	+3,600 +20,800	+31.0 +120.9		Studt 1994
Louisiana	1982-87	93	2909.6	2191.0	-718.6	-24.7	Permits req. mitigation 41% of total, 8% of imp. area compensated	Sifneos et al. 1992a
Alabama	1982-87	18	112.9	267.6	+154.7	+137.0	All permits req. mitigation	Sifneos et al. 1992a

Table 1. (continued)

Location	Date	No. of permits	Impacts (acres)	Mitigation (acres)	Change (acres)	Change (%)	Comments	Reference
Mississippi	1982-87	5	1,006.7	1,006.9	+0.2	+0.0002	Permits req. mitigation 50% of total, 37% of imp. area compensated	Sifneos et al. 1992a
Texas	1982-86	46	2,944.5	2,027.2	-917.3	-31.2		Sifneos et al. 1992b
Arkansas	1982-86	7	703.3	692.6	-10.7	-1.5		Sifneos et al. 1992b
Oregon	1977-87	58	182.8	103.7	-79.1	-43.3	Permits requiring mitigation 3% of total	Kentula et al. 1992b
Washington	1980-86	35	150.7	111.2	-39.5	-26.2		Kentula et al. 1992

Table 1. (continued)

Location	Date	No. of permits	Impacts (acres)	Mitigation (acres)	Change (acres)	Change (%)	Comments	Reference
California	1971-87	324	2,906.6	3,103.3	+196.7	+0.06		Holland & Kentula 1992
California	1976-90	13	12.7	16.8	+4.1	+32.2	Calif. Coastal Comm. permits req. mitigation	McEnespy and Hymanson 1997
Southern California	1987-89	75	198.8	275.8	+77	+38.7		Allen and Feddema 1996
SF Bay-Delta, CA	1983-93	30	415.3	599.4	+184.4	+44.3	Randomly selected from 168 projects	DeWeese 1994
Orange Co., CA	1978-93	70	335	376	+41	+12.2	Permits req. mitigation 13% of total	Sudol 1996

Table 1. (continued)

San Diego Co., CA	1985-89	ND	252.6	381.8	+129.2	+51.1		Fenner 1991

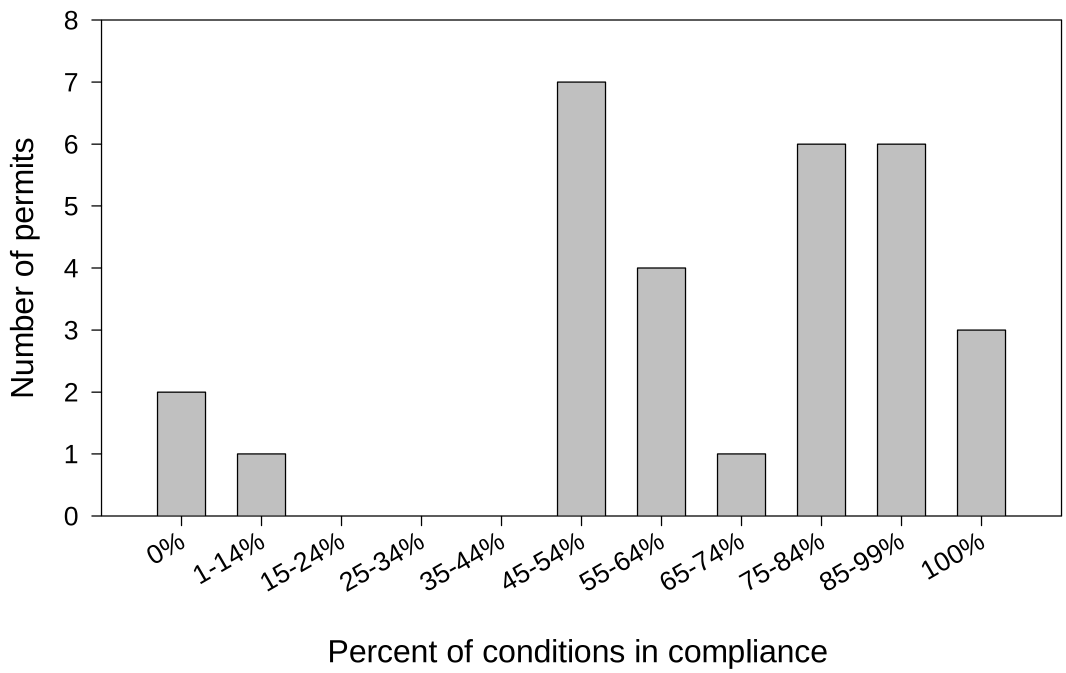
Figure Legends

Figure 1 Compliance of mitigation projects. (A) Compliance of mitigation projects in the San Francisco Bay-Delta region, California, with Section 404 permit conditions (data from (DeWeese 1994). (B) Compliance of coastal mitigation projects in California with conditions established in California Coastal Commission permits (data from (McEnespy and Hymanson 1997).

Figure 2 Habitat value of mitigation projects. (A) Qualitative ranking of 29 mitigation projects in San Francisco Bay-Delta region, California, based on best professional judgement (data from (DeWeese 1994). (B) Subjective ranking of mitigation projects permitted by the California Coastal Commission (data from (McEnespy and Hymanson 1997)). (C) Functional subgroup scores from Hydrogeomorphic (HGM) assessment of 20 riparian mitigation sites in Orange County, California (data from (Sudol 1996). Each project was scored for three functional subgroups (hydrology, biogeochemistry and habitat). Also shown are subgroup scores for 7 reference sites.

Figure 3 Success of riparian mitigation in Orange County using different criteria. “Planned mitigation” compares the required mitigation area to the area of impacted riparian habitat (97 ha or 240 acres). “Permit conditions” bases success on the degree to which a project met the special conditions established in its permit. “HGM Evaluation” bases success on the functional capacity of a mitigation site compared to reference sites.

A.


8
7
6
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4
3
2
1
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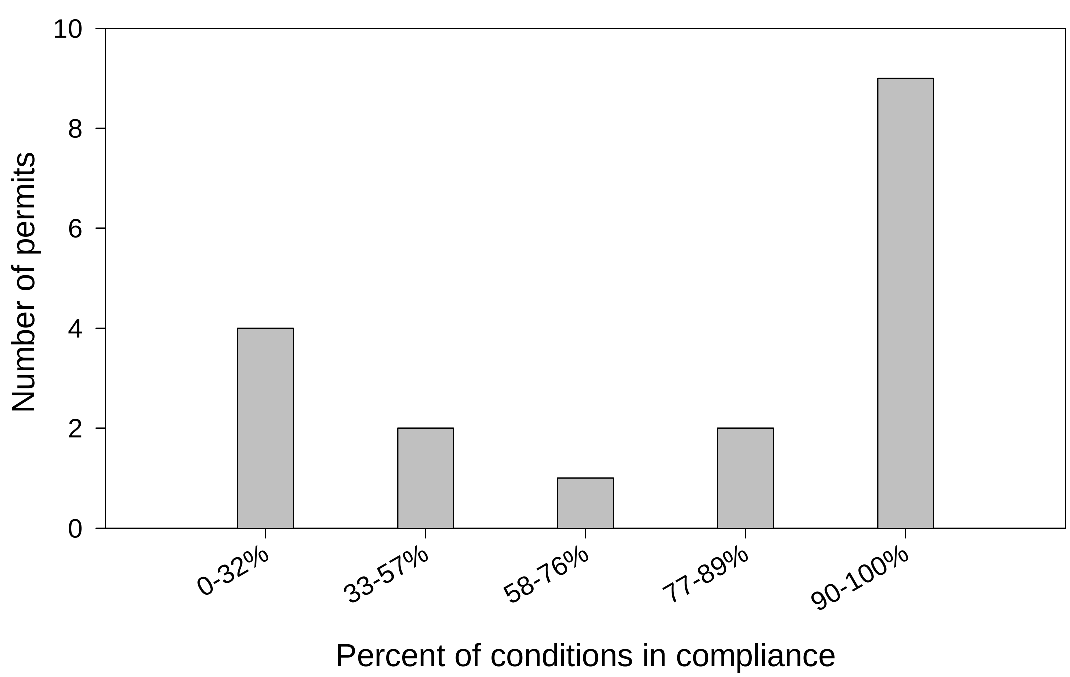
Number of permits
0%
1-14%
15-24%
25-34%
35-44%
45-54%
55-64%
65-74%
75-84%
85-99%
100%
Percent of conditions in compliance

B.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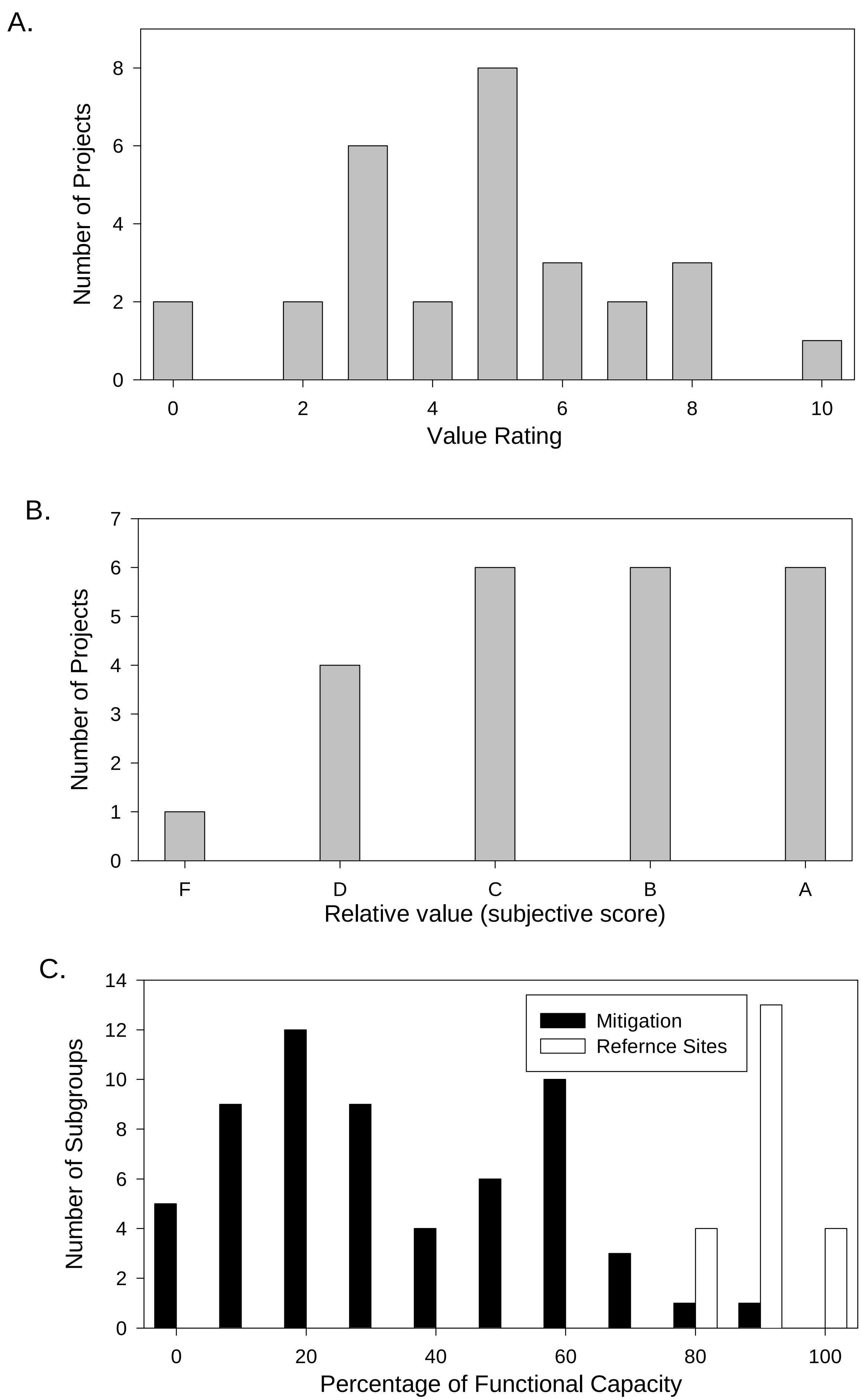
Number of permits
0-32%
33-57%
58-76%
77-89%
90-100%
Percent of conditions in compliance


A.
Number of Projects
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Value Rating
B.
Number of Projects
0
1
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3
4
5
6
7
F
D
C
B
A
Relative value (subjective score)
C.
Number of Subgroups
0
2
4
6
8
10
12
14
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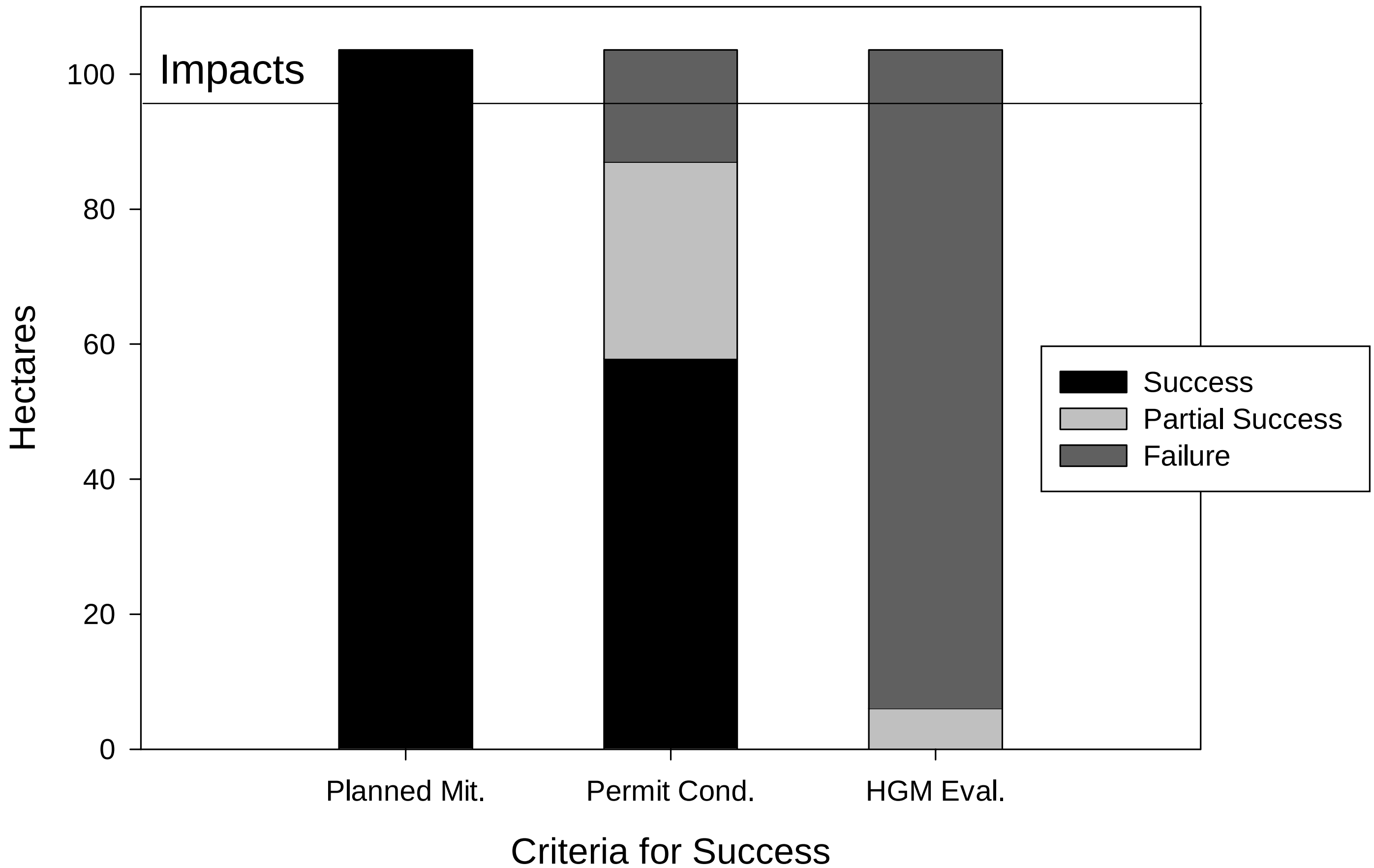
20
40
60
80
100
Percentage of Functional Capacity
Mitigation
Refernce Sites


Impacts
100
80
60
40
20
0
Hectares
Success
Partial Success
Failure
Planned Mit.
Permit Cond.
HGM Eval.
Criteria for Success

Evaluating the Success of the San Dieguito Lagoon Restoration Project through Independent Monitoring of Performance Standards

By Steve Schroeter and Mark Page, Research Biologists, and Coastal Commission Contract Scientists, UCSB Marine Science Institute

In the December 2005 issue of *Currents*, Dr. David Kay, Environmental Manager of Southern California Edison (SCE), provided an overview of the history and details of the San Dieguito Lagoon Restoration Project. The goal of this project required by the California Coastal Commission (CCC) is to provide out-of-kind mitigation for the impacts of the San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 on fish populations in the Southern California Bight. The San Dieguito Wetland Restoration is notable for its size, 440 acres in total, and that 150 acres of which are the actual creation of tidal wetland from upland habitats that were largely degraded (e.g. degraded farmlands, weedy old fields, a former World War II airfield). Other key elements of the Restoration Project include perpetual inlet maintenance to maintain tidal flushing and enhance biota in the lagoon, the establishment of trails and interpretive facilities, and the construction and maintenance of about 12.5 acres of nesting sites for the federally endangered California Least Tern. The inlet maintenance, an element of SCE's Coastal Development Permit (CDP), will ensure full tidal action to the project's 150 acres of created tidal wetlands and will enhance the biota in the pre-existing tidal salt marsh habitats fringing the restoration.

Aside from the size and scope of the San Dieguito Lagoon Restoration, this project is unique in requiring independent monitoring of specific performance standards to evaluate the success of the restoration in achieving the goals and objectives for the project as outlined in the SONGS CDP and the Restoration Plan. Monitoring is conducted independently of SCE and is overseen by scientists contracted by the CCC. The SONGS Coastal Development Permit provides a description of the performance standards and monitoring required for the wetland mitigation project, and the monitoring plan closely adheres to these requirements. The San Onofre Nuclear Generating Station CDP requires monitoring to be conducted for the operating life of the Station, which will likely be 40+ years.

There are 15 performance standards in the SONGS CDP, which fall into two categories. The first category includes four long-term physical standards relating to topography (erosion, sedimentation), water quality (e.g., oxygen concentration), tidal prism, and habitat areas. The second category includes eleven biological performance standards relating to biological communities (e.g., the abundance and species richness of fish, invertebrates, and birds), marsh vegetation, *Spartina* canopy architecture, reproductive success of marsh plants, food chain support functions, and exotic species. Compliance of some of the standards (e.g. topography, tidal prism, and habitat areas) will be evaluated using fixed criteria and measured only in the San Dieguito Restoration Project, whereas other standards (e.g. water quality, biological standards) are relative, with compliance based on performance in comparison to three reference wetlands in southern California (Carpinteria Salt Marsh and Mugu Lagoon to the north and Tijuana Estuary to the South).

SCE receives mitigation credit for acreage restored at or below 4.5′ NGVD – a water level benchmark – which is defined as "tidally-influenced" habitat for the purposes of this restoration by CCC staff. This elevation criterion was determined by independent research by the CCC contract scientists and represents the lower distribution limit (in tidally influenced systems) of upland weedy plant species. The restored acreage below 4.5′ NGVD will include a mix of subtidal, mudflat, tidal creeks and channels, and vegetated tidal salt marsh.

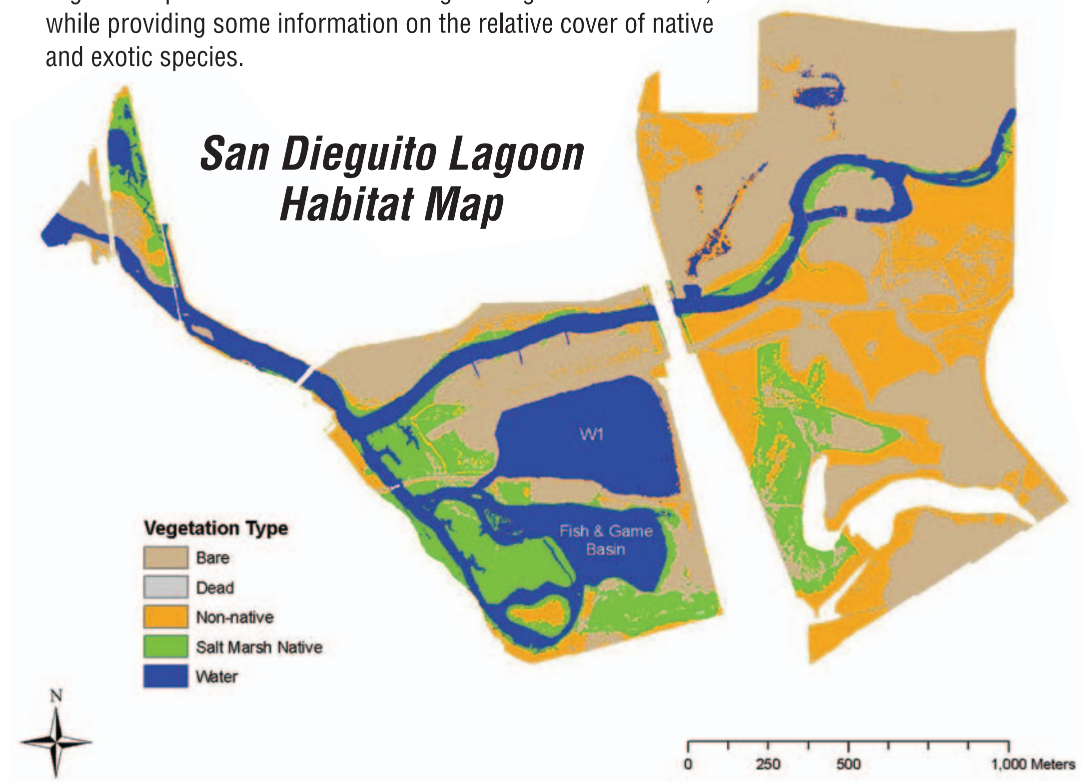
A significant amount of effort was involved in determining the appropriate sampling methods (e.g., for fish and invertebrates) and statistical analyses of the data to assess compliance of the restoration with the performance standards. Details of these methods and analyses are contained in the *Monitoring Plan for the SONGS Wetland Mitigation Program*. One group of organisms, small fish belonging to the family Gobiidae, presented a particular monitoring challenge. These fishes, commonly known as 'gobies' are numerically dominant and ecologically important elements in estuarine systems.

Goby Fish

However, because of their small size and cryptic nature (they live in burrows), it has proven difficult to obtain accurate estimates of their abundance using standard fish sampling techniques such as beach seines. To solve this problem, we developed an accurate and cost effective method using enclosure traps, large plastic cylinders that can be used to accurately and efficiently sample these fishes.

The enclosure trap for lagoon health assessment processes

One of the relative performance standards is that the proportion of total vegetation cover and open space in the restored wetland must be similar to that in the reference wetlands. We have developed a combination of 'on the ground' and high resolution aerial photography to assess this standard. The aerial photographs (which are taken twice a year, in the winter and spring) not only give true color images of the entire wetland, but also employ multi-spectral images that can distinguish bare from vegetated space – for use in evaluating the vegetation standard, while providing some information on the relative cover of native and exotic species.



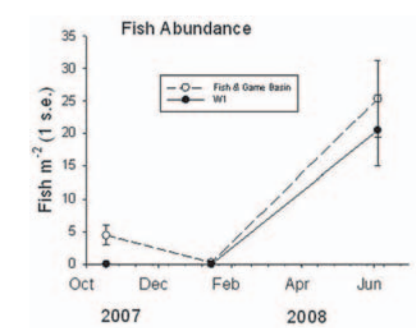
Monitoring for the operational life of the Station (approximately 40 years) is divided into two phases. Fully implemented (Phase 1) monitoring will ensue upon completion of wetland construction and be conducted for a period of not less than 4 years post-construction. The wetland restoration project will be considered successful when ***all of the performance standards have been met for each of three consecutive years***. Remediation may be required if the performance standards are not met within ten years and if three successive years of compliance has not occurred within 12 years. Condition D of the CDP establishes that upon determination that all of the performance standards have been met for three consecutive years, a scaled back level of monitoring (Phase 2) will ensue. All monitoring, whether it be Phase 1 or Phase 2 must be sufficient for assessing project compliance with the performance standards. If the restored wetland is not considered successful within 12 years post-construction or has not met the biological community standard by year 4, then the permittee shall be required to fund an independent study to collect the information necessary to determine what remediation is needed.

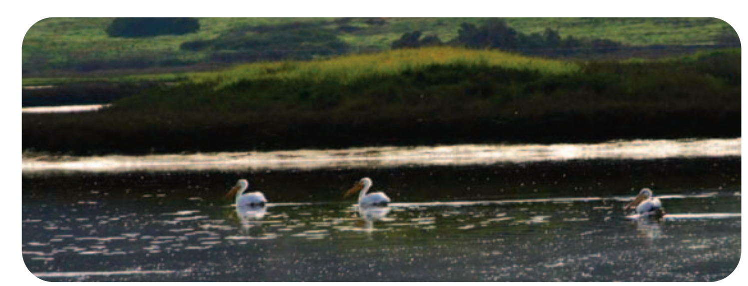
Fully implemented Phase I monitoring is scheduled to begin following completion of the construction of the restoration project and implementation of a planting plan, currently estimated as May 2010. In the meantime, independent monitoring of water quality and some fish sampling is being done in preparation for full Phase I monitoring. Monitoring of fish, in particular enclosure trap estimates of gobies, has been conducted in the constructed tidal basin W1 and a pre-existing tidal basin constructed by the California Department of Fish and Game. These early monitoring results are encouraging and show rapid colonization of the former by gobies and the establishment of native fish populations that are comparable and on some surveys greater than the fish populations in the pre-existing DFG basin.

"In addition to fish, … (there is) the dramatic increase in bird species and abundance, particularly in the newly created tidal habitats east of the I-5 freeway."

In addition to fish, an obvious change in the biota at San Dieguito is the dramatic increase in bird species and abundance, particularly in the newly created tidal habitats east of the I-5 freeway. Data on bird abundance and species richness was gotten incidentally from biological monitoring required to avoid any impacts on bird species by construction activities. Plans are underway to initiate low level monitoring in the near future that can be incorporated in the fully implemented Phase I monitoring.

"Early monitoring results are encouraging and show rapid colonization of the former by gobies and the establishment of native fish populations."





White pelicans enjoying the Lagoon

Success of Wetland Mitigation Projects

By Rebecca L. Kihslinger

Wetland mitigation accounts for a significant annual investment in habitat restoration and protection, but is it a reliable conservation tool? This article concludes that despite the nationwide goal of "no net loss," the federal compensatory mitigation program may currently lead to a net loss in wetlands acres and functions.

The nation's 1989 goal of achieving a "no overall net loss" of wetland acres and functions has a significant influence on how the regulatory agencies administer §404 of the Clean Water Act and, in particular, the decisions they make about compensatory mitigation for permitted losses. Each year approximately 47,000 acres of wetland mitigation are required under the §404 program (ELI 2007) to compensate for about 21,000 acres of permitted losses (Martin et al. 2006), a potential gain of 26,000 acres annually. Although the amount of compensatory mitigation required provides a significant buffer in meeting the "no net loss" goal, the required compensation must be implemented on the ground and the restored wetlands must successfully replace lost wetland acres and functions in order to achieve the goal.

The success of wetland mitigation projects can be judged on whether a project meets its administrative and ecological performance measures. Administrative performance refers to the degree to which compensatory mitigation projects meet their permit requirements, such as submitting monitoring reports in a timely manner. Ecological performance refers to meeting ecological standards that ultimately result in a compensatory wetland that replaces lost aquatic resource functions.

In 2001, the *National Wetlands Newsletter* published *Count it by Acre or Function: Mitigation Adds Up to Net Loss of Wetlands* (Turner et al. 2001), providing further insight to a National Research Council (NRC) report that found that compensatory mitigation failed to achieve the national policy of no net loss of wetlands. This article reviews recent literature to determine whether or not compensatory mitigation projects required by state and federal agencies are meeting administrative and ecological performance measures. Most of the studies evaluated permittee-responsible (also known as project-specific) mitigation projects. However, some more recent evaluations deal more specifically with wetland mitigation banks.

Administrative Performance

Turner and colleagues' (2001) seminal review of the success of mitigation implementation found that mitigation projects across the country often fail to comply with their permit conditions. Of 19 reviewed studies, 10 found that the majority of evaluated projects were compliant with permit conditions, while 9 studies found that only 4 to 49% of the projects were fully compliant.

More recent studies have similar findings. Of seven studies evaluating the percent of sites meeting 100% of the required permit conditions, four found that the majority of the projects reviewed complied with all permit conditions (Ambrose and Lee 2004—69%; Cole and Shaffer 2002—60%; Minkin and Ladd 2003—67%; Sudol and Ambrose 2002—55%), while three found that only 18 to 46% of projects complied with all permit conditions (Ambrose et al. 2006—46%; Brown and Veneman 2001—43%; MDEQ 2001—18%). Ambrose and colleagues (2006) found that, on average, permitees met 73% of permit conditions. A 2002 study of compensatory mitigation in New Jersey found that on average mitigation projects met only 48% of their design requirements and permit specifications (Balzano et al. 2002). Monitoring, submission, and long-term maintenance requirements seem to be the criteria that most often go unmet, while vegetation criteria are more frequently achieved (Ambrose et al. 2006, Ambrose and Lee 2004).

A lack of monitoring and oversight of mitigation projects may contribute to low success rates. Cole and Shafer (2002) found that fewer than 10% of permit files reviewed in their Pennsylvania study contained required monitoring reports. In 2005, the U.S. Government Accountability Office (GAO) published a review of the U.S. Army Corps of Engineers' oversight of compensatory mitigation in a representative sample of Corps districts. The GAO found that the districts performed limited oversight to determine the status of required compensatory mitigation (GAO 2005). The districts did, however, provide somewhat more oversight for mitigation conducted by mitigation banks and in-lieu fee mitigation than for permittee-responsible mitigation. For the 60 mitigation banks that were required to submit monitoring reports, 70% of the files showed that the Corps had received at least one monitoring report. The percentage of the mitigation bank files with evidence that the Corps conducted an inspection ranged from 13 to 78%.

Ecological Performance

Studies of the ecological performance of compensatory mitigation have shown that compensatory wetland projects fail to replace lost wetland acres and functions even more often than they fail in their administrative performance. In fact, permit compliance has been shown to be a poor indicator of whether or not mitigation projects are adequately replacing the appropriate habitat types and ecological functions of wetlands.

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Replacing Acres

Several studies have questioned the success of wetland compensatory mitigation in replacing lost wetland acreage. In its comprehensive national study on compensatory mitigation, the NRC reported that between 70 to 76% of mitigation required in permits is actually implemented (NRC 2001). A review of mitigation sites in Michigan found that only 29% of the permits implemented the required amount of mitigation (MDEQ 2001). A study in California found that 46% of sites met acreage requirements (Ambrose and Lee 2004). Several other studies have had similar results, suggesting that the §404 program is failing to compensate for lost wetland acres (Balzano et al. 2002, Johnson et al. 2002).

Replacing Functions

In addition to not meeting acreage requirements, mitigation wetlands often do not replace the functions and types of wetlands destroyed due to permitted impacts. Turner and colleagues (2001) found that an average of only 21% of mitigation sites met various tests of ecological equivalency to lost wetlands. Two recent studies compared mitigation sites to *impact sites*. One found that only 17% of the sites evaluated successfully replaced lost functions (Minkin and Ladd 2003). The other study determined that 29% of the sites were successful in this regard (Ambrose and Lee 2004). The former study also found that 50% of the mitigation sites evaluated were actually non-jurisdictional riparian and upland habitat. Four studies comparing mitigation sites to *reference wetlands* found that fewer than 50% of the sites evaluated were considered ecologically successful (Ambrose et al. 2006—19%; Johnson et al. 2002—46%; MDEQ 2001—22%; Sudol and Ambrose 2002—16%). Ambrose and colleagues' statewide study of 143 permit files in California found that 27% of the constructed mitigation did not even meet the jurisdictional definition of a wetland (Ambrose et al. 2006).

Compensatory mitigation as required under §404 may also result in a shift in wetland type. For example, a study of 31 mitigation sites in Indiana found failure rates of 71% for forested mitigation sites, 87% for wet meadow areas, and 42% for shrub areas, but only 17% of the shallow emergent areas and 4% of open water areas were failures (Robb 2001). These results indicate that mitigation may be resulting in the replacement of forested wetland sites with shallow emergent and open water community types. Similar results have been reported in New Jersey, where a study of that state's mitigation program found that emergent wetlands were the only wetland type that achieved a greater than 1:1 replacement ratio, while forested wetlands were successfully replaced at a ratio of only 0.01:1 (Balzano et al. 2002). A Pennsylvania study of 23 §404 permits issued from 1986 to 1999 showed that only 45% of the mitigation wetlands were of the same type as the impact sites and that the mitigation had resulted in a shift from wetlands dominated by woody species to less vegetated mitigation wetlands and a replacement of scrub-shrub, emergent, and forested wetlands with open water ponds or uplands (Cole and Shaffer 2002).

Several recent studies of bank sites indicate that banks are generally no more successful at replacing lost acres and functions than permittee-responsible mitigation. A 1999 study reported a net loss of 21,000 acres of wetlands due to inclusion of enhancement and preservation as mitigation methods at bank sites (Brown and Lant 1999). A more recent comprehensive review of 12 mitigation bank sites in Ohio found that 25% of the bank areas studied did not meet the definition of wetlands (Mack and Micacchion 2006). Of the actual wetland acreage, 25% was considered in poor condition, 58% was fair, and 18% was good quality in terms of vegetation as compared to natural reference wetlands. The study also found that amphibian community composition and quality was significantly lower at banks than at natural forest, shrub, or emergent wetlands and that pond-breeding salamanders and forest-dependent frogs were virtually absent from the bank sites. Overall, of the banks studied, three were mostly successful, five were successful in some areas and failed in others, and four mostly failed. A recent study from Florida found that of the 29 banks evaluated, 70% fell within the moderate to optimal range of function. Although the baseline conditions of most sites were in the high functional range, most of the projects relied upon enhancement, rather than restoration, as the mitigation method (Reiss et al. 2007).

In addition to not meeting acreage requirements, mitigation wetlands often do not replace the functions and types of wetlands destroyed due to permitted impacts.

Mitigation and Wildlife Habitat

Many compensatory mitigation projects do not include wildlife criteria in their design and performance standards (NRC 2001). Only a handful of studies on compensatory mitigation attempt to address the ability of compensatory mitigation to replace wildlife habitat lost through the §404 program. These studies indicate that compensatory mitigation sites are not effectively replacing lost wildlife habitat. One study reported that over half of the mitigation sites evaluated did not adequately compensate for wildlife habitat services lost due to permitted activities (Ambrose and Lee 2004). Only 41% of the studied sites had successfully replaced wildlife habitat and connectivity, while replacement failed at 38% of sites (25 of these sites were considered extreme failures). In Washington state, 55% of the sites surveyed in one study had only a moderate contribution to wildlife functions (Johnson et al. 2002), while in

New Jersey the wildlife suitability assessment criteria achieved the lowest score of all the assessment criteria used to evaluate mitigation sites (Balzano et al. 2002). The New Jersey study reported that, on average, mitigation sites provided limited protective cover, adjacent food sources, and nesting habitat for wildlife and that there were moderate human impediments to wildlife use of the sites.

Conclusion

Although wetland mitigation accounts for a significant annual investment in habitat restoration and protection, it has not, to date, proven to be a reliable conservation tool. Despite the nationwide "no net loss" goal, the federal compensatory mitigation program may currently lead to a net loss in wetlands acres and functions. On the high end, Turner and colleagues (2001) estimated that the §404 program may lead to an 80% loss in acres and functions. The success of compensatory mitigation could be enhanced by improving permit conditions and requiring clearly defined performance standards (Ambrose et al. 2006, NRC 2001, Turner et al. 2001). However, there are currently no national guidelines or models for developing ecological performance standards. Permits should clearly define performance standards that are based on ecological criteria such as community structure, soil, hydrology, amphibian communities, and vegetation (Fennessy et al. 2007). Currently, many permits simply require a certain percentage of herbaceous cover as a criterion for accessing the success of mitigation site because it is easily measured and may quickly reach required thresholds. However, percent herbaceous cover may not be a sufficient surrogate for most wetland functions (Cole and Shafer 2002).

Mitigation success may also be improved by making site selection decisions within the context of a watershed approach (NRC 2001). In 2002, the Corps issued guidance in support of the watershed approach, and draft compensatory mitigation regulations issued jointly by the U.S. Environmental Protection Agency and the Corps in 2006 may codify the approach. Under the watershed approach outlined in the proposed mitigation rule, there also may be opportunities for mitigation to support habitat conservation objectives (Bean and Wilkinson 2008). Improved compliance monitoring would also help to ensure the success of mitigation projects. As a recent GAO study indicates, many Corps districts have limited oversight of compensatory mitigation projects (GAO 2005). Increasing post-implementation monitoring and tying required monitoring periods directly to achieving final performance criteria would improve both the administrative and ecological performance of mitigation sites. ■

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Salt Marsh Restoration Experience in San Francisco Bay

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ABSTRACT

WILLIAMS, P.B. and FABER, P.B., 2001. Salt marsh restoration experience in San Francisco Bay. *Journal of Coastal Research*, Special Issue No. 27, 203-311. Royal Palm Beach (Florida), ISSN 0749-0208.

Efforts to restore ecologic functions in ten major tidal wetland restoration projects implemented in the San Francisco Bay over the last 25 years have had variable results. Although almost all restoration projects constructed do now support important wetland functions, in a number of cases they have performed or evolved in ways that were unanticipated at the time they were planned. This extensive restoration experience has provided important lessons for restoration planning and design that can be applied in other estuaries. These lessons include: 1) the need for well thought out, explicit, restoration objectives; 2) developing an understanding of restored salt marshes as evolutionary systems that have changing wetland functions as they mature; 3) the need to incorporate an understanding of the morphodynamics, or interaction of key physical processes in restoration design, and 4) the need to fully integrate monitoring into the restoration plan in order to institute a learning curve so that practitioners can build on the experience of earlier projects.

ADDITIONAL INDEX WORDS: *Salt marsh restoration, San Francisco Bay, wetlands.*

INTRODUCTION

The extensive tidal wetland restoration experience in the San Francisco Bay estuary can be viewed not just as a sequence of experiments in restoration techniques but also, more importantly, as a laboratory for testing restoration methodologies that are now being considered in other parts of the world.

At the advent of American colonization 150 years ago, approximately 220,000 ha of tidal marshes, including 80,000 ha of salt marsh, fringed the San Francisco Bay, the Pacific Coast's largest estuary (ATWATER *et al.,* 1979). The progressive diking and filling of more than 90% of these marshes (Figure 1) led to widespread public concern, and well organized environmental activists succeeded in having the first wetlands protection legislation enacted in the United States in 1966. This legislation prevented any further filling of tidal wetlands in the salt water regions of the estuary. It was inevitable that shortly following this success, plans would be proposed to reverse environmental damage through restoring tidal wetlands. The first project, restoring the 32 ha Faber Tract, (Table 1 and Figure 2) was implemented in 1972. In the 27 years since, many other projects, totaling more than 1,200 ha, have been carried out by different government agencies, using a variety of techniques and approaches, and ranging in size from a quarter of an acre to the 220 ha Pond 2A project. Combined with the effect of levee failures, a total of approximately 2,000 ha of the

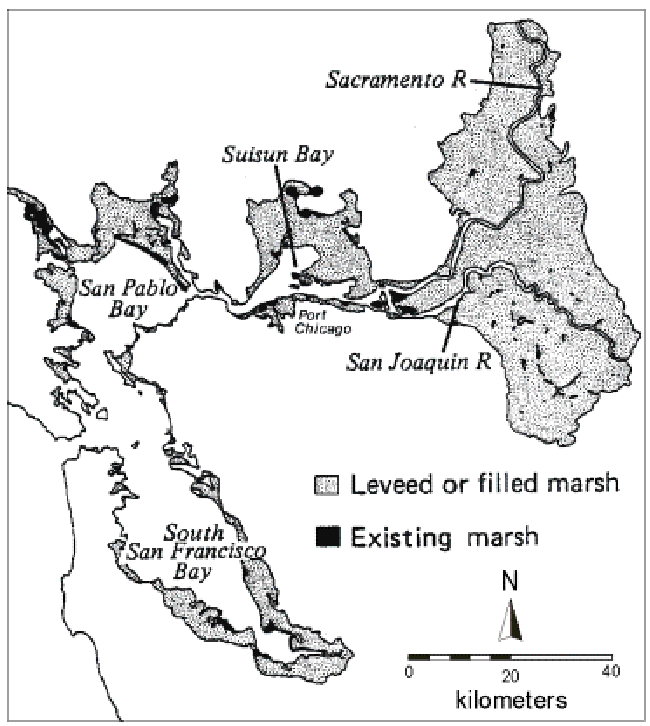

Figure 1. Historic changes in San Francisco Bay estuary.

Table 1. *Summary of the major tidal restoration projects in the San Francisco Bay estuary*[1]

	Name	Area (ha)	Year Restored	Remarks
1.	Faber Tract	32	1972	Dredged material site
2.	Pond 3	44	1975	Dredged material site
3.	Muzzi	52	1976	Dredged material site
4.	Bair Island	60	1978	Salt pond
5.	Cogswell	80	1980	Salt pond
6.	Warm Springs	80	1986	Borrow pit
7.	Carls Marsh	22	1994	Agricultural field
8.	Pond 2A	220	1995	Salt pond
9.	Sonoma Baylands	120	1996	Dredged material site
10.	Tolay Creek	20	1999	Agricultural field

[1] Sites larger than 50 acres where full tidal restoration was planned

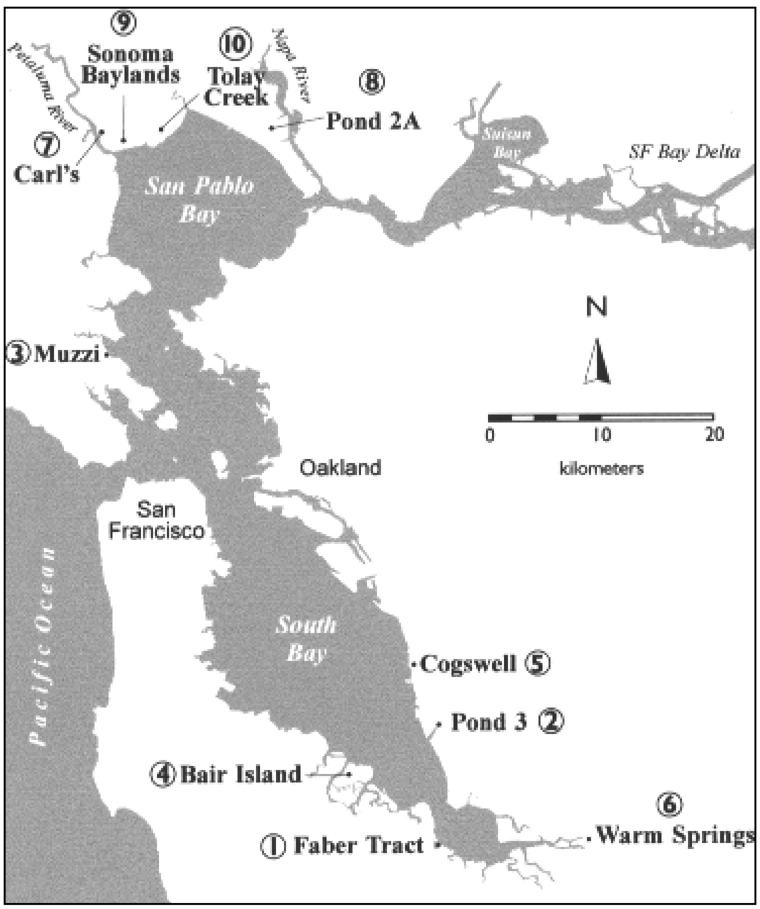

Figure 2. Major tidal salt marsh restoration sites (larger than 50 acres).

former tidal marsh has now been restored to tidal action. Active planning efforts are now underway on three large restoration projects to restore tidal action to about 4,800 ha and more than 24,000 ha are being recommended for restoration in the next few decades (SAN FRANCISCO BAY AREA WETLANDS ECOSYSTEM GOALS PROJECT, 1999).

In many respects, the San Francisco Bay estuary is a good restoration laboratory. The estuary receives runoff from the entire 257,000 square km watershed of the Central Valley of California, and is a meso-tidal, sediment-rich system formed by the sea-level transgression in the Holocene. It is subject to marked seasonal salinity variations due to large seasonal variations in freshwater inflow, is affected by strong summer sea breeze wave action, and is perturbed by only small storm surges and occasional large earthquakes. Historic landscape changes from pre-colonization to present day have been fairly well documented, and there is now a substantial governmental agency data collection and research effort underway. Its biota is fairly typical of mid-latitude systems, but species composition has been greatly influenced by successive exotic invasions (COHEN and CARLTON, 1995). Almost all restored sites around San Francisco Bay were diked former tidal marshes that had substantially subsided; some of these sites have been refilled with dredged material.

EVOLUTION OF RESTORATION APPROACHES

Tidal restoration projects in San Francisco Bay have been implemented by a variety of agencies with different objectives, expertise, financial resources and dogma. While this "balkanization" of effort has been a source of inefficiency, it has allowed for creativity and diversity in approaches. Over the last 30 years the impetus for restoration has changed. At first, most tidal restoration projects were "mitigation" projects, paid for by developers to compensate for loss of non-tidal wetlands elsewhere. As enforcement of "no net loss" provisions of wetland protection laws became more stringent, such projects became harder to win permits, and the developers' place was taken by resource management agencies undertaking "pure" tidal wetland restoration projects. Now, in the late 1990s, the emphasis is shifting again to implement large-scale tidal wetland restoration as an important component in restoring key processes for the entire ecosystem of the estuary.

"Horticultural" Wetland Restoration

In the 1960s, the prevailing argument used in defense of wetlands was that once marshlands were gone, they were gone forever. Restoration was not considered possible and the fate of whole ecosystems was considered doomed because of lost wetlands. Only acquisition of remaining wetlands would save the functions they provided. In their 1969 book, *Life and Death of the Salt Marsh* (J. TEAL and M. TEAL), the first lay book on the subject, the authors never even use the word "restoration."

By the early 1970s, attitudes had changed and restoration was considered a possibility, but only with the use of plantings. The first years of restoration were strongly influenced by new ecologic research from the U.S. east coast that emphasized Atlantic Coast cordgrass (*Spartina alterniflora*) marshes with their vast productivity (ODUM, 1961; GARBISCH, 1977). In San Francisco Bay projects like the Faber Tract (restored in 1972), and Pond 3 (restored in 1974), tidal wetland restoration objectives were defined almost entirely by the successful planting of cordgrass. The native *Spartina foliosa* was planted in the Faber tract. (HARVEY *et al.,* 1982). In Creekside Park, the exotic *Spartina densiflora*, collected from Humboldt Bay was planted. At that time, *S. densiflora* was mistakenly considered to be the native *S. foliosa.* In the Pond 3 restoration, the exotic *Spartina alterniflora* was imported from Maryland as an experiment to compare planting by broadcasting seed or by planting plugs. (Both of these exotics are now invading adjacent marshes displacing both the native *S. foliosa* and other wetland species.)

In these early efforts, physical factors were considered secondary, and restoration was accomplished by simply breaching a hole in the levee. It was rarely considered necessary to invest in developing a plan or a documented design for the project. Consequently, the evolution of some sites was impeded because either large parts of these sites were too high or they did not receive adequate tidal circulation because of constricted levee breaches.

In 1983, Margaret Race completed a critical review of these projects showing how more than 90% of *Spartina* plantings had died out and suggesting tidal restoration projects were failures because they did not meet their stated goals (RACE, 1983). Although *Spartina* did subsequently eventually colonize all these sites through natural seeding, the experience dampened enthusiasm for justification of restoration as equivalent mitigation for lost wetlands. Race's critique focused attention on the need to develop clear objectives and success criteria in wetland restoration. The subsequent debate highlighted the need to understand restored marshes as evolving systems, not as "instant wetlands" (JOSSELYN, 1988). By the early 1980s, recognizing the need to systematize restoration design, government agencies were formulating design guidelines (HARVEY and WILLIAMS, 1982) and conducting critical reviews of the success of mitigation projects (*California Coastal Conservancy*, 1985; BCDC, 1988). Furthermore, leading ecologists were emphasizing the need to properly consider physical criteria in restoration design (ZEDLER, 1984).

By the early 1980s, it was recognized that plantings were unnecessary because of the large seed source in San Francisco Bay that established naturally over time.

Replicated Wetlands

In response to this new focus on providing the right physical conditions for marsh vegetation, in the early 1980s some new restoration projects attempted to replicate the form of the natural marsh, but without properly addressing the underlying processes that sustained that form. Typically, in these projects, which are usually mitigation for a development project, restored marsh plains are graded or filled to the same elevation as a mature marsh and artificial tidal channels dug to replicate tidal sloughs. An example of this approach is shown in portions of the 1976 Muzzi restoration site modified in 1980 (FABER, 1980) (Figure 3) and the 1982 Cogswell Marsh. The problem with this type of design was that it created an expectation that could not be fulfilled: that wetlands with fully developed ecologic functions would be created within a few years. We now know that they take time.

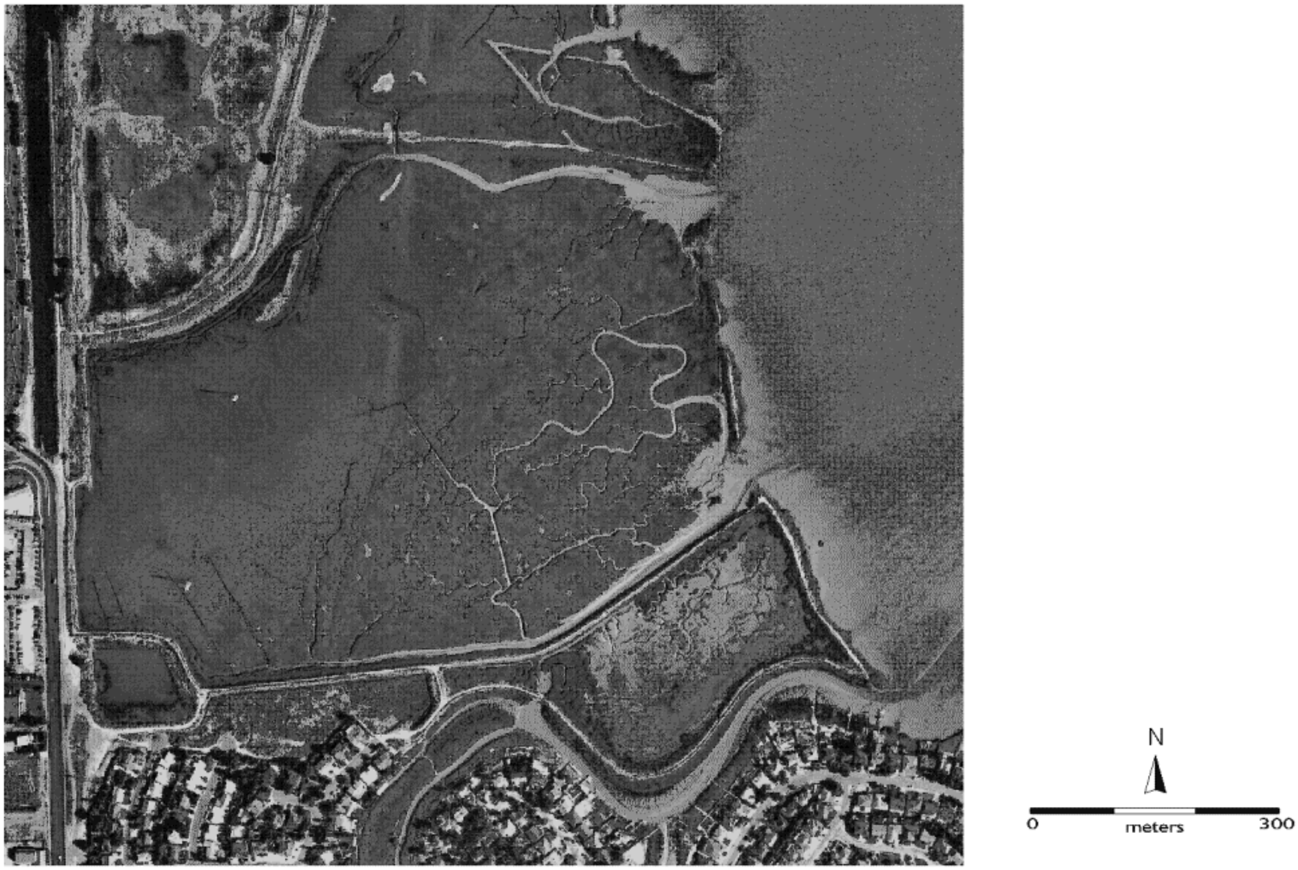

Figure 3. Muzzi marsh.

Observers noted that some accidentally restored sites, such as the abandoned subsided agricultural fields, were being colonized by marsh vegetation as rapidly as these highly engineered projects. By the late 1980s, regulatory agencies realized there needed to be greater accountability for the time-frame and success of restoration projects and started to require monitoring plans and clear definition of success criteria.

Manipulated Wetlands

In many locations, rapid wetland vegetation colonization by the replication approach was difficult to accomplish where land had subsided, or where marsh restoration projects doubled as flood control projects. On a number of these sites, a different approach was selected to create desired wetland conditions as quickly as possible. No attempt was made to restore natural tidal wetland processes, but instead, the project was designed to manage one or two physical variables, such as tidal range or salinity, to favor specific groups of such as shorebirds, or waterfowl, or even listed species such as the clapper rail or salt marsh harvest mouse. These projects typically incorporated artificial manipulation of tide levels through control gates and weirs, maintenance of a perimeter levee and grading to create sub-tidal and refuge habitat. Some sites attempted to "freeze" remnants of endangered species habitat by surrounding them with a ring levee. An example of this approach is the Shorebird Marsh in Cort Madera (GALE and WILLIAMS, 1988) (Figure 4). Subsequent experience has shown that the long-term management and maintenance costs were often underestimated and many sites were not managed as intended. In addition, the resilience of invertebrate populations and vegetation in these marshes responding to extreme events, such as large floods and their long-term sustainability, was overestimated. Recent reviews of managed marshes across the U.S. have cast doubt on their long term effectiveness and ecologic value as compared to restoring natural systems (EPA, 1998). Local resource managers now view with disfavor any system that requires active management. An unfortunate result of implementation of the managed marsh approach is that it has created com-

Figure 4. Shorebird marsh.

petition for easily restorable diked former tidal marshes between projects directed towards ecosystem restoration and those focused on shorter term single species management. Nevertheless, this conflict has had a positive result: it has forced attention on the need to define and understand exactly what is meant by the restoration of tidal wetland habitat.

Restoring Physical Processes

Observation of the rapid evolution of restoration sites where natural physical processes are unimpeded has now led practitioners to rely on encouraging natural physical processes as much as possible to restore ecologic functions (see WILLIAMS, this volume). This means grading an appropriate site template prior to breaching the levee to restore tidal action. The first large project of this type was the 80 ha Warm Springs Restoration, designed in 1981 and completed in 1986 (MORRISON and WILLIAMS, 1986). Here, encouraging rapid natural evolution of the site was a necessity because the site had not only subsided but had been used as a borrow pit for nearby development and had been excavated about 4 m below sea level. Unlike previous restoration efforts, this restoration relied completely on encouraging natural processes to evolve the site from subtidal to intertidal mudflats and vegetated tidal marsh. We were confident that this would happen rapidly because cohesive sedimentation measurements and predictions for the nearby Alviso Marina indicated siltation rates in excess of 60 cm per year. This site has been monitored since 1986 and shows that it is evolving as expected towards a fully developed marsh plain (Figure 5). Subsequent projects of this type include Carl's Marsh, a site that was restored in 1994 and has been monitored extensively since then (SIEGEL, 1998).

DEVELOPING A LEARNING CURVE

One of the greatest obstacles to improving restoration design has been the absence of documented design plans, clear statements of objectives and systematic long term monitoring of the evolution of key wetland functions in restored sites. Although monitoring has been recognized as an important priority since the mid 1980s (SAN FRANCISCO ESTUARY PROJECT, 1993), until recently very little has been sponsored by government agencies, leaving the burden to underfunded private initiatives. It was therefore not until 1992, twenty years after the first restoration project, where design criteria for a new project was developed from monitoring the evolution of earlier projects. This was the 120 ha Sonoma Baylands Project implemented in 1996 (USCOE, 1994) (Figure 6). Here,

1986 (Pre-breach grading)

1997 (11 years of tidal evolution)

Figure 5. Warm Springs marsh.

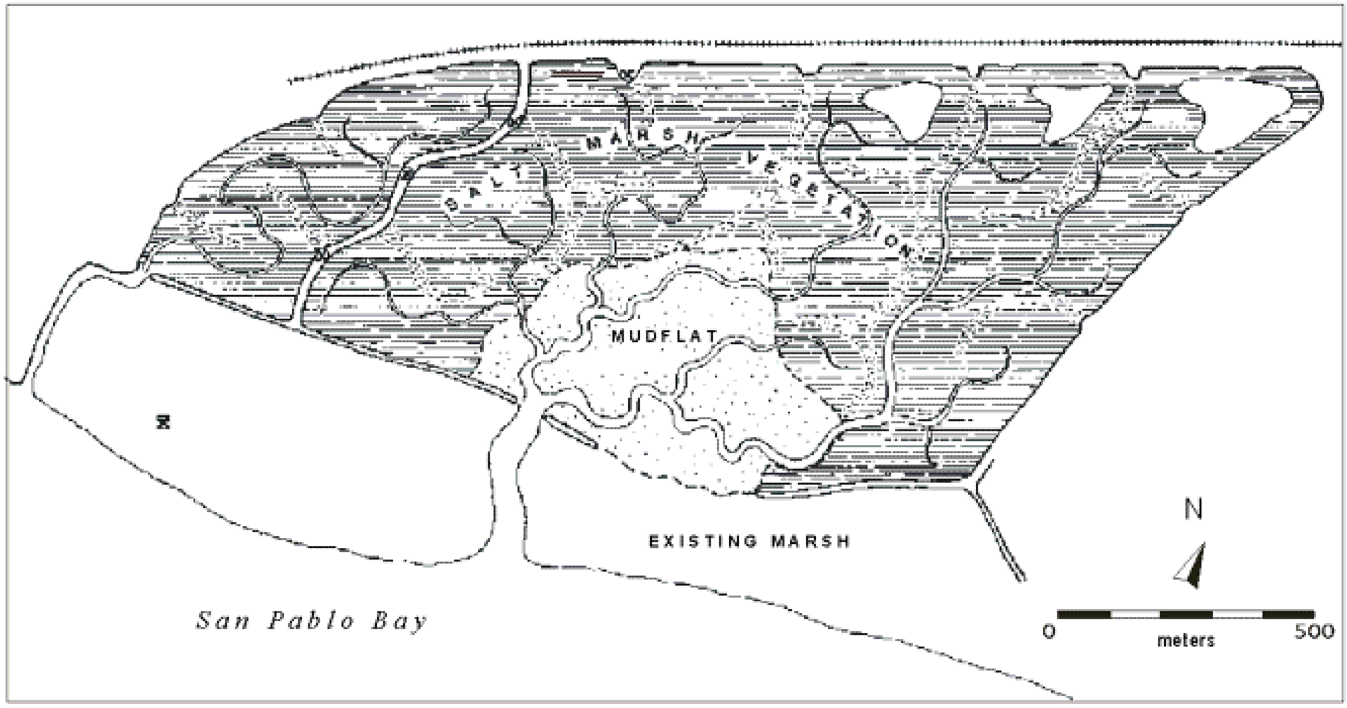

Figure 6 . Recommended design for Sonoma Bayland Marsh (approximately 10 years of evolution).

design parameters were developed based on observed sedimentation, tidal channel evolution and vegetation response at projects such as Pond 3, Faber Tract and Muzzi Marsh, making it a truly "second-generation" design (WILLIAMS and FLORSHEIM, 1995). It was desired to accelerate the evolution of the subsided site to tidal marsh faster than was occurring at Warm Springs. This was done by partially filling the site with dredged material. However, unlike the replication approach, natural sedimentation was allowed to dictate the evolution of the tidal drainage system and marsh plain, but influenced by a predetermined grading template that considered the full range of physical processes acting on the site. Another important aspect of this design was the incorporation of a complete long term monitoring program as part of the project-enabling the future design of third generation projects.

THE CHALLENGE OF LARGE SCALE ECOSYSTEM RESTORATION

The first restoration projects were planned at a time when there was little consciousness or understanding that they were an important habitat within a larger estuarine ecosystem. As late as 1971, important State officials denied that San Francisco Bay formed part of an estuary (HEDGEPETH, 1979). In addition projects were small (less than 20 ha), and their objectives were limited to providing ecologic benefits on site. As we have gained a better understanding of how tidal wetlands evolve in response to estuarine sedimentation, tidal range and salinity regime, we understand the need to plan them within a larger ecosystem context. At the same time, resource managers are now recognizing the important role tidal wetlands play in sustaining key functions in the estuarine/watershed ecosystem. So much of the historic tidal wetlands had been destroyed, that it had become a forgotten landscape whose important contributions as a fishery nursery or in increasing primary productivity has been neglected by researchers.

Now the potential for large scale restoration is starting to be understood and there are plans to significantly increase the area of tidal marshes. These larger scale initiatives pose new institutional challenges to successful restoration. One of the highest priorities is to develop restoration strategies and objectives that are compatible with long term estuarine processes. This can be difficult where there are many different overlapping agencies and organizations with differing biologic goals.

In addition, these larger projects pose new physical design considerations. Over time, restoration projects in San Francisco bay have become larger and, within the next decade, it is likely that the 480 ha Montezuma wetland project, the 480 ha Cullinan Ranch and the 280 ha Hamilton Air Force Base restoration will be completed. As sites become larger, additional physical constraints such as wind wave erosion, flood hazards, and sediment supply limitations become more important—and the consequences of failure become more significant. Extrapolating from the experience of smaller sites alone may not provide an adequate guide for successful restoration.

LESSONS LEARNED

The science, or art, of salt marsh restoration has progressed in a number of important ways since the 1960s—with a number of lessons learned that can be incorporated into new projects today. These include the following:

- Vegetated tidal salt marshes can be restored quite quickly if the appropriate site template is designed prior to breaching.
- The science of restoration is still experimental—we still do not fully understand what percentage of the original ecosystem function returns nor how long it takes.
- The key to successful restoration is insuring that physical processes are restored.
- It is very important in restoration projects to have clear statements of measurable, achievable biologic objectives that have been agreed on by all parties.
- Restoration is best viewed as re-creation of an immature system that evolves towards maturity over time.
- Natural evolution of the ecological processes of a restored salt marsh takes time—far longer than initially thought in the era of replicated wetlands.
- Manipulated systems do not work well as long term sustainable wetland ecosystems: natural tidal rhythms are not maintained, plants and invertebrates cannot tolerate the extreme conditions that occur and consistent operation is rarely maintained over time.
- Monitoring of projects is mandatory if lessons are to be learned for future projects.
- Planning for physical parameters should preferably be on the conservative side to allow unimpeded evolution of natural processes.
- For common plants with large seed sources in the bay, planting is both unnecessary and wasteful of resources.
- Cumulative impacts and cumulative benefits to the entire estuarine system need to be recognized.

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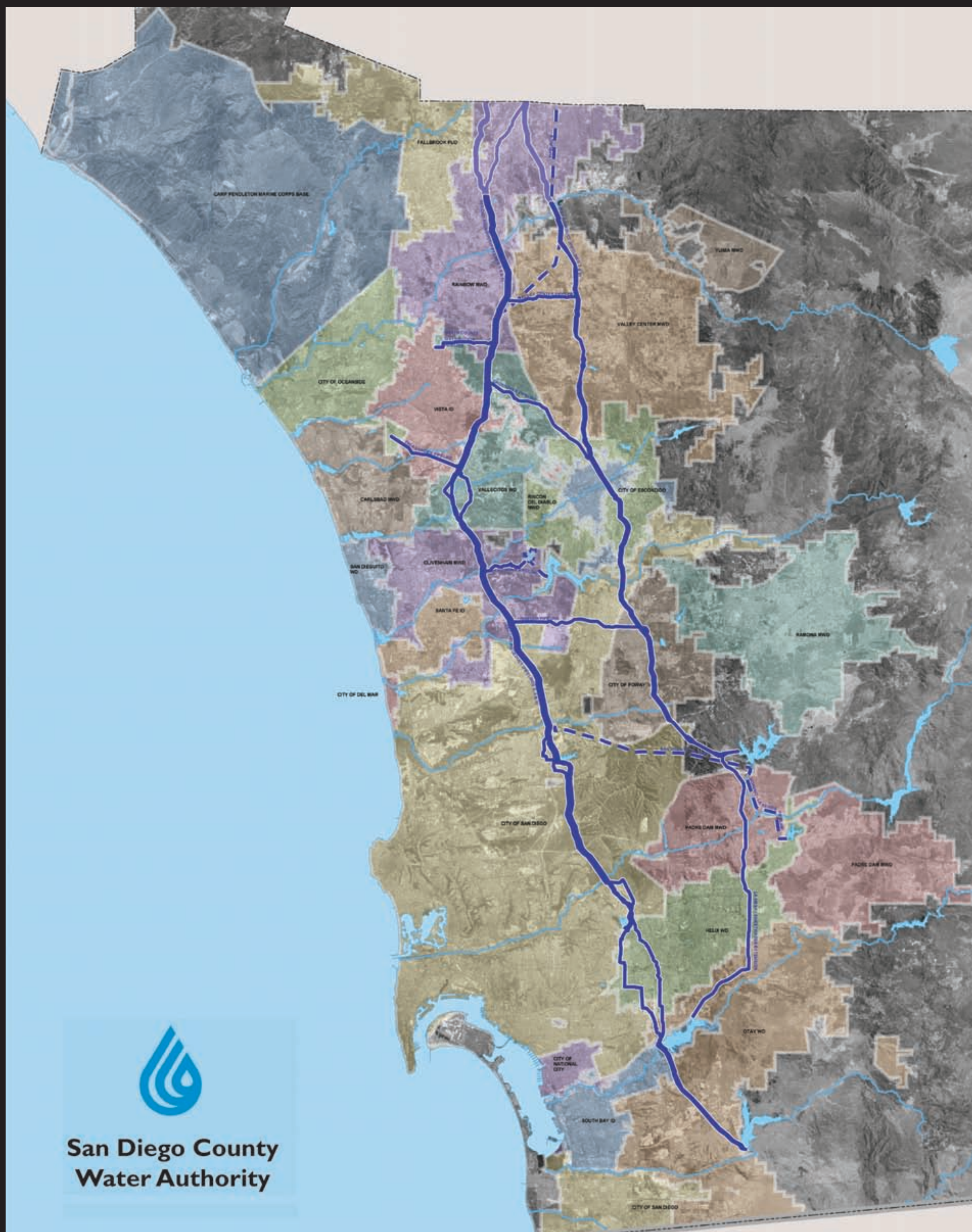
Regional Water Facilities Master Plan

December 2002



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Member Agencies of San Diego County Water Authority

CMWD	Carlsbad Municipal Water District
Del Mar	City of Del Mar
Escondido	City of Escondido
Fallbrook PUD	Fallbrook Public Utility District
HWD	Helix Water District
National City	City of National City
Oceanside	City of Oceanside
OMWD	Olivenhain Municipal Water District
OWD	Otay Water District
PDMWD	Padre Dam Municipal Water District
Pendleton	Pendleton Military Reservation
Poway	City of Poway
RMWD	Rainbow Municipal Water District
Ramona MWD	Ramona Municipal Water District
Rincon del Diablo MWD	Rincon del Diablo Municipal Water District
San Diego	City of San Diego
SBID	South Bay Irrigation District
SDWD	San Dieguito Water District
SFID	Santa Fe Irrigation Irrigation District
VCMWD	Valley Center Municipal Water District
VID	Vista Irrigation District
VWD	Vallecitos Water District
Yuima	Yuima Municipal Water District
Other Water Agencies	
SWA	Sweetwater Authority
Metropolitan	Metropolitan Water District of Southern California

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1 Introduction

Authority Mission

The mission of the San Diego County Water Authority (Authority) is to provide a safe and reliable supply of water to its member agencies serving the San Diego region. Over its 59-year history, the Authority has undertaken many initiatives to maintain and enhance the reliability of the San Diego region's water supply. Today these initiatives include the Imperial Irrigation District (IID) Water Transfer Program, supporting local water resource development, and persistent pursuit of water conservation. The *Regional Water Facilities Master Plan (Master Plan)* is one part of the overall Authority effort.

Legislative Mandate

The California Legislature has charged the Authority with responsibility to "provide each of its member agencies with adequate supplies of water to meet their expanding and increasing needs." Accordingly, the Legislature has authorized the Authority to acquire water and water rights within or outside the State; develop, store, and transport that water; reclaim and repurify sewage and wastewater; desalinate seawater; provide and deliver that water to its member agencies; and perform all other actions necessary or convenient to the full exercise of its statutory authorization (*County Water Authority Act § 5.*).

Authority Background

History

The Authority, San Diego County's regional water wholesaler, was formed in 1944 for the purpose of importing water to the region. At the time of its formation, the Authority supplemented local supplies with imported water. Today, the Authority provides 75 to 95 percent of the water used in its service area.

Throughout its history, the Authority has continually added facilities to meet growing water demands. Following a period of large population growth in the 1980s, the Authority completed the *Water Distribution Study* in 1987. This study described the additional facilities that would be needed to meet regional demands until the year 2010. These recommendations became the basis of the Authority's Capital Improvement Program (CIP).

Since the initiation of the CIP in 1989, the Authority's Board has annually reviewed the CIP and approved needed modifications, which have included adjustments to and the addition or deletion of various projects. The most significant addition to the CIP occurred in 1998 with the inclusion of the

Emergency Storage Project (ESP), the purpose of which is to protect the region against the impacts of a catastrophic interruption of imported water supply, a severe drought, or other similar events that would dramatically decrease the amount of water supplied to the region.

Service Area

The Authority's boundaries extend from the international border with Mexico in the south to Orange and Riverside Counties in the north, and from the Pacific Ocean to the foothills that terminate the coastal plain in the east. With a total of 920,000 acres (1,437.5 square miles), the Authority's service area encompasses the western third of San Diego County. The Authority supplies 75 to 95 percent of the region's needs, depending on the amount of annual surface runoff into local reservoirs. **Figure 1-1** shows this service area and the Authority's member agencies and pipelines.

Member Agencies

The Authority is comprised of 23 member agencies that purchase water for use at the retail level. A list of Authority member agencies is given in **Table 1-1.** A 34-member Board of Directors, consisting of representatives of each of the member agencies, governs the Authority.

Population

San Diego County's population has increased every year since the Authority was formed in 1944. During this time, the region has experienced several periods of rapid population growth associated with military and/or economic activity. The fastest rate of growth, 8.7 percent annually, occurred in the decade between 1950 and 1960, at the end of which the County's population reached 1 million people. From 1980 to 1990, the region experienced another period of rapid growth that was fueled primarily by expanding job opportunities, in which an average of 64,000 people (3.9 percent) was added each year. Beginning in 1990, regional growth slowed because of an economic downturn. Between 1990 and 1995, the population's average annual rate of growth was about 40,000 people (or 8 percent annual growth).

According to the U.S. Census for 2000, the total population in the San Diego region was 2.8 million. With about 96 percent of the County's population residing within the Authority's service area, this amounts to a population of 2.7 million served by the Authority. The City of San Diego is the member agency with the largest population, at an estimated 1.2 million.

Future regional growth has been projected by the San Diego Association of Governments (SANDAG) in its 2020 Regionwide Forecast and subsequently updated in its *Preliminary 2020 Cities/County Forecast— Technical Update,* dated February 26, 1999. The updated forecasts incorporate higher residential and employment densities within walking distance of transit stations and in certain town centers. The 2020 SANDAG Regionwide Forecast projects a population growth of 1.18 million people between 1995 and 2020, for a total regional population of 3.85 million in 2020. This gain represents an average annual increase of 47,000 people, and an average annual growth rate of 1.5 percent **(Table 1-2)**.

Water Delivery System

The Authority purchases water from the Metropolitan Water District of Southern California (Metropolitan) and delivers it to its 23 member agencies through two aqueducts containing five large-diameter pipelines. The aqueducts follow general north-to-south alignments, and the water is delivered largely by gravity. Delivery points from Metropolitan are located about 6 miles south of the Riverside/San Diego County line.

The design capacity of the Authority's total imported water system is approximately

Figure 1-1. Authority Service Area

Table 1-1. Member Agencies of San Diego County Water Authority

Acronym/ Abbreviation	Agency
CMWD	Carlsbad Municipal Water District
Del Mar	City of Del Mar
Escondido	City of Escondido
FPUD	Fallbrook Public Utility District
HWD	Helix Water District
National City	City of National City
Oceanside	City of Oceanside
OMWD	Olivenhain Municipal Water District
OWD	Otay Water District
PDMWD	Padre Dam Municipal Water District
Pendleton	Pendleton Military Reservation
Poway	City of Poway
RMWD	Rainbow Municipal Water District
Ramona MWD	Ramona Municipal Water District
Rincon del Diablo MWD	Rincon del Diablo Municipal Water District
San Diego	City of San Diego
SBID	South Bay Irrigation District
SDWD	San Dieguito Water District
SFID	Santa Fe Irrigation District
VCMWD	Valley Center Municipal Water District
VID	Vista Irrigation District
VWD	Vallecitos Water District
Yuima	Yuima Municipal Water District
Other Water Agencies	
Met	Metropolitan Water District of Southern California
SWA	Sweetwater Authority

Table 1-2. Population Forecasts for the San Diego Region, 1995-2020	
1995	2,669,200
2005	3,223,474
2010	3,437,697
2020	3,853,297
Total increase	1,184,097
Average annual increase	47,363

1,430 cubic feet per second (cfs). The greatest quantity of water used by member agencies in a single year was 686,529 acre-feet (ac-ft) in FY 2002, of which 615,571 ac-ft was imported. FY 2002 was one of the highest years of annual imported water on record, with a delivery of 659,244 ac-ft.

Master Plan Purpose and Guiding Principles

The purpose of the *Regional Water Facilities Master Plan* is to evaluate the Authority's ability to meet its mission through 2030. The evaluation was based on current plans for water supply and facility improvements, with consideration of additional facility improvements and new facilities needed to cost effectively meet the Authority's mission through 2030. Therefore, the *Master Plan*, once approved by the Board of Directors, is intended to serve as the roadmap for implementing the major capital improvements needed by the Authority to serve demands through 2030.

Five guiding principles have been followed during the preparation of the *Master Plan*—to plan facilities that:

1. are compatible with the future mix of water supplies
2. meet the projected needs of the member agencies for treated and untreated water
3. are cost effective
4. provide flexibility in system operation to maintain and enhance reliability
5. provide an ability to cost effectively adjust facility plans to changing needs.

Reliability

The mission statement of the Authority contains two operative words with respect to water supply: safe and reliable. In delivering a safe water supply, the Authority has an obligation to provide water to its member agencies that meets or exceeds all federal and state regulatory requirements. The fulfillment of this obligation is relatively easy to measure; however, this is not the case with respect to reliability. The reason for this is that the measure of what is "reliable" can be quite subjective. While there are many objective ways to measure reliability, the Authority and its member agencies do not currently have a commonly agreed upon understanding of what reliability is.

The measure of reliability is ultimately a question of policy, as is the standard to which the Authority should be held. For purposes of performing the analyses required for the *Master Plan*, the measure of water supply reliability has been established as the ability of the Authority to meet the daily needs of each of the member agencies. This means that no consideration is given in the analysis to meeting the hourly needs of a member agency and that a distinction is drawn between a member agency's requests and its need. If each member agency's needs are met within a calendar day, the interpretation is that the Authority has been 100 percent reliable for that day.

While a daily time frame may be acceptable for wholesale water service, such a time frame is typically not acceptable at the retail level. Retail customers expect water to be available concurrent with their needs whenever they arise and to be available on a constant basis. Wholesale customers, on the other hand, have storage facilities and can thus withstand small fluctuations in deliveries as long as they receive their full daily deliveries. In other utilities, a daily time frame is entirely unacceptable. One example of this would be the provision of retail electric power, in which acceptable time frames are in the millisecond range.

Carrying the stated measure of reliability to its ultimate conclusion would suggest that the Authority would be less than 100 percent reliable, if the needs of one member agency were not entirely met for a single day from now to 2030. Any amount of shortage would result in being less than 100 percent reliable. However, holding to this standard may be impractical and beyond the expectations of the Authority's customers.

This leads to the necessity of establishing a minimum standard against which the Authority's reliability should be measured. One way to establish a standard is to define a shortage event threshold, in which any shortage event beneath the threshold would not be considered in measuring reliability.

To establish a shortage event threshold, consideration should also be given to the magnitude and duration of the shortage. The magnitude can be measured in terms of volume (e.g., acre-feet or million gallons), rate of flow (e.g., cfs or mgd), or percentage of total need. The duration can be calculated as the number of days in a row in which a shortage occurs, or the number of years in a row during which no more than one shortage event is estimated to occur.

Some example shortage event thresholds would be:

- a 5 percent reduction in supply for 1 year
- a 10 percent reduction in supply for 1 month
- a 25 percent reduction in supply for 1 day

Multiple shortage event thresholds can be defined as long as they are not in conflict with one another. The above thresholds, for example, do not conflict because they are each for a different duration.

Reliability standards can be set once shortage event thresholds are established. This is accomplished by defining the maximum allowable frequency for each shortage event. Shortage events that occur less frequently than the standards indicate an acceptable level of reliability.

Using the previously listed thresholds, some examples of shortage standards would be:

- a 5 percent reduction in supply for 1 year every 10 years
- a 10 percent reduction in supply for 1 month every 5 years
- a 25 percent reduction in supply for 1 day every 30 years

Additional standards can be set that provide some accommodation for planned maintenance or construction. For example, a planned maintenance standard would allow for a yearly outage (which is a 100 percent reduction in supply) on a particular pipeline for a 10-day period.

Once a set of standards are established and approved as Authority policy, the reliability of the region's water supply system should be measured against those standards. To the extent the standards are met, the system should be deemed as 100 percent reliable.

The *Master Plan* results provide information on the amount, duration, and frequency of shortages, based on an analysis of future demands, projected supply availability, and construction of various facilities. Calculation of these three measures provides relevant input into decision-making. For each set of proposed facilities, a cost is estimated and a level of reliability is computed. Information can be provided that indicates the cost to provide a certain level of reliability.

This process allows decisions to be made regarding the level of reliability that is cost-effective and acceptable to the Authority's member agencies. Until agreement can be reached on the standards for measuring reliability, the potential will exist for substantial disagreements between individuals, agencies, and others over whether the Authority is meeting its mission. A major goal for the master planning process is to provide the basis for achieving region-wide agreement on what it means for the Authority to provide a "reliable supply of water to its member agencies serving the San Diego region" so that plans can be prepared and implemented to meet the Authority's mission.

The process of establishing reliability standards requires a balance between the preferences of customers for the level of service they desire and the price they are willing to pay. Since level-of-service preferences and price sensitivity can vary significantly between customers, this process may lead to establishing different classes of service, with each class of service defined by a particular level of service reliability. The Authority already has different classes of service. Retail customers have the option to sign up for Metropolitan's *Interim Agricultural Water Program* and not pay the Authority's storage charge. In return, they receive a lower level of service during significant supply shortages.

Authority Policies

Established Board Policies

The Authority Board of Directors has established a number of policies that affect the analysis in the *Master Plan*. The *2000 Urban Water Management Plan (Plan)* is the document that has provided much of the basis for the *Master Plan* study with respect to water supplies. The *Plan* analyzed different mixes of resources for supplying water to the region. The report discusses that the Authority currently receives 84 percent of its water from Metropolitan. The remaining 16 percent is composed of locally produced water from surface runoff into reservoirs, groundwater, and reclaimed water. By 2020, the *Plan* proposed a diversified mix of resources to increase water supply reliability and recommended pursuit of supply sources that increase diversity and minimize competition with other water users outside the region.

The Authority also established policies in March 1998 to partner with member agencies to maximize the use of local treatment capacity. These policies were amended in October 2002 to include the option for the Authority to construct its own treatment capacity. In addition, the Board also directed staff to return with recommendations for a peak demand reduction program.

Additional Board Policies

There are other policy issues needing resolution that have become evident during the preparation of the *Master Plan*. These will require discussion and resolution by the Board of Directors prior to approving the final *Master Plan*, and include:

- establishing reliability standards
- determining whether multiple levels of service reliability are needed, and what those levels should be
- establishing new pricing structures if there are levels of service reliability that differ from the current levels
- establishing an annexation policy regarding lands generally beyond the existing boundaries of the Authority's member agencies (i.e., not considered "in-fill")

These policies will be brought to the Board for discussion and resolution over the next several months.

Master Plan Report

The remaining chapters of this report will provide information on the development and conclusions of the *Master Plan*. Chapter 2 is an overview of the study methodology, Chapter 3 presents the demand forecasts used in the study, Chapter 4 discusses the water supply analysis, Chapter 5 is an assessment of the current Authority system, Chapter 6 presents the potential facility options, Chapter 7 is the alternative analysis, and Chapter 8 summarizes the study conclusions.

Environmental Compliance

A California Environmental Quality Act (CEQA) and possible National Environmental Protection Act (NEPA) review will be required before the *Master Plan* is completed. The environmental review process will be documented separately.

2 Study Methodology

The purpose of this chapter is to describe the methodology used in the *Regional Water Facilities Master Plan* analyses. The study challenge was to look at changing supply and demand patterns over the next 30 years and make reasonable predictions about what additional facilities, if any, would be needed to reliably meet these changing demands.

First, this chapter reviews the underlying concepts of the facilities master planning process and the probabilistic approach applied to facilities planning. The balance of the chapter describes the methodologies used to determine supply and demand probability distributions in the future and the subsequent modeling of existing baseline and future facilities infrastructure against these probability distributions. The goal was to determine the reliability of Authority water systems through the year 2030 and make recommendations for facilities to meet the Authority's mission of a safe and reliable water supply.

Water Facilities Master Planning Process

The water facilities master planning process is composed of three interrelated components: water demands, water supplies, and facilities. Facility planning began with estimating future water demands, proceeded to the identification of water supplies and their reliability, and then to the identification of facilities needed to treat and transport the supplies to the points of demand. As is often the case, this process was iterative and required the analysis of a variety of options for reliability. Finally, facility options were grouped into three alternatives for water delivery based upon the origin of the supply and location of new facilities required to convey that supply. Each alternative was evaluated according to established criteria, including cost (net present value), reliability, and qualitative criteria (see Chapter 7).

Fundamental to this planning process is the uncertainty of future conditions driving demand for water and the availability of supplies. A number of assumptions had to be made, most significant of which were projections of future population and the geographic distribution of the population. Using the principles of statistical theory, a reliability-based approach to forecasting used quantitative methods to characterize the uncertainty or risk inherent in these assumptions.

A reliability-based approach allows facility options to be developed that specifically address the uncertainty inherent in large infrastructure planning. The advantages to using a reliability-based approach are: 1) overly conservative designs that simply incorporate a peaking factor are minimized and 2) investment decisions can be made more easily that take into account both cost and reliability objectives.

The goal of a reliability-based approach is to give decision makers a range of reliability levels from which to choose. The costs of the alternative supply options, combined with the cost of the conveyance facilities to deliver the supplies, can be presented, along with the estimated level of reliability each option achieves. This allows facility investment decisions to be based not just on cost, but also on the level of reliability that is desired to be purchased. For example, a set of facility options might cost $10 million and provide an 85 percent level of reliability. To increase the level of reliability to 90 percent it might cost $15 million, while a 95 percent level of reliability might cost $50 million.

The following section outlines the steps taken in a reliability-based approach to facilities planning.

Water Facility Planning: a Reliability-Based Approach

Water facility planning begins with projections of future demands. Since demand estimation is the foundation on which facility planning is based, it is critical to invest significant effort in this first step. When developing supply and demand projections, there is always uncertainty about what will really happen in the future; as the planning horizon is extended further into the future, this uncertainty increases.

Rather than adding safety factors to allow for the possibility that demands could grow at a rate faster than anticipated, a reliability-based approach uses methods to quantify uncertainty using a probabilistic analysis. A probabilistic analysis focuses on the factors that drive the particular variable that is of interest. The variable of demand is driven by population, number of housing units, housing density, employment, location of water use (i.e., hot, dry versus cool, moist locations), type of use (e.g., agriculture, commercial, residential), and other factors. The historical impact of these factors on demand is analyzed so that relationships between the factors and demand can be established.

The Authority's existing demand analysis model, *CWA-MAIN*, has historically used factors such as these to estimate future demand; it should be noted, however, that the *CWA-MAIN* model uses a fixed estimate for each factor in any given year, resulting in a "point forecast," an estimate of the most probable demand forecast for each year. To translate the meaning of this point forecast into probabilistic terms, the probability of the actual demand in a given year exceeding the point forecast would be equal to the probability of the actual demand being less than the point forecast, or, in more common language, there is a 50 percent chance that realized demands will exceed the estimate.

Prudent planning dictates that facilities should not be designed to meet the "point forecast" demand for a future year, since that would risk leaving the region with a 50 percent probability of having insufficient capacity to meet demands in that year. In the water industry, this issue of risk is typically addressed by using peaking factors. This is usually done by observing past trends for water use and developing a percentage increase over normal demand that represents a high-demand scenario in warmer, drier years. Peaking factors estimate the maximum rate of flow, and are used as multipliers on the point forecast to estimate the maximum rate of flow. The maximum, or peak flow rate is used to size facilities.

One of the problems with using peaking factors to reflect unusual, high-demand events is that there is no understanding of how likely it is for these events to occur. Without knowing the probability of high-demand events occurring, it is difficult to ascertain the actual risk of not meeting demand and advise decision makers on the level of reliability that a particular facility or supply investment is providing. By using a probabilistic analysis, risk can be evaluated and expressed as the probability that water demands will exceed specified volumes. The magnitude by which water demand may exceed these volumes can also be given.

The second step in the water facility planning process is the identification and characterization of supplies. Characteristics such as quantity, reliability, availability (including the location of the supply), cost, and quality are evaluated for each supply. Reliability can be expressed as the probability that certain quantities of water will be available in the future. That analysis can be based on several factors including weather and implementation constraints.

The third step is to develop facility configurations to store, treat, and deliver the various supplies to the points of demand. Existing facilities are analyzed first to determine if they are adequate to meet future demands. If the existing facilities are not adequate, then additional facilities are added to the system at the locations where the capacity is constrained. Since there may be a variety of ways to add facilities, several different configurations or facility options may need to be developed and compared.

Since there may be a variety of supply and facility options in a comprehensive planning effort, the process described above is usually iterative. This is because the factors that can alter the types of supplies will impact the facilities needed to deliver the supplies.

Master Plan Approach to Determining Facility Requirements

A computer model capable of simulating the regional system of aqueducts, treatment facilities and surface storage reservoirs was required for the development of the *Master Plan*. The model selected was *Confluence*™, developed by Gary Fiske and Associates of Portland, Oregon.

Confluence was set up to simulate the San Diego regional system, which consists of:

- The aqueduct system – Pipelines 1, 2, 3, 4, and 5 and their extensions from the Metropolitan delivery point to the southern terminus of each.
- Other regional pipelines such as the Crossover, Tri-Agency Pipeline, North County Distribution Pipeline, and others.
- Treatment plants serving the region, including Skinner WTP and plants owned and operated by member agencies of the Authority.
- Surface reservoirs, typically owned by member agencies, including the historical hydrologic record of runoff into each reservoir.
- New facilities proposed as part of the *Master Plan* facilities alternatives.

Each analysis typically consists of a run of between 300 and 3,000 iterations, which provide statistical output of the resulting reliability of the system to meet demands. Output tables and plots are also included that present the probability of resulting flows through treatment plants and pipeline reaches. The contribution of local supplies is also included in the model; the hydrologic conditions at each local surface reservoir, based upon a 102-year hydrologic record, is part of the database included within the model.

Each simulation is driven by demand, that is, the monthly or daily demand of each member agency. The ability to meet that demand can be constrained by supply availability or by the capacity of the facilities to deliver supplies to meet the demand. In some cases, the delivery capacity constraint may be localized to a certain geographical area of the region.

The following sections describe the basic data used by the simulation model and the steps followed to develop and analyze the facility alternatives.

Water Demand

The Authority chose to use both a point forecast and a probabilistic forecast in its approach to determining facility requirements through the year 2030. Future demand and supply forecasts were determined as described below and subsequently used as inputs to the system simulation model (*Confluence*), which ran iterative combinations of supply, demand, and facilities to test system reliability.

The firm of Planning and Management Consultants, Ltd. (PMCL) was contracted in 1999 to update the Authority's demand forecast using the *CWA-MAIN* model previously developed by the firm. The prior forecast was prepared in 1996 for demands through the year 2015. The results of the update were (1) the development of a new point forecast for the Authority and each member agency, and (2) an extension of the demand forecast out to the planning year 2030.

A second task was to create a probabilistic forecast for each member agency to be used with the model selected to simulate the Authority delivery system. The methods used and forecasting results are presented in the project report and will not be repeated here. For reference, see Appendix C, San Diego County Water Authority, *Development of Probabilistic Water Demand Forecast for the San Diego County Water Authority* (Planning and Management Consultants, Ltd., November 2000).

These two demand forecasts were based on average weather conditions (see Chapter 3 for a summary of the demand forecasts). Annual demand estimates were developed for each member agency. These demand estimates were prepared for 2005, 2010, 2015, 2020, 2025, and 2030. Monthly coefficients were used to convert to monthly demands. Analysis of the Authority's delivery system required consideration of peak conditions; therefore, demand data had to be converted to daily demands. *Confluence* operates on a daily time step for the peak summer season (June through October, inclusive) to reflect peak demand conditions on the system of pipelines, treatment plants, and reservoirs. The method used to develop the daily demand estimates is presented in a report prepared for the Authority by A&N Technical Services, *Continuous-Time Short-Term Models of Daily Water Demand in San Diego County* (February 2001) (see Appendix D).

Each agency is indicated as a demand node in the schematic representation of the regional treatment and delivery system modeled within *Confluence*. **Figure 2–1** is the schematic representation of the system analyzed by the simulation program. This schematic represents the configuration of the system once the Emergency Storage Project (ESP) facilities are completed.

Water Supplies

Water supplies are generally thought of as either local or imported. In the last 20 years, imported water has accounted for 70 to 95 percent of the total supply in the Authority service area for any given year.

Local supply includes recycled water, groundwater (including brackish water desalination), captured runoff, and conservation. Conservation was dealt with early in the process by incorporating it

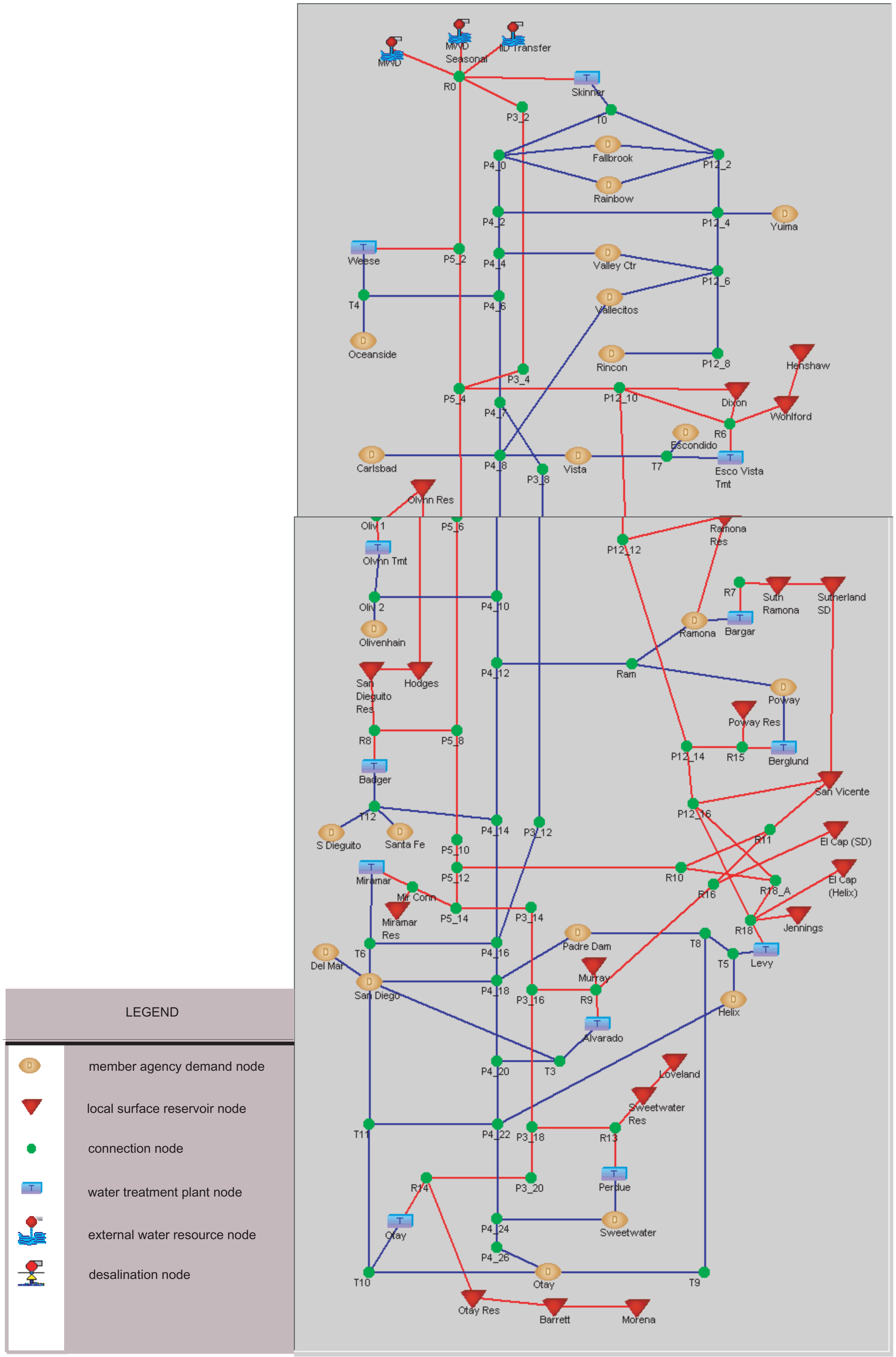

Figure 2-1. Schematic Representation of Regional Treatment and Delivery System, including ESP Projects, as Modeled by Confluence™

into the demand projections and treating it as a reduction in demand for each member agency. Details are given in Chapter 3.

Recycled water and groundwater availability are dealt with probabilistically in the model and are used to reduce demand for each member agency. **Table 4-7** of Chapter 4 presents the low, planned (expected), and high estimates of both recycled and groundwater supply, by member agency, for 2010, 2020, and 2030. Probabilistic curves of the utilization of each of these resources for each member agency are used within *Confluence*. The "planned" level of production from each source was obtained by surveying the member agencies. The planned level represents the amount of recycled or groundwater production that has the highest probability of occurring. Higher and lower estimates of production, along with the probability of these production rates being achieved, were then developed by Authority staff based on discussions with member agencies.

The available surface runoff is integrated into the model using 102 years of historical data obtained from each agency with a reservoir. For reservoirs with less than 102 years of historical record, synthesized hydrology was developed. Various data sources have been used to compile an extensive database of historical runoff quantities into the region's reservoirs. This information was compiled in support of the ESP optimization studies (Technical Support Memorandum No. 2.2, *Reservoir System Operations Modeling*, prepared by GEI Consultants, PBS&J, and West Consultants, July 17, 2002) and is also used for the analyses of the *Master Plan*. Where data was not available for a reservoir, hydrology was synthesized using available weather and hydrologic data. The hydrology used in the model is influenced by evaporation, storage capacity, and existing reservoir withdrawal capacity.

Imported supplies include those directly from Metropolitan and the Imperial Irrigation District (IID) transfer. Metropolitan supplies were given a comprehensive characterization of availability. The assessment of the reliability of these supplies is given in Chapter 4. IID deliveries were assumed to follow the current ramp-up plan, which starts in 2003 at 10,000 ac-ft increasing to 200,000 acre-feet by 2021. Throughout the 30-year study period, IID transfer water is considered to be 100 percent reliable.

Description of *Confluence*™ Model

A recent development in modeling, the *Confluence* model incorporates Monte Carlo simulation techniques in a sophisticated but relatively easy-to-use model. The *Confluence* modeling tool brings together three software applications—Microsoft Access database, Visual Basic, and Digital Visual FORTRAN 90—into a flexible and powerful modeling system. *Confluence* uses Monte Carlo simulation techniques to represent uncertainties in demand, weather, hydrology, and local supply production. Operations of supply and storage resources are simulated through a multi-area, distribution-constrained, dispatch algorithm, mimicking how daily Authority operations actually occur.

The model is also a multi-reservoir delivery simulation program that uses optimization techniques. That is, the model optimizes operating policies based on the constraints of the delivery system. The model includes information on the major reservoirs in the county and extensive transmission system data

Confluence permits each of the following variables to be treated probabilistically:

- ***Streamflows —*** The model samples from a 102-year hydrologic record for each local watershed.
- ***Weather —*** Separate 102-year records of daily, weather-adjustment factors were developed for each demand node.

- ***Growth —*** For the majority of the analyses, the model samples from 300 possible demand growth paths for each class of service within each demand node (classes used are single-family, multi-family, commercial-industrial, and agricultural).
- ***Local supplies —*** The model samples from a range of possible paths for local agency development of their own groundwater and recycled water supplies.

The *Confluence* model integrates and analyzes demand data, weather, hydrology, and local supply projects (i.e., groundwater and recycled) for a given set of regional facilities. The regional facilities simulated are represented schematically. **Figure 2-1** shows the base schematic Authority water supply and delivery system, assuming that ESP facilities have been completed. Each element of the schematic has a capacity associated with it. For example, each pipeline reach has an associated capacity in cubic feet per second (cfs), and each treatment plant has an existing and future capacity, with future capacities tied to a specific year. As new facilities are proposed, they are represented in the schematic, beginning in the year they are scheduled to be in operation.

For each configuration, *Confluence* allows Authority staff to evaluate service reliability in different parts of the service area, operating characteristics of supplies and facilities, and distributions of nodal and system demands. Probability distributions are applied to both supplies and demands. Each iteration of the model makes a minimum of 300 random passes of each type of data (demand path, hydrology, local recycled and groundwater production, etc.) for each year in the 30-year study period. At the end of an iteration, a wide variety of output information is available for both the Authority service area and individual water districts. Key reports and graphics are available to address supply reliability, demand, and system operations

Master Plan Development

The general sequence of developing and analyzing alternatives for this master planning effort was:

- Determined three alternatives, based upon a source of future delivery of supply (i.e, from the north, west and east).
- Identified new facility options needed to implement the three alternatives.
- Analyzed system using a demand forecast that only incorporates the weather variability.
- Reviewed reliability of entire system.
- Added/deleted/modified the proposed facilities and their online dates, until reliability (as expressed by magnitude and frequency of shortages) reached specific target levels, if possible.
- Applied demand forecast with demographic and weather variability to assess the impact on reliability of a wider range of demand potential.
- Added/deleted/modified the proposed facilities and their online dates, until reliability (as expressed by magnitude and frequency of shortages) reached specific target levels, if possible.
- Finalized the list of facilities needed to implement the alternatives.
- Evaluated the alternatives on the basis of cost, reliability, and qualitative criteria.

3 Water Demand Projections

This chapter presents information on historic water demand and, for the 2030 planning horizon, an overview of water demand forecasts developed for the Authority.

To ensure that forecasted demands are based on future growth projected for the region, the Authority uses demographic data from SANDAG. In 1992, the Authority and SANDAG entered into a memorandum of agreement (MOA), in which the Authority agreed to use SANDAG's most recent regional growth forecasts for planning purposes. The MOA also ensures that water supply is a component of SANDAG's overall regional growth management strategy. This approach will ensure adequate supplies are available to meet the forecasted growth for the region.

Since the Authority relies upon SANDAG's growth forecast numbers for its water supply and facility planning, it is imperative that the Authority, the County of San Diego and each city in the County of San Diego regularly communicate in a formal manner about any potential deviations from those forecast numbers in terms of land use decisions (including planning and permitting) or the availability of water supplies and facilities to support planned development. Thus, the County of San Diego and each city in the County of San Diego should immediately inform the Authority of their land use decisions that could result in growth numbers that are significantly above the SANDAG projections so that the Authority can plan to have supplies and facilities available concurrent with increasing demands. Likewise, as increases in water supply and facility capacity are costly and should therefore be developed concurrent with need, the County and the cities should regularly inform the Authority of changes in actual or expected land uses that are expected to result in growth that is substantially less or will occur at a slower rate than SANDAG has projected. This communication should be coordinated through SANDAG.

Since cities and counties cannot approve large projects or subdivisions without sufficient water and related infrastructure to supply the project or subdivision, it is imperative to the planning processes of the County of San Diego and each city in the County of San Diego that the Authority regularly provides updates regarding availability and development of water supplies and facilities. The Authority should, at minimum, provide the County of San Diego and each city in the County of San Diego with a copy of the Authority's most recent adopted Urban Water Management Plan and an annual statement regarding the Authority's water supplies and implementation of plans and programs for meeting future water supply requirements of its member agencies as determined by the Authority pursuant to law and its MOA with SANDAG. The

Authority should also inform the cities and the County on an as needed basis of any significant changes in the Authority's ability to provide water.

Historically, the Authority has relied on a deterministic forecast model for estimating water demands in the region. This model was used and presented in the Authority's *2000 Urban Water Management Plan,* for the planning years 2005 through 2020. In developing a demand forecast for the *Master Plan*, a probabilistic approach to forecasting demands was used so as to take into consideration the uncertainties inherent in demand forecasting. This type of approach facilitates decision-making based on levels of reliability and acceptable risk to be accounted for. A more thorough discussion of the deterministic and probabilistic approaches to forecasting is contained in the study, D*evelopment of the Probabilistic Water Demand for the San Diego County Water Authority,* prepared by Planning and Management Consultants, Ltd. (PMCL) (November 2000) (see Appendix C).

Current and Historic Water Use

Water demand in the San Diego area is closely linked to the local economy, population, and weather. Over the last half century a prosperous local economy stimulated population growth, which in turn produced a relatively steady increase in water demand. However, fluctuating economic and weather conditions in the 1990s, new conservation measures, and lingering effects from the 1987-1992 drought resulted in deviations from historic use patterns. By 1999, a new combination of natural population increase and job creation surfaced as the primary drivers of long-term water consumption increases.

Until FY 2000, spanning from July 1999 to June 2000, the peak-year water use in the Authority's service area occurred in 1990 when total use peaked at 646,645 ac-ft. The FY 2000 use did exceed the 1990 historic peak, reaching an estimated total water use of 695,000 ac-ft. Following the 1987-1992 drought, the Authority's service area experienced significant reductions in water use. This reduction in water use was attributable to several factors, including the economic recession, water conservation measures implemented by the Authority and its member agencies as a result of the 1987-92 drought, and relatively plentiful rainfall. From 1996 to 1999, yearly water use remained fairly constant in the low 600,000 ac-ft range (excluding the 1998 decrease, which was due to extreme El Niño weather conditions). A summary of historic water use is presented in **Table 3-1**.

Table 3-1. Historic Water Use within Authority Service Area (1990-2001)

Fiscal Year	Use (ac-ft/yr)
1990	646,645
1991	585,619
1992	503,210
1993	548,673
1994	536,907
1995	526,053
1996	615,900
1997	621,739
1998	562,225
1999	619,409
2000	695,000
2001	646,400
2002	686,529[a]

[a] Pending.

Deterministic Demand Forecast

Demand for water in the Authority's service area can be divided into two basic categories: municipal and industrial (M&I) and agricultural. M&I demand constitutes about 85 to 90 percent of regional water consumption. Agricultural water, used mostly for irrigating groves and crops, accounts for the remaining 10 to 15 percent of demand. By 2020, water demands are projected to reach 813,000 ac-ft/yr, which is an increase of approximately 18 percent over the 2002 actual demand of 686,529 ac-ft.

To forecast future M&I water demand, the Authority selected the *IWR-MAIN* (Institute for Water Resources, Municipal and Industrial Needs) computer model. Versions of this econometric model have evolved over a 20-year period and are being used by many U.S. cities and water agencies. The *IWR-MAIN* system is designed to translate local demographic, housing, and business statistics into estimates of existing water demand and to utilize projections of local population, housing, and employment to forecast M&I water demand.

The Authority's version of the *IWR-MAIN* model, called "*CWA-MAIN*," was completed in 1996 by Planning and Management Consultants, Ltd. (PMCL), using demographic data from SANDAG. M&I demands forecasted by the model served as the basis for the *1997 Water Resources Plan.*

An updated forecast was prepared for the *2000 Urban Water Management Plan* (see **Table 3-2** below in this report). The *CWA-MAIN* model was calibrated using historical water demand data from 1996 and 1997 as part of the update. The updated 1999 model being used for the *Master Plan* also incorporates SANDAG's 2020 Cities/County demographic forecast for the member agencies through planning year 2020 and preliminary regional forecasts through 2030.

Projecting future conservation was the last step in the development of the updated M&I forecast. The Authority developed the estimates of water savings based on implementation of the Best Management Practices for conservation and SANDAG demographic information for the period 2005 through 2020. These savings were then used to adjust the forecast.

The future water demands of the Camp Pendleton Military Reservation were forecasted by Camp Pendleton and included in the adjusted M&I forecast and agricultural forecast.

In addition to updating the *CWA-MAIN* model, a new agricultural water demand model was also developed. The new model estimates agricultural demand met by Authority's member agencies based on agricultural acreage projections provided by SANDAG, crop distribution data derived from the California Department of Water Resources (DWR) and California Avocado Commission, and average watering requirements.

Table 3-2 shows the total projected water demand for the Authority through the year 2020. The M&I demand forecast was adjusted to produce a total projected demand (without conservation savings factored in), Camp Pendleton demands, and forecasted agricultural water demand. Water conservation measures are expected to reduce total M&I demands by approximately 12 percent in 2020, with an estimated savings of 93,200 ac-ft/yr. Agricultural demand is expected to decrease about 17 percent over the 20-year period to an estimated demand of 91,500 ac-ft/yr, as development occurs.

Table 3-2. Deterministic Forecast of Normal-Year Water Use Forecasts Adjusted for Water Conservation Authority Service Area (2005-2020) (ac-ft/yr)

Year	M&I Baseline Forecast	Estimated Conservation Savings	M&I Forecast Reduced by Conservation[(a)]	Agricultural Forecast[(b)(c)]	Total Projected Demand
2005	643,900	54,900	596,200	109,900	706,100
2010	693,600	74,400	628,100	105,200	733,300
2015	747,100	83,400	672,600	99,400	772,000
2020	805,800	93,200	721,500	91,500	813,000

Source: *2000 Urban Water Management Plan* and *CWA-MAIN Forecast* (July 2000).

[(a)] Includes M&I demands from Camp Pendleton Military Reservation (7,200 ac-ft/yr in 2005 and 8,900 ac-ft/yr in 2010, 2015 and 2020).

[(b)] Consists of certified and non-certified Interim Agricultural Water Program (IAWP) agricultural water.

[(c)] Includes agricultural demands from Camp Pendleton Military Reservation (1,600 ac-ft/yr in 2005 and 2,300 ac-ft/yr in 2010, 2015 and 2020).

Demand Forecasts for Facilities Master Plan

In December 1998, in support of the *Master Plan*, work began on refinements and enhancements to the Authority's *CWA-MAIN* model. These refinements and enhancements included the following:

- extending the model forecast range from 2015 to 2030
- development of a probabilistic M&I demand forecast

As stated earlier, the probabilistic forecast of member agency demands was developed by Planning and Management Consultants, Ltd. (PMCL) for the Authority. Their final report was *Development of Probabilistic Water Demand Forecast for the San Diego County Water Authority* (November 2000) (see Appendix C).

In Chapter 7, both the probabilistic and deterministic demand forecasts are used to evaluate alternatives. The deterministic forecast represents the "mean" value in the figures and tables below.

The probabilistic demand forecast treats variables in the *CWA-MAIN* water demand equation as uncertain rather than as discrete values as used in the deterministic forecast. Authority, PMCL, and SANDAG staff jointly developed the probability distributions for these variables.

All demographic variables within PMCL's report were treated as uncertain, while weather was based on data collected at six San Diego County weather stations from January 1995 to December 1999. Weather variability is incorporated into reliability modeling (*Confluence*) that combines probabilistic supply and demand forecasts, as presented in Chapter 2 of this *Master Plan*.

Estimating the uncertainty surrounding long-term water demand forecasts is generally a mathematical and statistical exercise. Monte Carlo simulation techniques were applied to the econometric forecasting models to generate a range of potential future demands for M&I and municipally supplied agricultural water.

The forecasts were generated as statistical confidence intervals for 5-year increments in planning years 2005 through 2030. The summary tables and figures provided below show the mean forecasts for normal weather (with conservation), as well as the 5th percentile and 95th percentile values. The table demonstrates that there is a 95 percent probability that actual water demands will exceed the 5th percentile number for demand, while there is only a 5 percent probability that actual demands will exceed the 95th percentile number. One way of understanding these two values is to state that there is a 90 probability that actual demand will fall between these two values. Another way of stating this is to say that there is only a 5 percent probability that future demand will exceed the 95th percentile.

Probabilistic M&I Forecasts

Authority-wide forecasts are given in **Tables 3-3** and **3-4** for M&I and agricultural water demands. **Table 3-5** gives the combined M&I and agricultural demands forecasted for individual Authority member agencies.

Table 3-3 summarizes the simulation results for the M&I water demands for the 2005-2030 period, including conservation and assuming normal weather conditions. The projected mean forecast of Authority-wide M&I demand for the year 2005 is 589,000 ac-ft and 793,600 ac-ft for 2030.

Figure 3-1 shows that there is a 90 percent probability that the estimated M&I normal weather demands would fall between 560,400 and 617,500 ac-ft in 2005. By 2015, this interval increases about 10 percent per year until the demand interval ranges from 589,000 ac-ft to 740,500 ac-ft. By 2030, the 90 percent confidence interval expands to a range of 617,600 to 970,000 ac-ft/yr. These intervals are similar to the intervals for total demand. This is to be expected since M&I values are generally 85 to 90 percent of the expected total demand.

Probabilistic Agricultural Forecasts

Table 3-4 summarizes the simulation results for the municipally supplied, agricultural water demands forecasted for 2005 to 2030. The projected mean forecast of agricultural demand for the year 2005 is 108,324 ac-ft under normal weather conditions. Expected agricultural water demand increases by less than 1 percent from 2000 to 2005, before beginning a steady decline of 1 percent per year until

Table 3-3. Probabilistic Forecast of Municipal and Industrial Water Demand for Authority Service Area (2005-2030) (ac-ft/yr) [(a)]

	2005	2010	2015	2020	2025	2030
Probabilistic Forecast (with conservation; normal weather)						
Mean	589,002	619,245	663,695	712,569	759,529	793,606
Percentile						
5%	560,412	569,423	588,866	609,829	617,362	617,613
95%	617,480	668,940	740,449	813,891	908,313	969,803

(a) Camp Pendleton demand is not included.

Table 3-4. Probabilistic Forecast of Municipal Supplied Agricultural Water Demand for Authority Service Area (2005-2030) (ac-ft/yr)[a]						
	2005	2010	2015	2020	2025	2030
Probabilistic Forecast (normal weather)						
Mean	108,324	102,859	97,100	89,174	83,594	78,783
Percentile						
5%	95,529	90,349	85,088	78,124	73,162	69,151
95%	125,341	119,221	112,533	102,853	96,434	91,044

[a]Consists of certified and non-certified IAWP agricultural water.

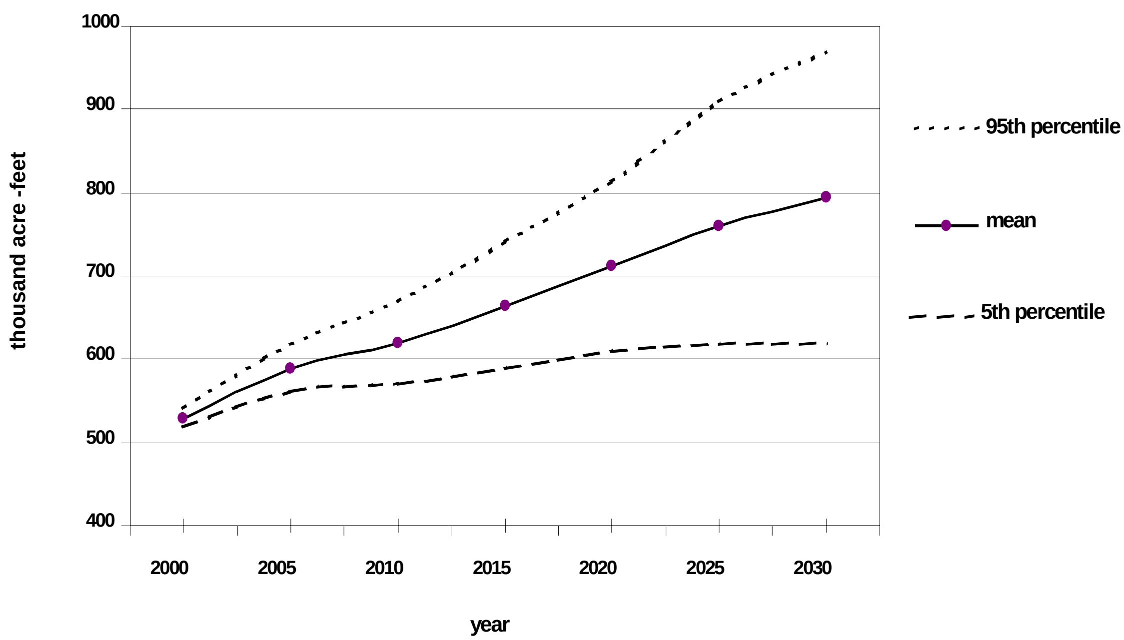

Figure 3-1. Ninety Percent Confidence Interval for M&I Water Demand (with Conservation), Under Normal Weather Conditions

2030, mostly brought about by an anticipated decrease in irrigated acreage.

The range of the 90 percent confidence interval gently declines from over 29,000 ac-ft/yr to just under 22,000 ac-ft/yr, as shown in **Figure 3-2**. This contrasts with the behavior of the M&I and total demand intervals. The greatest expected changes in acreage among the member agencies occur early in the forecast horizon, which leads to relatively greater forecast variances in those forecast years.

Probabilistic Combined M&I and Agricultural Forecasts

Table 3-5 presents a summary of the combined M&I and agricultural demands, broken down for each agency for the years 2005 through 2030. Forecasts for the Authority and member agencies are shown in the table. The Authority total equals the sum of the member agency demands for the 50 percent probability estimate (the mean). The Authority values are larger than the sum at 5 percent probability and smaller than the sum at the 95 percent probability. **Figure 3-3** graphically depicts the Authority demand projections for 2005 through 2030, for each percentile.

Analysis of Annual and Daily Peak Demands

In order to examine the ability of the system to meet daily member agency demands, an analysis of peak demands was performed by A&N Technical Services, Inc. (A&N) for the 2030 forecasting period. The final report, *Continuous-Time Short-Term Models of Daily Water Demand in San Diego County* (October 2000) is presented in Appendix C.

Using the forecasted long-term normal demands as a starting point, a set of empirical models was developed to predict daily demand fluctuations. Although these models do not replace long-term predictive models of water demand, they lead to a better understanding of short-term demand variations. Understanding these variations

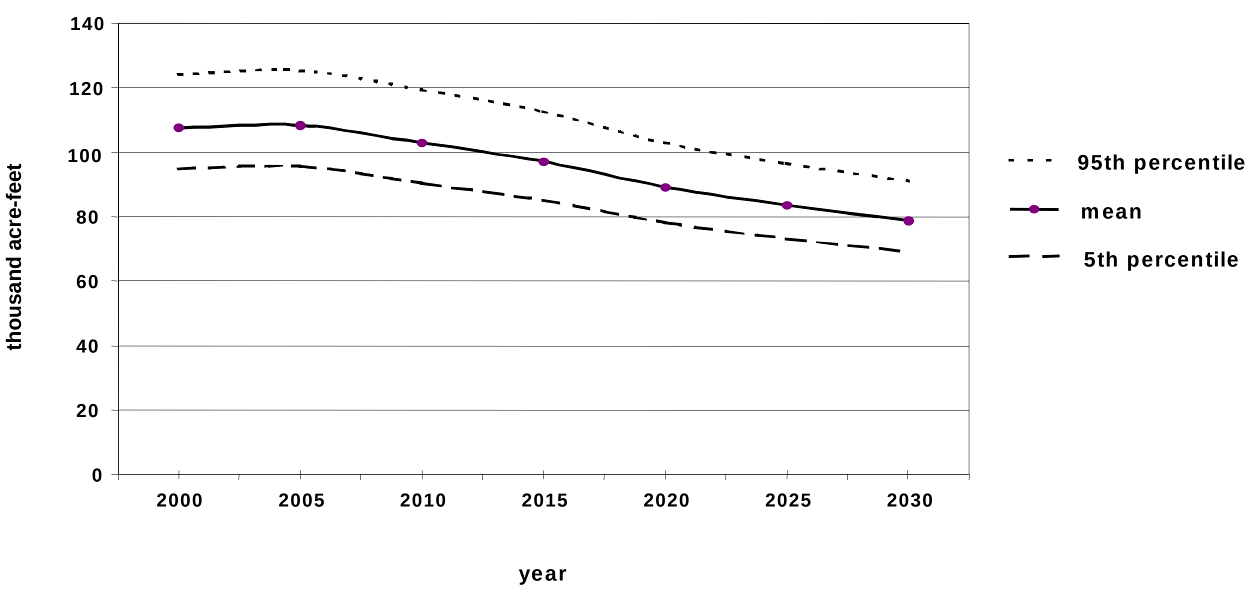

Figure 3-2. Ninety Percent Confidence Interval for Agricultural Water Demand

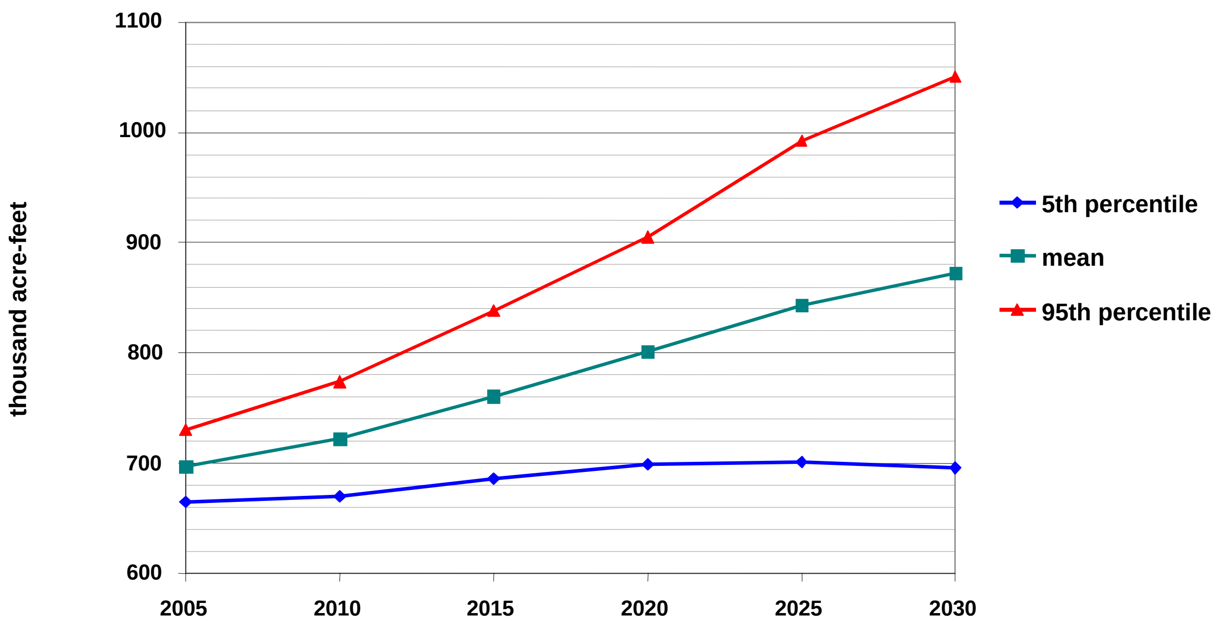

Figure 3-3. Ninety Percent Confidence Interval for Authority Demand (2005-2030) (M&I and Agricultural Water Demands, with Conservation)

is necessary to determine the effects of peaking, more effectively size facilities, and procure sufficient supplies.

These models are run at an aggregate level and, as such, should be interpreted as a synthesis of many types of relationships — meteorological, physical, behavioral, operational, legal, and chronological. Nonetheless, these models depict key short-term and long-term relationships and should serve as a solid point of departure for improved quantification of these linkages.

The variables used in the short-term models included:

- Deterministic time variables, such as the seasonal shape of demand and the day of the week
- Weather conditions: measures of temperature and rainfall (contemporaneous and lagged)
- Known cases where supply curtailments constrained demand (drought)

The models were then used to create high-resolution depictions of how variations in weather affect water demand over a wide range of conditions. The estimates then served as inputs to the Authority system-wide reliability simulations.

The probabilistic forecasts and peak demands discussed in this chapter, along with water supply data presented in Chapter 4, formed a database used in the *Confluence*™ model. This model is discussed in Chapter 2.

Table 3-5. Probabilistic Forecasts of M&I and Municipally Supplied Agricultural Water Demands for Authority Member Agencies (2005-2030) (ac-ft/yr)[(a)]

Agency	2005			2010			2015			2020			2025			2030		
	Percentile			Percentile			Percentile			Percentile			Percentile			Percentile		
	5	50	95	5	50	95	5	50	95	5	50	95	5	50	95	5	50	95
Carlsbad	20,500	21,700	23,000	21,600	23,500	25,300	23,300	6,100	29,100	24,900	28,900	32,900	25,500	30,800	36,500	25,700	32,300	39,100
Del Mar	1,500	1,600	1,700	1,500	1,600	1,700	1,500	1,700	1,900	1,500	1,800	2,000	1,500	1,900	2,200	1,500	1,900	2,300
Escondido	27,300	31,000	35,100	27,500	31,300	35,300	27,000	1,200	35,300	26,400	30,900	35,600	26,500	32,500	39,000	26,100	33,600	41,100
Fallbrook	14,200	16,800	21,100	14,300	17,000	21,200	14,600	17,600	21,800	15,100	18,400	22,900	14,700	18,300	22,800	14,400	18,100	22,600
Helix	36,900	39,400	41,900	36,300	40,100	43,900	35,600	40,900	46,300	35,300	42,200	49,100	34,900	44,400	54,100	34,200	45,700	57,500
Oceanside	33,100	35,700	38,100	34,000	37,500	40,900	35,200	39,600	44,100	36,000	41,700	47,500	36,100	43,300	51,300	35,300	44,300	53,400
Olivenhain	18,300	19,600	20,900	18,800	20,800	22,900	19,700	22,600	25,700	19,700	23,600	27,700	19,300	24,400	30,000	18,600	24,800	31,300
Otay	32,300	34,300	36,400	35,100	38,300	41,500	39,000	43,800	48,700	42,700	49,500	56,400	44,100	53,300	63,300	44,500	56,200	68,000
Padre Dam	19,700	21,100	22,400	19,800	21,900	24,000	20,300	23,200	26,200	21,400	25,600	30,000	22,100	27,800	34,200	22,300	29,700	37,500
Poway	18,400	19,500	20,600	18,800	20,400	22,100	19,000	21,300	23,700	19,200	22,200	25,300	19,200	23,100	27,300	18,700	23,500	28,400
Rainbow	26,900	31,100	39,500	27,200	31,500	39,800	28,600	33,400	41,800	30,500	36,000	44,800	30,100	36,200	44,800	29,500	36,300	45,000
Ramona	8,600	10,600	12,700	9,500	11,600	13,700	9,800	11,700	13,800	9,900	11,900	14,000	10,200	13,000	16,000	10,400	14,000	18,000
Rincon	8,100	8,800	9,400	8,100	9,000	9,800	8,300	9,500	10,800	8,200	9,800	11,300	8,000	10,000	12,200	7,800	10,100	12,600
San Diego	247,900	262,300	277,200	250,500	272,500	296,100	255,800	288,500	321,800	260,800	304,900	349,800	263,300	323,400	386,900	261,900	336,100	411,700
San Dieguito	6,900	7,400	7,800	6,600	7,300	8,000	6,500	7,500	8,400	6,600	7,700	9,000	6,500	8,100	9,800	6,400	8,300	10,300
Santa Fe	11,700	12,600	13,400	11,300	12,600	13,800	11,400	13,100	14,900	11,400	13,700	16,100	11,200	14,200	17,500	10,600	14,400	18,200
Sweetwater	21,900	23,300	24,600	21,400	23,400	25,600	21,400	24,200	27,100	21,600	25,400	29,100	21,600	26,800	32,200	21,500	27,800	34,200
Vallecitos	15,900	17,000	18,200	16,800	18,300	19,900	18,200	20,400	22,900	19,700	23,100	26,600	20,500	25,300	30,500	20,900	27,300	33,700
Valley Center	41,300	48,600	63,300	40,300	47,100	60,800	39,200	45,800	58,700	37,400	43,600	54,100	37,300	44,500	55,400	37,300	45,700	56,200
Vista	23,900	25,300	26,800	24,500	26,700	29,000	25,300	28,500	31,900	26,000	30,500	34,800	26,200	32,100	38,300	25,900	33,000	40,300
Yuima	5,000	9,800	14,700	5,000	9,800	14,800	5,200	10,100	15,100	5,300	10,400	15,500	5,000	9,800	14,500	4,800	9,200	13,700
Authority	665,400	697,300	730,300	670,200	722,100	774,000	686,500	760,800	838,700	699,200	801,700	905,100	701,000	843,100	992,400	696,100	872,400	1,050,400

[(a)] Does not include 11,700 acre-feet of water demand for Camp Pendleton (a deterministic forecast).

4 Water Supply Analysis

As San Diego County's population has increased, so has its reliance on imported water supplies. Since 1990, the Authority has imported 75 to 95 percent of the region's water supply from Metropolitan. Although imported water currently meets the majority of the region's water demands, local water resources are also an important component of the region's projected water resources mix. Local resources include demand management, surface and groundwater supplies, as well as recycled water.

The availability of imported supplies is directly linked to the reliability of and dependence upon the State Water Project and the Colorado River. In order to reduce the effect of shortages on San Diego County supply (from one or both of these sources), the Authority and its member agencies have taken steps to increase reliability through diversification of supplies. A major step was taken in April 1998, when the Authority entered into an agreement with the Imperial Irrigation District (IID) for the transfer of 200,000 acre-feet (ac-ft) of conserved water. This transfer is a cornerstone of the *California Colorado River Water Use Plan*. It is expected that the water transfer agreement with IID, along with continued development of additional local supplies, will be implemented in the near future to increase the reliability of the Authority's water supply and reduce sole dependance on the two sole sources of imported water supplies.

The following paragraphs describe the existing and anticipated imported and local water supplies for the San Diego region. Deterministic and probabilistic estimates for projected local and imported water supplies are discussed at the end of the chapter.

Imported Water Supplies

Metropolitan, a wholesale agency, is currently the sole source of imported water supply to the Authority. Metropolitan also supplies water to its member agencies located in Ventura, Los Angeles, Orange, San Bernardino, and Riverside Counties. Metropolitan obtains its water from two sources: the Colorado River Aqueduct (CRA), which it owns and operates, and the State Water Project (SWP). The extent to which Metropolitan's member agencies rely upon Metropolitan's imported water supplies varies considerably. The Authority is the largest of Metropolitan's 27 member agencies in terms of deliveries, purchasing about 40 percent of all the water Metropolitan delivered in FY 1999-2000. **Table 4-1** shows Authority water use as a comparison to the total of all other Metropolitan member agencies.

Table 4-1. Local Supply and Water Deliveries by Metropolitan (1998-99) (acre-feet)

Agency	Local Water Supply	Metropolitan Water Deliveries [(a)]	Total Water Use	Preferential Right to Metropolitan Supply[(b)]
SDCWA	150,173	454,436	604,609	302,190
All other Metropolitan member agencies	2,038,920	1,079,217	3,118,137	1,797,810
Total	**2,189,093**	**1,533,653**	**3,722,746**	**2,100,000**

(a) Includes Metropolitan's replenishment deliveries.
(b) Member agencies' preferential right to Metropolitan supplies in FY 98-99 was based on 2.1 MAF, which Metropolitan indicated is its firm supply.

Source: Metropolitan Water District and SDCWA Water Resources Department, *2000 Urban Water Management Plan* (December 2000).

Colorado River Water Supply

Metropolitan was initially formed to import water from the Colorado River and, during the 1930s, Metropolitan built the CRA to convey this water. The first deliveries from the CRA were made to Metropolitan member agencies in 1941.

Reliability Issues

Before 1964, Metropolitan had a firm allocation of 1.212 MAF of Colorado River water through contracts with the U.S. Department of the Interior, which was enough to keep Metropolitan's aqueduct full. However, as a result of the U.S. Supreme Court decision in *Arizona vs. California*, Metropolitan's firm supply fell to 550,000 ac-ft. In recent years, Metropolitan has kept its aqueduct full through access to unused apportionments from other states or declarations of surplus water from the Department of Interior. This reduction in firm allocation is the most pressing issue Metropolitan faces regarding its Colorado River supplies.

The availability of water from the Colorado River is governed by a system of priorities and water rights that have been established over many years. The Colorado River Lower Basin states (California, Arizona, and Nevada) have an annual apportionment of 7.5 MAF of water. This supply is divided as follows:

- California: 4.4 MAF
- Arizona: 2.8 MAF
- Nevada: 0.3 MAF

California agency priorities for water were established by the 1931 *Seven Party Agreement*. These priorities are shown in **Table 4-2**. As shown in the table, Metropolitan's 4th priority of 550,000 ac-ft is junior to that of the first three priorities (3.85 MAF), which go to California agricultural agencies. Water used to satisfy priorities 5(a)-6(b) must come from unused allocations within California, Arizona, or Nevada, or from surplus.

In recent years, Metropolitan has filled its aqueduct to capacity, using an average of 1.2 MAF per year from the Colorado River. To do this, Metropolitan has relied on unused apportionments for Arizona and Nevada and unused apportionment for California agricultural agencies, as well as surplus water. However, more recently

Table 4-2. Seven-Party Agreement of California Priorities to Colorado River Water Supply

Priority	Description	Amount (ac-ft/yr)
1	Palo Verde Irrigation District	Priorities 1, 2, and 3 shall not exceed 3.85 MAF per year.
2	Yuma Project Reservation Division	Same as above.
3 (a)	Imperial Irrigation District and lands in Imperial and Coachella Valleys to be served by All-American Canal	Same as above.
3 (b)	Palo Verde Irrigation District	Same as above.
4	Metropolitan Water District	550,000
	Subtotal	4,400,000
5 (a)	Metropolitan Water District[a]	550,000
5 (b)	City/County of San Diego[a] [b]	112,000
6 (a)	Imperial Irrigation District[a]	
6 (b)	Palo Verde Irrigation District[a]	300,000
	Total	**5,362,000**

[a] Priorities 5a through 6b are only available if there are unused portions in the California, Nevada, and Arizona allocations or if there is a surplus.

[b] In 1946, San Diego's rights were merged with and added to the rights of the Metropolitan Water District as one condition of the Authority's annexation to Metropolitan.

Source: Metropolitan Water District and SDCWA Water Resources Department, *2000 Urban Water Management Plan* (December 2000).

Arizona and Nevada have increased water demand at or near apportionment levels, limiting the availability of unused apportionments to Metropolitan. Arizona's demand has been substantially increased by deliveries to an in-state groundwater banking program. Nevada is banking water under an interstate water banking rule established by the Department of Interior in 1999, which allows Nevada to bank water in Arizona for Nevada's future use.

Metropolitan has been able to keep its aqueduct full since 1996 through a successive string of annual surplus declarations by the Department of the Interior. This was initially made possible because above-normal precipitation filled the river's reservoirs to near-capacity. In January 2001, the Department of Interior implemented *Interim Surplus Guidelines* (ISG) for operating Lake Mead that make additional surplus water available to Metropolitan through 2016. This was done to enable California to develop and implement programs to reduce demand on the river to California's 4.4 MAF apportionment of water. Since early 2001, the Colorado River has experienced a severe drought. Without the ISG, Metropolitan would not have had access to surplus water for calendar year 2002 and would not have been able to keep the CRA full. Reservoir levels have continued to drop, making supplies for calendar year 2003 also dependent upon the ISG.

Future Supplies and California's Colorado River Water Use Plan

Metropolitan is working with other agencies to increase its Colorado River supplies and improve its water reliability, primarily through California's *Colorado River Water Use Plan (California Plan)* and the *Quantification Settlement Agreement* (QSA). The *California Plan* is designed to reduce California's demand on the river to its 4.4 MAF apportionment when surplus water or other states' apportionment are not available.

Water supply programs identified in the *California Plan* include the Authority's 200,000 ac-ft water transfer with IID. In April 1998, the Authority entered into an agreement with IID for the transfer of conserved water. Deliveries into San Diego County from the transfer are expected to begin by early 2003. This original agreement specified that the Authority would receive between 130,000 and 200,000 ac-ft of water per year after an initial 10-year steady increase in water deliveries. Negotiations on an agreement are currently under way (see the section below on IID water transfer).

Other supplies include 93,700 ac-ft from a conservation project to line portions of the All-American and Coachella Valley Canals, located in Imperial and Coachella Valleys, respectively, as well as several off-stream groundwater storage programs that would develop about 400,000 ac-ft of dry-year supplies. These programs are intended to offset the reduced availability of unused apportionment and surplus water supplies.

The *California Plan* also incorporates the terms of the QSA among Metropolitan and California's agricultural agencies. This settlement limits the amount of water that each agricultural agency may take from the 3.85 MAF first priority listed previously in **Table 4-2**. The settlement also provides for the allocation of future water supplies and transfers among California's Colorado River water users.

State Water Project

Metropolitan's other water source, the State Water Project (SWP), is owned by the State of California and operated by the California Department of Water Resources (DWR). SWP water is pumped from the San Francisco Bay/Sacramento-San Joaquin River Delta (Bay-Delta) for delivery through the California Aqueduct.

Reliability Issues

The reliability of SWP supplies is limited by the level of SWP supply development compared to current and future demands and, increasingly, by pumping restrictions due to state and federal environmental regulations. The SWP was initially planned to deliver 4,230,000 ac-ft to 32 contracting agencies. Subsequent contract amendments reduced total contracted deliveries to 4,172,786 ac-ft and the number of contracting agencies to 29. Metropolitan's contracted entitlement is 2,011,500 ac-ft, or about 48 percent of the total.

An important feature of the SWP contracts is that the full amount of water was not anticipated to be needed for at least the first 20 to 30 years of the project. Facilities needed to produce the full 4,230,000 ac-ft were expected to be constructed over time as demands on the system increased. However, these additional facilities were repeatedly deferred, and public attitudes and environmental regulations changed. New state and federal environmental laws put some potential water supply sources off limits to development. More stringent water quality standards adopted by the State Water Resources Control Board (SWRCB) to protect the San Francisco Bay/Sacramento-San Joaquin River Delta (Bay-Delta) have also reduced the amount of water available for diversion.

By the late 1980s, the SWP was unable to meet contractor demands during drought periods. During the initial years of the 1987–92 drought, DWR maintained SWP deliveries using water stored at Lake Oroville and the San Luis Reservoir. In 1991, however, the SWP delivered only 549,113 ac-ft of entitlement water. Of this amount, Metropolitan received 381,070 ac-ft, or about 20 percent of its entitlement.

SWP shortages are expected to become more frequent as demands on the system increase. **Figure 4-1**, from DWR's *Bulletin 160-98,* shows existing and future SWP delivery capability (1995 and 2020, respectively), as estimated by operations studies, under the SWRCB's *1995 Water Quality Control Plan*. According to this bulletin, existing SWP facilities have a 65 percent chance of making full deliveries under 1995 level demands and an 85 percent chance of delivering 2.0 MAF to contractors in any given year. Under a 2020 demand scenario, the chance that existing SWP facilities will make full deliveries is less than 25 percent.

Environmental Considerations

In recent years, actions taken to protect the ecosystem of the Bay-Delta have placed additional restrictions on SWP operations. The Bay-Delta is the largest estuary on the West Coast, supporting more than 750 plant and animal species. But 150 years of human activity, dating back to 19th century gold mining, has taken its toll on the Bay-Delta ecosystem and the fish that live there. In 1989, the winter-run Chinook salmon was designated, or "listed," as a threatened species under the ESA. Over the next 10 years, the Delta smelt, steelhead trout, and spring-run Chinook salmon joined the list of threatened species, and the winter-run Chinook salmon's population declined to such an extent that its status was changed to endangered.

The decline of Delta fisheries can be traced to numerous factors—habitat loss, water diversions, pollution, overfishing, and the introduction of non-native species—which have all contributed to the degradation of the Bay-Delta ecosystem. Regulatory protection efforts have nevertheless tended to focus on the operations of the SWP and the federal Central Valley Project (CVP). In 1999, the SWP was forced to reduce pumping by about 500,000 ac-ft to protect Delta smelt and spring-run Chinook salmon. These pumping reductions were in addition to fish protection measures built into the water quality standards established by the SWRCB. Although the SWP was able to offset some of the water supply impact by increasing pumping rates later in the year, SWP contractors lost access to more than 150,000 ac-ft of water for storage and suffered a significant reduction in water quality.

Water Quality Considerations

The quality of SWP water as a drinking water source is affected by a number of factors, most notably seawater intrusion and agricultural drainage from peat soil islands in the Delta. SWP water contains relatively high levels of bromide and total organic carbon, two elements that are of particular concern to drinking water agencies. Bromide and total organic carbon combine with chemicals used in the water treatment process to form disinfection by-products that are strictly regulated under the federal *Safe Drinking Water Act*. Wastewater effluent discharges from cities and towns surrounding the Delta also add salts and pathogens to Delta water, further reducing its suitability for drinking and recycling.

Water agencies treat all water to meet stringent state and federal drinking water standards before delivering it to customers. However, source water of poor quality will make it increasingly expensive and difficult to meet such standards. The California Urban Water Agencies (CUWA) retained the assistance of a panel of

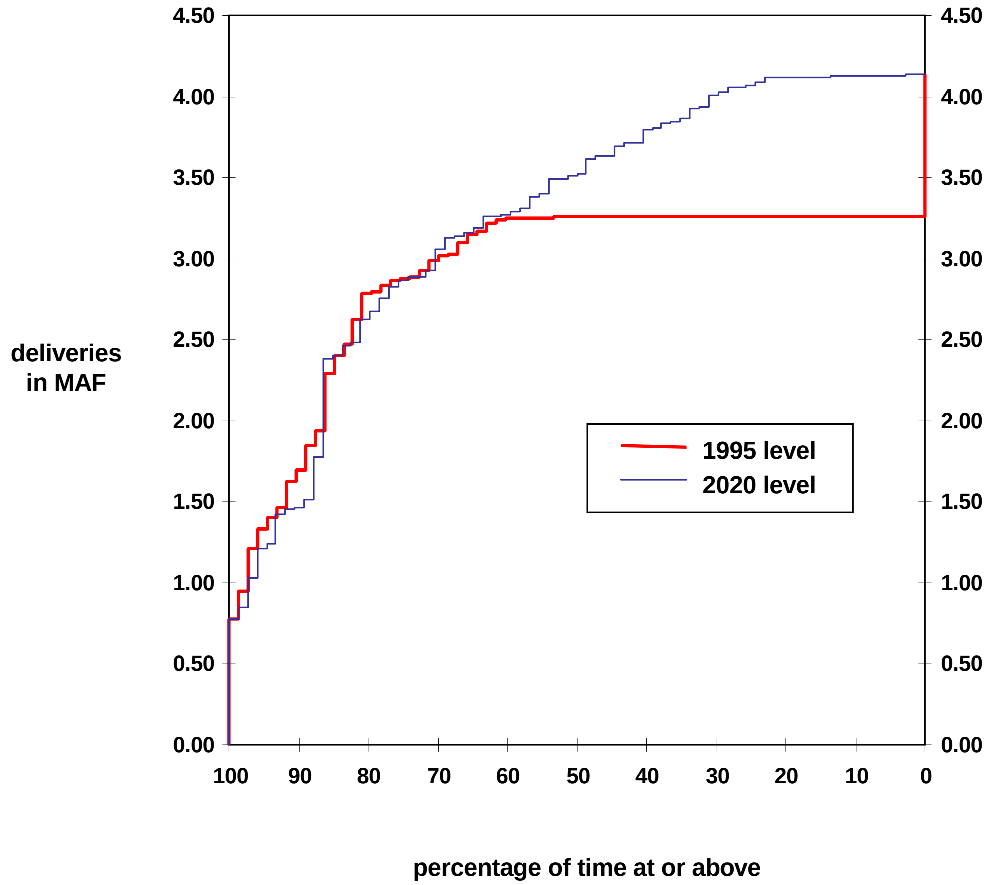

Figure 4-1. State Water Project Delivery Capability with Existing Facilities (1995 and 2020)

Source: San Diego County Water Authority,
2000 Urban Water Management Plan (December 2000).

drinking water quality and treatment experts to evaluate the source water quality that would be needed to allow agencies treating Delta water to comply with future drinking water regulations (under a plausibly conservative regulatory scenario). The expert panel identified target concentrations of bromide and total organic carbon of 50 parts per billion (ppb) and 3 parts per million (ppm), respectively. By comparison, the average bromide concentration of SWP water is 290 ppb, about six times the target level. The average concentration of total organic carbon in SWP water is about 3.3 ppm, about 10 percent above the target level.

Actions to protect Delta fisheries have exacerbated existing water quality problems by forcing the SWP to shift its diversions from the spring to the fall, when salinity and bromide levels are higher. Closure of the Delta Cross Channel gates to protect migrating fish has also degraded SWP water quality by reducing the flow of higher quality Sacramento River water to the SWP pumps.

Current Supplies

SWP delivery contracts were amended in 1995 to reflect principles developed under the December 1994 *Monterey Agreement*. Under the Monterey amendments, all SWP supplies are allocated to contractors in proportion to their contractual entitlements. Metropolitan's approximately 48 percent share of total SWP contract entitlements entitles it to a proportionate share of available SWP supplies. Metropolitan estimates that existing SWP facilities, operated in accordance with the 1995 Water Quality Control Plan, will produce about 1.2 MAF in a dry year and 2.7 MAF per year on average. Metropolitan's proportionate share of dry-year and average-year SWP supplies is estimated at 0.6 MAF and 1.35 MAF, respectively. A September 2000 State Court of Appeal decision sustained challenges to the adequacy of the *Monterey Agreement's* Environmental Impact Report that were made by two environmental agencies and one of the SWP's contractors. The contractors and environmental groups have since been negotiating to resolve the disputed terms of the agreement.

Future Supplies and the CALFED Bay-Delta Program

Although the outcome is still uncertain, the CALFED Bay-Delta Program (CALFED Program) is expected to provide the greatest opportunity to improve SWP supply reliability and water quality. The state and federal governments organized the CALFED Program in 1995 to develop a comprehensive long-term solution to the ecosystem, levee stability, water quality, and water supply reliability problems affecting the Bay-Delta system.

The CALFED Program began its transition from planning to implementation in June 2000 with the release of a document entitled, *California's Water Future: A Framework for Action* (*Framework*). The *Framework*, which focuses on the first 7 years (Stage 1) of what CALFED envisions to be a 30-year program, outlines a number of specific steps to improve the quality and reliability of Bay-Delta water supplies, increase the efficient use of water throughout the State, restore the Bay-Delta ecosystem, stabilize Delta levees, and foster the water transfer market. The *Framework* was followed in July 2000 by a final programmatic EIS/EIR that sets the stage for implementation of the CALFED Program. A federal record of decision was released in August 2000. Three separate legal challenges were filed during the 30-day period following the certification of the EIS/EIR. One of the legal challenges has been resolved, but the other two remain active. It is not clear what impact they will have on implementation of the CALFED Program.

Two elements of the CALFED Program have the greatest potential for increasing the reliability and quality of SWP supplies: 1) improvements to the existing Delta conveyance system, including expansion of the permitted capacity of the SWP pumping plant from its current level of 6,680 cfs to 8,500 cfs and, ultimately, to 10,300 cfs, subject to certain conditions; and 2) a new water "budget" for protection of fish known as the Environmental Water Account (EWA). The conveyance system improvements would improve the reliability and quality of SWP supplies, by allowing the SWP to increase pumping during times of the year when additional water is available and when water quality is highest and reduce pumping when endangered fish are migrating through the Delta. The improvements will also increase the amount of pumping capacity available for other purposes, such as water transfers.

New surface and groundwater storage could also enhance the reliability and quality of SWP supplies. The *Framework* calls for the construction of up to 4.75 MAF of new surface and groundwater storage over the life of the CALFED Program; however, it is not known whether any of the new storage would be constructed as part of the SWP. Pending further analysis, it also remains to be seen how much Southern California would benefit from additional storage capacity constructed in Northern and Central California.

The amount of water produced through the proposed conveyance improvements will depend on how the individual facilities are operated and on the level of assurances provided by the state and federal regulatory agencies. The EWA, as proposed in the *Framework*, will be used to provide the SWP and CVP regulatory assurances for the first 4 years of the CALFED Program, with the expectation that the assurances will be extended periodically thereafter. The regulatory assurances are intended to ensure that the projects will not face additional water supply impacts due to regulatory actions taken under the federal ESA or other federal or state laws or regulations.

If the CALFED Program succeeds in its mission of restoring stability to the Bay-Delta system, and the regulatory assurances are extended beyond the initial 4-year period, then the improvements called for in the *Framework* have the potential to increase Metropolitan's share of average SWP supplies by about 0.15 MAF, to a total of 1.5 MAF. If the CALFED Program is not successful, and the Bay-Delta system continues to decline, then the improvements proposed in the *Framework* may produce little or no supply reliability or water quality improvement and Metropolitan's average SWP supplies could even decline from existing levels.

Firm Water Supply from Metropolitan – Preferential Right to Water

For many years, Metropolitan has been the sole provider of imported water to the Authority; however, circumstances have changed dramatically since the Authority joined Metropolitan in 1944. One of the key issues is the Authority's preferential right to water at Metropolitan. Under Section 135 of the Metropolitan Act, each member agency has a preferential right to water. As calculated by Metropolitan, the Authority has a preferential right to approximately 15 percent of Metropolitan's water, but the Authority typically purchases in excess of this percentage. For example, in FY 1999-2000, the Authority purchased approximately 40 percent of the total amount of water Metropolitan delivered. At any time under preferential rights rules, Metropolitan could allocate water without regard to historic water use or dependence on Metropolitan. On January 30, 2001, the Authority filed a lawsuit in Superior Court to seek clarification regarding current application and legality of Section 135.

The Authority-IID Water Conservation and Transfer Agreement

On April 29, 1998, the Authority and IID signed a *Water Conservation and Transfer Agreement*. The agreement is the largest agriculture-to-urban water transfer in United States history. Under terms of the agreement, Colorado River water will be conserved by Imperial Valley farmers and then transferred to the Authority for use in San Diego County. Imperial Valley farmers, who voluntarily participate in the program, will conserve the water by employing extraordinary conservation measures. Deliveries into San Diego County from the transfer are expected to begin by 2003. The Authority will receive 200,000 ac-ft per year (ac-ft/yr) after an initial 19-year increase in the water deliveries.

The initial term of the agreement is for 45 years, with a provision that either agency may extend the agreement for an additional 30-year term. Under certain conditions, up to 34,000 ac-ft can be recalled by IID at the end of the initial 45-year term.

During dry years, when water availability is low, the conserved water will be transferred under IID's Colorado River rights, which are among the most senior in the Lower Colorado River Basin. Without the protection of these rights, the Authority could suffer delivery cutbacks. In recognition of the value of such reliability, the contract requires the Authority to pay a premium on transfer water under defined regional shortage circumstances.

The Bureau of Reclamation and the California agencies involved in the QSA are currently identifying methods to offset potential environmental impacts of water transfers included in the QSA, based on the requirements of the following legislation: the National Environmental Policy Act (NEPA), the California Environmental Quality Act (CEQA), federal and state Endangered Species Acts (ESA), and California's fully protected species statutes. Because the Authority's water transfer involves conservation of irrigation water within IID, less water will run off Imperial Valley fields and drain into the Salton Sea. Less runoff will have impacts, including a temporary accelerated increase in sea salinity levels over the current rate, an increase which is already occurring.

In order to address these environmental issues, the parties to the QSA approved a Term Sheet that includes revisions to the *1998 Imperial Irrigation District–San Diego County Water Authority Water Transfer Agreement*. Under the Term Sheet, water transfers from Imperial Valley to San Diego County could begin in 2003. The Term Sheet provides for a combined temporary fallowing and system improvement program during the first 15 years of the transfer. In the 16th year of the agreement, all temporary fallowing would end and all water for transfer would be produced through on-farm and system conservation measures.

In the first year of the transfer (2003), IID will transfer 10,000 acre-feet to the Authority. IID will deliver 1 MAF of water over the first 15 years. This represents a reduction from the minimum 1.6 MAF (and 2.1 MAF maximum) called for in the 1998 water transfer agreement. The Authority will receive additional water over the first 15 years from Metropolitan's land management, crop rotation, and water supply program with the Palo Verde Irrigation District. In all, the Authority will receive nearly 1.4 MAF of transfer water in the first 15 years. The annual quantities would increase over the term of the agreement to 140,000 acre-feet in year 15 (2017). The quantities would increase to 200,000 acre-feet annually by the 19th year (2021) and remain fixed there for the duration of the transfer agreement. The 75-year agreement is comprised of two terms; an initial 45-year term and a 30-year renewal. Either party can compel the 30-year renewal term.

The *Interim Surplus Guidelines* were implemented to provide a "soft landing" while the *California Plan* transfers and other conservation programs are implemented. However, the ISG will be suspended if the QSA is not implemented by December 31, 2002, and the QSA cannot be implemented until environmental compliance requirements are met. The agencies are revising the necessary agreements on the basis of the approved Term Sheet.

Future Supplies

Based on the 1998 Authority-IID transfer agreement, the anticipated delivery schedule is shown in **Table 4-3** in 5-year increments.

Other Competitive Imported Water Sources

The Authority is also pursuing additional local and/or imported water supplies. Potential imported sources include various types of water transfers and Metropolitan non-firm supplies that may be available to the Authority.

It may be possible to obtain other transfer supplies, in addition to the IID transfer, to meet the future demands of the San Diego region.

Table 4-3. Projected IID Transfer Supply (ac-ft/yr)[(a)(b)]				
2005	**2010**	**2015**	**2020**	**2021**
30,000	110,000	140,000	190,000	200,000

(a) Assumes transfers begin in year 2003 at 10,000 acre-feet and increase, until the total delivery is 200,000 acre-feet per year, based on the October 2002 Term Sheet..

(b) Includes PVID transfer.

Source: SDCWA Water Resources Department.

In 1998, the Authority's Board of Directors authorized staff to prepare and distribute a request for proposals for additional transfers. The Authority has explored and will continue to explore transfer and water storage opportunities throughout California that have the potential to provide a reliable imported water supply to help meet the Authority's supplemental water needs.

In addition to transfer supplies, other imported supplies from Metropolitan may be available to the Authority.

Table 4-4 shows the Authority's projected mix of future imported water supplies.

Local Water Resources

Before 1947, the San Diego region relied upon local surface water runoff in normal and wet-weather years and upon groundwater pumped from local aquifers during dry years when stream flows were reduced. As the economy and the population grew, local resources were not sufficient to meet the region's water supply needs. From the 1950s onward, the region became increasingly reliant upon imported supplies. Since 1980, approximately 5 to 30 percent of the water used within the Authority's service area has come from local sources, primarily from surface water reservoirs that have yields varying directly with annual rainfall.

Other local resources include demand management measures (water conservation), surface supplies, recycled water, groundwater supplies, and, in the future, desalinated seawater.

Demand Management

Demand management, or water conservation, is frequently the least costly resource available to the Authority and its member agencies. The Authority and its member agencies continue to demonstrate a commitment to conserving water through implementation of the urban water conservation Best Management Practices (BMPs) and agricultural Efficient Water Management Practices (EWMPs).

Projected water savings through implementation of the BMPs are based on industry standard methodologies for calculating savings and updated demographic information from SANDAG. In the Authority's *2000 Urban Water Management Plan (Plan),* it is projected that the implementation of existing and proposed urban BMPs would produce water savings of approximately 93,000 ac-ft/yr by the year 2020 within the Authority's service area **(Table 4-5)**.

Table 4-4. Projected Average-Year Imported Water Supplies (ac-ft/yr)

Water Supply	2005	2010	2015	2020
IID water transfer[(a)]	30,000	110,000	140,000	190,000
Firm supply from Metropolitan[(b)]	344,800	368,100	386,400	389,500
Other sources	161,200	71,000	50,700	10,000
Total imported supplies	**556,000**	**549,100**	**577,100**	**589,500**

[(a)] Assumes transfers begin in year 2003 at 10,000 acre-feet, based on the October 2002 Term Sheet.

[(b)] 2002 estimate.

Source: San Diego County Water Authority, Water Resources Department.

Table 4-5. Potential Water Conservation Savings within Authority Service Area (2005-2020) (ac-ft)

	2005	2010	2015	2020
Existing Best Management Practices				
Residential surveys	1,100	1,100	1,100	1,100
Plumbing retrofits	8,100	8,100	8,100	8,100
New residential construction	6,800	10,900	14,100	17,300
Main line leak detection	13,230	18,320	18,360	19,310
Large landscape audits	1,400	1,600	1,900	2,200
Commercial, industrial, and institutional	1,100	1,100	1,100	1,100
Residential landscape	900	900	900	900
Ultra-low-flush toilet (ULFT) incentives	20,800	28,280	31,240	31,240
Clothes washer incentives	1,000	3,000	4,000	5,000
Subtotal	**54,430**	**73,300**	**80,800**	**86,250**
Proposed Best Management Practices				
Appliance efficient standards	200	560	2,060	6,400
Car wash retrofits	240	500	500	500
Greywater	30	40	40	50
Subtotal	**470**	**1,100**	**2,600**	**6,950**
TOTAL	**54,900**	**74,400**	**83,400**	**93,200**

Surface Water

Surface water supplies represent the single largest local resource in the Authority's service area. Seven major stream systems originate in the mountains of San Diego County and drain into the Pacific Ocean. Runoff within these watersheds has largely been developed over the last century; however, annual surface water yields can vary substantially due to fluctuating hydrologic cycles. In the last 26 years (July 1975 through June 2001), the amount of local water used to meet annual demand has been as high as 146,000 ac-ft and as low as 20,600 ac-ft. The long-term average production of local surface water is projected to be 85,600 ac-ft/yr.

Water Recycling

Water recycling is an important component of the area's local water resources. Water recycling is defined as the treatment and disinfection of municipal wastewater to provide a water supply suitable for non-potable reuse. Non-potable reuse is the term applied to recycled water used for non-drinking water purposes. Examples range from landscape irrigation to recreational impoundments. Agencies in San Diego County use recycled water to fill lakes, ponds, and ornamental fountains; to irrigate parks, campgrounds, golf courses, freeway medians, community greenbelts, school athletic fields, food crops, and nursery stock; to control dust at construction sites; and to recharge groundwater basins. Recycled water can also be used in certain industrial processes and for flushing toilets and urinals in nonresidential buildings.

There are a number of issues that local agencies have to consider when developing recycled water projects. These include economic and financial considerations, water quality, regulatory, institutional, and public acceptance. These issues, if left unresolved, can limit the amount of wastewater effluent that can be recycled in San Diego County.

A number of agencies in the San Diego region continue to implement and expand their water recycling projects. San Diego agencies currently reuse about 13,700 ac-ft/yr of recycled water, primarily for landscape irrigation and other industrial and commercial uses. The *Plan* projects that the region's supply of recycled water will increase to about 45,100 ac-ft/yr in 2010 and about 53,400 ac-ft/yr in 2020. These projections were provided by the local member agencies implementing the projects.

Groundwater

Agencies within the Authority's service area currently use about 24,000 ac-ft of groundwater annually. In addition, private well owners also draw on local basins for their water supplies, which offset imported water demands. The amount of groundwater pumped by private wells is estimated to be significant, but has not yet been accurately quantified for the region due to a lack of documentation.

Groundwater supplies in the Authority's service area are limited by the geology and the semi-arid hydrologic conditions of the region. Additionally, overpumping has led to excessive salinity in many of the most promising basins. Although groundwater supplies are less plentiful in the San Diego region than in some other areas of southern California, such as the Los Angeles Basin, sufficient undeveloped supplies exist to help meet a portion of the region's future water needs. Because of the saline nature of the groundwater basins in San Diego County, the cost of groundwater development usually includes demineralization, a process removing salts and minerals that can be costly to construct and operate. However, because treated groundwater is suitable for all potable uses, groundwater recovery projects face less variation in demand than recycling projects and do not require the construction of separate distribution facilities.

Several agencies within the Authority's service area have identified potential projects that could provide an additional 35,000 ac-ft/yr of groundwater production in the coming years. Agencies within the Authority's service area are expected to develop close to 59,000 acre-feet of groundwater supply by the year 2020. The estimated yields from the projects that make up this projection were provided by the local member agencies implementing the projects.

Seawater Desalination

Desalinated seawater is used throughout the world as a potable water supply and is sometimes described as the ultimate solution to Southern California's water supply needs. Until recently, the cost of seawater desalting has limited its large-scale application in the United States. Current projects being developed in Tampa, Florida and the island of Trinidad seem to indicate that the cost of seawater desalting is decreasing to a point that makes it a viable resource option for coastal areas such as San Diego County.

Processes commonly used for large-scale seawater desalination fall into two general categories: (1) thermal processes and (2) membrane processes. Thermal processes use heat to separate salt and other impurities from seawater. Membrane processes, such as reverse osmosis (RO), use pressure to force seawater through a semipermeable membrane. As membrane technology continues to improve, RO is gaining popularity as a less costly, more energy-efficient desalination technique.

Recent advances in reverse osmosis membrane technology as well as recent cost data from new seawater desalination facilities around the world, including the Tampa Bay Desalination Project, indicate that the cost of desalting seawater is competitive with other new water supplies.

In 2001, the Authority received a proposal from a private developer of seawater desalination projects for the development, construction, and operation of a 50-mgd seawater desalination plant located at the Encina Power Station in Carlsbad. The project would deliver 56,000 ac-ft/yr to the Authority, Carlsbad, and Oceanside. The Authority, in cooperation with Carlsbad MWD and the City of Oceanside, has completed a due diligence review of the proposal and recently completed project development discussions with the private developer and the owner of the Encina Power Station. As a result of these discussions, the Authority Board approved a term sheet with the developer that provides the basis for a future detailed agreement, which will be required to continue development of the project. The term sheet focuses on key project development issues, including the Authority assuming ownership of the desalination plant after a minimum initial operating period of 5 years. The term sheet also requires that the Authority have approval rights , involvement and oversight in the desalination plant development, and contractor procurement activities. Negotiations on a detailed agreement between the Authority, the developer, and the power plant owner are scheduled to be completed in 2003.

In December 2002, the Metropolitan Board authorized finalizing terms and conditions for an incentive funding agreement that would provide a $250 per acre-foot incentive for 56,000 acre-feet of annual production from the Carlsbad Seawater Desalination Project. In the event the Board determines to proceed with the Carlsbad project, environmental documentation would commence in 2003 and the project could be operational as early as 2007.

Foundation for Master Plan Resource Mix

At the time of its conception, the Authority's *Plan* presented the Authority's projected water resources mix necessary to provide a reliable water supply for the region through the year 2020 (**Table 4-6**). The *Plan* included deterministic projections (**Table 4-6**) for regional local supply development, including surface water, recycled water and groundwater. The *Master Plan* sought to enhance the modeling of this resource mix stated in the *Plan* through reliability analyses derived from the Confluence model (see Chapter 2 for model details).

Reliability Analysis of Local Groundwater and Recycled Water Supplies

A probabilistic projection of local groundwater and recycled water supplies was made, using a methodology similar to the one used for this *Master Plan's* probabilistic demand forecast. The purpose of the probabilistic approach is to attempt to represent a range of possible outcomes, rather than the single-point deterministic estimates typically used. The deterministic projections for recycled water and groundwater production given in the *Plan* (shown previously in **Table 4-6**) were used as a starting point in the development of the probabilistic supply forecast. Long-term average production of surface water is also shown in the table for reference.

Midpoint forecasts were made, based on these deterministic forecasts, and subsequently refined with input from the implementing agencies. As a result, the "Planned" or midpoint projections shown in **Table 4-7** vary slightly from the *Plan* projections shown in **Table 4-6**. Since most agency supply planning did not extend past 2020, a conservative assumption was made that projections for project implementation in 2030 would be equal to 2020 planned supply development amounts.

Using this updated data, a series of workshops were held to elicit expert judgment of the probability of local supply development. In the initial workshop, effort was focused on developing ranges of regional outcomes for recycled water and groundwater supply projections. After the initial workshop, Authority staff developed additional "Low" and "High" scenarios, by agency, for local supply development. Using structured elicitation of expert, subjective judgment, it was decided that the low scenario was, in general, a very low probability; it was assigned a 5th percentile level. Scenarios even less than the low scenario were considered very unlikely to occur (less than 5 times out of 100). Conversely, the high scenario reflects the 95th percentile, indicating that scenarios even higher than the high scenario are very unlikely to occur (less than 5 times out of 100). **Table 4-7** show planned, low, and high scenarios for each agency, while **Figure 4-2** depicts the cumulative probabilities for all recycled water and groundwater projects and their total capacities.

On a region-wide basis, **Table 4-7** shows that scenarios for annual beneficial reuse of recycled water range in 2010 from a low of 26,275 ac-ft (5th percentile) to a high of 57,000 ac-ft (95th percentile) and in 2030 from 36,890 ac-ft (5th percentile) to 88,060 ac-ft (95th percentile). These ranges represent the interval within which 90 percent of potential recycled water supply scenarios would fall. This means that there is a 90 percent confidence level that recycled water use will fall between 26,275 and 57,000 ac-ft in 2010 (a range of 30,725 ac-ft). In 2030, this 90 percent confidence level ranges from 36,890 to 88,060 (a range of 51,170 ac-ft), reflecting a higher level of uncertainty into the future.

Similarly, **Table 4-7** shows groundwater annual production scenarios that range from a low of 23,280 ac-ft (5th percentile) to a high of 58,600 ac-ft (95th percentile) in 2010 and from 27,280 ac-ft (5th percentile) to 64,600 ac-ft (95th percentile) in 2030. These ranges represent the interval within which 90 percent of potential

Table 4-6. *2000 Urban Water Management Plan* Projected Development of Local Supply (ac-ft/yr)[(a)(b)]				
Local Water Supply	**2005**	**2010**	**2015**	**2020**
Recycled water	33,400	45,100	51,800	53.400
Groundwater	31,100	53,500	57,500	59,500
Long-term average production of surface water	85,600	85,600	85,600	85,600
Seawater desalination[(b)]	0	0	0	25,000
Total	150,100	184,200	194,900	223,500

[(a)] Deterministic forecasts.

[(b)] As stated in the *2000 Urban Water Management Plan*. These projections differ from the analyses within this *Master Plan*.

Source: Authority Water Resources Department, *2000 Urban Water Management Plan* (December 2000).

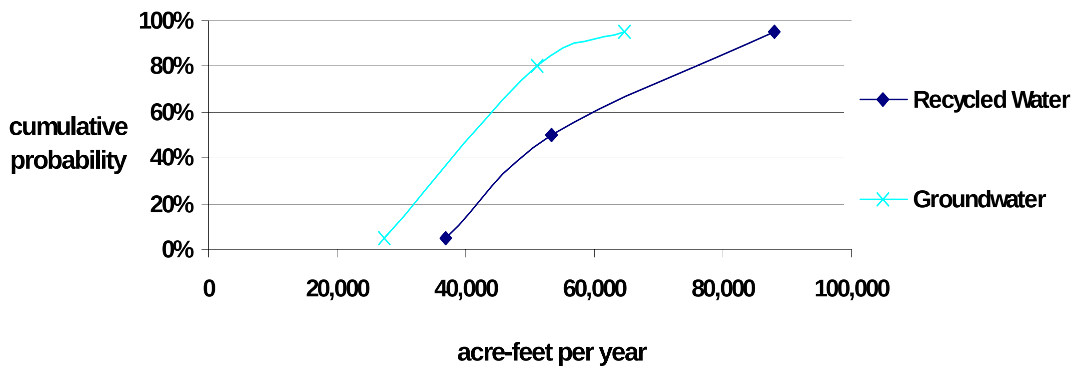

Figure 4-2. Probability of Local Supply Development in 2030

Table 4-7. Local Supply Forecasts for Member Agencies for Three Scenarios (Low, Planned, and High) (2010-2030)[a]

Agency	2010 Low	2010 Planned	2010 High	2020 Low	2020 Planned	2020 High	2030 Low	2030 Planned	2030 High
Carlsbad									
Recycled	3,000	5,000	7,700	3,000	5,000	7,700	3,000	5,000	9,500
Del Mar									
Recycled	150	150	150	150	150	150	150	150	150
Escondido									
Recycled	1,700	3,300	3,300	3,300	4,200	7,600	3,300	4,200	7,600
Fallbrook									
Recycled	700	850	850	700	850	850	850	850	1,500
Groundwater	0	0	6,000	0	0	6,000	0	0	6,000
Helix									
Recycled	0	0	0	0	0	1,500	0	0	1,500
Oceanside									
Recycled	300	2,700	2,700	300	2,700	7,000	300	2,700	7,000
Groundwater	2,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
Olivenhain									
Recycled	1,000	2,800	4,000	2,000	3,800	6,000	2,000	3,800	6,000
Groundwater	0	2,000	3,000	0	2,000	3,000	0	2,000	3,000
Otay									
Recycled	1,000	6,160	7,840	6,160	7,840	10,000	7,840	7,840	10,000
Groundwater	0	0	2,000	0	2,000	3,000	0	2,000	3,000
Padre Dam									
Recycled	600	900	900	600	900	4,400	600	900	4,400
Groundwater	1,500	3,500	5,000	1,500	3,500	5,000	1,500	3,500	5,000
Pendleton									
Recycled	800	800	960	800	800	960	800	800	960
Groundwater	8,240	10,300	10,300	8,240	10,300	10,300	8,240	10,300	10,300
Poway									
Recycled	1,200	2,700	2,700	1,200	2,700	3,250	1,200	2,700	3,250
Rainbow									
Recycled	0	0	0	0	0	2,200	0	0	2,200
Ramona									
Recycled	975	1,300	1,560	1,000	1,300	1,560	1,000	1,300	1,560
Rincon del Diablo									
Recycled	400	400	500	400	400	500	400	400	500
San Diego									
Recycled	13,500	16,100	20,100	13,500	19,700	23,700	13,500	19,700	23,700
Groundwater	0	4,000	7,000	0	8,000	12,000	0	8,000	12,000
San Dieguito									
Recycled	350	700	840	350	700	840	350	700	840
Santa Fe									
Recycled	0	450	450	0	450	450	0	450	450
Sweetwater									
Groundwater	4,000	10,000	10,000	4,000	10,000	10,000	4,000	10,000	10,000
Vallecitos									
Recycled	0	0	500	0	0	1,000	0	0	2,000
Valley Center									
Recycled	300	460	1,620	1,300	1,620	1,950	1,300	1,620	1,950
Vista									
Recycled	300	300	330	300	300	1,500	300	300	3,000
Yuima									
Groundwater	7,040	8,800	8,800	7,040	8,800	8,800	7,040	8,800	8,800
Total recycled	26,275	45,070	57,000	35,060	53,410	83,110	36,890	53,410	88,060
Total groundwater	23,280	45,100	58,600	27,280	51,100	64,600	27,280	51,100	64,600
Total supply	49,555	90,170	115,600	62,340	104,510	147,710	64,170	104,510	152,660
Percentage of planned	**54.96**		**128.20**	**59.65**		**141.34**	**61.40**		**146.07**

(a) Midpoint projections were refined with input from member agencies.

groundwater supply scenarios would fall. This means that there is a 90 percent confidence level that annual groundwater production will fall between 23,280 and 58,600 ac-ft in 2010 (a range of 35,320 ac-ft). In 2030, this 90 percent confidence interval ranges from 27,280 to 64,600 ac-ft in 2030 (a range of 37,320 ac-ft).

These results reflect the fact that opportunities to develop groundwater in San Diego County are more constrained than those to develop new recycled water supplies. It should be noted that as a result of the workshop elicitation of subjective judgment, it was concluded that the probability for planned implementation of recycled water would be 50 percent (higher or lower scenario just as likely), whereas the cumulative probability of planned implementation of groundwater was set at 80 percent, indicating only a 20 percent likelihood that groundwater supply development would exceed the amount planned.

Imported Supply Variability

Evaluation of available supply in the *Master Plan* is essential before developing or expanding infrastructure. Metropolitan has been and still is the sole source of imported supply. Imported supply reliability is integral to this analysis since to date all Authority infrastructure has been designed to distribute water from north to south. As the Authority's sole source of supply an analysis of the reliability of Metropolitan supplies is of critical importance to the Authority in its planning efforts as it evaluates this and all other supply options for reliability and cost effectiveness through 2030. The addition of other sources of imported water supplies such as the IID/ Authority water transfer are considered to improve imported supply reliability over existing sources due to the very senior water rights associated with IID's contractual obligation to transfer that water.

In evaluating the reliability of supplies the Authority receives from Metropolitan, the primary source of information is Metropolitan's *Integrated Resources Plan* (IRP), which was approved by their Board of Directors in 1996. Metropolitan staff is currently updating the IRP and the data on imported supply reliability analyzed in the *Master Plan* has been provided to the Authority by Metropolitan from information prepared for the 2002 IRP update. The IRP analysis and the data provided to the Authority are based on the IRPSIM model, which was developed during the initial 1996 IRP. Metropolitan has since refined and enhanced IRPSIM and uses it as an integral tool in its long-range planning efforts. IRPSIM is a sophisticated water supply and demand-balancing model that utilizes 77 sequential hydrologies to determine variations in supply and demand due to changes in weather conditions. The model considers all of Metropolitan's sources of supplies, including the various in-basin and out-of-basin groundwater and surface water storage that Metropolitan has available to it as well as its principal sources of supply, the CRA and the SWP. IRPSIM also takes into account Metropolitan member agency supplies and the effect hydrology has upon them. This supply data is then balanced with variations in demands under the 77 sequential hydrologies and a supply-demand surplus, balance, or shortfall is determined on a probabilistic basis.

In its current update of the IRP, Metropolitan is indicating that they would be able to meet all Municipal and Industrial (M&I) water demands through 2025 under all hydrological conditions modeled. Some of the key assumptions in the IRP analysis include that water demand for all Metropolitan member agencies will grow on a point forecast growth path and will only vary with weather conditions. Metropolitan also assumes that it will develop new water resource options, as they are needed.

The IRP update is still ongoing as of the date of this draft. The data provided to the Authority by Metropolitan does not include the development of an additional amount of buffer supply that is currently under consideration by the Metropolitan Board and in part takes into account supply planning efforts of the Authority and other Metropolitan member agencies.

In incorporating the IRP data supplied to the Authority by Metropolitan, Metropolitan supplies and all other supply options were compared, with both the Authority median forecast and the full range of probabilistic demands. An analysis of supply reliability using the median forecast was selected, since it best approximates the range of Authority demands used in the IRP. The use of the full range of demands provides the most complete picture of reliability under all uncertainties.

Because Metropolitan does not include demographic uncertainty or supply project implementation risk in their analysis, the data provided to the Authority does not reflect planned supplies to account for it. Current consideration by Metropolitan of a buffer supply is a strategy that would address those uncertainties.

The probability of these supplies being available does not consider factors beyond the effects of variations in weather and hydrology. That analytical approach differs from the manner in which local water recycling and groundwater projects are analyzed in the *Master Plan* in that the availability of those supplies takes into account probability of implementation. Below is a list of water resource projects included in Metropolitan's IRP update and considered in this analysis:

State Project Water Assumptions

- Metropolitan Entitlement Firm Deliveries Based On Bay/Delta Accord Standards, 2.011 MAF
- DWCV Entitlement Firm Deliveries Based On Bay/Delta Accord Standards, 0.062 MAF
- Augmented Supplies On The SWP Associated With Phase 8 Settlements, CALFED Improvements, Or Other Programs, 0.200 MAF

State Water Project Storage

- Castaic Lake Storage (Monterey Agreement), 0.154 MAF
- Lake Perris Storage (Monterey Agreement), 0.065 MAF
- State Water Project Carryover Storage, 0.200 MAF
- Arvin-Edison Storage, 0.350 MAF
- Semitropic Storage, 0.350 MAF
- San Bernardino Storage (Linked to the San Bernardino Transfer), 0.050 MAF
- Kern-Delta Storage, 0.250 MAF

State Water Project Transfers

- San Bernardino Transfer, 0.080 MAF

Colorado River Water Assumptions

- Metropolitan's Base Entitlement, 0.550 MAF
- Interim Surplus Guidelines, in effect through 2016
- 1998 Metropolitan/IID Conservation Agreement, 0.090 MAF
- All American Canal Lining, 0.068 MAF
- Coachella Canal Lining, 0.026 MAF
- IID/Metropolitan/Authority Trans-

fer and Exchange, 0.200 MAF

- Quantification Settlement Agreement - Transfer to CVWD, operational in 2046
- Quantification Settlement Agreement - Transfer to CVWD, operational in 2027
- Present Perfected Rights, 0.047 MAF
- DWCV SWP Entitlement Delivery, 0.062 MAF

Colorado River Water Storage Programs

- Lower Coachella Valley Storage, 0.500 MAF
- Hayfield Storage, 0.800 MAF
- Cadiz Storage, 1.000 MAF
- Arizona Groundwater Banking, 0.089 MAF
- DWCV Advance Delivery Account, 0.600 MAF

Colorado River Water Transfer Programs

- Cadiz Transfer, 1.500 MAF
- Palo Verde Irrigation District Transfer, 0.111 MAF

Other Storage Programs

- Diamond Valley Lake, 0.800 MAF
- North Las Posas Groundwater Storage Program, 0.210 MAF
- Raymond Basin Groundwater Storage Program, 0.075 MAF
- Other Prop 13 Programs, 0.225 MAF

Other Programs

- Desalination, 0.050 MAF

Imported Supply Model

The *Confluence* model was used to initially determine the ability of the existing system to reliably deliver water to the member agencies under the full range of probabilistic demands. Because determining the Authority's requirements for conveyance and treatment capacity is linked to the demand for imported water it was also necessary to analyze the availability of local supplies to the member agencies. These first runs of the model assumed a perfect reliability of imported supplies in that whatever demand was not served locally was met by Metropolitan under all conditions. This analysis was used to determine the current efficiency of the system, identify bottlenecks and develop additional improvements to increase capacity. The next step in the process was to gain a balance in the model by evaluating supply options. A model of imported supply variability was developed by A&N Technical Services to work in concert with the *Confluence* analysis of the Authority's system and local supplies.

In an effort to be sensitive to the range of supply possibilities three scenarios were developed. The scenarios are:

- Unlimited imported supply. No constraints on the amount of imported supply available
- Imported supply reliability. Supply availability derived from data provided by Metropolitan varied by hydrology
- Limited imported supply. Metropolitan supply is limited to Authority preferential right

Unlimited Imported Supply

This scenario can be used to answer the question, "If the amount and availability of imported supply were not an issue, what other Authority system constraints might be encountered?" The imported supply is effectively unlimited. This scenario is used to examine the existence and nature of other constraints to delivery reliability, such as instantaneous flow capacity, storage, treatment or blending requirements.

Imported Supply Reliability

How does hydrology affect imported supply? As previously discussed, the analytical approach contained within IRPSIM is that the imported Metropolitan supply varies as a function of the hydrologic year. The estimates for hydrologically varying Metropolitan supply come from data provided by Metropolitan.

Metropolitan data was provided to the Authority as a system-wide supply. To translate the potential Metropolitan system-wide supply into supply available to San Diego County, an additional assumption was required. For the purposes of this simulation scenario, it was assumed that San Diego County's share of the total potential Metropolitan supply equaled the Authority share of total Metropolitan demand. Thus the relationship can be depicted as:

Supply Available to Authority = Potential Metropolitan Supply X Authority Percentage of Total Metropolitan Demand

Data Infilling

Though the equation above provides the basic concept behind the Simulation in this scenario, the planning data available from Metropolitan cover different forecast years (2002-2025) and use a different set of hydrologic years for the sequential trace (1922-1991). Thus to extend these data to the forecast period (2000-2030) and hydrological trace (1888-1989) used by Authority, additional modeling assumptions and methods were required. In the forecast years 2000-2001, Metropolitan supplies available to San Diego County were assumed to be identical to the available supply in 2002. For the forecast years 2026-2030, Metropolitan supplies available to San Diego County were assumed to be identical to the available supply in 2025. This assumption implies Metropolitan supply development exactly equal to Metropolitan demand growth. The missing hydrologic years (1888 to 1922) were empirically estimated using statistical models. A predictive model was developed for the quantity in question as a function of two hydrological indices: The Palmer drought severity index for the Southern California region (a proxy for demand) and the Four River Index in Northern California (a proxy for imported water supply).

The range of results on Metropolitan supply availability from the analysis of Metropolitan data and the necessary data infilling are as shown in **Figure 4-3**. Simulation runs were made assuming that the available supply was never less than the preferential right.

Limited Imported Supply

When the available Metropolitan imported supply was limited to the Authority preferential right, the results from this simulation predictably showed significant shortages throughout the service area with very limited options for improvement.

Summary

Results from the analysis of Metropolitan supplies projected to be available to the Authority were then input into *Confluence* and simulations were run. These simulations showed that varying hydrology (hydrologically-varying imported supply) on all supply sources (imported and local) could affect the ability of the existing Authority system to meet demand in contrast with an unlimited imported supply that was assumed in the initial runs of the model. It should be noted that *Confluence* results differ from Metropolitan's conclusion in the IRP primarily because of the inclusion of local supply uncertainties in the Authority's analysis and the

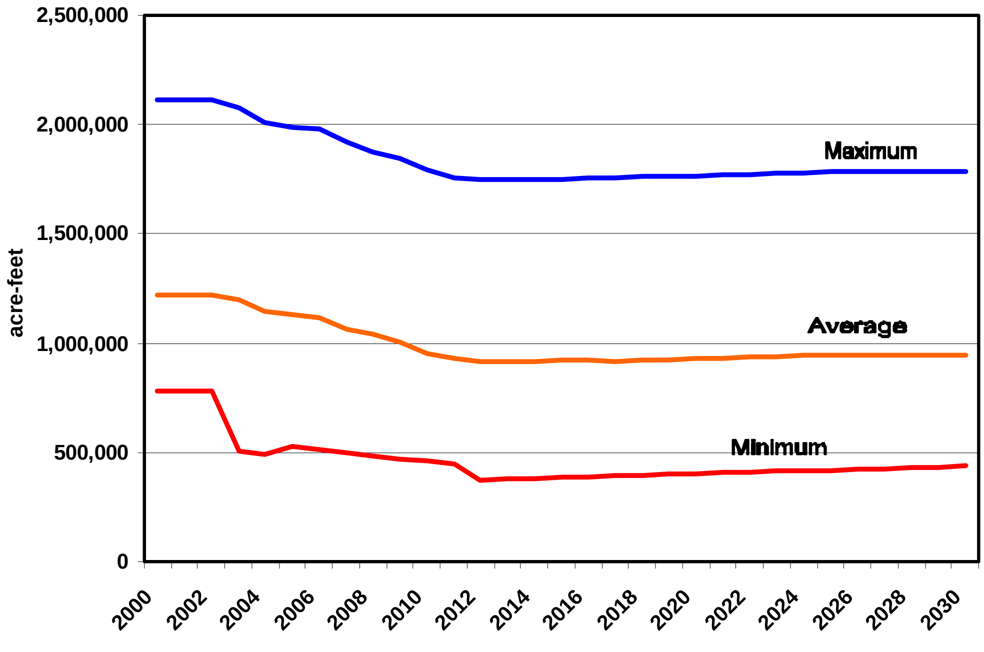

Figure 4-3. Portion of Metropolitan Water Supply Available to Authority (2000-2030)

subsequently greater need for imported supplies. Metropolitan's IRP assumes that local recycling and groundwater projects are built as planned whereas the *Master Plan* builds in levels of uncertainty as to their implementation. This result is even more pronounced when the full range of demands that account for demographic variability are analyzed.

5 Assessment of the Regional System: Baseline Condition

This Chapter describes the current facilities in the region and any projected additions, based on the Authority's currently approved Capital Improvement Program (CIP) and those of its member agencies. The combination of the existing and planned improvements is referred to as the Baseline System. **Figure 5-1**, Authority Service Area, and **Figure 5-2**, Water System Schematic, may be referred to while reading the description of the Baseline System.

The Chapter concludes with an analysis of the reliability of the Baseline System, using the methodology discussed in Chapter 2, to meet the projected demands discussed in Chapter 3 with the supplies discussed in Chapter 4.

Existing Facilities

First Aqueduct

The First Aqueduct consists of Pipelines 1 and 2, which are located in a common right-of-way, share seven common tunnels, and are operated as a unit. The two 48-inch-diameter pipelines deliver treated water from the Metropolitan Water District of Southern California (Metropolitan) delivery point to the connection with the Crossover Pipeline, located in Escondido. Each pipeline has a design capacity of 90 cfs. The water in this reach has been treated at Metropolitan's Skinner WTP located in Riverside County. Treated water delivered through the First Aqueduct serves Rincon, Vallecitos, Valley Center, Vista, and Yuima.

South of the connection with the Crossover Pipeline, the two pipelines deliver untreated water. The Crossover Pipeline is used to deliver the untreated water from the Second Aqueduct's Diversion Structure, located in the Twin Oaks Valley area of San Marcos, to the connection with the First Aqueduct pipelines in Escondido. The capacity of each pipeline (Pipeline 1 and Pipeline 2) below this connection is 95 cfs. The First Aqueduct terminates at the San Vicente Reservoir in Lakeside.

Untreated water delivered through the Crossover-First Aqueduct system serves Escondido, Helix, Poway, Ramona, San Diego, and Vista. Water delivered to Helix at its Levy WTP is also treated to supplement the demands of Padre Dam and Otay through a contractual agreement between the Authority and Helix, whereby the Authority has a 26 mgd capacity right in the Levy WTP.

A smaller diameter pipeline extends from the First Aqueduct near San Vicente Reservoir through Lakeside, El Cajon and Spring Valley to the Sweetwater Reservoir. This pipeline is known as the La Mesa-Sweetwater Extension (LMSE). The LMSE is a 39-inch-diameter pipeline from the First Aqueduct to the Lakeside Control Station

Figure 5-1. Authority Service Area

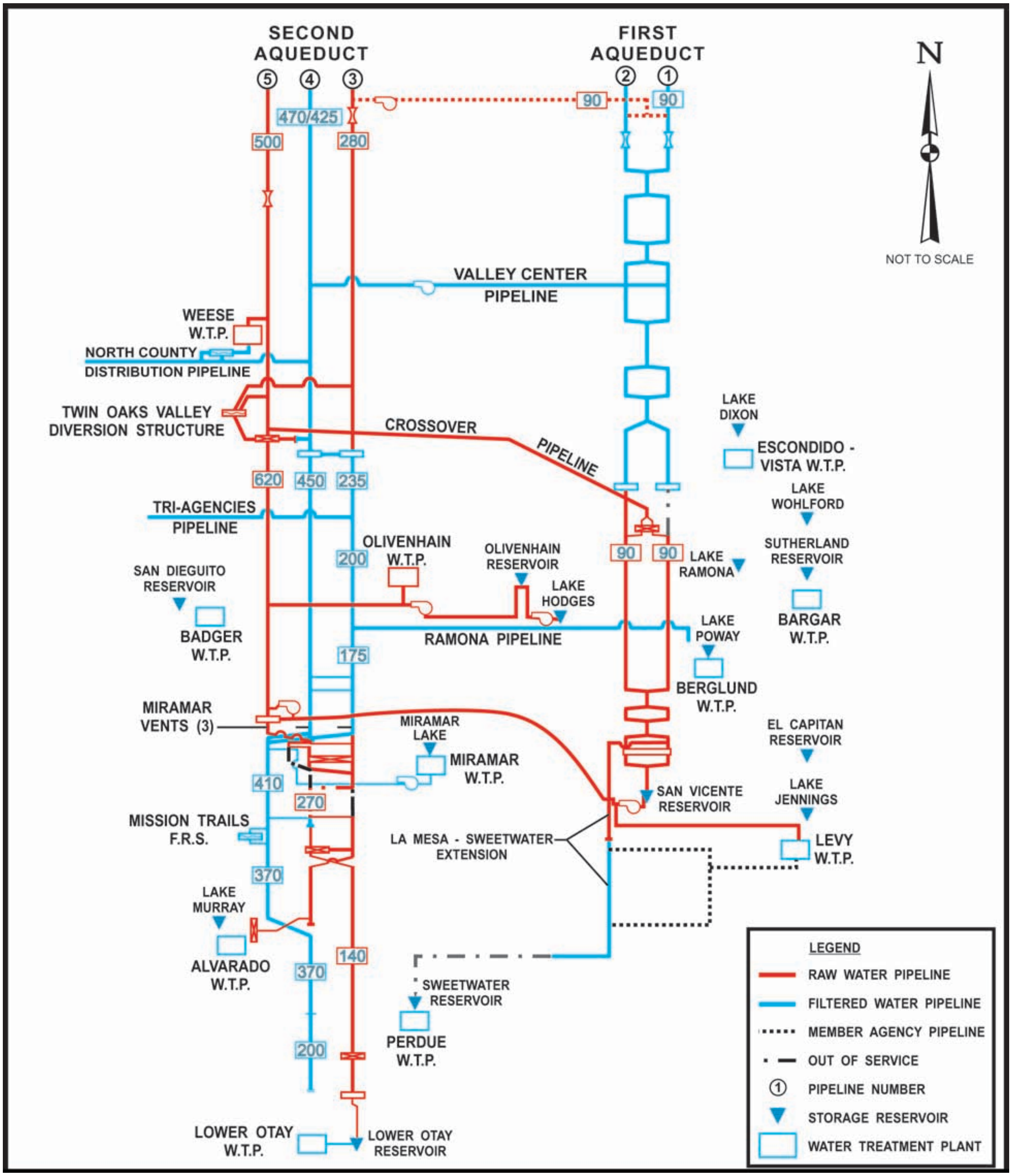

Figure 5-2. Water System Schematic

(near Highway 67) and is used to convey untreated water to Helix. South of the Lakeside Control Station, the LMSE is used for treated water delivery to Otay. The treated water is supplied from the Levy WTP. This portion of the pipeline is 27 inches in diameter for about 17,000 feet and then reduces to a 24-inch-diameter pipeline for most of the remaining distance to Sweetwater Reservoir.

Second Aqueduct

Pipelines 3, 4, and 5 form the Second Aqueduct. Each of these pipelines is operated independently. All three pipelines run from the Metropolitan delivery point to the Diversion Structure in Twin Oaks Valley and south to the Miramar Vents in the vicinity of Miramar Reservoir. Pipeline 5 terminates at the Miramar Vents while Pipelines 3 and 4 continue to the south end of the County, terminating at the City of San Diego's Lower Otay Reservoir a few miles north of the U.S. - Mexico border.

The pipelines of the Second Aqueduct deliver both treated and untreated water. While the Skinner WTP provides treatment for the vast majority of the treated water delivered by the Authority, the Authority also operates a pump station at the City of San Diego's Miramar WTP that allows the Second Aqueduct treated-water pipeline flow to be supplemented when capacity is available at the treatment plant. The Authority also has the ability to purchase treated water from Oceanside's Weese WTP to supplement the water delivered from the Second Aqueduct through the North County Distribution Pipeline.

Reach from Metropolitan Delivery Point to Twin Oaks Valley Diversion Structure

The design capacity for Pipeline 3 is 280 cfs and for Pipeline 4 is 425 cfs. Pipeline 5 has a design capacity of 480 cfs at the delivery point from Metropolitan. Metropolitan has agreed that Pipeline 4 can be operated at approximately 10 percent higher than its design capacity for limited peak demand periods until Pipeline 6 is built. Therefore, a peak capacity of 470 cfs is being used for master planning purposes.

Pipelines 3 and 5 are used to deliver untreated water, and Pipeline 4 is used to deliver treated water in this reach, thus providing a treated-water capacity of 470 cfs and a total untreated-water capacity of 780 cfs. Pipeline 4, operating in conjunction with the First Aqueduct, provides a total treated-water delivery capacity of approximately 650 cfs to the Authority's service area from Metropolitan. Treated water is delivered in this reach of Pipeline 4 to Fallbrook, Oceanside, Rainbow, Vallecitos, Valley Center, and Vista.

The Valley Center Pipeline is a treated-water pipeline running from west to east that interconnects the treated-water pipelines in Aqueducts 1 and 2 and can be used to supplement flows in either direction. The Authority also operates the North County Distribution Pipeline (NCDP) in this reach. This is a line running from Pipeline 4 to the west, which delivers treated water to Oceanside, Vista, Vallecitos, and Rainbow from both Pipeline 4 and Oceanside's Weese WTP.

Untreated water is delivered to Oceanside's Weese WTP from Pipeline 5. All water treated at Weese is imported water since there is no local supply and no storage reservoir.

At Twin Oaks Valley Diversion Structure, water either continues south in Pipeline 3, 4, or 5 or is diverted to the First Aqueduct through the Crossover Pipeline. The Crossover Pipeline was originally designed for a capacity of 130 cfs and was intended to refill the First Aqueduct pipelines (with a capacity of 190 cfs) at the connection point near Hubbard Hill in Escondido. This connection point is also known as the Terminal Structure. Modifications have allowed the capacity of the Crossover Pipeline to be increased to 200 cfs. This pipeline is now the sole method to deliver untreated water to the First Aqueduct for delivery to the south. There is also a connection to the Crossover Pipeline at the Terminal Structure for delivery to the Escondido-Vista WTP.

Reach from Twin Oaks Valley Diversion Structure to Miramar Vents

The three pipelines continue in this reach. Pipeline 3 has a reduced capacity of 235 cfs. Pipeline 4 has a capacity of 450 cfs. Pipeline 5 was extended south of the Diversion Structure in two phases in the 1990s. The northerly section is the San Marcos Pipeline from the Twin Oaks Valley Diversion Structure to Paint Mountain and the southern section is the Rancho Penasquitos Pipeline from Paint Mountain to the Miramar Vents. The capacities of these two sections are each 620 cfs.

Pipelines 3 and 4 are used for treated water and the San Marcos and Rancho Penasquitos Pipelines are used for untreated water, providing a total treated water delivery capacity of 685 cfs and an untreated water delivery capacity of 620 cfs.

Untreated water is delivered to San Dieguito and Santa Fe for treatment at the Badger WTP. In addition, Olivenhain has recently commenced treatment at a new membrane filtration plant.

Treated water is delivered to Vallecitos, Carlsbad, Vista, Oceanside, Olivenhain, San Dieguito, Santa Fe, San Diego, Del Mar, and Ramona in this reach.

The Authority operates two lateral lines in this reach, the Tri-Agency Pipeline (TAP) and the Ramona Pipeline. The Tri-Agency Pipeline delivers treated water to Vista, Carlsbad and Oceanside. The Ramona Pipeline is a treated-water line that runs from west to east and delivers water from the Second Aqueduct to Ramona and portions of Olivenhain and San Diego.

Reach from Miramar Vents to Miramar WTP

Four pipelines span the reach from the Miramar Vents to the City of San Diego's Miramar WTP. They are Pipelines 3, 4, 4A, and 4B. Pipeline 4B in this reach is also know as the Scripps Ranch Pipeline. Pipelines 3, 4, and 4A are located in the same right-of-way, crossing Interstate 15 and passing just west of Miramar Dam and adjacent to the Miramar WTP along Scripps Lake Drive. Pipelines 3, 4, and 4A deliver untreated water. Portions of Pipelines 3 and 4A are currently not in use.

All three untreated-water pipelines are 72-inch-diameter lines in this reach. One pipeline terminates at the flow control facility (turnout) into the Miramar plant. Immediately past the turnout, the two remaining pipelines are 69 and 72 inches in diameter until Red Cedar Drive. Beyond Red Cedar Drive, only the 69-inch-diameter line continues, delivering untreated water. The 72-inch line past the turnouts is currently not in use.

The Scripps Ranch Pipeline is used to deliver treated water and is located away from the other three pipelines in this reach, and generally in surface streets.

Reach from Miramar WTP to Alvarado WTP

Beginning at Red Cedar Drive and continuing to the south, Pipeline 4 is an 84-inch line and Pipeline 3 is a 69-inch line. Just south of Pomerado Road. The Scripps Ranch Pipeline re-unites with Pipelines 3 and 4 in the right-of-way.

Except for a short reach immediately south of Scripps Lake Drive, Pipeline 4 is used for untreated-water delivery through MCAS Miramar. Pipeline 3 is currently out of service through MCAS Miramar to Highway 52, but is refilled by Pipeline 4 at Highway 52. Untreated water is delivered to the Alvarado WTP in Pipeline 4, at which point it terminates. Pipeline 3 will ultimately revert to City ownership and be used to deliver treated water from the Miramar plant to the City's Pomerado Pipeline at Highway 52. South of Highway 52, Pipeline 3 continues south to Lower Otay as a untreated-water pipeline.

Treated water in this reach is delivered through the Scripps Ranch Pipeline to a San Diego turnout at Highway 52. South of

Highway 52, the Scripps Ranch Pipeline connects to the Mission Trails Pipeline, which delivers treated water to Padre Dam near Mission Gorge Road. The Mission Trails Flow Regulatory Structure (FRS) is located along the Mission Trails Pipeline, and provides regulatory storage for the treated water pipeline south of Mission Trails Regional Park. South of Mission Gorge Road, the Mission Trails Pipeline connects to the La Mesa-Lemon Grove Pipeline.

Reach from Alvarado WTP to Lower Otay Reservoir

South of Alvarado, two pipelines continue the entire length to Lower Otay Reservoir. Pipeline 3 has a capacity of approximately 145 cfs and is used to deliver untreated water. The La Mesa-Lemon Grove Pipeline delivers treated water and has a capacity of 370 cfs from Alvarado to Sweetwater Reservoir. At that point, it connects to the Lower Otay Pipeline and reduces to a capacity of 200 cfs to its termination at Lower Otay. Treated water service is provided to San Diego, Helix, Sweetwater, and Otay in this reach.

Untreated water service is provided in Pipeline 3 to Sweetwater Authority at the Perdue WTP and San Diego at the Otay WTP. Untreated water can be delivered either directly to the treatment facility or into storage at both Sweetwater and Lower Otay reservoirs.

Treatment Plants

Most of the water delivered by the Authority's member agencies is treated, potable water. The exceptions are recycled wastewater delivered through separate distribution systems and an area of Ramona served with untreated water for agricultural purposes through a dual distribution system.

Water filtration for all retail water service is provided by either a member agency or by Metropolitan. Metropolitan's Skinner WTP is the primary source of treated water provided by the Authority. This regional treated-water capacity supplements the local water treatment facilities that have been constructed by the member agencies. The Skinner facility also provides treated water to two other Metropolitan member agencies in Riverside County, Eastern MWD and Western MWD.

A list of the local and regional treatment plants and their capacities is given in **Table 5-1**. The location of each facility is shown on **Figure 5-3**.

Some of the facilities are currently scheduled for expansion and/or upgrade. The known expansions and the anticipated dates are presented in **Table 5-2**.

Planned Improvements

Capital Improvement Program

The Authority's Capital Improvement Program (CIP) was established in 1989 to identify the construction of facilities needed to provide a safe, reliable, and operationally flexible water storage, treatment, and delivery system for member agencies.

The CIP grew out of the *1987 Water Distribution Study*, which proposed eight pipeline projects to increase the reliability of the aqueduct system and meet projected demands through the year 2010. The first CIP was presented to the Board in August 1989. The *Water Distribution Plan, A Capital Improvement Program Through the Year 2010* included the eight projects of the *Water Distribution Study*. The initial CIP projects were estimated to cost $530 million (1988 dollars).

Since 1989, an annual review has allowed the CIP to be adjusted for changing conditions, particularly with respect to changes in demand projections, the economy, and the changing needs of member agencies. All of these changes have resulted in the addition or deletion of projects to the CIP, and the acceleration,

Agency	Treatment Facility	Rated Capacity (mgd)
Escondido-Vista	Escondido-Vista	65
Helix	Levy	106
Olivenhain	Olivenhain	25
Oceanside	Weese	25
Poway	Berglund	24
Ramona	Bargar	4
San Diego	Alvarado	150
	Miramar	140
	Otay	40
San Dieguito-Santa Fe	Badger	40
Sweetwater Authority	Perdue	30

Table 5-1. Existing Area Water Treatment Facilities and their Rated Capacities in 2002

Table 5-2. Anticipated Expansions to Existing Facilities

Agency	Treatment Facility	Current Capacity (mgd)	Planned Plant Expansion Capacity (mgd)	Anticipated Date
Helix	Levy	106	120	ND
Oceanside	Weese	25	50	ND
Olivenhain	Olivenhain	25	50/80	ND/ND
Poway	Berglund	24	36	ND
San Diego	Alvarado	150	200	2008
	Miramar	140	215	2009
	Otay	40	60	ND
San Dieguito-Santa Fe	Badger	40	54	2015
Sweetwater Authority	Perdue	30	45	ND

ND – not determined.

Figure 5-3. Location of Local and Regional Water Treatment Plants

modification, or delay of projects and schedules. The annual review has also allowed cost estimates to be updated as more accurate planning and design information becomes available. The results of the annual review are contained in the recommended CIP Budget and Appropriation that is presented to the Authority's Board each year.

The projects contained in the current CIP are intended to continue meeting the goals and objectives originally identified in the *1987 Water Distribution Study*. These goals and objectives are to:

- increase the reliability and operational flexibility of the aqueduct system
- increase the capacity of the aqueduct system
- obtain additional water supplies from the Metropolitan Water District of Southern California and other sources
- provide adequate storage to meet emergency needs

An additional goal was added to the CIP in 1995 as a result of concerns over the ability of the region to continue to meet treated water demands:

- monitor treated and untreated water demands to ensure that adequate treatment plant capacity is available to meet the region's needs

Table 5-3 lists the major projects of the CIP that are relevant to the *Regional Water Facilities Master Plan*, as adopted in the 2002-2003 Budget. The table shows the anticipated operational date, total recommended project budget, and category ranking. The highest ranking is Category A, with respect to continuing expenditures.

Each project meets one or more criteria for its category.

1. **Category A**

- Already under construction to meet CIP goals of increasing aqueduct capacity and reliability
- Required to meet current water demands.
- Requested by member agency and reimbursable.
- Required to implement other "A" priority projects.
- Required to replace or repair critical portion of aqueduct system that is near the end of its useful life.
- Designed to improve personnel safety.

2. **Category B**

- Needed to meet projected future water demands or add reliability to the aqueduct system.
- Designed to increase the water supply to the Authority to meet future water demands.
- Designed to meet terms of agreements with member agencies for future water supply.
- Designed to repair and replace deteriorating aqueduct facilities with some useful life remaining.

3. **Category C**

- Reduces operating costs and/or increases operating efficiency.
- Improves ability to meet non-water-related needs of member agencies and the public, such as encroachments.

4. **Category D**

- Project is completed or has continuing mitigation monitoring only.

Table 5-3. Current CIP Projects Relevant to Master Plan

Project	Anticipated Operational Date	Category[(a)]	Total Recommended Budget (Dollars, FY 2002)
Aqueduct Protection Program	Ongoing	B	8,000,000
Replacement/Relining of PCCP	Various	B	78,770,000
Moreno-Lakeside Pipeline	2003	B	27,107,140
Pipelines 3 and 4 Conversion-Diversion Structure	2002	A	2,818,900
Pipeline 3 Transfer to City of San Diego	2002	A	265,000
Pipeline 6	2015+	B	121,900,000
Ramona Reservoir Bypass	2005	B	400,000
Rancho Penasquitos Hydroelectric Facility	2006	B	16,618,142
Rancho Penasquitos Pipeline Pressure Control Facility	2004	A	5,374,000
San Diego 17 Pump Station	2005	A	100,000
Twin Oaks Valley – Diversion Structure	2002	A	18,620,000
Aqueduct Protection Program	Ongoing	B	8,000,000
Emergency Storage Project			
ESP – Lake Hodges Inlet/Outlet	2009	B	7,283,794
ESP – Lake Hodges to Olivenhain Pipeline	2009	B	24,729,426
ESP – Lake Hodges Pump Station	2009	B	34,370,000
ESP – Olivenhain Dam and Reservoir	2003	B	183,225,000
ESP – Olivenhain Pump Station	2004	B	37,450,000
ESP - Pump Station at Pipeline 3 and Interconnect	2010	B	6,500,000
ESP - Pump Station at Pipeline 4	2010	B	4,666,701
ESP - San Vicente Dam Raise	2010	B	96,000,000
ESP – San Vicente Pipeline and Aqueduct Interconnect	2007	B	199,233,000
ESP – San Vicente Pump Station	2007	B	56,667,500
ESP – San Vicente / MLP Interconnect Pipeline	2003	B	4,234,800

[(a)] See text for a list of criteria for each category ranking.

Emergency Storage Project

The Authority's Emergency Water Storage Project (ESP) is central to the agency's overall program to deliver a reliable supply of water in the event of a natural disaster. Authority supplies are transported by large pipelines that are vulnerable to earthquakes and other hazards. In fact, the Authority's pipelines cross the Elsinore fault, and Metropolitan's imported water conveyance facilities cross both the San Andreas and San Jacinto faults.

The ESP is being designed to meet emergency demands for two planning scenarios: (1) an interruption in water delivery to Metropolitan for up to 6 months due to an earthquake along the San Andreas or San Jacinto faults (in which case the Authority would receive a substantially reduced level of water service from Metropolitan) and (2) an interruption in water deliveries from Metropolitan for 2 months because of an earthquake on the Elsinore Fault.

On June 11, 1998, the Authority's Board of Directors approved construction of a system of reservoirs, pipelines, and other facilities related to the ESP. Combined with storage space already dedicated to emergency use, the additional capacity is projected to meet the County's emergency needs through at least 2030. Total project costs are estimated at $827 million.

The ESP will provide the largest increase in storage capacity in the county since 1944, adding 90,100 ac-ft in additional water storage capacity. Use of emergency water held in the ESP will be limited to emergency situations, such as prolonged drought or the catastrophic failure of one or more of the Authority's pipelines during an earthquake or other disaster.

Although the Authority does not own or operate any treatment or storage facilities, it does have an agreement with the City of San Diego to store up to 40,000 ac-ft of water in San Vicente, Lower Otay, and other reservoirs until construction of the last phase of the ESP is initiated.

The ESP calls for construction of a new dam and reservoir at Olivenhain with a capacity of 24,000 ac-ft (a portion of which is owned by Olivenhain MWD), re-operation of Lake Hodges with a capacity of 20,000 ac-ft for ESP purposes, and expansion of the San Vicente Reservoir with a capacity of 52,000 ac-ft for ESP purposes. The system will include 17 miles of pipelines and five pump stations to connect existing and proposed reservoirs.

Currently consisting of 16 projects (see **Table 5-3**), the ESP is being constructed in four phases. The first phase is underway and will continue through 2003. It includes the Olivenhain Dam, Olivenhain Pipelines, and Olivenhain Pump Station (OLVPS) projects. Construction for the second phase of the ESP consists of the San Vicente Pump Station (SVPS), San Vicente/Moreno-Lakeside Pipeline (MLP) Interconnect Pipeline, and San Vicente to Second Aqueduct Pipeline (SVSAP), and is scheduled from 2003 through 2007. The third phase will be constructed from 2006 through 2008 and will include the Lake Hodges to Olivenhain Pipeline, Lake Hodges Pump Station, and pump stations at Pipelines 3 and 4 in the northern part of the county. Construction work for the raising of San Vicente Dam and San Vicente Recreation Facilities, which comprise the fourth and final phase of the ESP, is expected to occur from 2008 through 2010.

System Condition Assessment – Aqueduct Protection Program (APP)

San Diego County has some of the most corrosive soils in the country and, beginning in 1979 and into the early 1980s, the Authority experienced some corrosion failures on its treated water Pipeline 3 made of prestressed concrete cylinder pipe (PCCP). These failures resulted in development of rehabilitation technology by the Authority to install steel-plate lining inside 5 miles of the corroded PCCP Pipeline 3, in the communities of Spring Valley and Bonita in south San Diego County in the early 1980s.

The Aqueduct Protection Program (APP) began in 1991 and is a part of the Authority's Capital Improvement Program (CIP). The purpose of the APP is to protect and ensure structural integrity, perform pipeline condition assessments, and extend the service life of existing pipelines.

The Authority's first pipelines consisting of concrete cylinder and non-cylinder pipe were constructed in the late 1940s and early 1950s. Steel and PCCP pipelines were constructed from 1958 to the early 1960s along the Authority's Second San Diego Second Aqueduct, and also between 1969 and 1982, until construction began on the most recent CIP pipeline projects in 1989. There are 60 miles of concrete cylinder and non-cylinder pipe, 41 miles of steel, and 81 miles of PCCP that were constructed prior to 1982.

The APP was designed as a two-phase program. Phase 1 involves data collection and correlation to determine and, where possible, mitigate factors contributing to corrosion and loss of pipeline service life. This involves conducting extensive literature research of past pipeline design, fabrication, and construction records and correlating information to each pipe section along each pipeline. Corrosion and soil resistivity field surveys along all the Authority's pipeline rights-of-way are conducted and correlated to each pipe section. Pipelines are internally inspected to locate potentially deteriorating pipe. External pipe inspections requiring excavation are only conducted when internal inspections indicate a pipe section may be near failure, or during repair of failed pipe sections. Forensic investigations are conducted to determine the physical and chemical properties of the pipe materials and soils surrounding these pipes. Finally, all information is assembled into a database to secure a baseline of pipeline condition and the soils environment in which the pipelines are operating, and to facilitate monitoring of subsequent deterioration of each pipe section along each of the Authority's pipelines.

Phase 2 involves analyzing all information collected in Phase 1, performing pipeline condition assessment studies, and estimating the remaining pipeline service life. Work also includes determining interim and long-term rehabilitation, repair, and replacement projects and priorities, as well as developing budget estimates and schedules.

The next step is the Replacement and Relining Program which implements the results of the APP. The Replacement and Relining Program consists of preventive maintenance, rehabilitation and repair, and pipeline replacement. Preventive maintenance involves development and implementation of pipeline internal inspection schedules and a corrosion monitoring and control procedures manual to extend pipeline service life. Rehabilitation and repair work may include installation of corrosion monitoring test stations and cathodic protection, internal joint repairs, concrete coating and lining rehabilitation, pipeline replacement and steel plate relining.

Related Studies

Urban Water Management Plan

The Authority's *2000 Urban Water Management Plan* presents the Authority's projected water resources mix necessary to provide a reliable water supply for the regional service area through the year 2020. This *2000 Plan* updates the previous *Urban Water Management Plan* prepared by the Authority in 1995, as well as the *1997 Water Resources Plan.* All of these plans were written to satisfy the *California Water Code's Urban Water Management Planning Act of 1983* and its subsequent amendments. Recent amendments to the Act now require that total projected water use be compared to water supply sources over the next 20 years in 5-year increments. The Act also requests the information be shown for a single dry water year and for multiple dry water years. Additional amendments to the Act now require that all plans include a detailed water recycling analysis that includes a description of the wastewater collection and treatment system within the agency's service area, as well as current and potential recycled water uses. The *2000 Plan's* recommended water resource mix is discussed in Chapter 4 of this report.

Groundwater Storage and Recovery Studies

In 1999, the Authority's Board of Directors authorized studies to explore potential groundwater storage and recovery projects in the *San Diego Formation and Lower San Luis Rey River Valley*. These two feasibility studies are being conducted in coordination with the *Regional Water Facilities Master Plan* so as to better quantify future regional storage requirements.

Groundwater recharge and storage projects could provide significant regional benefit by allowing member agencies more opportunity to purchase seasonally discounted water, or spot transfer water, thus reducing the overall regional cost of imported water. In the future, the availability of additional storage could also provide the Authority with increased operational flexibility to serve peak summer demands and to defer other, more costly capital improvements.

Lower San Luis Rey River Valley Groundwater Storage and Recovery Feasibility Study

The Authority is conducting a phased study in the Lower San Luis Rey River Valley to evaluate the feasibility of storing imported water in the Mission and Bonsall groundwater basins. The first phase of the study was completed in April 2000. The basic concept developed in Phase 1 for projects in the Mission and Bonsall Basins assumes discounted imported water would be available in the winter season to replenish groundwater that would be extracted throughout the calendar year. During periods of drought or emergency, when discounted imported water is not available for recharge, newly constructed groundwater extraction and treatment facilities would continue production, drawing on the groundwater basin's storage capacity.

Groundwater recharge, extraction, and treatment facilities were sized in Phase 1 **(Table 5-4)** based on current understanding and several assumptions regarding the physical and chemical characteristics of the Mission and Bonsall alluvial groundwater basins. The Authority intends to conduct field investigations as part of Phase 2 to verify the assumptions made during Phase 1.

Phase 2 investigations include subsurface hydrogeologic exploration, groundwater modeling, additional engineering analysis, as well as environmental investigation and documentation for the Mission Basin Groundwater Storage and Recovery Project (Mission Basin Project).

The Mission Basin Project is based upon a concept developed by the Authority in the *Phase 1 San Luis Rey Study*. The Mission Basin Project was selected by Metropolitan Water District to receive $7.2 million in Proposition 13 grant funding. The Mission Basin Project could add 6.7 mgd of brackish groundwater treatment capacity to the Mission Basin Desalter. Oceanside is currently expanding its Mission Basin Desalter from 2 mgd to 6.37 mgd. A Bonsall Basin groundwater storage and recovery project could include the construction of a new 3.6 to 4.6 mgd (4,030 to 5,150 acre-feet/yr) desalting facility.

The purpose of the Phase 2 hydrogeologic investigations is to further evaluate specific assumptions regarding aquifer characteristics and behavior to enhance the study team's understanding of how groundwater storage and recovery

Table 5-4. Storage Potential and Production of Mission and Bonsall Basins

Basin	Storage Potential (ac-ft) Total	Storage Potential (ac-ft) Useable	Current/ Planned Production without Replenishment (ac-ft/yr)	Proposed Additional Production with Replenishment (ac-ft/yr)
Mission	90,000	30,000	10,000	5,600 to 7,500
Bonsall	18,000 to 40,000	9,000	400	4,000 to 5,150

projects might perform. The results of Phase 2 investigations will be used to refine project concept designs, operational scenarios, and cost estimates.

San Diego Formation Aquifer Storage and Recovery Feasibility Study

In the early 1990s, the Sweetwater Authority began investigating the San Diego Formation for the purpose of developing additional local water. These investigations suggested that the San Diego Formation has significant production capability throughout a broad area and might be suitable for conjunctive use and/or artificial recharge operations. Subsequently, a multi-agency Task Force conducted a geophysical survey and found that opportunities for sustained groundwater production are presently limited by the amount of natural recharge to the Formation and the potential for seawater intrusion. Groundwater quality in the Formation is highly variable, ranging from 350 milligrams per liter (mg/l) to 8200 mg/l of total dissolved solids (TDS). It was determined that the Formation would be best suited for underground storage of surface water supplies (conjunctive use operations).

The purpose of Phase 1 of the current *San Diego Formation Study* was to identify the most cost-effective and regionally beneficial storage concept alternatives and potential well sites.

Based on what is currently understood about the Formation, it was estimated that a useable storage capacity of between 40,000 and 90,000 ac-ft/yr could ultimately be developed if all the project concepts were implemented. The Formation's complex hydrogeology makes it difficult to predict the location and extent of productive aquifers and well performance. Site-specific hydrogeologic investigations would be necessary to accurately determine project costs. All project concepts included multiple well groups that could be implemented one well group at a time, thus allowing well performance to guide further development of a particular site.

Two types of storage projects were considered: 1) Aquifer Storage and Recovery (ASR) wells to inject water during availability for later extraction when needed, and 2) Constant-Yield Projects designed to operate on a constant, or near-constant basis (with recharge) and providing a constant water supply. Recharge projects can be operated to provide carryover (dry-year), seasonal, or emergency storage, or a combination of these. San Diego Formation hydrogeology, groundwater quality, and other considerations will determine the actual project design and operation mode ultimately implemented at a particular site.

Five ASR project concepts and two constant-yield project concepts were developed and evaluated. Constant-yield project concepts were developed assuming the availability of surplus surface or recycled water for recharge.

The Study's cost-benefit analysis led to the conclusion that the regional benefits of increased water storage capacity will likely exceed the projected costs of the ASR projects. It was also found that constant-yield projects may be cost-effective, depending on the resolution of key regulatory and institutional issues related to the availability of reclaimed water and its treatment prior to recharge. Further development of project concepts will be dependent upon future interest of the local water agencies overlying the San Diego Formation.

Analysis of Baseline System

To evaluate the existing water delivery system, a Baseline System was defined, which includes all of the projects defined in the currently approved CIP, with the exception of Pipeline 6. The fully constructed ESP is included in the Baseline System. Including these facilities was considered appropriate since they are scheduled, funded, and backed by agreements between the Authority and member agencies. Of particular note are those facilities that provide not only emergency operation but also enhance the regional system during normal day-to-day and year-to-year operations.

New storage capacity at Olivenhain Dam and the San Vicente Dam Raise are for the purpose of emergency storage. However, there is an operating benefit associated with the seasonal variation in volume required. In addition, the emergency storage requirements are based on 2030 demands. During the period from 2010, when all ESP facilities will be completed, and 2030, the amount of storage available in the ESP will exceed the required emergency volume. The difference between what is available and what is required can be used for seasonal and operational purposes. While the amount of this storage will gradually decrease over the 20-year period, it will provide valuable operational benefits. Also, the ESP conveyance facilities provide a benefit to Authority normal operations.

The evaluation of the Baseline System was conducted using the probabilistic simulation model called *Confluence*™, described in Chapter 2. *Confluence* was run with the configuration of Authority facilities and member agency treatment plants to be constructed by 2010. The ESP facilities listed above were included in the model, beginning in the year scheduled for each project's completion. Known expansions of local water treatment plants were also incorporated. A complete list of facilities is given in **Table 5-5**.

This regional system was then analyzed for its ability to meet future demands, for two conditions of supply. The two supply conditions are:

- No constraint on import supply availability (Unlimited Import Supply).
- Constrained Import supply (Limited Import Supply).

The first condition assumes that Metropolitan or the Authority will obtain whatever supply quantity is needed to meet all needs of its member agencies even if member agency demands far exceed current projections. The second condition recognizes that the demand in Metropolitan's service area could grow beyond the capacity of available supply sources and that the Authority, and other Metropolitan agencies, could be in a position to have deliveries curtailed.

The Authority's assessment of the potential for reduced supply was described in Chapter 4. The data from the results of

Table 5-5. New or Expanded Facilities – Baseline Condition			
Name	**Agency**	**Action**	**Year**
Treatment Plants			
Alvarado WTP	City of San Diego	expand to 200 mgd	2005
Miramar WTP	City of San Diego	expand to 215 mgd	2008
Pipelines/Connections			
Ramona Pipeline to Poway	City of Poway	capacity of 32 cfs	2005
Olivenhain Pipeline	Authority	capacity of 380 cfs	2002
Olivenhain Pump Station	Authority	capacity of 168 cfs (expand to 314 or 380 cfs)	2004
Otay WTP to Otay WD	Otay WD	capacity of 15 cfs	2004[a]
Alvarado to P-4	City of San Diego	capacity of 93 cfs	2005
Moreno-Lakeside Pipeline	Authority	capacity of 128 cfs	2005
San Vicente Pipeline	Authority	capacity of 575 cfs[b]	2007
San Vicente Pump Station	Authority	initial capacity of 90 cfs	2007
Olivenhain-Hodges Tunnel	Authority	capacity of 168 cfs	2009
Olivenhain-Hodges Pump/Hydro	Authority	capacity of 560 cfs (pump mode)	2009
Dams/Reservoirs (Emergency Storage)			
Olivenhain	Authority/ Olivenhain MWD	volume of 24,000 ac-ft[c]	2003
Hodges	Authority/ City of San Diego	re-operate to provide 20,000 ac-ft of emergency supply	2007
San Vicente	Authority/ City of San Diego	increase by 52,000 ac-ft	2010

[a] Project schedule according to Otay Water District.

[b] Assumed capacity for computer modeling purposes.

[c] Approximately 20,000 ac-ft for use by Authority and 4,000 ac-ft for emergency and operational use by Olivenhain.

that analysis have been utilized in *Confluence* to develop the results presented in the following discussions.

Overall Reliability

The regional system is expected to be very reliable through the year 2015 as long as supply is available to meet demands. This is shown in **Figure 5–4** for the probabilistic demand with weather and demographic variability for the Unlimited Import Supply scenario. Beyond 2015, peak season shortages would be expected to develop if no additional facilities are constructed to overcome capacity limitations in the region's pipelines and treatment plants.

Figure 5–5 presents the same reliability results if the Imported Supply Reliability condition is imposed. Comparing Figures 5-4 and 5-5 indicates that supply shortages to 2015 are driven entirely by supply reliability. Beyond 2015, the potential shortages are a combined reduced supply and facility constraints.

The results in **Figure 5-4** indicate that the region's needs can be met without an additional conveyance and/or source of supply if the current supply sources are 100 percent reliable. Thus Pipeline 6, the Regional Colorado Conveyance Facility, or seawater desalination (the three long range alternatives of Supply from the North, Supply from the East, and Supply from the West presented in Chapter 7) would not be required prior to that date. However, if import supply is less than 100 percent certain, then a new source (seawater), or carryover storage, would need to be implemented as soon as possible **(Figure 5-5)** to offset the potential shortages shown.

Figures 5-6 and 5-7 focus on the planning years of 2005, 2010, 2015, and 2020 for the Unlimited Import Supply condition. The figures present the duration curves for the annual unserved demand.

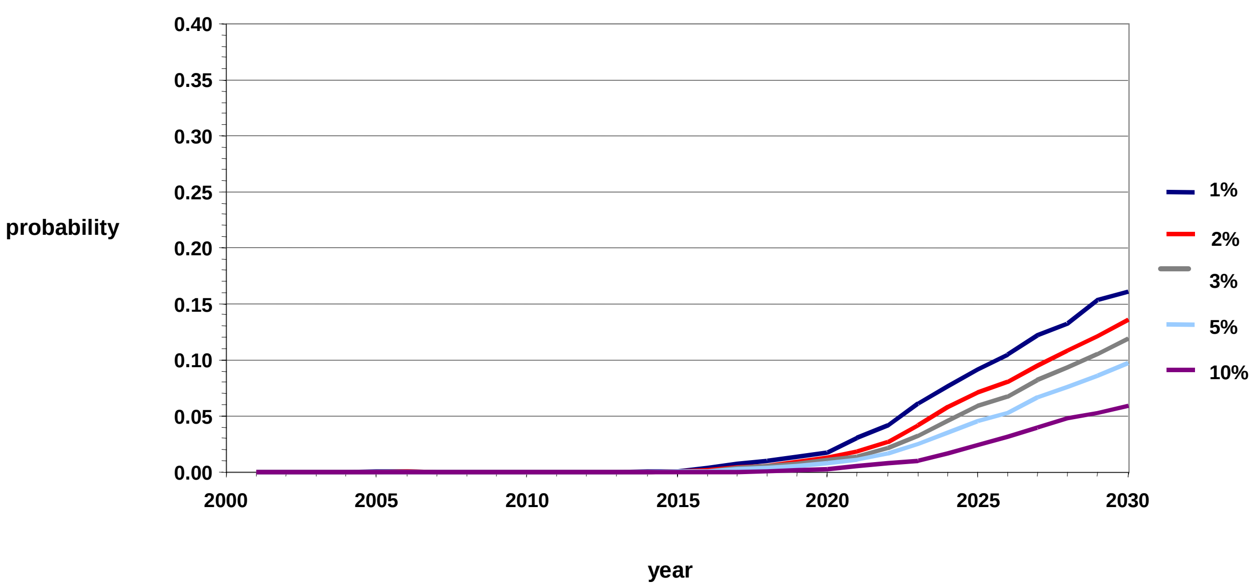

Figure 5-4. Probability of Designated Shortage – Baseline Condition of Regional System, Unlimited Import Supply

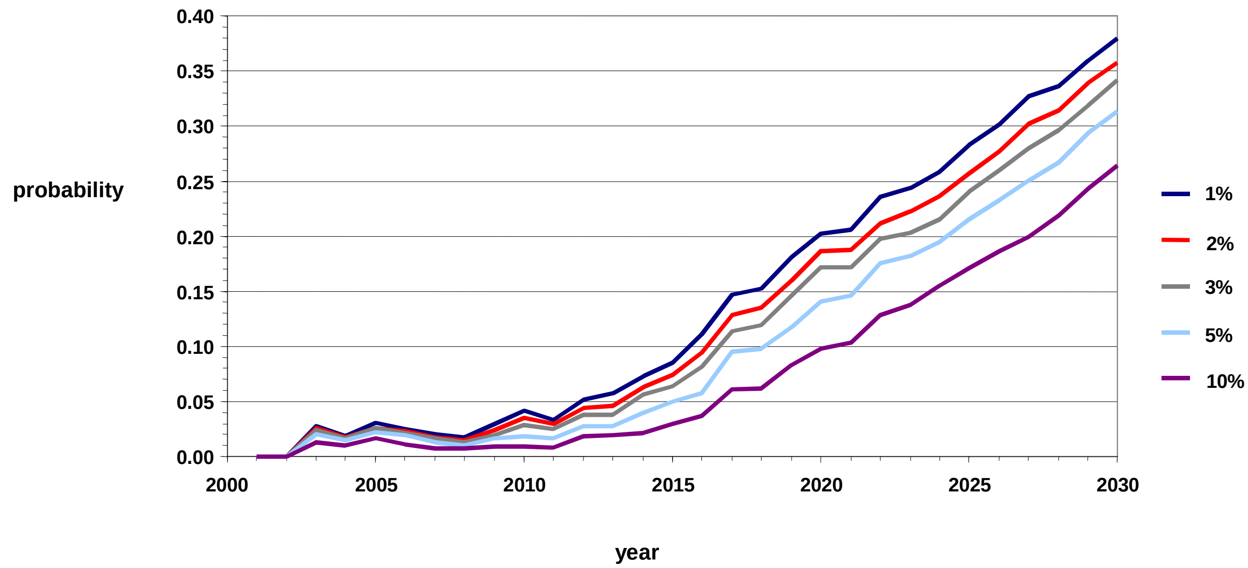

Figure 5-5. Probability of Designated Shortage – Baseline Condition of Regional System, Imported Supply Reliability

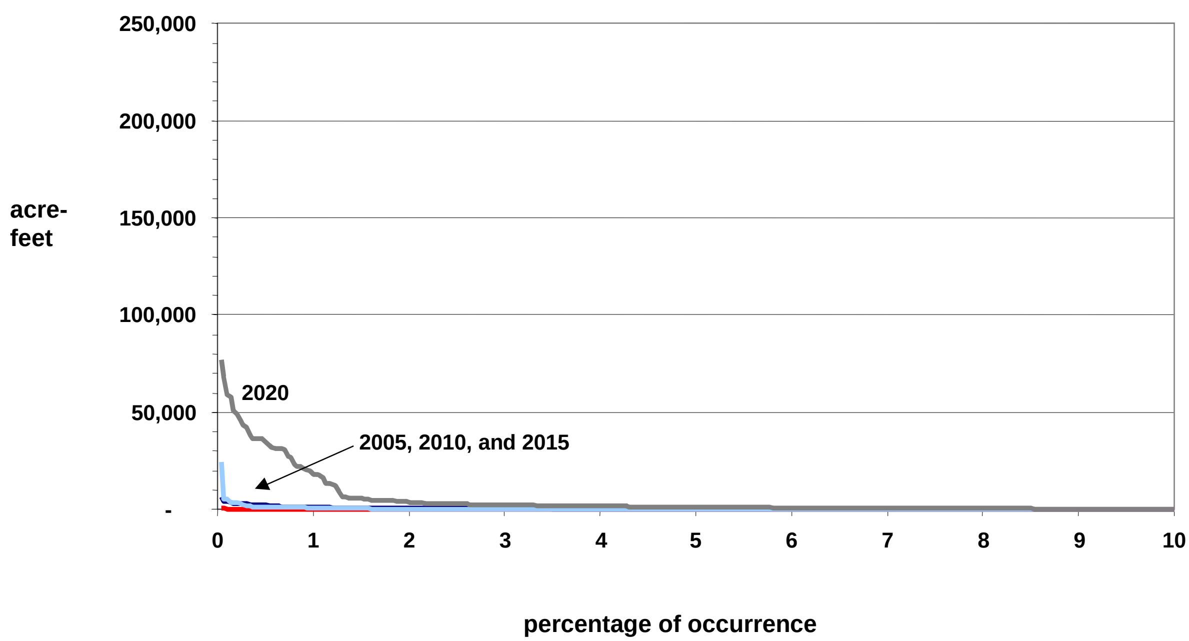

Figure 5-6. Annual Unserved Demand Duration Curve – Baseline Condition of Regional System, Unlimited Import Supply

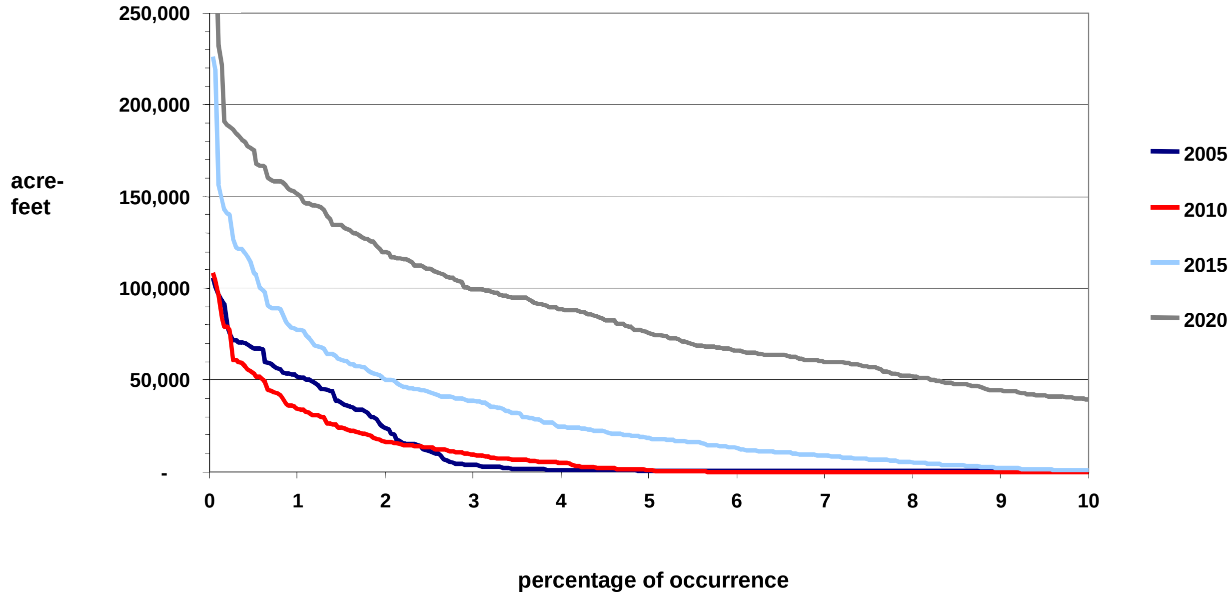

Figure 5-7. Annual Unserved Demand Duration Curve – Baseline Condition of Regional System, Imported Supply Reliability

Figure 5-6 shows that shortages, at a 1 percent probability of occurrence rate of would be less than 5,000 acre-feet in the peak season through 2015. The worst potential year is 2005. These shortages are associated with regional treatment capacity utilization as shown in a subsequent section of this chapter. With Imported Supply Reliability added (Figure 5-7), these potential shortages, at a 1 percent probability of occurrence, increase to about 52,000 acre feet in 2005 and then reduce to about 34,000 acre feet for 2010 and 78,000 for 2015 as local facilities come on-line.

Treatment Facilities

A key assumption for this analysis was the amount of treated water capacity available to the Authority from the Skinner WTP. Since 1997, the Authority had assumed availability of up to 420 mgd from Skinner WTP, which had been rated at 520 mgd. This capacity matched the 420 mgd of pipeline capacity available from Skinner, as determined by Metropolitan.

After demands on Skinner exceeded its capacity for a few hours during several different days in 2000, Metropolitan and its affected member agencies began studying the Skinner Service Area conditions and future needs. This led to the preparation of the January 2001 *Skinner Filtration Plant Study*, and a later updated study in June 2002, the *Skinner Service Area Study*. As a result of these studies, Metropolitan has accelerated the expansion of Skinner from the previously planned date of 2014, to a date between 2006 and 2007. The expansion will add 120 mgd of capacity to the plant. After the expansion is completed, Metropolitan will be able to provide treated water to the Authority up to the capacity of the pipelines serving the Authority.

Until the Skinner expansion is completed, it is unlikely that 420 mgd of treated water will be available to the Authority during peak demand periods.

There are two reasons for this. The first is that the Skinner Filtration Plan Study has stated the sustained daily capacity of Skinner is 494 mgd, a reduction of 26 mgd from the previously stated number. Secondly, demands from Eastern MWD and Western MWD have risen substantially, and are anticipated to continue to rise in response to the substantial land development occurring in the Temecula and Murrieta areas of southern Riverside County. The maximum day demand from southern Riverside County on Skinner reached 125 mgd in July 2002, and would have limited the Authority to less than 370 mgd had other actions not been taken.

Fortunately, Metropolitan has been able to exceed the plant's capacity for short periods. Despite Metropolitan's ability to "push" the plant beyond its rated capacity in the past, all agencies agree that every effort needs to be made to keep demands within the plant's current rated capacity. For this reason, the reliability analysis of the Baseline System utilizes a maximum availability of treated water from Metropolitan of 405 mgd in 2002, decreasing 5 mgd per year until 2006, when a capacity of 385 mgd is assumed. After the Skinner expansion is to be completed in 2007, a maximum availability of 420 mgd is assumed, with a 10 mgd decrease per year through 2010. From 2010 onward, the capacity remains at 390 mgd. The decreases in capacity availability are estimates made by the Authority, and are based on assumed demand growth in southern Riverside County impacting Skinner as well as statements by Metropolitan regarding the long-term capacity availability to the Authority in Pipeline 4.

New local treatment plants or expansions of existing treatment plants that are part of this Baseline Condition are listed below, with their incremental capacities:

- Helix WD – 106 mgd in 2002 (39-mgd expansion from 67 mgd capacity)
- Olivenhain MWD – 25 mgd in 2002
- Alvarado – 150 mgd in 2002 (30-mgd expansion) and 200 mgd in 2008 (50-mgd expansion).
- Miramar – 215 mgd in 2009 (75-mgd expansion)

As shown above, 94 mgd has been added this year (2002), and an additional 50 mgd is expected by the year 2005. Current plans show a total of 219 mgd will have been added to the regions' total treatment capacity by the year 2009.

The results presented in this section on treatment facilities will all be based upon the condition of Unlimited Import Supply as this will focus on the capacity of the regional facilities to meet peak demands.

Figure 5–8 shows the probability of a peak demand (peak day) shortage in 2005. This indicates that at a 1 percent probability the shortage ratio would be 0.1. In 2005, the treatment capacity required for the median forecast is about 1000 mgd for the region. This says that there is a 1 percent chance that the region could experience about a 100-mgd shortfall of the peak day of the season. This shortfall would be in capacity that can be utilized, as not all local plants can deliver excess capacity to others if their own system demand is less than their treatment capacity. An examination of the estimated plant production at the 1 percent occurrence indicates that there was a total of 47 mgd of unused treatment capacity, resulting from either a lack of facilities to deliver the treated water to areas of unserved demand or a limitation on untreated-water supply to a particular treatment plant. Thirty to thirty-five mgd of that unused treatment capacity was at Levy. The reason for the underutilization is a restriction in the untreated-water delivery capacity to the plant. This restriction will be lessened with

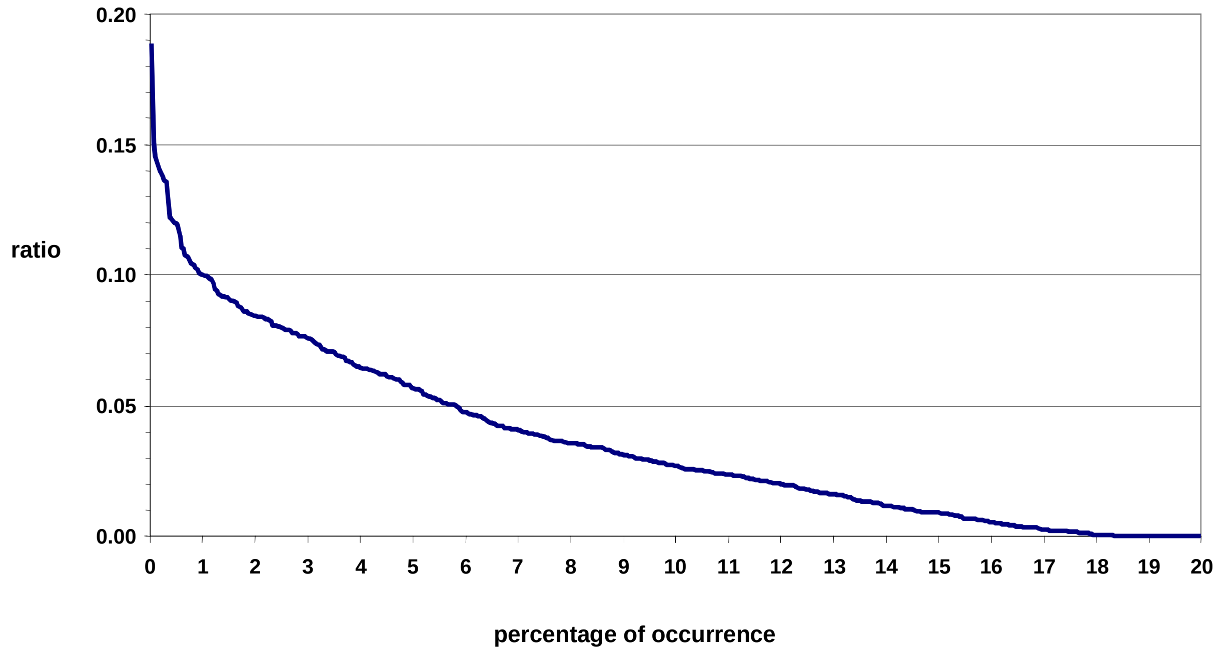

Figure 5-8. Shortage Event Ratio for Peak, One-Day Event in 2005 – Baseline Condition of Regional System, Unlimited Import Supply

the completion of the Moreno-Lakeside Pipeline (MLP) that is currently scheduled for completion in September 2005. The full capacity of the MLP will be realized when the San Vicente Pipeline and Pump Stations are completed in 2008.

By 2010, the peak day shortage falls to virtually zero at the 1 percent occurrence level (**Figure 5-9**) as the City of San Diego puts into operation its expanded Alvarado and Miramar treatment plants and more of the Levy capacity is utilized. By 2015 the potential for peak demand shortages will return and additional treatment capacity must be considered.

Conveyance System

Pipelines 1, 2, and 4 deliver treated water from Metropolitan's Skinner treatment plant. Pipelines 3 and 5 deliver untreated water into the Authority's service area. The results of the modeling indicated that the flows required in the untreated water pipelines into the Authority service area were within the lines' capacities through 2015 and beyond. In later years the capacity of the untreated water pipelines was reached for an increasing percentage of the peak season.

In general, flow requirements in the rest of the system were within the current capacities. Two potential areas of concern were noted. These are untreated water capacity in the Crossover reach between the Second and First Aqueducts, and in the untreated water pipelines of the Second Aqueduct from the Miramar Vents to Alvarado.

The Crossover line is used to supply untreated water to the Escondido-Vista WTP and to fill Pipelines 1 and 2 from Hubbard Hill in Escondido to San Vicente Reservoir. Pipelines 1 and 2 have a combined capacity of 190 cfs and supply Poway, and portions of the demand of Ramona, Helix and San Diego. The potential combined needs of the Escondido-Vista plant plus the First Aqueduct is greater than the operating capacity of the existing Crossover. Completion of the San Vicente Pipeline and Pump Station in 2008 will relieve some of the demand on the Crossover Pipeline; however, untreated water demand from Escondido, Poway, and Ramona will continue to grow, eventually taxing the capacity of the Crossover Pipeline.

The San Vicente Pipeline will be connected to the Second Aqueduct at a point north of the Miramar Vents. The untreated-water delivery to the Miramar WTP must come from the Second Aqueduct. The existing capacity of the untreated-water pipelines south of the Miramar Vents is approximately 480 cfs. As flows to Miramar WTP increase to its ultimate capacity of 215 mgd, or 350 cfs, then flow south of Miramar would decrease to 130 cfs (for Alvarado, Perdue and Otay) if there are no changes to the existing system. These constraints will become more significant once the expansions at Alvarado and Miramar are completed and the City increases its order for untreated water instead of treated water.

Of particular note is the reach south of the Miramar WTP. The combined capacity of the three treatment plants supplied by this reach is 270 mgd or 420 cfs. This capacity is significantly larger than the capacity of the aqueduct. Each plant is supported by a large storage reservoir so there does not appear to be a need to provide peak delivery capacity from the Second Aqueduct. However, the delivery capacity may need to be increased to assure more reliability against an outage of any of the other sources of untreated water to the plants.

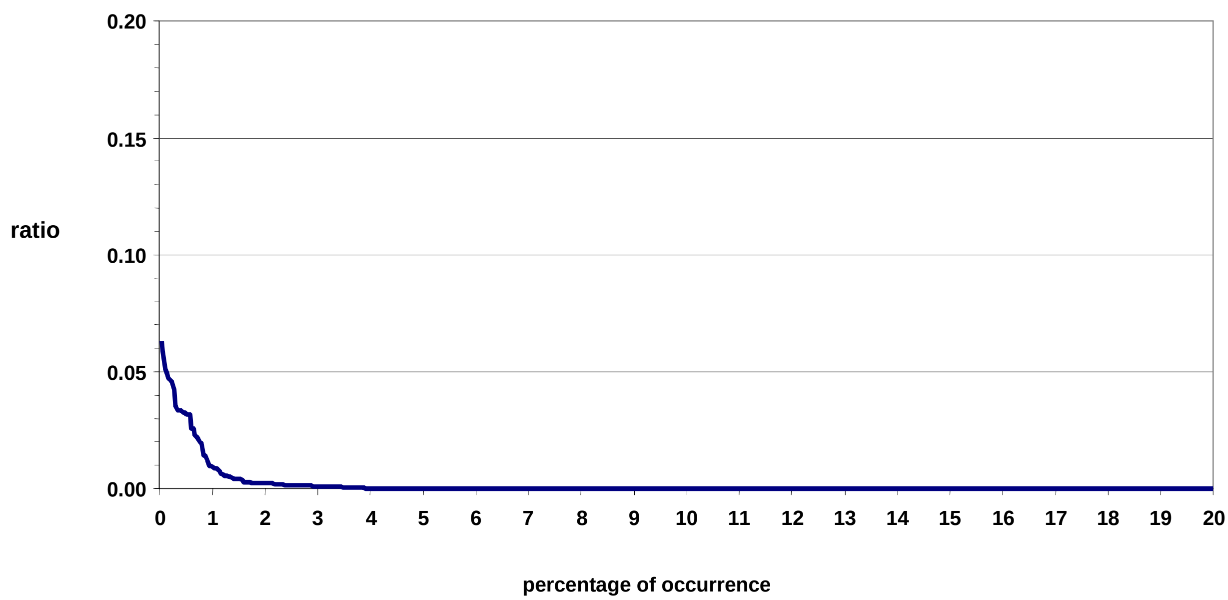

Figure 5-9. Shortage Event Ratio for Peak, One-Day Event in 2010 – Baseline Condition of Regional System, Unlimited Import Supply

6 Facility Options

This chapter presents five categories of potential projects used in the development of alternatives for this *Master Plan*. These categories are:

1. Rehabilitation of existing facilities
2. Expand system capacity
3. Additional water treatment capacity
4. Additional seasonal/carryover storage
5. New conveyance and supply

The process to develop the list of projects included brainstorming sessions with the engineering and operations staffs of the Authority, along with input from the member agencies. Input from the member agencies was obtained by direct staff contacts and through a series of Member Agency Panel (MAP) meetings attended by management, technical, and/or operational personnel of member agencies.

In some instances, project descriptions are based on previous engineering studies. In other cases, the description is based upon preliminary layout and estimating work carried out with this *Master Plan* to provide an order of magnitude quantification of what the project would entail.

Throughout the master planning process, an effort was made to keep current with the facility planning of each member agency and Metropolitan, which could impact the Authority's planning.

One of the objectives of this master planning process is to evaluate each facility option on the basis of cost and reliability. For a given cost, each option is evaluated to determine the level of reliability improvement that is achieved by implementing that option. By the very nature of the variety of the facility options, some will have a much greater impact on reliability then others. In addition, some options will duplicate the benefits provided by other options, with only one being needed. For this reason the inclusion of an option in this chapter is not meant to indicate any preference. All options, however, were considered for inclusion in the final alternatives discussed in Chapter 7.

The inclusion of a facility option should not be taken as a commitment by the Authority to fully pay for the facility should it be selected. In cases where a facility is serving a single agency or where it is replacing an existing facility owned by a single agency, cost sharing arrangements may need to be negotiated.

Rehabilitation of Existing Facilities

The Authority's Aqueduct Protection Program (APP) began assessing and cataloguing the condition of existing pipelines in 1991 as part of the Capital Improvement Program (CIP) .The pipeline condition assessments have been used to define the location and extent of rehabilitation work needed for all pipelines along the Authority's Second Aqueduct, and the Crossover Pipeline. This work is reflected in the CIP project, Replacement/ Repair of Existing PCCP (RRP).

As part of this *Master Plan* effort, the RRP was analyzed for opportunities to provide additional system capacity, when and where needed. Potential modifications to the RRP are discussed in the sections that follow. Note, in particular, the discussion of Crossover Pipeline No. 2 in the next section, "Expand Internal System Capacity."

Expand Internal System Capacity

Potential projects in this category include flow regulatory storage projects, projects to increase regional conveyance capacity security improvements, and system monitoring and control equipment. The conveyance projects include replacement of certain sections of existing pipelines to achieve greater capacity and two new pump stations for delivery of untreated water.

The flow regulatory reservoirs or tanks that would facilitate operation of the regional system are listed in **Table 6-1**. A typical flow regulatory project would be a steel or concrete tank with a capacity of from 3 to 20 million gallons (mg). **Table 6-2** is a listing of pipeline or tunnel projects that would increase system capacity.

Table 6-1. Potential Flow Regulating Storage Projects (Expand Internal System Capacity)
Hubbard Hill Terminal Structure Terminal tank at end of Pipelines 1 and 2 at Hubbard Hill (treated water)
Slaughterhouse Terminal Structure Flow regulatory storage at Slaughterhouse on untreated-water system (at end of Pipelines 1 and 2 near San Vicente Reservoir)
North County FRS Replacement (or second) tank on North County Distribution Pipeline (NCDP)
Mission Trails FRS II Flow regulatory storage in Mission Trails Park on untreated-water system (adjacent to treated-water FRS)
Filtered FRS – Twin Oaks Diversion Structure Second flow regulatory structure at Twin Oaks Diversion Structure on treated-water system

Table 6-2. Potential Pipeline and Tunnel Projects (All Project Categories)
Pipelines to deliver unused capacity from the Escondido-Vista WTP Phase 1 • New untreated-water pipeline from the Crossover to Dixon Lake • Transmission from Escondido-Vista WTP to First Aqueduct (Hubbard Hill) or conversion of existing 42-inch untreated-water line to treated water Phase 2 • Transmission pipeline from Hubbard Hill north to Valley Center FCF (Nos. 5 and 6) and/or Pipeline 2A or • Replacement of Vista Flume to Pechstein Reservoir with delivery to Vista ID and Vallecitos WD or • Relining of Crossover Pipeline and use of it for delivery of treated water, following construction of Crossover No. 2
Crossover Pipeline No. 2
Pipeline from Helix flume to Otay Regulatory reservoir for treated water
Conversion of LMSE from treated to untreated water between Hwy 67 and Sweetwater Reservoir
Second pipeline, or tunnel, for fill/drain of El Capitan
Loveland to Sweetwater (with pumping and/or hydrogeneration)
El Capitan – Loveland pipeline and pump station/hydrogeneration
Project to maintain capacity from Henshaw: • Replace portions, or all, of existing Escondido Canal or • Tunnel/pipeline – Henshaw to Wohlford (new alignment) or • Tunnel/pipeline – Henshaw to Sutherland, Sutherland to Lake Ramona Lake
Convert one pipeline of First Aqueduct south of Hubbard Hill to treated water (from Escondido)
Santa Margarita – Extension of South Coast Pipeline to deliver treated water from Metropolitan to the North Coast area of San Diego County and/or to connect to a possible seawater desalination facility at San Onofre
Convert one pipeline of First Aqueduct from Escondido to San Vicente to recycled water

Flow Regulatory Storage

Flow regulatory storage can provide flexibility in operating the aqueducts so that spills from the vents can be avoided in the event that a member agency suddenly rejects water at a flow control facility (FCF). Current operational storage is limited to an 18-mg flow regulatory structure (FRS) located on the treated-water pipeline of the Second Aqueduct in Mission Trails Regional Park, a 1-mg tank on the North County Distribution Pipeline (NCDP) (also treated water), and the Twin Oaks Valley Diversion Structure, which will regulate flows on the untreated-water pipelines of the Second Aqueduct.

The Authority's operating and engineering staffs have identified five additional locations where operational storage would provide operational flexibility and system reliability.

- Hubbard Hill Terminal Structure (Escondido), located on the First Aqueduct at the end of treated-water Pipelines 1 and 2 (3 to 5 mg)
- Slaughterhouse Terminal Structure (near San Vicente), located on the First Aqueduct at the end of untreated-water Pipelines 1 and 2 (10 mg)
- Larger FRS at North County Distribution Pipeline (NCDP) (5 mg)
- An FRS on untreated Pipeline 3, adjacent to treated water FRS in Mission Trails Regional Park (18 mg)
- Treated-water FRS at Twin Oaks Valley Diversion Structure

Hubbard Hill FRS

A 3- to 5-mg flow regulatory structure at the terminus of the treated-water pipelines of the First Aqueduct will offset two reoccurring problems at this location: the loss of treated water to the untreated-water system downstream and spills at the current terminal facility, following the rejection of water by an upstream user. **Figure 6-1** shows the location of the facility adjacent to the terminal facilities on the First Aqueduct pipelines.

Slaughterhouse Terminal Structure

The Slaughterhouse Terminal Structure is located at the end of the untreated-water pipelines (Pipelines 1 and 2) near San Vicente Reservoir (**Figure 6-2**). These pipelines provide untreated water to Ramona, Poway, Helix (and, thus, to Padre Dam and Otay), San Diego, and the San Vicente Reservoir. Flows at this location are controlled and directed to the flow control facilities for San Diego (San Diego Nos. 1 and 2), Helix (Helix No. 2) and/or the La Mesa–Sweetwater Extension (and subsequently to Helix No. 1).

A preliminary capacity of 10 mg has been established, under the assumption that the facility would normally operate at one-half full.

North County FRS

The existing 1-mg facility provides insufficient storage to regulate the variations in demand along the NCDP, as well as the variable output of the adjacent Weese Treatment Plant. A replacement facility of approximately 5 mg is recommended for this treated-water delivery system (**Figure 6-3**).

Mission Trails FRS II

This project would provide the same operational benefit for the untreated-water system as the existing FRS provides for the treated-water system of the Second Aqueduct. However, it can only function if the pipelines south of the facility have been

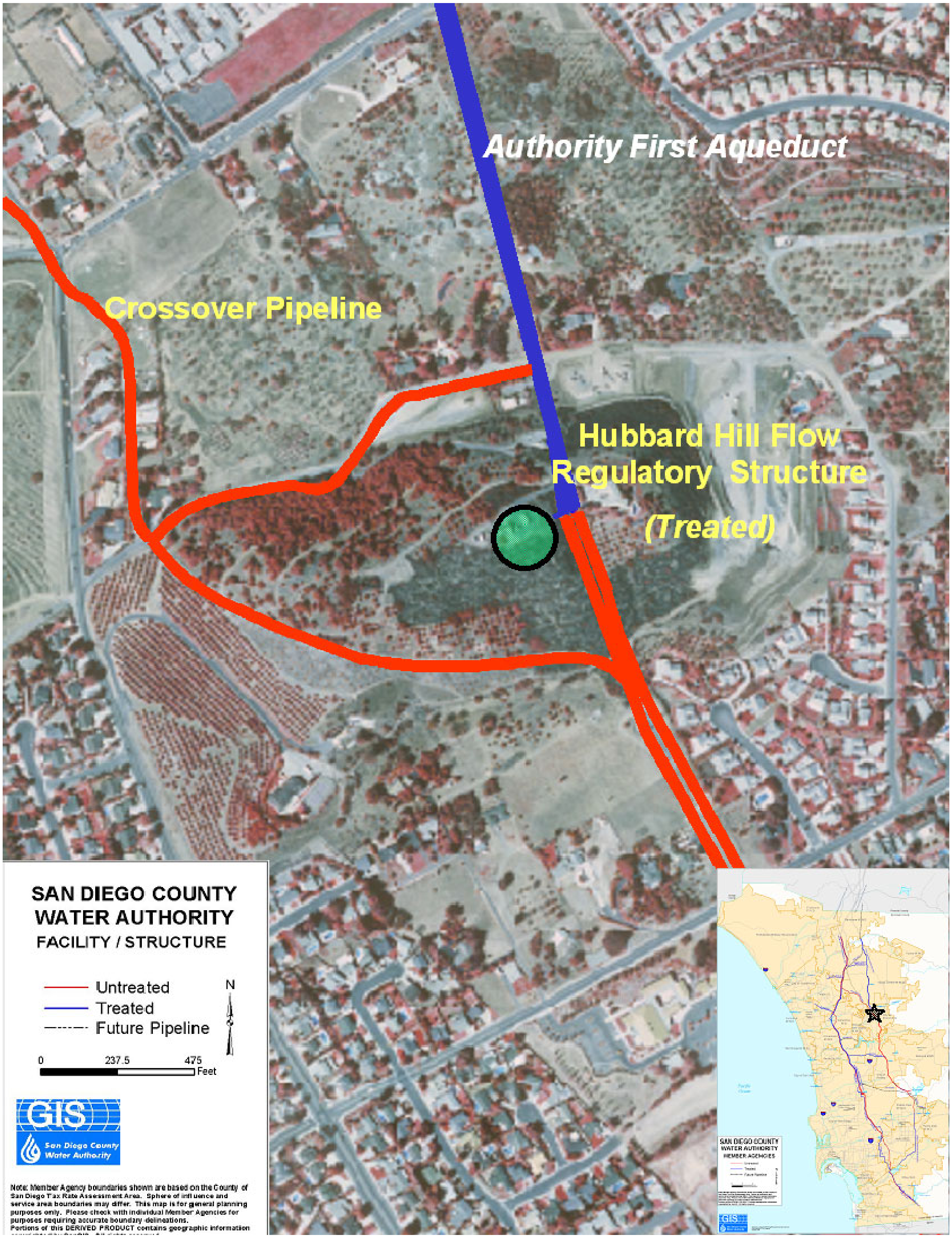

Figure 6-1. Hubbard Hill Flow Regulatory Structure

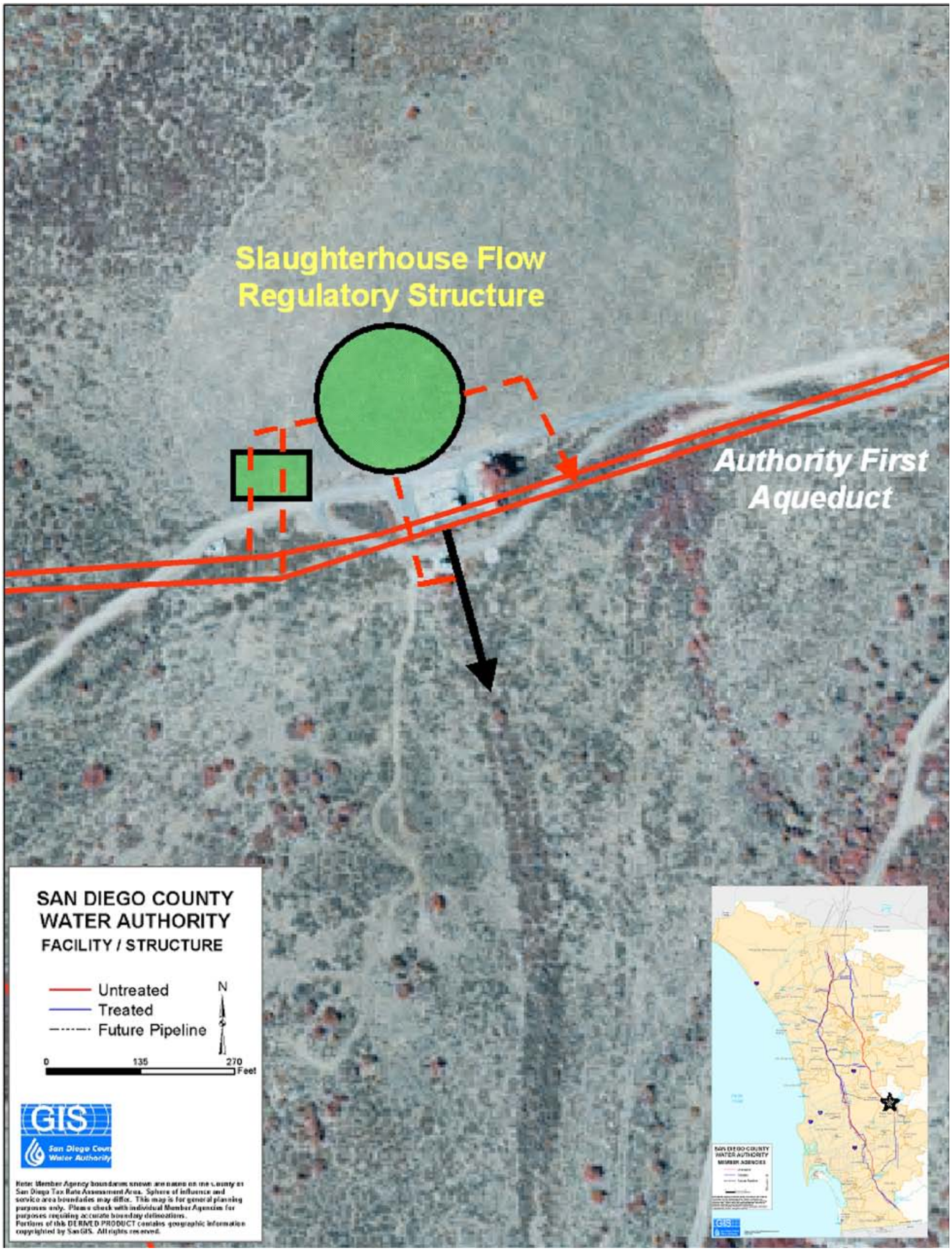

Figure 6-2. Slaughterhouse Flow Regulatory Structure

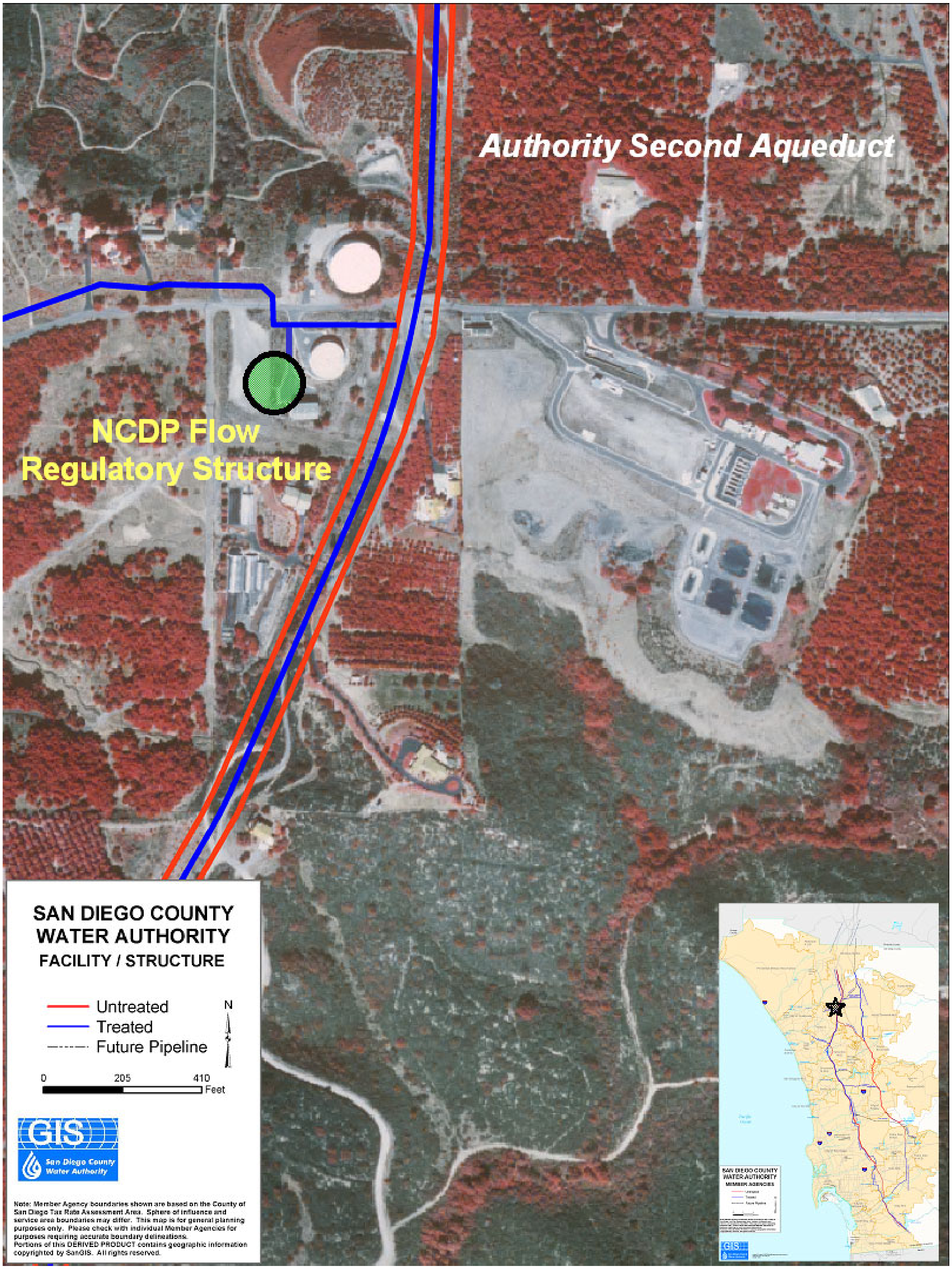

Figure 6-3. North County Distribution Flow Regulatory Structure

rehabilitated to operate with higher pressures; this applies primarily to Pipeline 3 as far south as Lower Otay Reservoir. The FRS would protect against flow rejections causing spills, would allow the Authority to remove existing vents in Mission Trails Regional Park, and would provide higher hydraulic service to treatment facilities south of Mission Trails (as well as increased power production). This project would be completed in conjunction with the project to increase untreated-water capacity along the Second Aqueduct between the Miramar and Alvarado treatment plants. The project would replace Pipelines 3 and 4 with a new pipeline that would be constructed as a tunnel to lower the hydraulic gradeline. The facility would be similar to, and adjacent to, the treated-water FRS in Mission Trails Regional Park **(Figure 6-4)**.

Treated FRS – Twin Oaks Valley Diversion Structure

An FRS has recently been completed at the Authority's Diversion Structure complex in Twin Oaks Valley. Located on the untreated- water delivery system, this FRS allows Pipeline 5 to operate in a pressure mode between the Diversion Structure and the future Rancho Penasquitos Hydroelectric and Pressure Control Facility located just north of Miramar Reservoir. A second FRS in Twin Oaks Valley could support operation of the treated-water pipelines (currently Pipelines 3 and 4 between the Twin Oaks Valley Diversion Structure and Miramar). However, converting these pipelines to pressure operation could only be achieved if the proposed relining of either of these pipelines would include their entire length. All reaches would have to be capable of withstanding the higher water pressure that would result from the change in operation of the aqueduct's pipelines.

No size has been estimated at this time. This FRS project is more likely to be implemented, if an adjacent treatment facility is also ultimately constructed. In that case, the treated-water storage volume would serve as clearwell storage for the treatment facility and would be sized accordingly.

Vallecitos has recently constructed a 32 mg concrete reservoir adjacent to the Diversion Structure, and has space to construct a second reservoir of similar size. While the elevation of the current reservoir is a bit lower than what might be requires by the Authority, further study of the second reservoir in partnership with Vallecitos is merited.

Projects to Increase Regional Untreated-Water Conveyance Capacity

Several potential projects to enhance untreated-water deliveries have been identified, which involve either new facility construction or modification of an existing facility's function. These projects are listed below, followed by a brief discussion.

- Convert La Mesa–Sweetwater Extension to untreated water from Lakeside to Sweetwater Reservoir (untreated water from Slaughterhouse to Sweetwater Reservoir)
- Crossover Pipeline No. 2
- Convert Pipeline 3 to untreated water from Twin Oaks Valley Diversion Structure to Miramar Vents
- Reconfigure pipelines from Miramar Vents to Highway 52
- New pump station at Lower Otay Reservoir for delivery of untreated water into Pipeline 3, following pipeline relining
- New pump station at Sweetwater Reservoir for delivery of untreated water into Pipeline 3, following pipeline relining

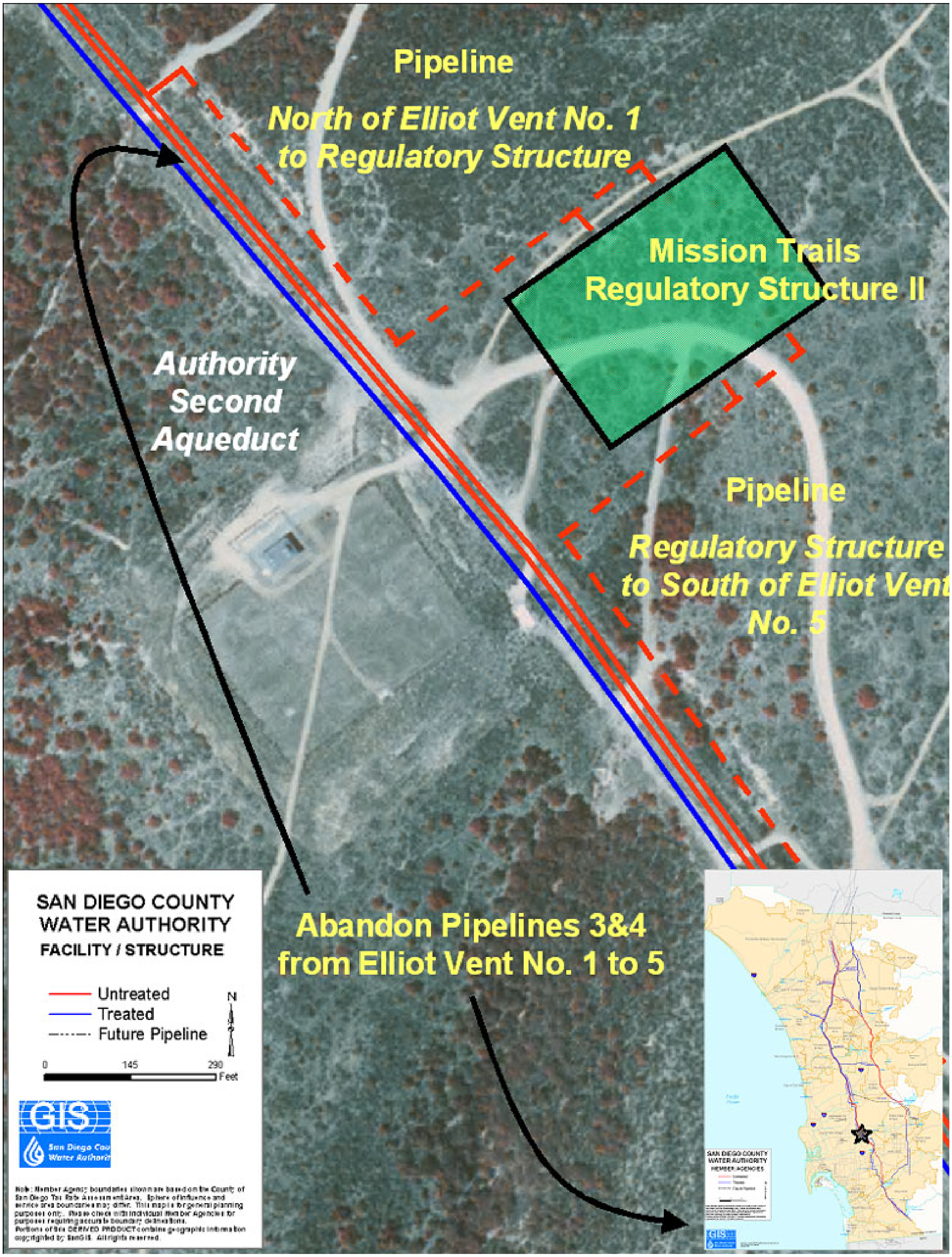

Figure 6-4. Mission Trails Flow Regulatory Structure II

Convert LMSE to Untreated Water

If a new delivery pipeline to Otay WD is constructed from Otay No. 14 FCF to the regulatory reservoir complex, the LMSE (currently delivering treated water) becomes available to deliver untreated water to Sweetwater Reservoir. Piping modifications to reconnect the line at the Lakeside Control Structure and deactivation of the Otay No. 8 FCF would be required. This line is capable of delivering up to about 10,000 ac-ft/yr to Sweetwater, depending upon other deliveries upstream to other member agencies.

Crossover Pipeline No. 2

The Crossover Pipeline supplies imported water to Escondido–Vista WTP, and, through the First Aqueduct, to the following agencies: Ramona, Poway, Helix (and, thus, to Padre Dam and Otay), the City of San Diego, and potentially Sweetwater. The existing pipeline was designed for 130 cfs, but modifications at the Twin Oaks Valley Diversion Structure have allowed as much as 200 cfs through the line.

The pipeline is scheduled for rehabilitation in 2015 as part of the APP; however, more capacity is desirable. Instead of relining and, thus, reducing capacity, a new pipeline for untreated water could be constructed (Crossover Pipeline No. 2). A preliminary capacity of 330 cfs has been identified, based upon the capacity of the First Aqueduct and the anticipated needs of the Escondido-Vista WTP **(Figure 6-5)**. The new pipeline would be approximately 52,000 feet long and would be constructed as a 96-inch-diameter line to provide the design flow rate at the hydraulic conditions existing at each end of the line.

Convert Pipeline 3 from Twin Oaks Valley Diversion Structure to Miramar Vents

Pipelines 3 and 4 deliver treated water from the Twin Oaks Valley Diversion Structure to the Miramar Vents. This dual feed provides greater reliability to the customers served in this reach, since each FCF has been modified to allow delivery from either pipeline. One line can be out of service for inspection or maintenance, while the other maintains service to member agencies.

Both pipelines are scheduled for rehabilitation. Once the rehabilitation work is completed, Pipeline 3 could be converted from delivering treated water to untreated water, since the untreated-water capacity needed will be greater than the capacity of Pipeline 5, the other untreated-water delivery pipeline in this reach **(Figure 6-6)**. At the same time, the treated-water delivery demand will be less than the capacity of Pipeline 4. The conversion will be relatively easy, involving reconnection at each end of the reach and removal of spool pieces of pipe at each FCF to prevent cross-connections. Accommodations for those agencies that take off of either Pipeline 3 or 5, but not both, will have to be investigated further.

Reconfigure Pipelines from Miramar Vents to Highway 52

Currently, a hydraulic capacity constraint exists on untreated-water deliveries south of the Miramar Vents. **Figure 6-7** provides a schematic of the pipelines, showing diameters and current usage (untreated, treated, or out-of-service). These pipelines are scheduled for rehabilitation as part of the RRP.

Beyond Miramar FCF, at the Red Cedar Crossover, Pipeline 3 connects to Pipeline 4 and vice versa. By past agreement with the City of San Diego (made when Pipeline 4 was constructed), one of these pipelines will become a City pipeline as far south as Shepherd Canyon (Highway 52). This

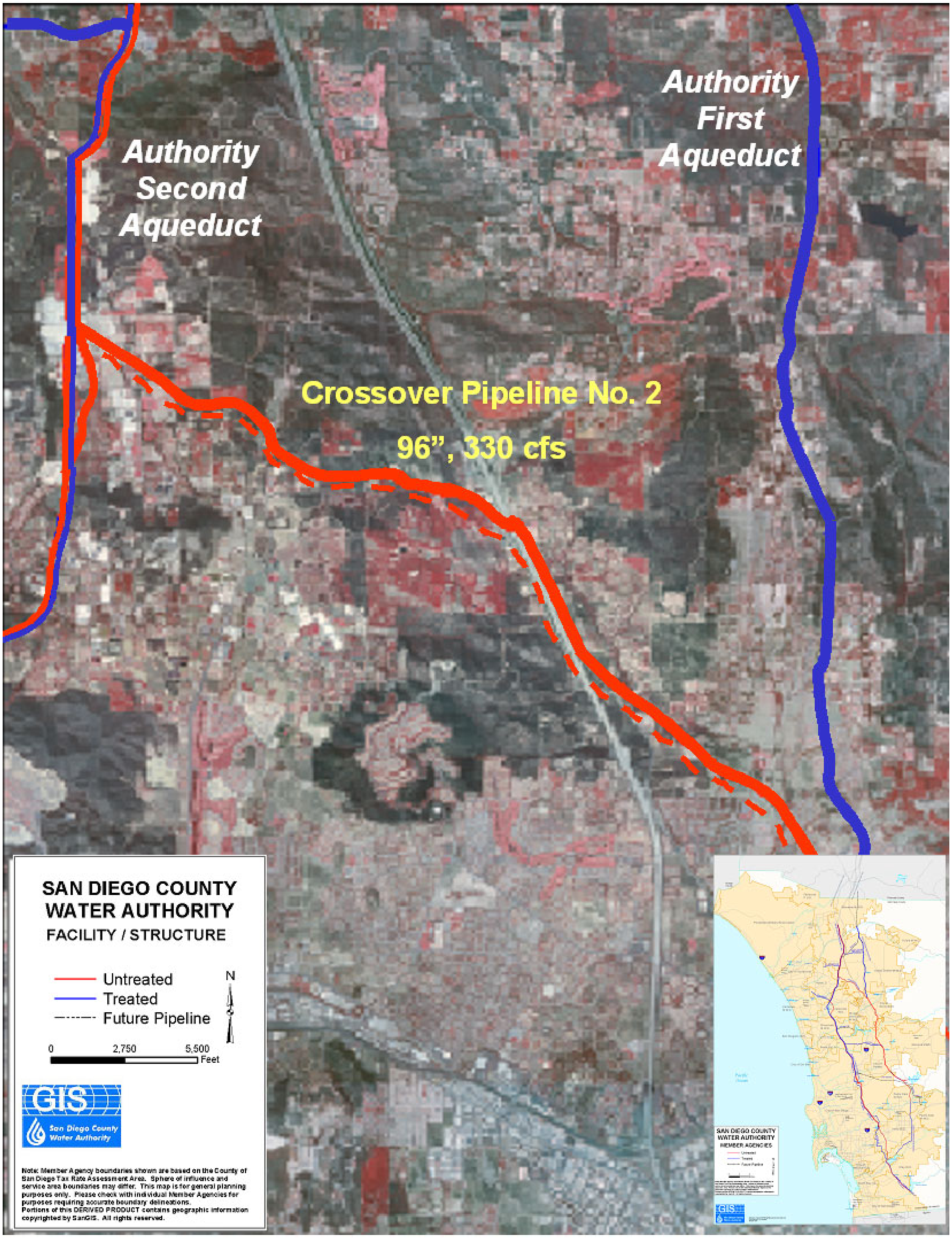

Figure 6-5. Crossover Pipeline No. 2

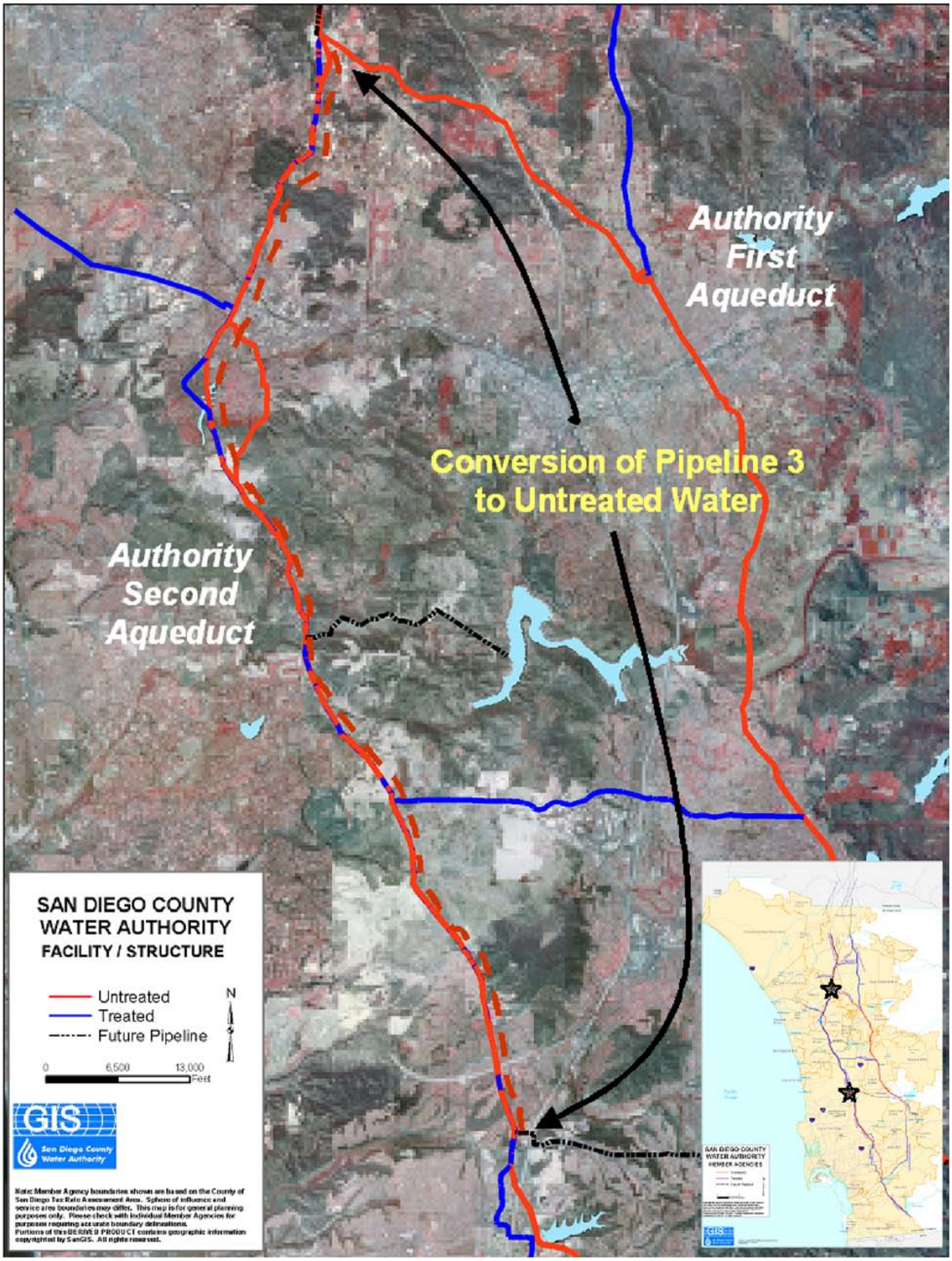

Figure 6-6. Conversion of Pipeline 3 to Untreated-Water Delivery (Twin Oaks Valley Diversion Structure to Miramar Vents)

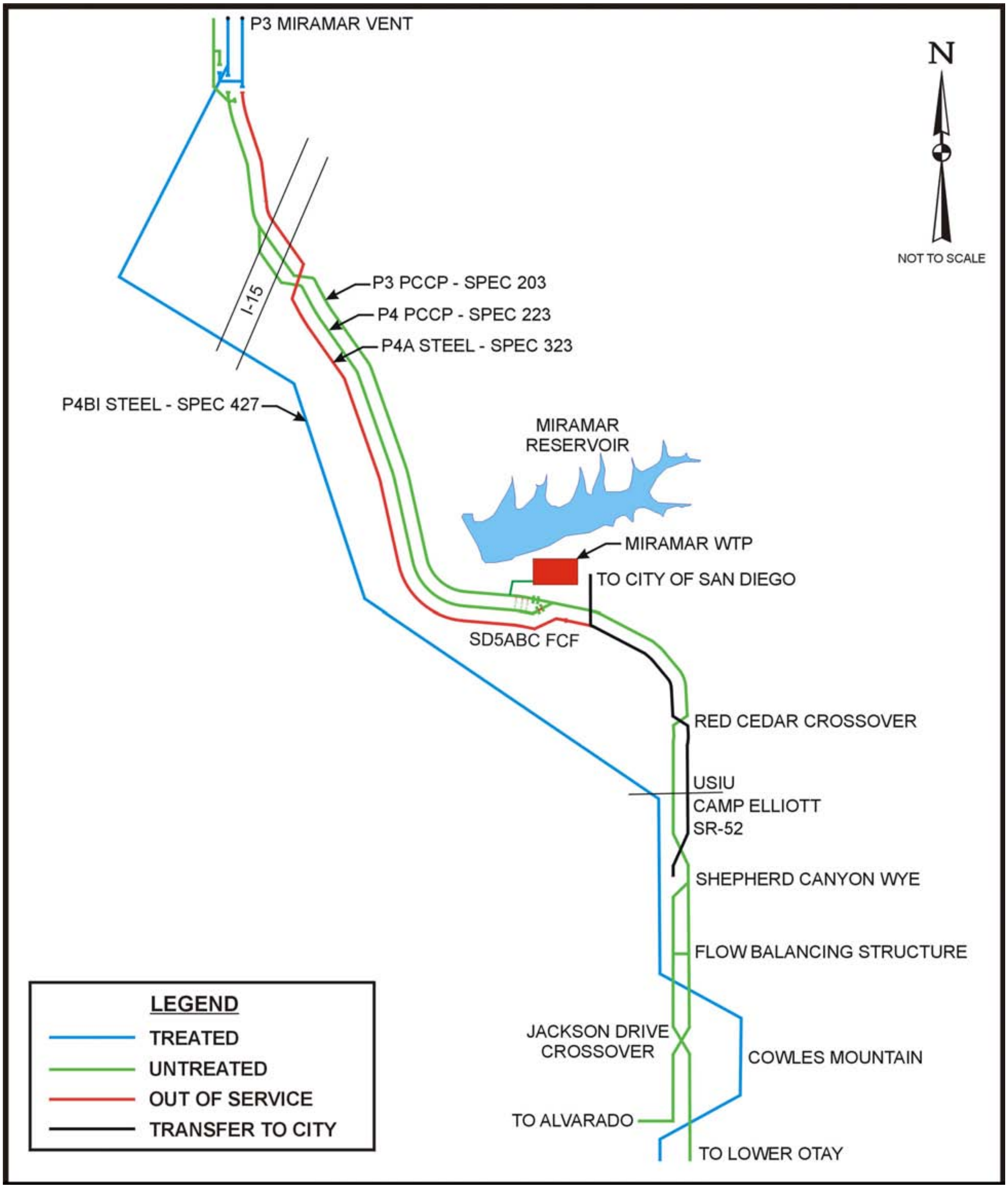

Figure 6-7. Schematic of Pipelines from Miramar Vents to Highway 52

Table 6-3. Hydraulic Capacity of Untreated-Water System, South of Miramar Vents				
	HGL at Miramar Vents of 818±		HGL at Miramar Vents of 846±	
Condition	Miramar Vents to WTP (cfs)	South of WTP (cfs)	Miramar Vents to WTP (cfs)	South of WTP (cfs)
Water Flow to Miramar WTP of 333 cfs				
Option 1 [(a)]	469	136	534	201
Option 2 [(b)]	479	146	549	216
Option 3 [(c)]	533	200	583	250
Water Flow to Miramar WTP of 200 cfs				
Option 1	386	166	426	226
Option 3	425	225	475	275

[(a)] Option 1: 72-inch line (Pipeline 4A between Miramar Vents and Miramar WTP) reactivated and relined.

[(b)] Option 2: 72-inch line reactivated and relined; 72-inch line extended to Red Cedar Drive and connected to existing 84-inch line.

[(c)] Option 3: 72-inch reactivated, relined, and extended; new FRS (at 750 feet) and piping in Mission Trails.

leaves one pipeline for untreated-water delivery south of Miramar, as far as Highway 52, where the line splits into two 72-inch-diameter pipelines (the Shepherd Canyon Wye). One terminates at Alvarado WTP; the other continues to Lower Otay Reservoir.

Untreated-water capacity can be increased incrementally in this reach. **Table 6-3** summarizes the estimated capacity, for two different operating hydraulic constraints, from the Miramar Vents to the turnouts for Miramar WTP and from the Miramar WTP to the south. The operating constraints are the water surface operating level within the Miramar Vents. Keeping the water level within the pipe by not allowing it to rise into the vent itself is shown in the table as "Miramar Vents at HGL of 818 +/-". Allowing the water surface to rise into the vents provides more capacity, but at a higher risk for spills.

For calculation purposes, an elevation of 846 feet was used as the operating level within the vents. The Miramar Vents have a spillway elevation of 860 feet mean sea level (MSL); thus, the level of 846 feet represents operating two thirds of the way up the vents. These results are shown in the last two columns of the table. These calculations assume that the hydraulic constraints from the Miramar FCF to the plant's headworks have been alleviated by planned projects as part of the plant's expansion and upgrade.

Flows to Miramar impact the capacity to deliver water to connections south of Miramar. Thus, two different conditions are shown. A flow of 333 cfs (215 mgd) to Miramar represents the future maximum anticipated flow while a flow of 200 cfs (130 mgd) is more representative of current peak, and future average, flows.

Option 1 is to place the 72-inch pipeline from the vents to the Miramar turnout back into service following its relining. The capacity south of Miramar then ranges from 136 to 166 cfs at the 818 gradient and 201 cfs to 226 cfs for the 846 gradient. This is the easiest modification in that it requires no new construction other than the relining project.

Option 2 would be to extend the 72-inch line to Red Cedar Drive, where a connection to the existing 84-inch line could be made. This would provide a parallel line to the 69-inch line that is now the only untreated-water pipeline that will be in service between the Miramar FCF and the 84-inch line at Red Cedar. This pipeline segment does not provide significant new capacity by itself, but it does provide some additional level of reliability for this reach.

Option 3 would be to reactivate, reline, and extend the 72-inch line and operate it in conjunction with the implementation of another recommended project, the second FRS in Mission Trails Regional Park, described earlier in this chapter. In this case, the second FRS would be constructed at a lower elevation than its companion FRS on the treated-water pipeline. This lower elevation would increase the untreated-water capacity south of the Miramar WTP to between 200 cfs and 225 cfs at 818 feet and to between 250 cfs and 275 cfs at the 846-foot operating gradient in the Miramar Vents.

New Pump Station at Lower Otay Reservoir for Delivery of Untreated Water to Pipeline 3

Once the section of Pipeline 3 near the lower Otay Reservoir has been rehabilitated, it will be able to handle higher internal pressures. A pump station to pump water back to the north from Lower Otay Reservoir could be provided **(Figure 6-8)**. This would allow local water in the Morena-Barrett–Lower Otay system to be treated at facilities other than the Otay WTP. Water could be conveyed to either the Perdue or Alvarado treatment plants. If the local runoff levels were creating a potential for spills from Lower Otay, additional water could be pumped and used by more treatment plants (as long as the local hydrology of the adjacent facilities is not creating a similar problem). Such a pump station would also provide an additional source of peak period supplies to the Alvarado and Perdue WTPs to augment local supplies and Authority supplies from north of Alvarado.

A new pump station and associated facilities to lift water from Lower Otay would be required (at a high-water level of 495 feet to the probable aqueduct grade line of 700 feet).

New Pump Station at Sweetwater Reservoir for Delivery of Untreated Water to Pipeline 3

The same situation exists at Sweetwater Reservoir as defined above for Lower Otay. Excess water from local runoff could be treated at Alvarado and/or Otay WTPs as a means of preventing spills from Sweetwater Reservoir.

A pump station would need to lift from Sweetwater Reservoir's high-water level of 237 feet to the aqueduct grade line of approximately 700 feet.

Additional Water Treatment Capacity

Three groups of projects are discussed below as part of this category (potential projects that will provide additional water treatment capacity):

- projects to supplement the treated-water aqueducts
- projects to expand treatment capacity

Table 6-4 is a listing of pump stations that can provide supplemental flow of either untreated or treated water to the

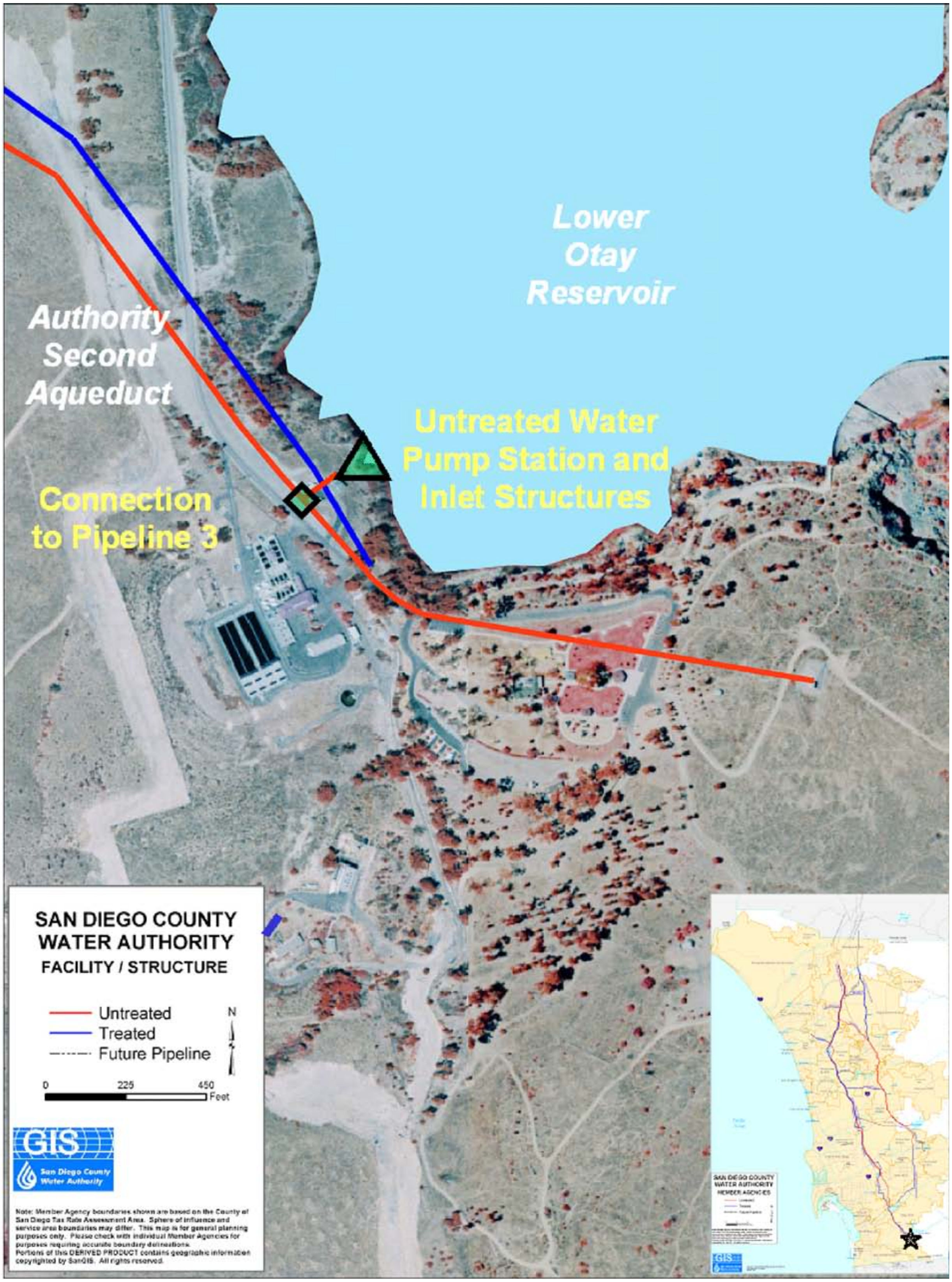

Figure 6-8. New Pump Station at Lower Otay Reservoir for Delivery of Untreated Water to Pipeline 3

Table 6-4. Potential Pump Station Projects (Expand Internal System Capacity and Additional Water Treatment Capacity)

Untreated-water pump stations

- At Lower Otay Reservoir to pump into Pipeline 3 (following rehabilitation)
- At Sweetwater Reservoir to pump into Pipeline 3 (following rehabilitation)

Treated-water pump stations

- At Otay WTP, from City of San Diego to Pipeline 4 or at Otay WTP from City of San Diego to Otay WD (current contract exists)
- At Perdue WTP, from Sweetwater Authority to Pipeline 4
- At Alvarado WTP, from City of San Diego to Pipeline 4 (current City CIP)
- At Weese WTP, from Oceanside to Pipeline 4
- From Escondido-Vista WTP to First Aqueduct at Hubbard Hill
- At Berglund WTP, from Poway to Ramona Pipeline or converted Pipeline 1
- Near Levy WTP to Padre Dam (enlarge or replace existing)

regional system. In most cases, a relatively short pipeline would also be required to connect to the regional system. This list does not include pump stations currently included in the Authority's CIP as part of the Emergency Storage Project (ESP). **Table 6-5** is a listing of regional treatment plants that could be expanded beyond the needs of the owner agency or whose current surplus capacity could be used. Surplus capacity could be used either for peaks or by other agencies during winter months.

Projects to Supplement Treated-Water Aqueducts

Seven projects were identified that could potentially provide additional treated-water capacity to the region. These projects would offset non-peak deliveries from Metropolitan's Skinner WTP, resulting in lower unit costs for local facilities. In some cases, they also offset peak demands in the summer on Skinner. These projects are:

- Delivery of treated water from the Escondido-Vista WTP to the First and Second Aqueducts' treated-water pipelines
- Expansion of Oceanside's Weese WTP and pump station to pump treated water into Pipeline 4
- Expansion of Olivenhain's WTP and gravity flow of treated water into Pipeline 4
- Use of available capacity of the City of San Diego's proposed pump station at Alvarado to pump treated water into La Mesa–Lemon Grove Pipeline
- Projects to expand the delivery capacity of Levy WTP to Padre Dam MWD and Otay WD are also discussed below, including a new pipeline and new pump station

Table 6-5. Potential Water Treatment Facility Projects (Additional Water Treatment Capacity)

Plants with existing, unused peak capacity

- Escondido-Vista (City of Escondido and Vista ID)
- Levy (Helix WD)
- Otay (City of San Diego)

Plants that could provide off-peak capacity

- Levy (Helix WD)
- Weese (City of Oceanside)
- Olivenhain (Olivenhain MWD)
- Miramar (City of San Diego)
- Alvarado (City of San Diego)
- Otay (City of San Diego)
- Perdue (Sweetwater Authority)
- Berglund (City of Poway)

Plants that could be expanded beyond existing (or planned) capacity

- Levy (Helix WD) to 120 mgd
- Olivenhain (Olivenhain MWD) to 85+ mgd
- Weese (City of Oceanside) to 50 mgd
- Otay (City of San Diego) to 60 mgd
- Perdue (Sweetwater Authority) to 45 mgd
- Berglund (City of Poway) to 36 mgd

New plants (not including seawater desalination)

- Lake Ramona (Ramona MWD)
- North City (City of San Diego)
- Crossover (SDCWA)
- Loveland (Sweetwater Authority or Padre Dam MWD)

- Pumping of treated water into La Mesa–Lemon Grove Pipeline from Sweetwater's Perdue WTP
- Pumping of treated water into Otay Mesa Pipeline from City of San Diego's Otay WTP
- Lining and converting of Fallbrook PUD's Red Mountain Reservoir

The first three projects listed above provide essentially the same benefit; that is, they supplement the delivery of treated water in the regional delivery system at a point far enough north to supply many of the treated-water FCFs.

Treated Water from Escondido–Vista WTP

The Escondido–Vista WTP is rated at 65 mgd and is currently experiencing peak demands somewhat less than capacity. Utilization of this capacity could be developed in two phases. The first phase would provide capacity to the First Aqueduct near Hubbard Hill, supplementing demand by supplying Rincon del Diablo (Rincon No.3) and small portions of Vista (Vista No. 1), Vallecitos

(Vallecitos No. 2), and Valley Center (Valley Center No. 2). The second phase would involve a pipeline to deliver treated water from the Hubbard Hill area to the Second Aqueduct. The total capacity would be 70 cfs, with the initial phase sized for about 25 percent of the ultimate capacity.

First-phase facilities would include the following (shown on **Figure 6-9**):

- A new untreated-water pipeline from Crossover Pipeline No. 2 to Dixon Lake
- Conversion of the existing untreated-water pipeline to treated water (42-inch pipeline from Escondido No. 3 to the plant)
- Pump station and piping near Hubbard Hill to connect the 42-inch pipeline to the Hubbard Hill FRS (note that this would also include a FCF to provide emergency treated water to Escondido from the First Aqueduct)

A new untreated-water pipeline would be constructed to replace the current 42-inch-diameter pipeline so it can be converted to treated-water use. The new untreated-water line could run from Crossover Pipeline No. 2 Pipeline to Dixon Lake and would be approximately 7,000 feet in length, if constructed next to the existing pipeline. Based upon the lake level and aqueduct gradient, a 54-inch-diameter line would provide a capacity of 70 cfs, which should be adequate to meet plant needs when operating in conjunction with other untreated-water supply lines.

Conversion of the 42-inch pipeline would require construction on the treatment plant site to connect the line to the outlet of the clearwell reservoir rather than to the flash mix structure on the plant influent. A pump station, constructed in two phases, would be required to lift the water to the aqueduct gradient at Hubbard Hill (the operational reservoir proposed in the discussion above).

The second phase would require a pipeline (and perhaps a pump station) to deliver to the Second Aqueduct. Three options are available for this delivery. One option would be a new pipeline. The third option would be to utilize the existing Crossover Pipeline after it is rehabilitated. The second option would be a pump station and pipeline running north along the First Aqueduct, north of the Oat Hills Tunnel.

The first option, a new pipeline, could be constructed to terminate at Vista ID's Pechstein Reservoir. This line would replace the Vista Flume with more capacity than the flume's current 18 mgd. The new pipeline could either be constructed within the existing flume right-of-way or in an entirely new alignment, most likely in city streets across San Marcos and Twin Oaks Valley to Pechstein. A potential new alignment has also been identified, resulting in a pipeline of approximately 42,000 feet.

The second option would be to construct a pump station on the First Aqueduct somewhere south of the Oat Hills Tunnel. The tunnel and the pipeline between the tunnel and the pump station would have to be modified to accept pressure flow. This would provide the capability of moving treated water north beyond the Oat Hills Tunnel to reach the larger capacity service connections to Valley Center (VC No. 5 and No. 6). This supply would function as a redundant supply if restrictions occurred on the First Aqueduct and Valley Center pipeline.

The third option is to use the existing Crossover Pipeline to deliver the treated water. This could only occur after Crossover Pipeline No. 2 is constructed (proposed for the year 2015) and the existing Crossover Pipeline is relined (scheduled for 2016 as part of the Aqueduct Protection Program). In this option, additional pumping would be required from Hubbard Hill (see **Figures 6-10 and 6-11**) to the Diversion Structure in Twin Oaks Valley, but connection to the treated-water pipelines of the Second Aqueduct would be easy and no new FCFs would be required. This option would allow

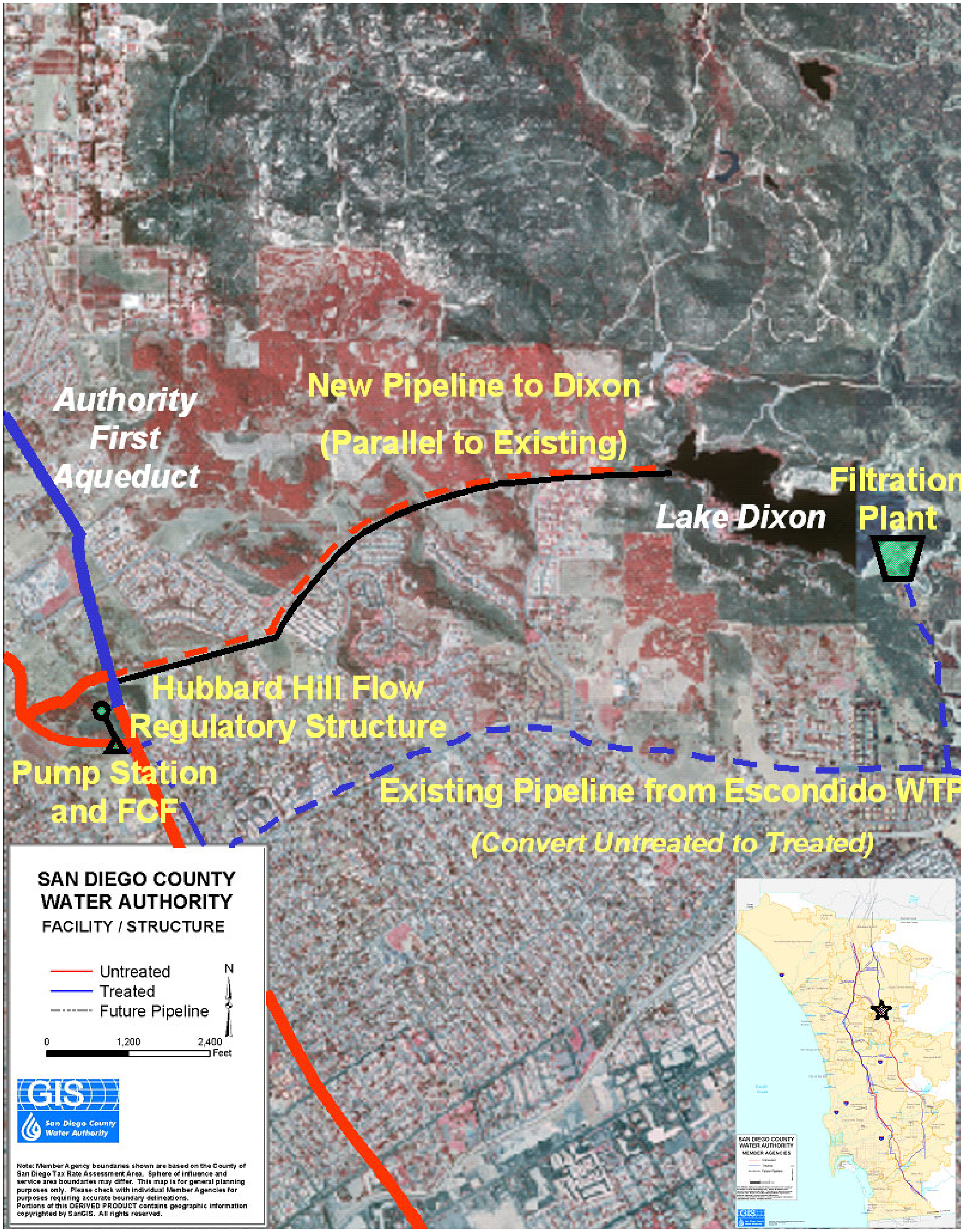

Figure 6-9. Treated Water from Escondido-Vista WTP (Phase 1)

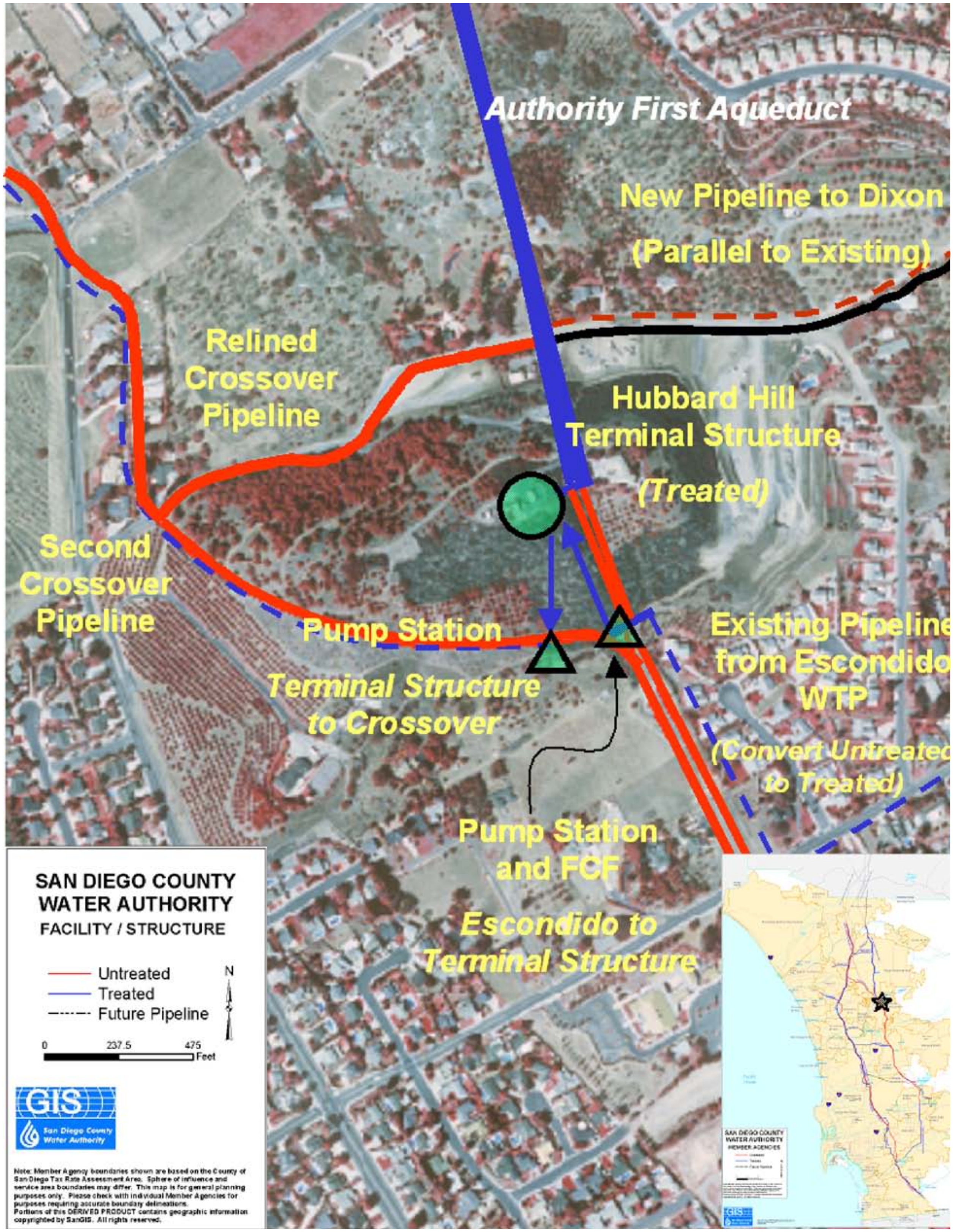

Figure 6-10. Treated Water from Escondido-Vista WTP (Phase 2, Option 3)

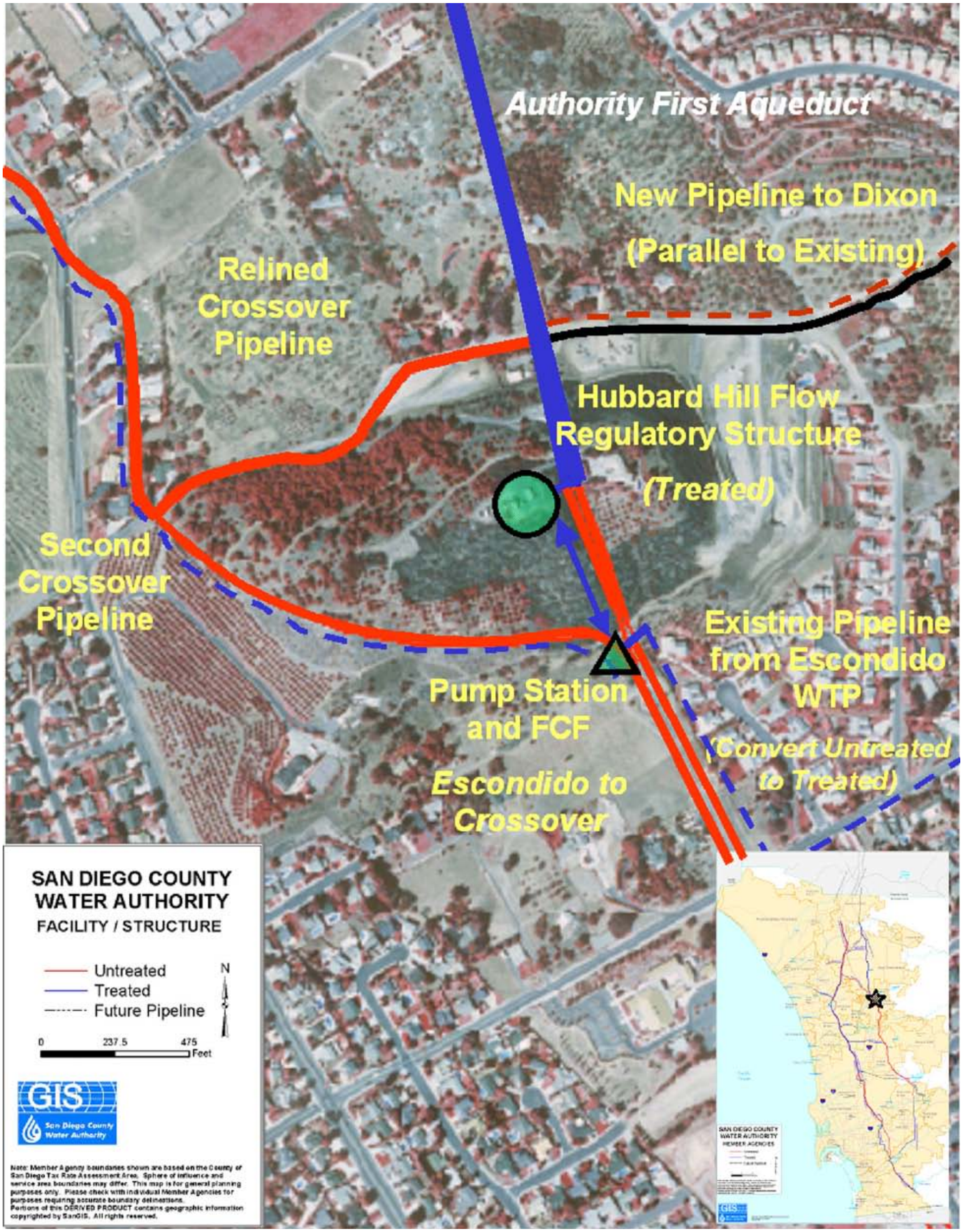

Figure 6-11. Treated Water from Escondido-Vista WTP (Phase 2, Option 3)

the most use of non-peak water from the treatment plant.

If the third option above is selected, the ultimate capacity of the pump station would be 70 cfs, requiring four 500-horsepower (hp) pumps, plus one standby, for a total of 2,500 hp. If the first option above is selected, the first phase would include only one operating pump and the standby unit, a gravity line to Vista ID's Pechstein Reservoir. The pump station's capacity would be reduced to that needed for Rincon only.

Treated Water from Oceanside's Weese WTP

The 25-mgd Weese WTP is a direct filtration facility that feeds Oceanside's distribution system directly and can feed the Authority's NCDP (for delivery to the City of Oceanside, Rainbow MWD, Vallecitos WD, and Vista ID). Oceanside is currently expanding its groundwater extraction and treatment facilities to increase peak production to 6.3 mgd. It may also derive some direct delivery of desalted seawater, if the Encina Desalination Project moves forward. Therefore, off-peak capacity and limited peak capacity may be available at Weese for supplementing Pipeline 4. The Weese plant can also be doubled in capacity (to 50 mgd) for additional supplemental delivery.

Facilities to take up to 25 mgd from Weese to supplement Pipeline 4 would consist of a short pipeline and a pump station (**Figure 6-12**). The new pump station could be constructed in the space now occupied by the 1-mg FRS, which may be replaced by a larger, 5-mg facility. Preliminary sizing for a 25-mgd pump station would require six 200-hp pumps, each rated at 5 mgd at a total dynamic head (TDH) of 145 feet. One pump would be a standby pump. A new discharge line from the pump station would be relatively short, approximately 1,000 feet, and would connect into Pipeline 4. Surge facilities may be required but no surge analysis has been performed for this arrangement.

Treated Water from Olivenhain WTP

Olivenhain MWD has constructed a microfiltration treatment facility at the Olivenhain dam site. The facility was originally to be constructed in phases. The initial phase is 25 mgd. Recent advances in membrane technology will allow the initial building to provide another 9 mgd without building modifications. A second building would increase the site's capacity by 44 mgd to a total of 78 mgd.

Treated water is carried in a 48-inch-diameter pipeline to Olivenhain MWD's distribution system. This pipeline crosses the Authority's aqueduct (**Figure 6-13**), and provisions have been made to allow a connection to the treated-water pipeline of the aqueduct. The aqueduct's hydraulic gradient is lower than the Olivenhain gradient at this point, so water could be delivered without pumping. Hydraulic analyses would have to be performed to determine the limitations of this delivery.

Treated Water from Miramar WTP

The Authority has a pump station at Miramar that pumps from the Miramar clearwell reservoirs into Scripps Ranch Pipeline (Pipeline 4B-1) (**Figure 6-14**). This station can pump as much as 120 cfs, but is more typically operated at a maximum of 80 to 85 cfs. The pump station was originally envisioned to allow the City of San Diego to provide the treated water taken at the Shepherd Canyon location south of Miramar (San Diego No. 11). In recent years, the pump station has also replaced water taken out of Pipeline 4 north of Miramar at Black Mountain (San Diego No. 10). At peak times, the City currently takes more water from the treated-water aqueduct than is replaced. This practice will be discontinued with the completion of the expansions at Miramar and Alvarado and related pipeline projects. At that time, the Authority and the City could agree to

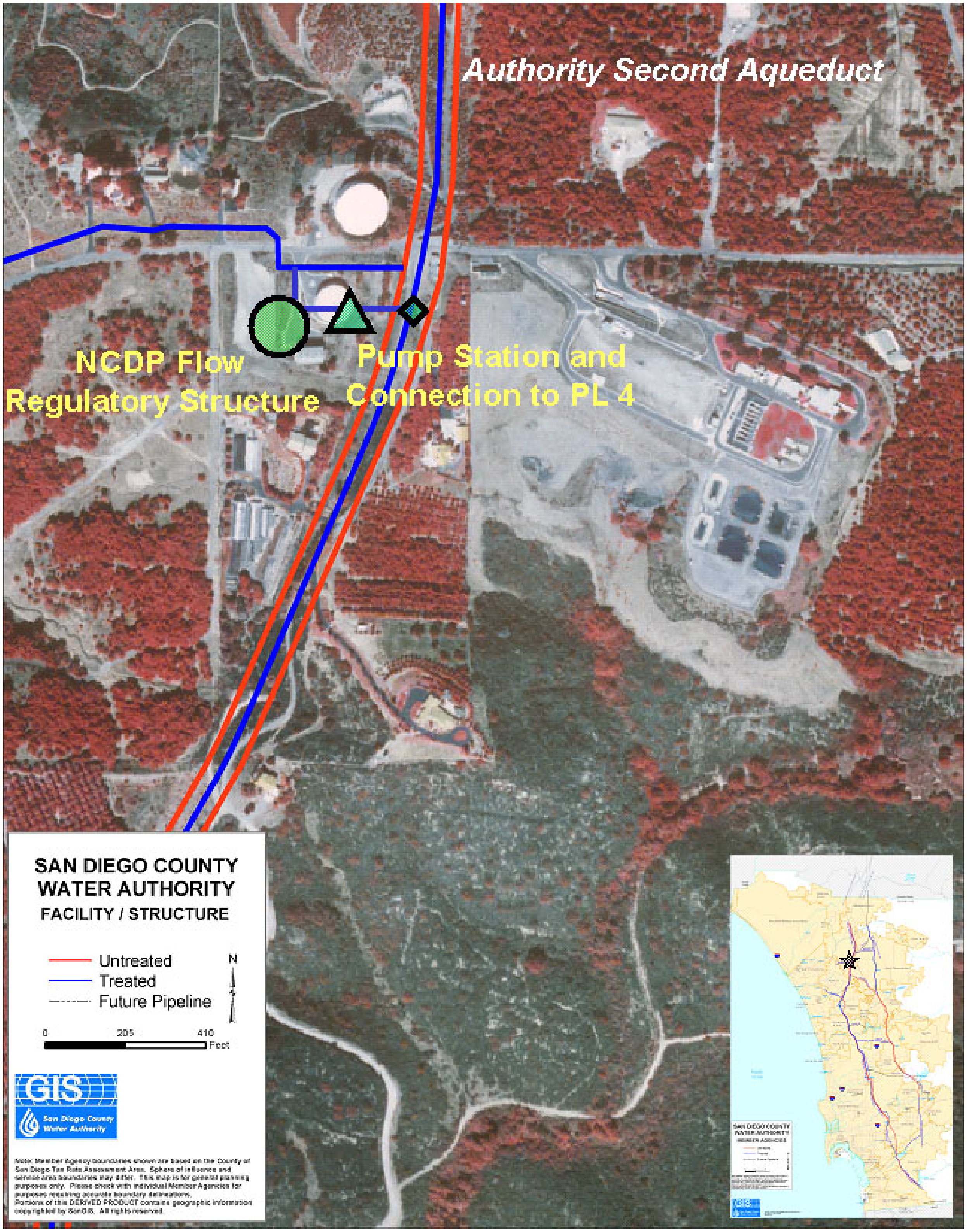

Figure 6-12. Treated Water from Weese WTP

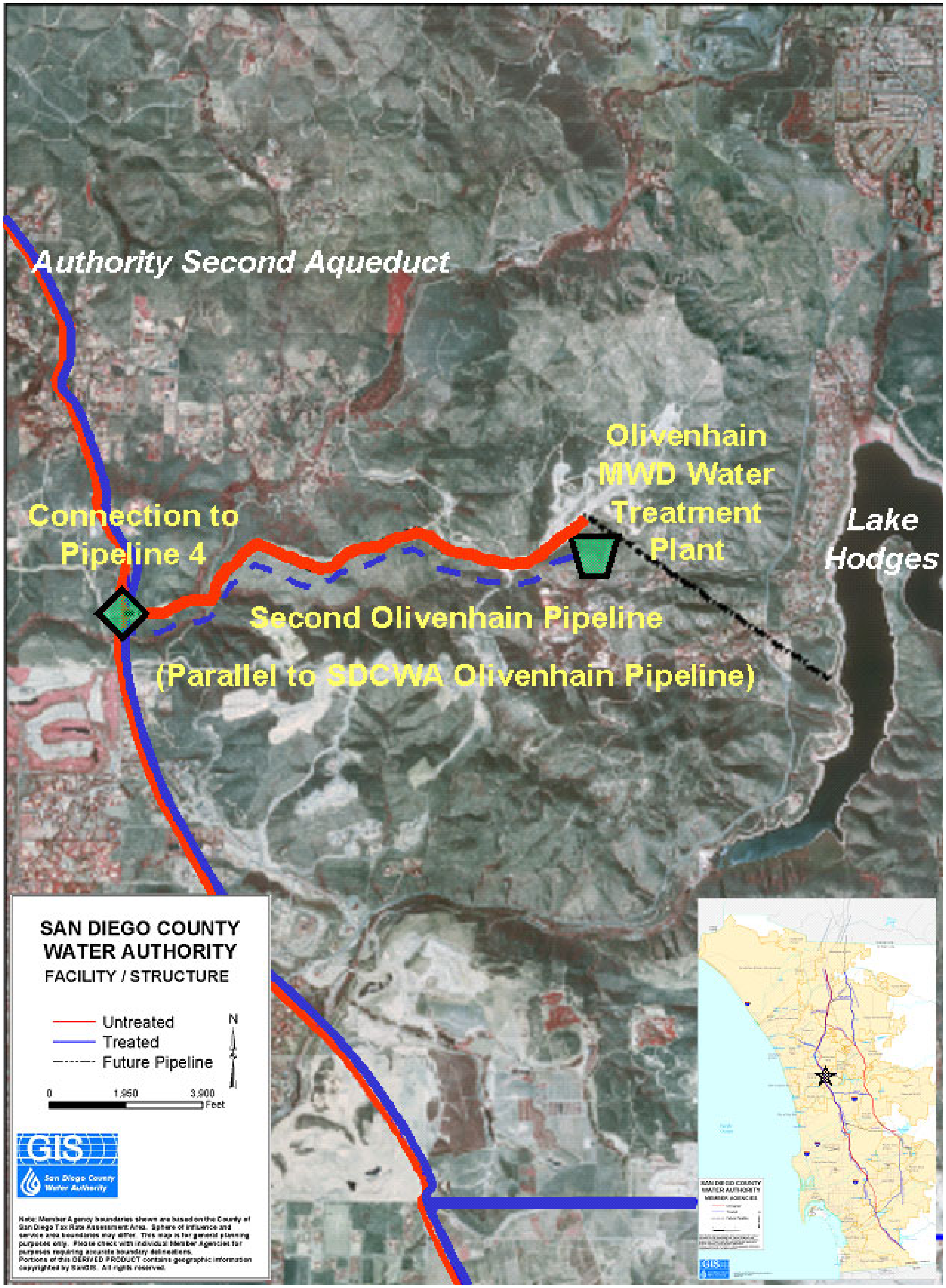

Figure 6-13. Treated Water from Olivenhain WTP

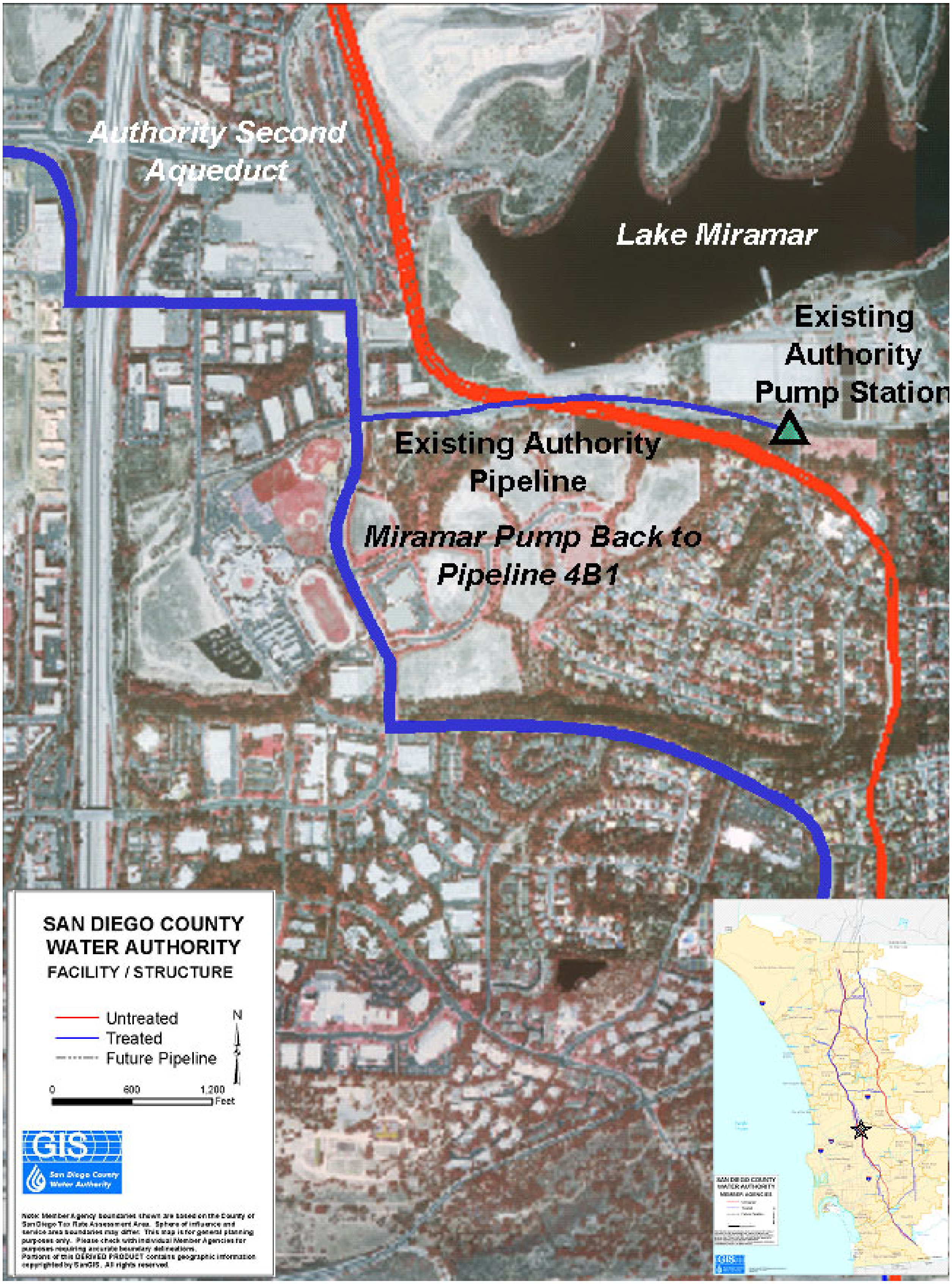

Figure 6-14. Treated Water from Miramar WTP

maintain the flexibility of operating the pump station in times when excess treatment capacity exists, which would provide benefits to both agencies. Treated-water users that could be supplied are limited to Padre Dam and Otay service areas. No additional facilities would be required.

Treated Water from Alvarado WTP

The City is designing a pump station to move as much as 93 cfs from Alvarado WTP to La Mesa–Lemon Grove Pipeline (Pipeline 4E-1) (**Figure 6-15**). This flow is then taken out through the City's Mid-City Pipeline (San Diego Nos. 18 and 21), located south of Interstate 8. The City paid for the La Mesa-Lemon Grove Pipeline to be oversized in this reach to provide this transmission capacity, thus avoiding construction of its own transmission pipeline in a highly congested area. In this reach, the pipeline is essentially a two-way flow pipeline, the hydraulics of which are controlled by the FRS located north of Alvarado in the Mission Trails Regional Park. Agencies taking treated water include the City of San Diego, Padre Dam, and Otay. Emergency connections to Helix and Sweetwater also exist.

With the pump station on line, the Authority and the City could agree to operate the pump station in excess of the City's needs. As noted above, the potential demand is limited to a few agencies. No additional facilities would be required.

Increase Delivery of Capacity from Levy WTP (Helix WD) to Padre Dam MWD and Otay WD

The expansion of Levy WTP to a capacity of 106 mgd was completed in early 2002. The Authority was a partner in the project to obtain 26 mgd of treated water capacity for use in supplying other agencies. This capacity is nominally slated for Padre Dam MWD (18 mgd) and Otay WD (8 mgd). Since Helix is not expected to utilize its full 80 mgd of the plant for some time, projects to increase peak and non-peak delivery capacity to Padre Dam MWD and Otay WD could be implemented.

Padre Dam has a connection (Padre No. 6) to the 54-inch-diameter Helix transmission pipeline near the treatment plant (see **Figure 6-16**). At low flows, water is delivered by gravity. As Padre's flow increases, pumping is required. A single-pump, in-line booster pump station is currently in place. The maximum delivery capacity of the pump is about 18 mgd. Increasing the delivery capacity to 28 mgd would involve meter modifications and a new pump station rated at the higher capacity.

No detailed study to expand this pump station has been performed. It has been assumed that a new site must be found, interconnecting piping constructed, and a new facility constructed with two or three pumps installed.

Otay WD currently takes delivery through the La Mesa–Sweetwater Extension (LMSE) pipeline into its regulatory reservoirs. There are two flow-control facilities that feed the LMSE, one from each of Helix's two transmission pipelines that deliver water from the Levy plant. Otay No. 8 is tied to the 54-inch pipeline in Lakeside. A second connection to the Helix Flume in El Cajon supplements the deliveries. Hydraulic constraints (of the LMSE pipeline and Otay's pipeline from LMSE to the reservoirs) have restricted deliveries to less than 8 mgd. With the completion of Helix's project to replace the flume (now in service) and construction of the new Otay No. 14 connection (scheduled for 2003), the capacity to deliver to Otay WD will increase to 12 mgd.

Capacity in excess of 12 mgd could be supplied if a new pipeline to serve Otay WD were constructed between the new Otay No. 14 FCF and the regulatory reservoir complex. An agreement between the Authority and Helix WD would be required that all water delivery to Otay WD be provided through the Flume pipeline (thus,

Figure 6-15. Treated Water from Alvarado WTP

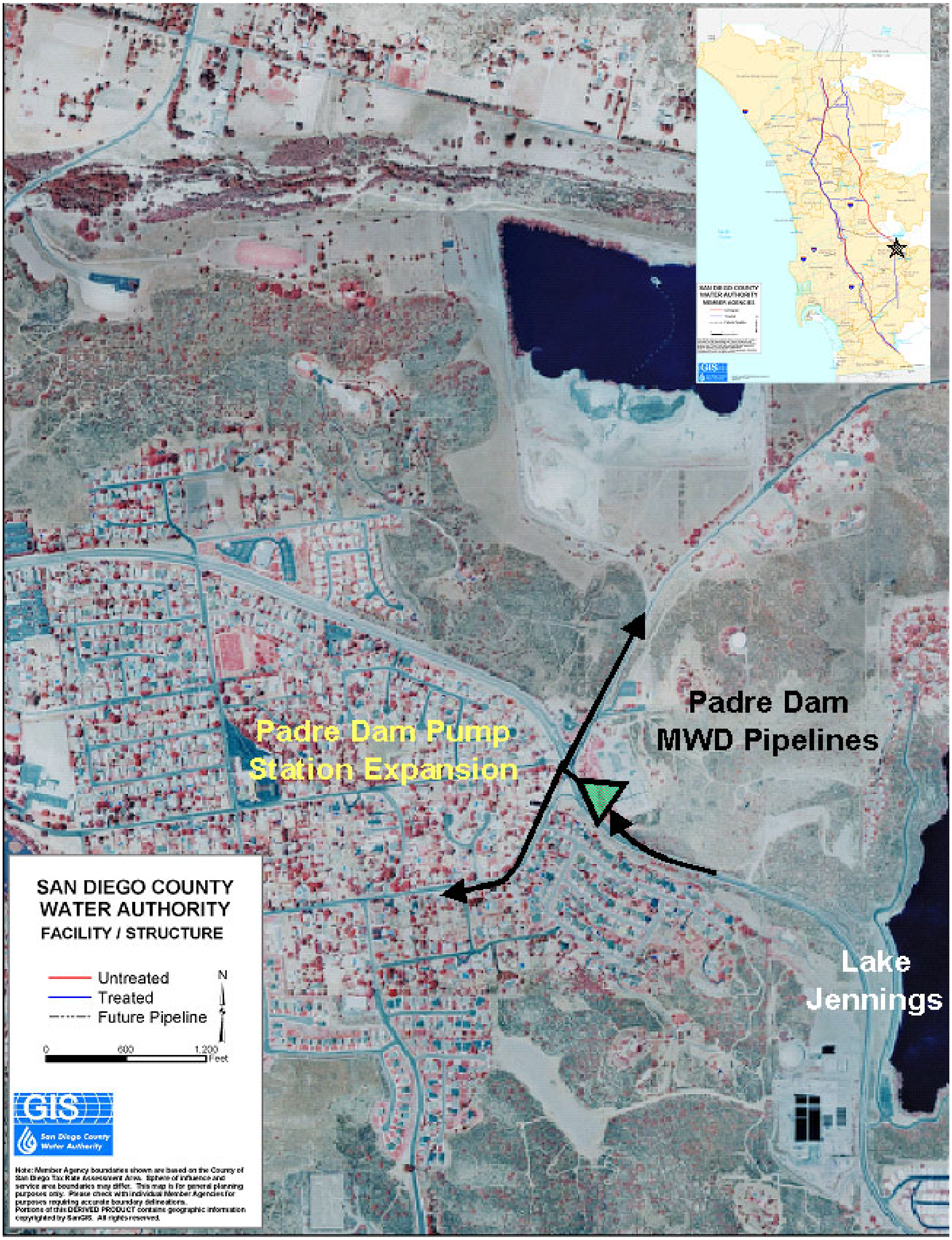

Figure 6-16. Padre Dam Pump Station Expansion

abandoning the No. 8 connection). The new pipeline would be approximately 28,000 feet long, if the LMSE alignment could be followed (**Figure 6-17**). A pipe diameter of at least 24 inches would be needed for a 12-mgd capacity. If future capacities greater than 12 mgd are necessary, then a pipeline diameter of 30 inches would be more appropriate.

With a new pipeline in place to serve treated water to Otay WD (from Levy WTP), the LMSE could revert to its old function of delivering untreated water. In that case, the LMSE could continue to provide untreated water to Helix, as well as delivering untreated water to Sweetwater Reservoir.

Treated Water from Sweetwater Authority

The Perdue WTP is a 30-mgd conventional treatment facility located at Sweetwater Reservoir in Spring Valley. The site has the capability for the plant to be expanded to 45 mgd. Sweetwater Authority's current *Master Plan* indicates that a plant expansion is not required to meet the needs of the service area. The district's demands do approach the full plant capacity at peak times. Provision of peak capacity to others would require an expansion.

Off-peak capacity could be pumped into the regional system (La Mesa–Lemon Grove Pipeline); however, the lift is fairly substantial as the aqueduct gradient is based on the 780-foot water level in the FRS, while Sweetwater Authority's clearwell reservoir has a high-water level of 270 feet. Delivery of 15 mgd of treated water into Pipeline 4 would require a 2,400-hp pump station, consisting of six 400-hp units (including one standby), each providing 3 mgd at a TDH of 575 feet (**Figure 6-18**).

Treated Water from Otay WTP

The City of San Diego owns and operates the 40-mgd treatment facility located at Lower Otay Reservoir. The Otay WTP is a conventional treatment facility. There is an ongoing project to add a clearwell reservoir, and other improvements. Proposed elevations for the new treated-water storage facility on the site are a high-water elevation of 515 feet and a floor elevation of 478 feet.

The plant treats both local and imported water. The Authority's treated-water pipeline, the Lower Otay Pipeline (Pipeline 4) terminates near the treatment plant. This pipeline, which normally flows from north to south, was designed to allow water to be pumped back from the south to the north as far as the FRS located in Mission Trails Regional Park.

Otay WD has an agreement with the City of San Diego that would provide up to 10 mgd from the plant to Otay WD and up to 20 mgd following an expansion of the treatment plant. Otay WD plans to build a forebay storage tank and a pump station to utilize this source. An alternative to the Otay WD project is a pump station that would take unused peak or non-peak capacity from the plant and pump it back into the Lower Otay Pipeline. Agencies with aqueduct connections include Padre Dam, Helix, Otay, and the City of San Diego. Provision of 15 mgd would require a 1,250-hp pump station, consisting of five 250-hp units (including one standby), each providing 3.75 mgd operating at a TDH of 280 feet based upon the new clearwell tank's water elevation of 485 feet **(Figure 6-19)**.

Red Mountain Reservoir

The Red Mountain Reservoir (Fallbrook PUD) is a 1,330-acre-foot storage facility located adjacent to the Second Aqueduct. The District uses it for storage of treated water. Treated water is delivered from a connection to the First Aqueduct. The reservoir serves Fallbrook PUD's 1140 Zone, which is connected to lower zones through pressure reducing stations.

There is a potential that a portion of the volume could be used to supplement Pipeline 4 deliveries during peak-demand

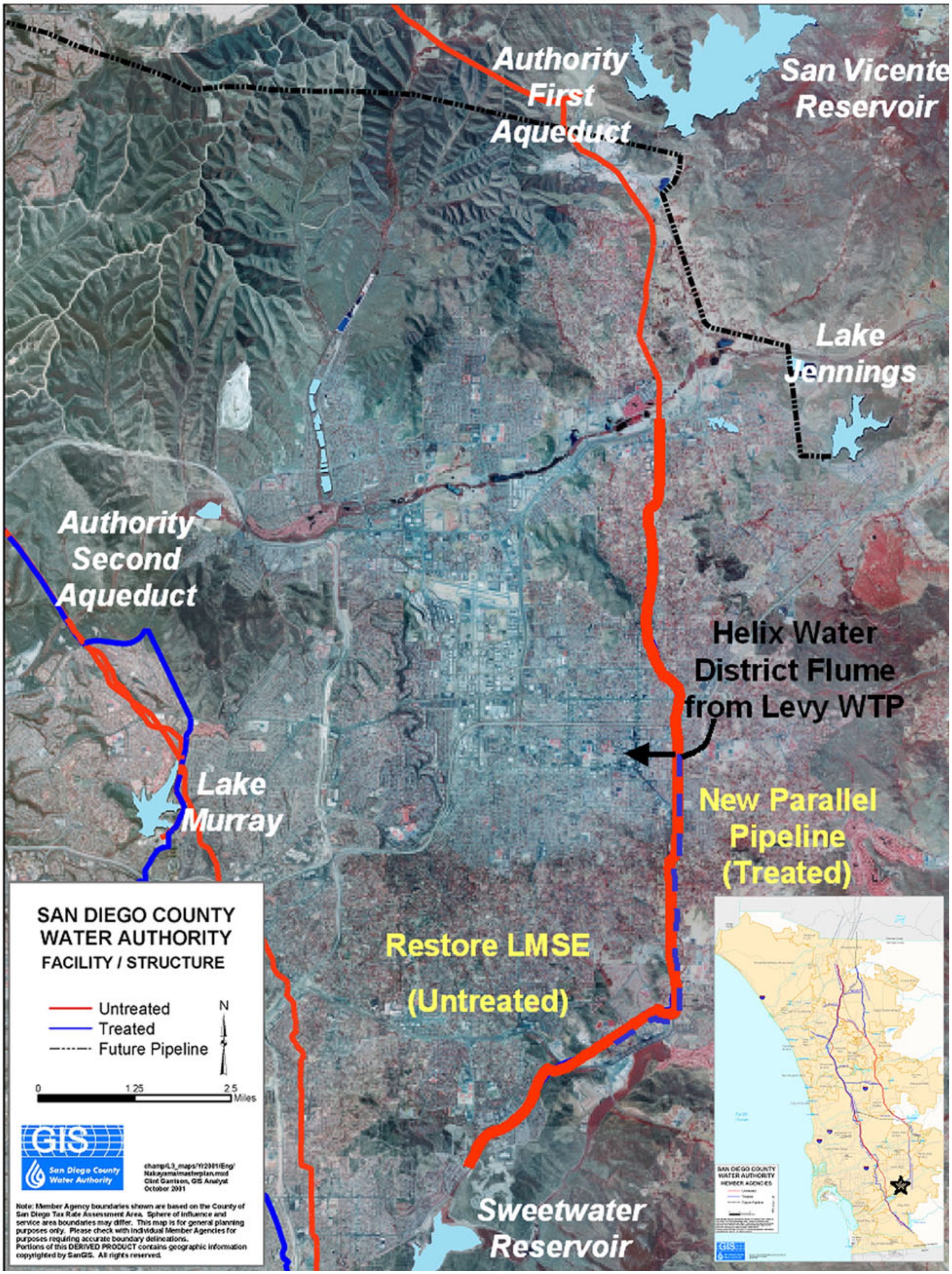

Figure 6-17. Parallel LMSE Pipeline – Helix to Otay

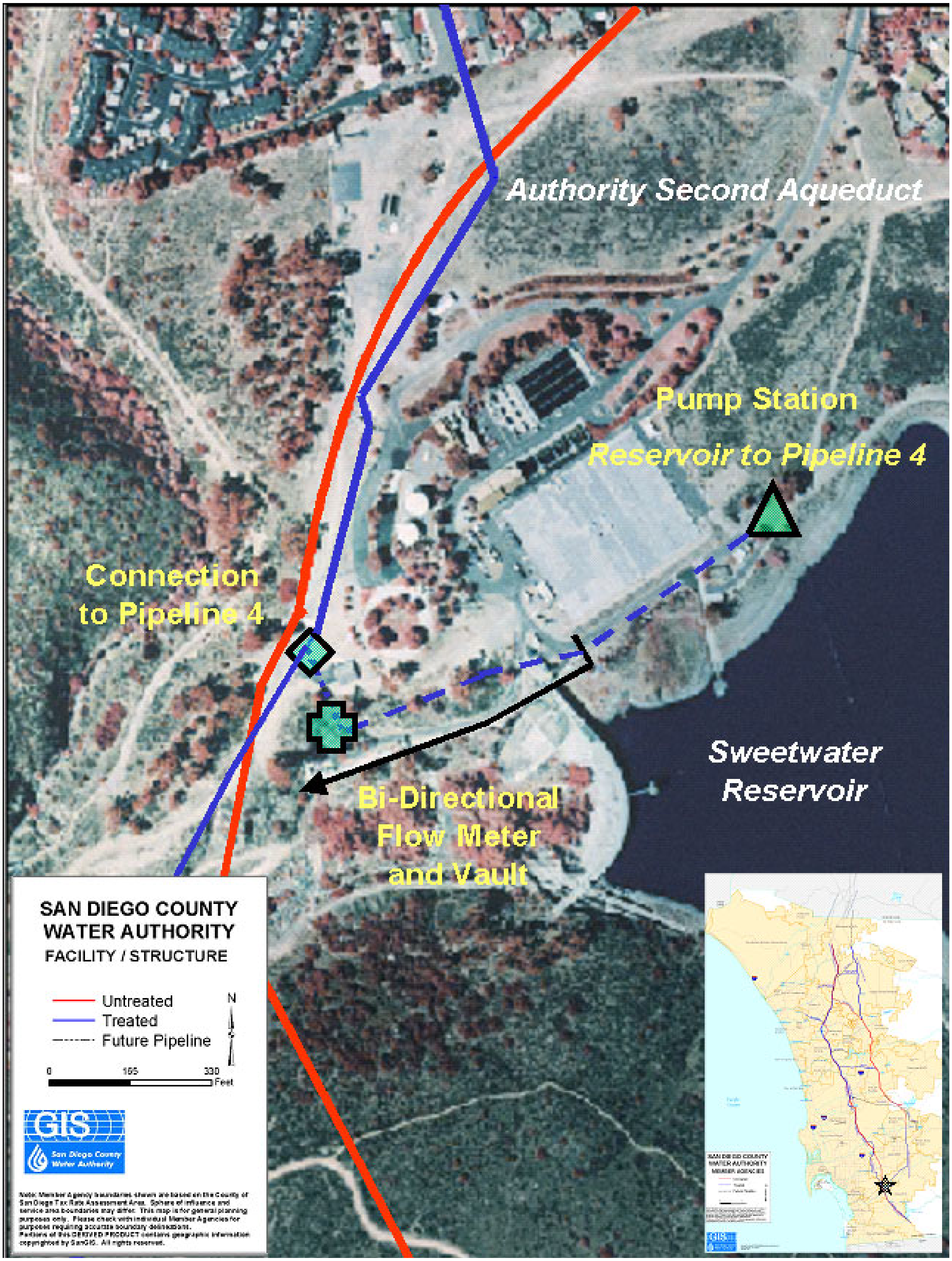

Figure 6-18. Treated Water from Perdue WTP

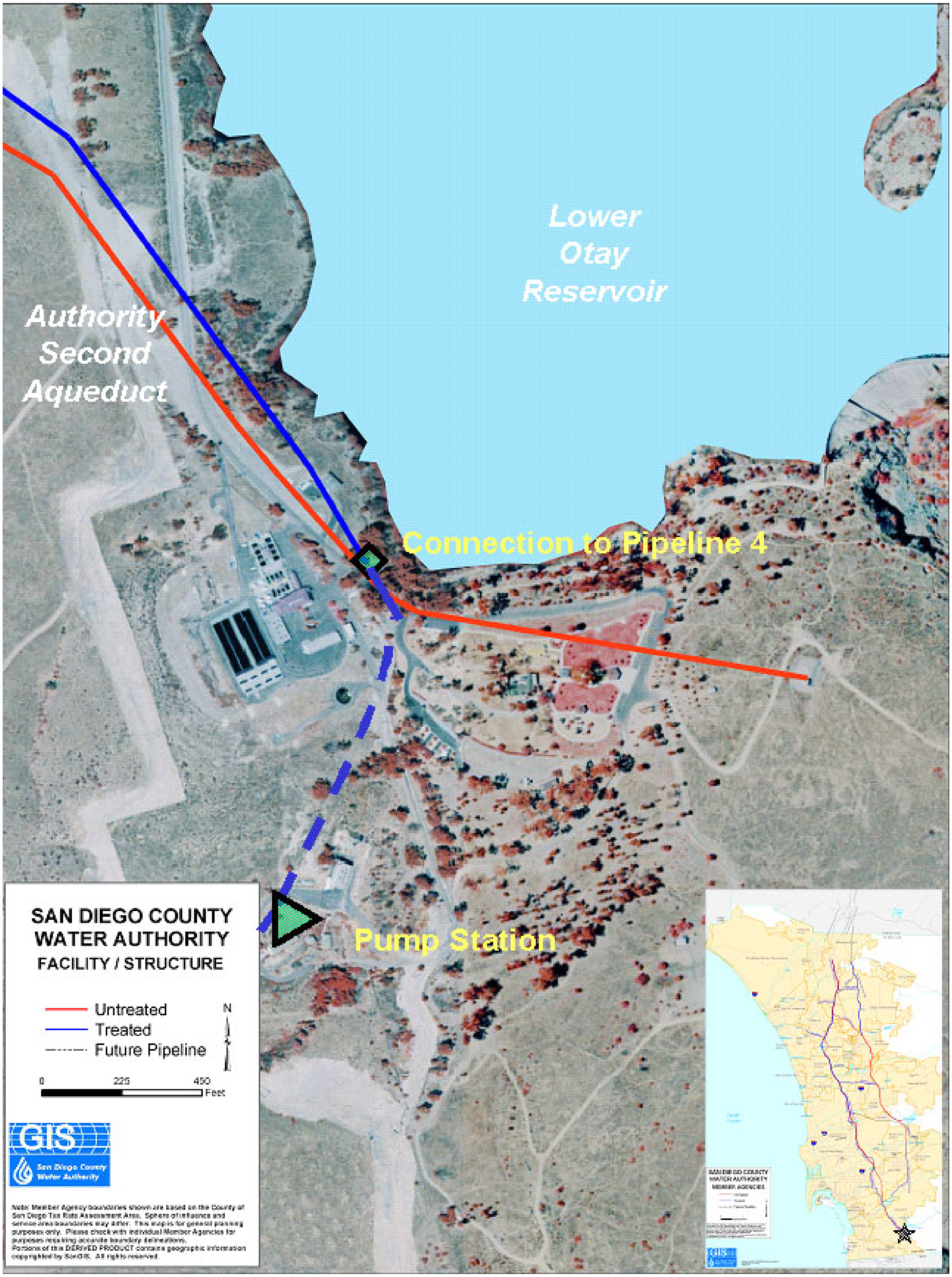

Figure 6-19. Treated Water from Otay WTP

events when the capacities of the filtration plants are at, or near, peak production capacity. The region could benefit if Fallbrook PUD met all of its demand from the reservoir (during a 5-day peak event for example) and therefore reduce the demand on the Skinner Filtration Plant.

Simultaneously, the Authority could pump an additional amount back into Pipeline 4 further reducing the demand on Skinner. For the sake of this analysis it is assumed that one-third of the volume is allocated to each of the following:

- supply to Fallbrook PUD during the 5-day peak
- supply to the Authority during the 5-day peak
- remainder for subsequent use by Fallbrook PUD

The one-third allocated to the Authority, and thus pumped into Pipeline 4, would result in an average delivery over the 5-day period of about 30 mgd.

An engineering study of the specific needs to modify the facility to pump back into Pipeline 4 has not been conducted. A cursory review has indicated that the modifications may consist of a new liner and floating cover, new reservoir supply piping, a larger outlet pipeline and pump station to boost into Pipeline 4, and chemical addition facilities.

Projects to Expand Treatment Capacity

Total treated water production in the region will need to increase about 30 to 50 percent by 2030 depending on whether constrained or unconstrained demands are analyzed. Some of this growth in demand should be offset by increased recycled water and groundwater production, but it is reasonable to expect that the total treatment capacity needed will increase proportionately to demand. The current treatment capacity of member agencies is approximately 550 mgd. With the addition of 420 mgd of Skinner's 520 mgd total capacity, there is about 970 mgd of capacity meeting the region's needs.

The treatment capacities above are instantaneous rated capacities; however, for a variety of reasons (e.g. filter backwashing), the maximum daily production rates may be less. The maximum daily production of the Skinner WTP, per Metropolitan, is 494 mgd.

All of this capacity is not fully utilized. If we adjust the total for recent peak production rates, then the total would be reduced by about 50 mgd for a net usage of 920 mgd. If the current net usage needs to be increased by 36 percent, then an additional 330 mgd is needed to meet the region's needs. Some of this capacity increase is already under way (as shown in **Table 6-6**).

Thus, at least an additional 80 mgd of new capacity or utilization of unused capacity appears to be needed. The options for additional treatment capacity are listed below and discussed in the text that follows.

Plant Expansions

- Expansion of Skinner
- Expansion of Weese

Table 6-6. Treatment Plant Expansion Projects in Progress in 2002 – Authority Service Area

Agency	Treatment Facility	Incremental Capacity (mgd)
San Diego	Alvarado	80
San Diego	Miramar	70
Total		150

- Expansion of Olivenhain
- Expansion of Levy
- Expansion of Perdue
- Expansion of Otay
- Expansion of Berglund

New Plants

- North City
- Crossover
- Desalting plant(s)
- Loveland
- Lake Ramona

Expansion of Skinner WTP

Metropolitan is designing an expansion of its Skinner WTP from 520 mgd to 640 mgd (or 990 cfs), with a maximum daily production rate of 608 mgd (941 cfs). This expansion must be compatible with the construction of Pipeline 6 and the conversion of Pipeline 3 to deliver treated water (along with Pipelines 1, 2, and 4). These four pipelines have a combined design capacity of 895 cfs, but are expected to operate at 940 cfs or higher. The Skinner service area includes the Authority and portions of Eastern MWD and Western MWD. Peak demands by others have exceeded 100 mgd and are expected to increase with time, so that the peak capacity delivered to the Authority will likely be less than 520 mgd.

Expansion of Weese WTP

As discussed above in "Projects to Supplement Treated-Water Aqueducts," Oceanside's Weese WTP serves the City of Oceanside, and can also supply the Authority's NCDP, which delivers to Oceanside, Vista, and Carlsbad. The plant (previously shown on **Figure 6-12**) has operated at 25 mgd with Department of Health Services approval. The plant is a direct filtration facility with unit processes of rapid mix, flocculation, filtration, and disinfection.

The site was developed to allow expansion; the City of Oceanside envisioned that two expansions could occur to triple the overall capacity. For the purposes of this master planning effort, it is assumed that expansion would be limited to a total capacity of 50 mgd. The Authority would take up to 25 mgd, using a pump station to deliver supplemental water into Pipeline 4.

Expansion of Olivenhain WTP

As discussed above in "Projects to Supplement Treated-Water Aqueducts," Olivenhain MWD has constructed a 36-mgd microfiltration plant that was put into service in 2002. The plant (shown previously on **Figure 6-13**) is located adjacent to Olivenhain Dam. The treated-water pipeline from the plant crosses the aqueduct, and the Authority will provide the capability to deliver treated water into Pipeline 4. The site can accommodate a second module that would more than double the initial capacity. Although a second transmission pipeline would also be required, delivery into the aqueduct would not require pumping.

Expansion of Levy WTP

Helix WD completed the upgrade and expansion of the Levy WTP to a capacity of 106 mgd in 2002. The Authority has capacity rights to 26 mgd and is planning to deliver 18 mgd to Padre Dam MWD and 8 mgd to Otay WD. The facility can be further expanded to 120 mgd. An expanded plant would require additional transmission capacity away from the plant. It would also be necessary to further expand, or provide additional, facilities to deliver to Padre Dam and/or Otay.

Expansion of Perdue WTP

Sweetwater Authority's Perdue WTP is a conventional facility with a capacity of 30 mgd. The plant could be expanded to 45 mgd with the addition of a flocculation/ sedimentation basin and two additional filters. Sweetwater Authority is also contemplating other plant upgrades to meet changing regulations, as well as replacement of the clearwell reservoir.

Treated water from the plant could be pumped back into Pipeline 4. Potential users include Otay, Padre Dam, Helix, and the City of San Diego.

Expansion of Otay WTP

The City of San Diego's Otay WTP is located at Lower Otay Reservoir. The 40-mgd plant can be expanded to 60 mgd. Otay WD and the City of San Diego have an agreement in place that would provide up to 10 mgd to Otay WD (and up to 20 mgd following the plant expansion). Otay intends to build a pump station and pipeline to use this capacity. Otay WD's current plan is to use this source for emergencies only and not on a routine basis.

If the City of San Diego and Otay WD decide not to implement their agreement, the Authority could consider a project to pump from the treatment plant into Pipeline 4. The Authority option would require a larger horsepower pump station since it would be pumping to the aqueduct hydraulic grade line. The potential customers would be Padre Dam, Sweetwater Authority, Helix, and Otay. Water now taken from Pipeline 4 at the Paradise Mesa Cross-Tie could be supplied from the Otay plant, rather than from the north.

Expansion of Berglund WTP

The City of Poway owns and operates the 24-mgd Berglund WTP. The plant has been operating successfully at 26-mgd, and the City of Poway staff have determined that this capacity is adequate to meet the City's projected needs. There is room at the site to expand the facility by one-third, up to 36 to 40 mgd. Past studies indicated that a third flocculation/sedimentation basin, four filters, upgrades to the influent pump station, and upgrades to supporting systems would be required.

Treated water would have to be delivered to the Ramona Pipeline to be of regional benefit. Ramona MWD, Olivenhain MWD, and the City of San Diego take treated-water service from the Ramona Pipeline. The operating HGL of the Ramona Pipeline is very close to the water elevation in the clearwell at the treatment plant. Service would require pumping, but the lift would be nominal. Preliminary analysis determined that 12 mgd would require a 200-hp pump station, consisting of four 50-hp units (including one standby) with a TDH of 50 feet.

New North City WTP

The City of San Diego has prepared preliminary studies for a new 60-mgd water treatment plant in the North City area. An initial siting study prepared for the North City WTP recommended a site for a 60-mgd conventional treatment facility. The recommended site is located near the intersection of Black Mountain Road and the future Carmel Valley Road. The site includes a proposed 25-mg clearwell reservoir storage was constructed in 2002.

The source of untreated water supply to the North City WTP would be a connection to the Authority's Second Aqueduct, in the vicinity of the Black Mountain Turnout.

The preliminary studies proposed a 60-mgd conventional treatment plant, consisting of rapid mix, flocculation, sedimentation, dual-media filtration, and disinfection.

A pump station is required if the capacity is to be used regionally. The pump station would be located at the nearby reservoir to pump the entire 60 mgd into Pipeline 4 at an operating HGL of 880 feet.

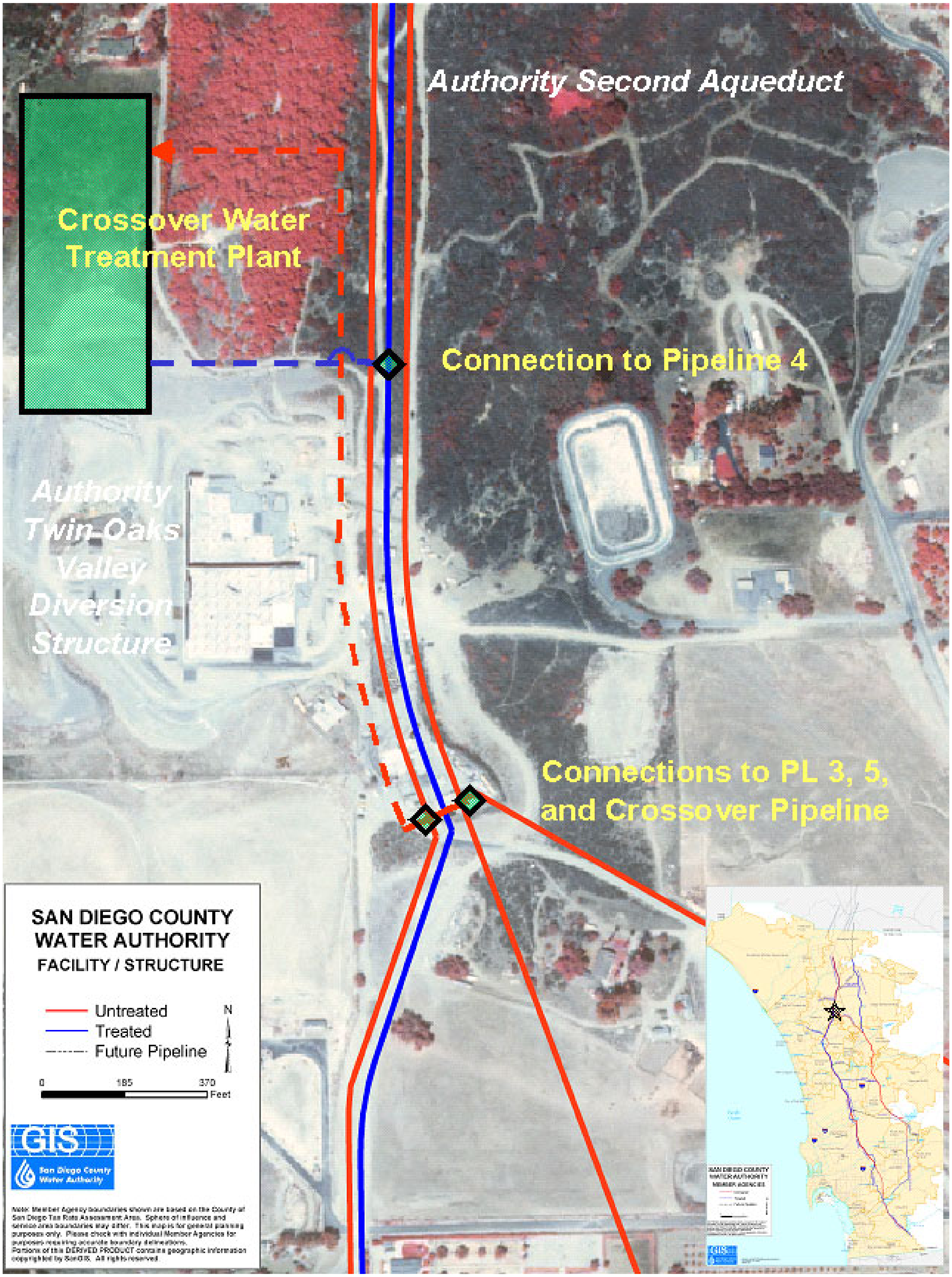

Figure 6-20. Crossover WTP

New Crossover WTP

A new treatment plant could be located in Twin Oaks Valley near the Authority's Diversion Structure **(Figure 6-20)**. This area does not have a large reservoir site, but is ideally located with respect to the Authority's aqueduct pipelines. Pipelines 3, 4, and 5, and the future Pipeline 6, all meet at this location. If constructed, the WTP could draw from pipelines directly and refill Pipeline 4 for delivery of treated water to the south.

A preliminary site plan was developed for a 60-mgd treatment plant facility as part of the *1998 Treated Water Study*. While this capacity appears to push the site to its limit, this capacity was selected to provide a comparison to the North City WTP discussed above. The layout was based upon using conventional treatment processes, which could be built to 40 mgd initially and then expanded to 60 mgd.

Note that there could be additional costs associated with this location since a significant amount of grading is required to provide a constructible pad for the treatment plant and clearwell. A microfiltration plant is a likely alternative to a conventional plant at this location.

There is adequate room for the pump station, adjacent to the Second Aqueduct just north of the Crossover. The pump station would be sized to pump 60 mgd into Pipeline 4, which has an operating HGL of 1,150 feet elevation from the clearwell's operating level of approximately 1,040 feet elevation. The pump station would be a 2,100-hp station, consisting of seven 300-hp units (including one standby). Each unit is rated at 7,000 gallons per minute (gpm) (10 mgd), operating at a 130-foot TDH. The pipeline from the plant to Pipeline 4 has a 54-inch diameter for the 60-mgd capacity.

New Desalting Plants

See the discussion below for "Seawater Desalting" in "New Conveyance and Supply."

New Loveland Reservoir WTP

A new treatment facility in the vicinity of Loveland Reservoir, serving Padre Dam's eastern service area, would provide benefits to Padre Dam MWD and Sweetwater Authority. This project would also require an agreement for storage capacity in Loveland Reservoir. Benefits of the project would be the reliability provided by diversification of resources and the potential savings achieved by not pumping water to the Alpine area from the wholesale system.

The downside is that the natural runoff into Loveland is highly variable. Without facilities to allow imported water to be delivered to the reservoir (see later discussion), a treatment facility would have to be sized small enough so that the reservoir could be operated on a "safe yield" basis.

For discussion purposes, we have assumed that an annual yield that could be made available by contract between the agencies is about 3,000 ac-ft/yr. Allowing for some peaking, a 4-mgd treatment plant capacity would be appropriate. The 3,000 ac-ft is about 30 percent of the eastern service area's annual demand in the year 2020 and about 55 percent of the current annual demand. Thus, a plant could operate at a relatively high efficiency throughout the winter months, as well as the summer months.

Facilities needed would include:

- A new intake structure at Loveland Reservoir, with a low-lift pump station to the treatment plant. The preliminary size of this pump station is 125-hp, with a flow of 4 mgd and a total dynamic lift of 125 feet.
- The treatment plant is assumed to

be a micro- or ultrafiltration (MF/UF) treatment facility.

- A high-lift pump station to deliver water from the treatment plant to the existing Alpine Heights Tank (at 2,055 feet elevation MSL). The preliminary size of this pump station is 600 hp, with a flow of 4 mgd and a total dynamic lift of 610 feet.
- A pipeline from the treatment plant to Alpine Heights Tank, estimated as 23,500 lineal feet of 18-inch-diameter, mortar-lined and taped, coated steel pipe.

An alternative to constructing a "safe-yield" treatment plant would be to construct facilities to move imported water into Loveland. Such a facility could be constructed between El Capitan and Loveland (see section on New Conveyance and Supply). Facilities for this alternative would include:

- Approximately 40,000 feet of 36-inch-diameter pipeline, the majority of which would need to be installed in a tunnel
- A 3,500-hp pump station at the base of El Capitan Dam, with a flow of 20 mgd (38 cfs) and a total dynamic lift of 800 feet

Other possible alternatives exist, including converting to untreated water use a portion of the existing pipeline that delivers treated water to the existing service area (which would make this area entirely dependent on the new WTP). Another possibility would be to construct a pipeline from Loveland to Sweetwater, plus a pump station to pump to Loveland (see the discussion below in "Pipeline/Tunnel – Loveland to Sweetwater").

Lake Ramona WTP

Ramona MWD has previously considered construction of a treatment facility in the western portion of the District, as an alternative to, or possibly operating in parallel with, the treated-water pump station and pipelines that deliver treated water to the Mount Woodson Reservoir from the Poway area (Ramona Pipeline). A treatment plant would draw water from Ramona Lake and would operate in parallel with the District's Bargar WTP, which treats water from Sutherland Lake. Capacities ranging from 10 to 25 mgd have been considered for the Lake Ramona WTP.

There are currently no definitive plans to proceed with a water treatment facility. Authority planning will continue to assume that Ramona's treated-water demand will be met from the Ramona Pipeline.

Projects to Increase Local Yield

A number of local projects may be expected to increase the annual yield of local surface supplies by eliminating or reducing the amount of spill from dams, infiltration during transfer, and evaporation. These potential water savings are qualitative in nature and were not estimated as part of the *Master Plan* effort.

Pipeline/Tunnel – Loveland to Sweetwater

In the early 1980s, Sweetwater Authority had a study prepared to assess the potential of constructing a pipeline between Loveland and Sweetwater Reservoirs. The intent of the study was to determine if the increase in yield would justify the expense of the facility. The criteria used at that time, basically a pipeline to deliver at a rate of 30 mgd (the treatment plant capacity), resulted in a 30-inch-diameter pipeline, with a length of approximately 75,000 feet following the Sweetwater River. The net increase in yield ranged from 300 to 2,300 ac-ft/yr. Most of the net increase in yield was due to the elimination of losses due to infiltration and evaporation during transfer when using the river for conveyance. Environmental constraints today would likely either increase the pipeline's length and/or require tunneling in certain portions to avoid sensitive areas. Sweetwater Authority scheduling of water transfers from Loveland has been impacted by environmental concerns.

A pipeline project would provide benefits to Sweetwater Authority of increased annual yield, more flexible operation to transfer water from Loveland to Sweetwater, and the potential to deliver the higher quality Loveland water directly to Perdue WTP.

If the Regional Colorado River Conveyance Facility (RCRCF) becomes a reality and an alignment just west of Loveland Reservoir is selected, the pipeline from Loveland to Sweetwater could provide most of the imported water for Sweetwater. This would necessitate a connection be provided from the conveyance facility to either Loveland and/or the pipeline. This additional delivery source would supplement the untreated-water pipelines of the Second Aqueduct. Delivery of water from the RCRCF would result in additional treatment at Perdue to reduce total dissolved solids (TDS) levels.

Pipeline/Tunnel – El Capitan to San Vicente

The outlet pipeline from El Capitan Reservoir is the 48-inch-diameter El Capitan Pipeline that connects to the two 42-inch outlet lines from San Vicente in Lakeside for delivery to Alvarado WTP through the El Monte Pipeline. This untreated- water delivery system has been adequate until the present time, since it has only been used to meet demands of the Alvarado WTP. With the pending completion of the San Vicente Pipeline and Pump Station as part of the Authority's Emergency Storage Project, the potential exists to more fully utilize the storage volume available in El Capitan. The restriction is the pipeline capacity to move water into and out of the reservoir. More capacity out of El Capitan could result in an increase in annual yield. Two options are apparent. One would be to inter-tie San Vicente and El Capitan with a conveyance that is primarily a tunnel. The second option would be to parallel the existing 48-inch-diameter outlet pipeline with another pipeline to the point of connection with the 68-inch-diameter El Monte Pipeline.

Option 1 would enhance the ability to store imported water in El Capitan since water could be moved in and out at a higher rate of flow and be delivered to both Miramar and Alvarado WTPs for treatment. The higher capacity could also be used to increase yield in wet years.

Option 2 could also increase yield as the capacity to deliver El Capitan water to Alvarado WTP would increase. This increase would work in conjunction with the ESP facilities that can divert San Vicente water to Miramar WTP in lieu of Alvarado.

The City of San Diego has had a draft *Raw Water Master Plan* prepared by Metcalf and Eddy (January 2002), which proposes projects to increase untreated-water delivery capacity to Alvarado WTP from both San Vicente and El Capitan Reservoirs. The Lakeside Pump Station would be replaced with a larger facility, and new pipelines are proposed to parallel the existing pipelines from:

- El Capitan to Lakeside Pump Station (El Capitan Pipeline)
- Lakeside Pump Station to Alvarado WTP (El Monte Pipeline)

The goal of the proposed improvements is to meet the full capacity of the Alvarado WTP (200 mgd) in 2005 from these locations. The existing El Capitan Pipeline (48-inch diameter) would be paralleled with a 54-inch diameter pipeline. The existing El Monte Pipeline (68-inch diameter) would be paralleled with a 72-inch diameter pipeline. Finally, a new pump station would replace the existing one. Preliminary planning would include two sets of three pumps to meet the wide variation in hydraulic conditions anticipated.

Additional Seasonal/ Carryover Storage

In 1992, the Authority published the results of a regional storage study. The final report, *Summary Report: Storage Study* (July 1992) presents the analysis and ranking of potential storage sites within the San Diego region. This study was a precursor to the ESP.

The sites included in the storage study were selected to meet certain criteria:

- A volume of 25,000 ac-ft or more
- A high-water elevation between 1,000 and 2,000 feet MSL
- A location within the boundaries of the Authority

From an extensive list of new and expanded surface reservoirs and groundwater storage sites, a total of 14 storage projects emerged from an initial screening for comparison. Four of the projects were groundwater basins, two were enlargements of existing facilities, and the remaining eight were new reservoirs. **Table 6-7** summarizes the storage options that were identified and progressed through the initial screening. The table lists enlarged and new surface storage facilities, large enough to provide emergency or carryover capacity to meet supply needs. Groundwater basins are not included in the table.

The Emergency Storage Project subsequently expanded upon the storage study and through a comprehensive effort developed a project report based on four alternatives:

- San Vicente Expansion Stand-Alone
- San Vicente Expansion and Re-Operation
- Olivenhain/Hodges/San Vicente
- Moosa/Hodges

These four alternatives were carried through the environmental and public review process, and the Olivenhain/ Hodges/San Vicente project was selected. Detailed planning, design and construction have been initiated on the individual projects that will bring the ESP to completion.

The need for, and benefit of, carryover storage will be discussed in subsequent chapters of this report. It is anticipated that carryover storage volume needs would have to be relatively large to be effective. Any of the sites identified in the *Storage Study* could be considered. Two stand out because they could provide as much as 100,000 ac-ft and are in close proximity to the existing, or planned, aqueduct system: Moosa Canyon Reservoir and an additional San Vicente Raise.

Table 6-7. Potential Storage Facility Projects (Additional Seasonal/Carryover Storage)

Gopher Canyon
Moosa
Pamo
San Vicente raise (above the level planned as part of the ESP)
Loveland raise
Lake Ramona – agreement with Ramona to use a portion, or all, of the facility
Vail Lake

Moosa Canyon Reservoir

Moosa Canyon is located approximately 3.5 miles northwest of the city of Valley Center. Moosa Canyon Reservoir was ranked as one of the top five storage options in the Authority's *Storage Study*. Two different concepts were presented: one would have a reservoir capacity of 148,000 ac-ft and the other would have 72,000 ac-ft. The Moosa Canyon site was subsequently considered as part of the Authority's ESP. One of the final four alternatives was the Moosa/Hodges alternative that consisted of re-operating Hodges Reservoir to provide 22,000 ac-ft of emergency storage in conjunction with 68,000 ac-ft of new storage at the Moosa Canyon site. The ESP ultimately selected the Hodges/ Olivenhain/San Vicente alternative and is in the process of design and construction of the facilities to fully implement the project.

Two Moosa Canyon sites (North and South) were also evaluated in a technical memorandum for Phase I of the ESP, *Conceptual Design of Dam Alternatives* (GEI Consultants, 1994). The North Site would accommodate a storage capacity of 100,000 ac-ft (or more), with the characteristics shown in **Table 6-8**.

New drain/fill pipelines, pump stations, and interconnection facilities may be necessary for the new Moosa Reservoir. Details on these components originally designed for ESP storage can be found in the *ESP Phase II Report*, Volume III, System 10A (GEI Consultants, Inc., 1996). It should be noted that the ESP assumed a connection from Moosa Reservoir to the proposed alignment of Pipeline 6 along the Authority's First Aqueduct.

The Moosa site offers the advantages of being in North County with close proximity to existing and planned aqueduct pipelines. This location means that water drafted from storage could be delivered to almost every member agency. It could provide direct backup storage to both the Weese WTP and the potential Crossover WTP.

Table 6-8. New Moosa Canyon Reservoir

Storage volume (ac-ft)	100,000
Spillway elevation (ft MSL)	1,247
Dam crest, including freeboard (ft MSL)	1,771
Dam structural height (ft)	480

MSL – mean sea level

Expansion of Existing San Vicente Reservoir

San Vicente Dam and Reservoir (San Vicente) are currently owned and operated by the City of San Diego. With the San Vicente Dam Raise, slated for completion in 2010, the Authority will raise the dam by 54 feet and own 52,100 ac-ft capacity in San Vicente. As a condition of the San Vicente Agreement, the Authority also retains the right to be the first agency to raise the dam by an additional amount. Additional information on the original dam's construction can be found within the final construction report, *San Vicente Dam, Final Report on its Construction* (Williams, 1943), and details on the Authority's CIP Project for the San Vicente Dam Raise can be found in the *ESP Phase II Report*, Volume V, Appendix E, System 25 (GEI Consultants, Inc., 1996).

The additional 100,000 ac-ft increment of storage at San Vicente proposed in this *Master Plan* would result an approximate 111-foot total dam raise, including the currently planned 54 feet. The new dam crest elevation would reside at just over 770 feet, with the dam's structural height at an estimated 330 feet.

The new spillway elevation of 760 feet was determined from a 758-foot water surface elevation established on Figure B.3.1 in *ESP Phase II Report,* Volume II, Appendix B, System 5 (GEI Consultants, Inc., 1996). The new dam crest at 774 feet sits above the 771-foot upstream elevation of the San Diego Weir; however, it should be noted that the 774 feet elevation includes approximately 4 feet for freeboard. The details of the dam raise, as planned for the ESP and as proposed in the *Master Plan*, are summarized in **Table 6-9**.

All necessary drain/fill pipelines, respective pump stations, and interconnection facilities for the San Vicente Dam Raise project within the current CIP (G1400) are assumed to be sufficient for the operation of this additional dam raise, and must be further evaluated during each project's design phase.

The primary advantages of providing additional storage in San Vicente is that the reservoir is scheduled to be enlarged in the Authority's CIP and all other infrastructure needed will be in place with the completion of San Vicente Pipeline and Pump Station projects.

Groundwater Projects

The Authority has conducted preliminary investigations on the use of two of the area's groundwater basins (Mission Basin and San Diego Formation) for storage and recovery. **Table 6-10** lists the potential groundwater storage and recovery projects.

These basins have the potential to provide both an annual local supply and/or storage for emergency or carryover purposes. The annual supply component is being handled in the *Master Plan* methodology as a probabilistic forecast of groundwater production by member agency. The potential use of this supply as seasonal or carryover storage is being assessed in on-going studies described in Chapter 5, in the section "Related Studies."

Table 6-9. San Vicente Dam Raise — ESP and Master Plan

	Storage Volume (ac-ft)	Spillway Elevation (ft MSL)	Dam Crest, including freeboard (ft MSL)	Dam Structural Height (ft)
Current dam	90,200	650	663	219
ESP dam raise	52,100	49	54	57
Additional master plan dam raise	100,000	61	57	57
Total dam raise	242,300	760	774	330

MSL – mean sea level

Table 6-10. Potential Groundwater Projects: New Supply or Aquifer Storage and Recovery (ASR) Facilities (New Conveyance and Supply)
San Luis Rey River Basin (Oceanside Mission Basin project)
San Diego Formation • National City wells ASR (Sweetwater Authority) • Demineralization (Sweetwater Authority) • City of San Diego project(s)
San Pasqual Basin
Santee – El Monte Basin

New Conveyance and Supply

Two major pipelines are being considered to convey imported water to the Authority's service area. Each project is the key facility in one of the three alternatives presented in Chapter 7 of this report. These projects are Pipeline 6 and the RCRCF.

Other potential pipeline/tunnel, canal, and aqueduct conversion projects are also discussed below.

Pipeline 6

Pipeline 6 is currently listed in the Authority's CIP as providing the next increment of delivery capacity for imported water. A preliminary design report was prepared for the Authority by Boyle Engineering Corp., *Feasibility/Alignment Study: Pipeline No. 6* (January 1992 Draft).

Pipeline 6 would originate at Metropolitan's Skinner Lake and treatment plant complex in Riverside County. The northern portion of the pipeline would be constructed by Metropolitan. The northern portion extends from Skinner to a point inside San Diego County near the San Luis Rey River east of the existing First Aqueduct. The last reach of that pipeline would be a tunnel through Mount Olympus that straddles the county line. At the San Luis Rey River, the Authority would continue the pipeline, which would eventually terminate at the Twin Oaks Valley Diversion Structure.

The Authority's reach of Pipeline 6 is planned to have a capacity of 500 cfs for delivery of untreated water.

Regional Colorado River Conveyance Facility (RCRCF)

The Authority has conducted a joint study with Mexico to assess the potential for a single new conveyance facility to meet long-term needs on both sides of the border. The Authority is interested in delivering the water available from the IID transfer agreement. Mexico's interest is in delivering water to meet the growth needs of the Tijuana area from Mexico's Colorado River entitlement.

A comprehensive study of options for the RCRCF is complete, and details of that study can be found in Boyle Engineering Corp.'s *Regional Colorado River Conveyance*

Feasibility Study prepared for the San Diego County Water Authority (February 2002).

El Capitan – Loveland

Transfer of water between Loveland and El Capitan Reservoirs could be of value, if a larger capacity inlet and outlet system were in place to move import water into and out of El Capitan. Then, a pump station and pipeline could be used to transfer the local runoff into Loveland Reservoir to El Capitan, rather than Sweetwater Authority transferring water to Sweetwater Reservoir by releasing it to the Sweetwater River. If a tunnel and pipeline could be constructed, it might be possible to omit the pump station and have a hydro plant at the outlet to El Capitan, since Loveland's elevation is about 1,300 feet while El Capitan has a high-water level (HWL) of 700 feet MSL. The most direct route crosses the developed areas of Alpine, so finding an acceptable alignment is not a certainty.

Escondido Canal

The City of Escondido (Escondido) and Vista ID use water from Lake Henshaw, Warner Basin, and San Luis Rey River for their respective service areas. Water is diverted from the San Luis Rey River at a point about 5 miles downstream of Henshaw Dam into the Escondido Canal. Runoff into Lake Henshaw can be supplemented by groundwater pumping from the Warner Basin. Releases from Henshaw are collected at the diversion works, along with any runoff into the San Luis Rey River below the dam, and transferred in the Escondido Canal to Lake Wohlford. From Lake Wohlford, water is transferred to the joint filtration plant located at the base of Dixon Dam.

The nominal capacity of the canal is about 70 cfs. Annual deliveries typically vary from about 5,000 to 30,000 ac-ft. An annual production of 18,000 ac-ft was used in the *Master Plan* analysis.

A physical inspection and evaluation of the canal was conducted in 1994. The project report by Powell et al., *Escondido Canal and Wohlford Penstock Evaluation – Facilities Rehabilitation, Improvement and Management Plan*, prepared for the City of Escondido (June 1994 Draft) recommended a series of improvements. The improvements include replacement of timber flumes (trestles), and rehabilitation or replacement of tunnel sections, trapezoidal channel sections, and pipe siphons.

None of the improvement work had been initiated as of February 2002; however, Escondido has indicated that some of the improvements should begin in the near future. Many of the improvements will prove to be difficult and expensive, because limited access and steep terrain will force the use of extraordinary methods, such as moving materials by helicopter.

An alternative to the rehabilitation effort would be to construct a new facility in a completely new alignment. Two possibilities seem apparent. One would be a tunnel/pipeline system running almost directly (southeast) to Lake Wohlford; the other would be a tunnel and pipeline system to Sutherland Reservoir. The Sutherland option would have a negative impact on Escondido and Vista ID, since the agencies would lose the benefit of the higher quality local water. It has been assumed that they would be given credit for the quantity of water transferred and a like amount delivered to the filtration plant from the aqueduct system.

No engineering evaluation has been prepared for a different system to deliver to Lake Wohlford. However, it would likely involve a long tunnel beginning just below Henshaw Dam and running to Guejito Valley, and a pipeline across Guejito Valley to Wohlford. The Guejito Valley is in the Wohlford drainage. The tunnel would cross both U. S. Forest Service and privately held lands. The pipelines would all be within privately held land. The tunnel length would be approximately 43,000 feet and the pipeline length is about 31,000 feet.

Transfer to Sutherland Reservoir could be accomplished by construction of tunnels and pipelines. A preliminary alignment would be a tunnel running southeast and then turning due south through Angel Mountain to Black Canyon. A short pipeline reach would lead to another shorter tunnel section, terminating in the canyon downstream of Sutherland Dam. Power generation at this location would be possible based on the relative elevation of Lake Henshaw (2,600 feet MSL) to Sutherland Reservoir (2,000 feet MSL). A short pipeline and then a tunnel through the embankment at a point away from the dam, as well as an outlet tower, would be required. There is no outlet tower now. Approximately 10,000 feet of pipeline and 43,000 feet of tunnel would be required.

Some of the local runoff into Sutherland is used by Ramona MWD and is treated at the Bargar WTP. The remainder of the water is transferred by the City of San Diego to San Vicente Reservoir. This transfer is in a pipeline from Sutherland, which crosses the Santa Maria Valley (Ramona) before discharging into a canyon that drains to San Vicente Reservoir.

Santa Margarita WD – Extension of South County Pipeline (SCP) (Orange County)

The Santa Margarita Water District approached the Authority late in 1997 regarding excess capacity in the South County Pipeline (SCP). At that time, it was estimated that 70 to 120 cfs of excess capacity was available in the line that extended into San Clemente. At this point, the pipeline is a 48-inch diameter line. The pipeline is supplied from Metropolitan's Diemer WTP, primarily through the Allen-McCulloch Pipeline. This system requires pumping.

The SCP provides service to Moulton Niguel WD, Santa Margarita WD, Trabuco Canyon WD, Capistrano Valley WD, Tri-Cities, and South Coast WD. The Santa Margarita WD and Metropolitan share ownership of the pipeline. By agreement, Metropolitan will ultimately own and operate the entire pipeline.

Extending capacity to the Authority's service area would require a pipeline 126,000 feet long to reach the Oceanside-Camp Pendleton border, if an alignment along I-5 could be followed across the base. An additional pipeline to the end of the Tri-Agency Pipeline would be needed to provide any regional benefit. This adds another 54,000 feet of pipeline and a pump station to move the water to the aqueduct gradient. At a 70 cfs design flow, the pump station would have to be in excess of 8,500 horsepower.

Aqueduct Conversions

The following three aqueduct conversions have been considered and are discussed in more detail below:

- Pipeline 1 south of Escondido to treated water
- Pipeline 1 south of Escondido to recycled water
- Pipeline 3 south of Twin Oaks Valley Diversion Structure from treated to untreated water

Consideration has been given to converting one of the two pipelines of the First Aqueduct south of Hubbard Hill in Escondido. Currently, both pipelines deliver untreated water. The capacity of each line is 95 cfs. Service of water is made to Ramona (Lake Ramona and the district's dual-water system), Poway (Berglund WTP), Helix (Levy WTP), and the City of San Diego through San Vicente Reservoir. The conversion could occur only after the San Vicente Pipeline and the Moreno-Lakeside Pipeline were completed, which could offset the need to deliver San Diego's water in the First Aqueduct.

Pipeline 1 to Treated Water

If converted to treated water, the pipeline would provide additional capacity to Ramona MWD to supplement the Ramona Pipeline deliveries. It could also backfeed into the Ramona Pipeline, thus providing dual supplies to other meters (San Diego and Olivenhain) located on the Ramona Pipeline.

Treated water in the line would come from either the Escondido-Vista WTP or the Second Aqueduct. The Second Aqueduct source would be possible, only following construction of Crossover Pipeline No. 2, so that the existing Crossover Pipeline could be converted to treated-water deliveries.

Pipeline 1 to Recycled Water

Conversion of Pipeline 1 to recycled-water delivery was considered in the *Regional Recycled Water System Study*. The "Combined Regional Strategies" concept presented in that report utilized Pipeline 1 to transfer recycled water from Escondido's Hale Avenue Resource Recovery Facility (HARRF), the San Pasqual Valley Water Reclamation Plant (WRP) (San Diego), and Padre Dam's Santee WRP. Ties with the distribution systems of Olivenhain, San Diego, Escondido, Otay, and Padre Dam were envisioned. Projected flow rates were relatively small compared to the pipeline's annual capacity as a untreated-water delivery line.

Pipeline 3 to Untreated Water

The Second Aqueduct consists of three pipelines in the reach from the Diversion Structure in Twin Oaks Valley to Miramar Hill. Two pipelines (No. 3 and No. 4) are used for treated-water delivery. Pipeline 5 is used for untreated-water delivery. Of the three, Pipeline 3 has the smallest capacity; its ultimate use should be a function of the relative demand for untreated and treated water in the reach. This analysis is presented in Chapter 7.

Seawater Desalting

Table 6-11 is a preliminary list of potential seawater desalination projects. The Authority has a detailed study under way (as of January 2002) separate from the *Master Plan* that will identify all potential sites that could serve the Authority. In the early 1990s, the Authority studied the potential to develop seawater desalination facilities. Early studies evaluated both thermal and membrane processes and concluded that reverse osmosis (RO) would be the most cost-effective desalination technology for this region. From 1991 to 1993, the Authority conducted a detailed study of the feasibility of developing a seawater desalination facility adjacent to the South Bay Power Plant in Chula Vista.

The study envisioned a three-phase project. Phase 1 included a 5-mgd project, with local product delivery to Sweetwater Authority, while Phases 2 and 3 would have

Table 6-11. Potential Seawater Desalination Projects (New Conveyance and Supply)
Carlsbad – at Encina power plant
San Onofre – at San Onofre power plant
South Bay – at South Bay power plant

produced a total of 15 mgd and 30 mgd, respectively. Proposed product delivery for Phases 2 and 3 included construction of 9 miles of 36-inch pipeline that would have connected the seawater desalination facility to Pipeline 4. The Authority Board chose not to proceed with the project, primarily due to the high cost of seawater desalination at that time and the elimination of potential power plant co-location benefits by San Diego Gas and Electric Company, the power plant owner at the time of the study.

Since the South Bay Project ended in 1994, the Authority has continued to monitor seawater desalination technology advances and project development worldwide.

Recent developments, including new projects such as the one being developed in Tampa, Florida, indicate that the cost of seawater desalination may be decreasing. In addition, power plant ownership changes at South Bay and Carlsbad (Encina), prompted the Authority Board to authorize the *Seawater Desalination Action Plan* in January 2001. The plan consists of three tasks:

1. To seek out partnership opportunities with the City of Carlsbad related to a seawater desalination project in Carlsbad.
2. To initiate discussions with owners, operators, and interested parties regarding future seawater desalination opportunities at the South Bay Power Plant in Chula Vista.
3. To conduct a reconnaissance–level study of other potential locations where seawater desalination facilities could be developed on a regional scale.

At the request of the Carlsbad MWD, Poseidon Resources Corporation has completed a study of the feasibility of a seawater desalination facility located in the City of Carlsbad with the potential to supply water to Carlsbad, the City of Oceanside, the Authority, and other local agencies. The study evaluated project sizes capable of producing up to 56,000 ac-ft/yr of high-quality drinking water. Poseidon proposes to sell the water produced at the facility pursuant to one or more long-term water sales agreements. Carlsbad is currently conducting its own internal evaluation of the study.

Authority staff have been working with Carlsbad and Poseidon to incorporate this proposed regional seawater desalination supply into the *Master Plan* reliability modeling process.

Since Board authorization of the *Seawater Desalination Action Plan*, Authority staff have had discussions with staff from Sweetwater Authority, Otay WD, Duke Energy, and the Port of San Diego regarding the potential development of a seawater desalination facility at or near the South Bay Power Plant in Chula Vista. While conditions have changed at the site since the Authority conducted detailed studies in the early 1990s (including ownership and development plans), it remains an attractive location for a seawater desalination facility. A desalination project appears to be consistent with current bayfront development planning at the site.

In May 2001, the Authority executed a Letter of Intent (LOI) with Poseidon, which is also interested in development of a desalination facility at the South Bay site. Under the LOI, Poseidon will undertake the cost and risk of conducting a feasibility study of a seawater desalination project at the South Bay site. The Authority is responsible for coordination with interested member agencies and for providing Poseidon with information, such as demand and water facility data. The Authority has agreed to sponsor the project before land use, permitting, and funding agencies for the purposes of completing the feasibility study. The Authority would be responsible for its internal costs (e.g., staff resources) during the term of the LOI, which will be a maximum of 24 months. The LOI would not commit the Authority to anything beyond receipt of a feasibility study and the possible terms and conditions of a project development proposal from Poseidon.

Other than the two existing power plant sites, there may be other potential locations for siting a regional seawater desalination facility. The Board of Directors has authorized staff to conduct a reconnaissance-level study of other potential sites within the County. A team led by Parsons Brinckerhoff (PB) was selected to conduct the reconnaissance-level study. The PB project manager also served as owner's representative for the development of the Tampa Bay Water desalination project. This study is under way.

Recycled Water

Finally, **Table 6-12** identifies projects that could increase the production and use of recycled water in the region in one of two ways: by using existing regional facilities water or by constructing new facilities that would deliver the recycled water from one agency to two or more agencies. The projects are grouped by strategy in the table. A detailed study was prepared for the Authority by a team led by RBF Consulting, titled, *Regional Recycled Water System Study* (January 2002). Concepts or strategies for enhancing the delivery of recycled water were analyzed. Reference should be made to the final report for details.

Table 6-12. Potential Regional Recycled Water Facilities (New Conveyance and Supply)	
Stand-Alone Strategies	
Strategy 1	*Pendleton Groundwater Recharge* TDS reduction, pump station, and pipeline to recharge area from new WTP
Strategy 2	*Pendleton Golf Course* Pump station and pipeline from San Luis Rey Water Reclamation Facility (WRF) to golf course
Strategy 3	*Conversion of Fallbrook/Oceanside Pipeline* Pump station and use of existing line for flow from San Luis Rey WRF to Fallbrook area
Strategy 4	*Conversion of Shadowridge Pipeline* Use of existing pipeline to deliver from Carlsbad system (and new Carlsbad WRF) to Shadowridge golf course
Strategy 5	*Vallecitos Extension from Carlsbad System* Pump station, pipelines to Vallecitos area from Carlsbad system (and new WRF)
System Strategies	
Strategy 6	*Carlsbad/Olivenhain/ San Dieguito Inter-Tie (includes Strategies 4 & 5)* Expanded WRF, pump stations, and pipelines
Strategy 7	*Escondido/Rincon/San Pasqual/North Poway* Pump station, pipelines, and conversion of Pipeline 1 to recycled water delivery from Escondido to the vicinity of the Ramona Pipeline
Strategy 8	*Escondido/Padre Dam/Helix/San Diego/Sweetwater* *(includes Strategy 7)* Expansion of capacity at Escondido and/or Padre Dam plus pumping plus piping plus conversion of Pipeline 1 from Escondido to San Vicente and the LMSE to recycled water

7 Alternatives Analysis

This chapter will provide a description of the alternatives developed and analyzed to meet the needs of the Authority service area through 2030. The reliability of the alternatives is presented first, followed by a present value comparison of the capital and incremental Operation and Maintenance (O&M) costs.

Three alternatives were developed to analyze the ability of the regional system to meet the range of demands projected for each member agency. The three alternatives provide additional conveyance of supplies to expand the regional system, as follows:

- Alternative 1: Conveyance of Supplies from the north, or Metropolitan with Pipeline 6
- Alternative 2: Conveyance of Supplies from the west, or regional seawater desalination
- Alternative 3: Conveyance of Supplies from the east, or Regional Colorado River Conveyance Facility (RCRCF)

While Pipeline 6 is in the current CIP, for comparison purposes it is included only as part of Alternative No. 1 - Supply from the North. Pipeline 6 was assumed to be deferred for the other two alternatives. Alternative 1 can therefore be viewed as the base alternative against which the other two alternatives may be compared.

The alternatives were analyzed using the probabilistic computer model (*Confluence*™) described in Chapter 2, with up to 3,000 simulations run for each analysis of a given alternative. The results are given in the summary figures presented in this chapter under two demand scenarios. The first is the most probable demand scenario based on the latest official demographic forecast by SANDAG reflective of variations in weather only. The second scenario incorporates variations in demographic projections as well as weather and is used to quantify the risk associated with departures from the forecasted rate of growth in the County. The upper bounds of this latter scenario can be considered to provide the worst-case scenario for demand growth over the planning horizon.

The assumed facilities for all the alternatives include the projects in the current CIP placed into operation according to the current project schedules, with the one exception of Pipeline 6. While Pipeline 6 is in the current CIP, for comparison purposes, it is included only as part of Alternative No. 1 – Supply from the North. Alternative 1 can therefore be viewed as the base alternative against which the other alternatives may be compared.

Table 7-1. Summary of Demand and Supply for Average Weather Conditions Alternative 1, Supply from the North (ac-ft/yr)

	2005	2010	2015	2020	2025	2030
DEMAND [a]						
M&I	589,002	619,245	663,695	712,569	759,529	793.606
Agriculture	108,324	102,859	97,100	89,174	83,594	78,783
Total demand	697,326	722,104	760,795	801,743	843,123	872,389
SUPPLY						
Local supply						
Average local surface runoff[b]	85,600	85,600	85,600	85,600	85,600	85,600
Planned local recycled water	33,400	45,100	51,800	53,400	53,400	53,400
Planned local groundwater	31,100	53,500	57,500	59,500	59,500	59,500
Total local supply	150,100	184,200	194,900	198,500	198,500	198,500
Imported water						
Imported water (Metropolitan)[c]	344,800	368,100	386,400	403,400	418,400	431,400
Imported water (IID transfer)[d]	30,000	110,000	140,000	190,000	200,000	200,000
Additional supply required (imported or other)	172,426	59,804	39,495	9,843	26,223	42,489
Total imported plus additional supply required	547,226	537,904	565,895	603,243	644,623	673,889
Total supply	697,326	722,104	760,795	801,743	843,123	872,389

[a]Deterministic demand forecast for average weather conditions (point forecast).

[b]Numbers shown represent long-term average production.

[c]Based on estimated preferential right.

[d]Includes both Imperial Irrigation District (IID) and Palo Verde Irrigation District (PVID) transfer water, based on October 2002 Term Sheet.

As discussed in Chapter 2, Methodology, the approach taken in analyzing each of the alternatives is to run several hundreds of computer simulations that vary both supplies and demands across predefined ranges, each of which has a certain probability of occurrence. The frequency with which demands in any part of the service area are unable to be met, and the magnitude of any shortage, are tallied and expressed as probabilities of occurrence. The results are discussed in this chapter by comparing the frequency and magnitude of shortages throughout the service area by year. Thus, any shortage at any location in the service area is tallied as a shortage for the entire service area.

Basis of Analysis

Supply and Demand Forecasts

The average or most probable forecast of demand and supply for average weather conditions is presented in **Table 7-1** (for Alternative 1). Total demand is the sum of municipal and industrial (M&I) demand and agricultural demand as discussed in Chapter 3.

Supplies are shown for both local and imported sources as discussed in Chapter 4. The local supplies are surface runoff into the region's water supply reservoirs, recycled water, and groundwater. The number shown for surface runoff (85,600 ac-ft) is the long-term average production from these sources. The values shown for recycled water and groundwater represent the total planned amounts provided to the Authority by member agencies. The local supply is expected to increase to 198,500 ac-ft/yr by 2020, staying at that level throughout the remainder of the study period.

Imported supplies fall into three categories: Metropolitan supply, the Imperial Irrigation District Transfer supply, and Other Supplies.

The IID transfer is scheduled to begin in 2003 at 10,000 acre-feet and ramps up to 200,000 ac-ft per year by 2021 according to a schedule discussed in Chapter 4.

The Additional or Other Supply required is the difference between total demand and the sum of total local supply, Imported, and IID transfer supplies. This estimated Other Supply is the same for Alternatives 1 and 3, and will be less for Alternative 2 in direct relationship to the amount of desalted seawater that is produced each year. **Tables 7-1, 7-5, and 7-7** depict the mix of supplies assumed for each alternative under average supply and demand conditions.

Each alternative was analyzed using the probabilistic forecast of supply and two different probabilistic forecasts of demand:

- Constrained Demand (Demand Forecast with Weather Variability Only)
- Unconstrained Demand (Demand Forecast with Demographic and Weather Variability)

The Constrained Demand forecast is based upon SANDAG's projected population with no demographic variability in the forecast. This equates to the most probable demand forecast. The weather

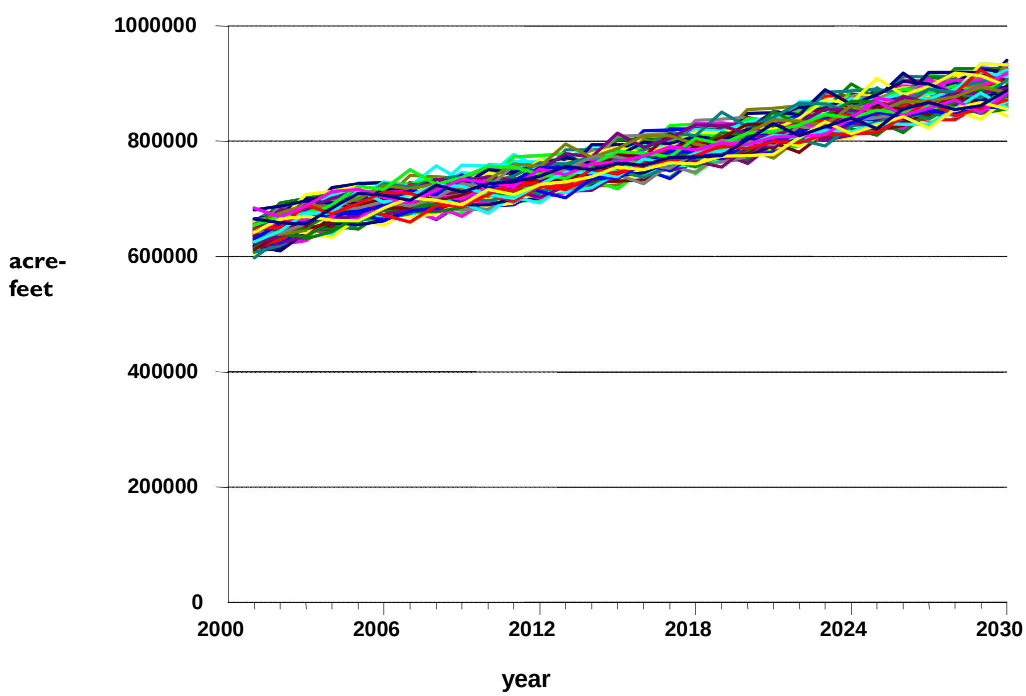

Figure 7-1. Range of Annual Demand Forecasts Simulated for Authority Service Area (Demand Forecast with Weather Variability)

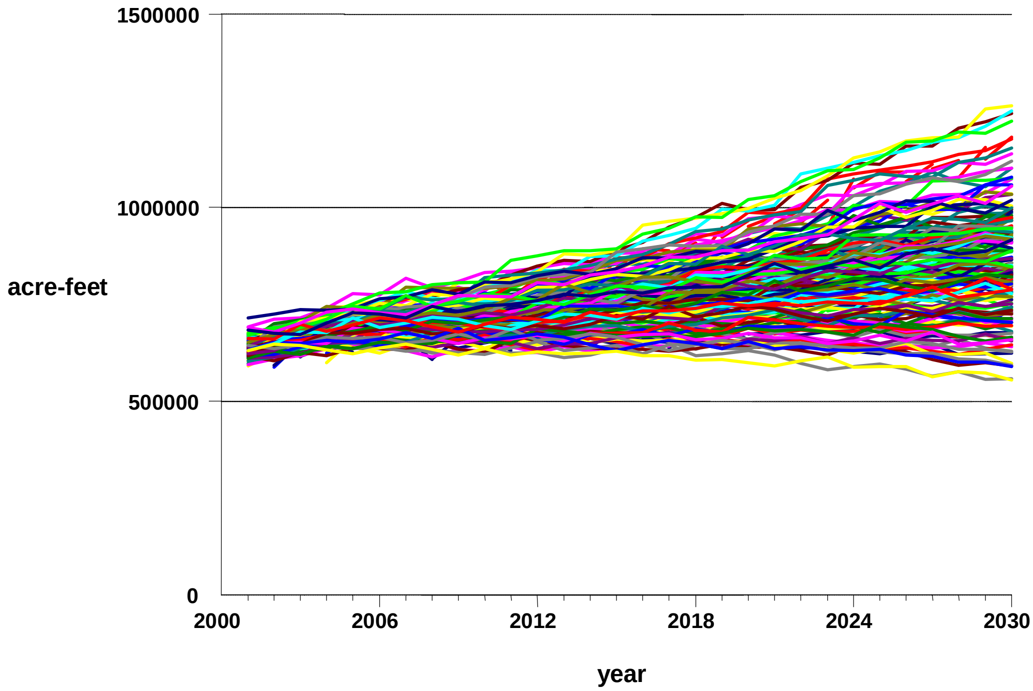

Figure 7-2. Range of Annual Demand Forecasts Simulated for Authority Service Area (Demand Forecast with Weather and Demographic Variability)

adjustment reflecting hydrologic variability is performed within the Confluence model.

Figure 7-1 presents the range of demand forecasts simulated when only the weather is varied and demographic factors are held constant. In 2030, the demand is expected to range from a low of 843,500 ac-ft to a high of 946,500 ac-ft under the Constrained Demand forecast.

If we now add demographic variability to the forecast a much wider range of possible demand occurs. **Figure 7-2** presents the full range of variability in potential demand. In this case the demand can range from a low of 557,000 to a high of 1,262,000 ac-ft in 2030.

The difference in the demand ranges representing Unconstrained and Constrained demands indicates the amount of variability that is introduced when considering the full range of demographic possibilities, including the range of variabiliity of future population, housing density, and employment. Incorporating ranges of projected demographic factors can have a substantial impact on the range of future water demands. This is used to quantify the risk associated with changes in growth and to construct a worst-case scenario.

End user demands for each alternative are identical. Only the supplies and the facilities are varied between alternatives.

Facilities Common to All Alternatives

The starting point for this master planning process is that the projects in the on-going Capital Improvement Program (CIP) will be completed as planned, including all of the facilities associated with the ESP. In addition, the Replacement/ Relining Program (RRP), which is also in the CIP, is assumed to be expanded to include replacement or relining of all 80 miles of Prestressed Concrete Cylinder

Pipe. The RRP will consist of a series of projects to be constructed through 2030 and beyond.

Several projects are also assumed to be funded and constructed by Authority member agencies:

- Expansion by the City of San Diego of the Alvarado and Miramar water treatment plants (WTPs) to 200 and 215 mgd, respectively.
- Construction by the City of San Diego of a pump station at Alvarado WTP to convey treated water into Pipeline 4.
- Construction by the Otay Water District of a 10 mgd pump station to take delivery of water from the City of San Diego's Otay WTP, expanded to 20 mgd once the Otay WTP is expanded to 60 mgd.

At this time (December 2002), expansion of Metropolitan's Skinner WTP is being planned. The schedule calls for the expanded facility to be put into operation in time to meet Summer 2007 demands. The expansion is assumed to add 120 mgd to the facility, bringing the total rated capacity to 640 mgd. In addition to the Skinner expansion, treatment capacity was added under each alternative to maintain peak day service as needed, with the amount of the additional capacity varying according to the needs under each alternative.

A number of new projects will be required under all alternatives. These projects are listed in **Table 7-2** according to the five-year period when they are needed. They are described below and will not be shown in the tables for the individual alternatives discussed later in this chapter.

Three projects are shown in the 2000-2005 period. Each project is related to providing more treatment capacity to meet regional needs. The first is a flow control facility at the intersection of Pipeline 4 with the Olivenhain treated water transmission main. The connection of the Olivenhain Pipeline to the treated-water pipeline of the Second Aqueduct will allow any excess capacity from the new Olivenhain WTP to be used regionally. The key advantage for delivery of treated water at this location is that it would require no pumping.

Excess capacity during peak periods from the existing Olivenhain WTP is expected to be approximately 10 mgd through 2004, and will diminish after this to zero within a few years. Additional capacity would be available during non-peak demand periods. For this reason, available excess treatment capacity will be limited after 2005 unless Olivenhain MWD expands their plant from the current 25 mgd to 34 mgd. Expansion of the Olivenhain WTP is expected to be a fairly simple project since it primarily involves the purchase and installation of more membranes. Olivenhain has determined that it can recover its cost for constructing the 9 mgd expansion if the Authority agrees to purchase a minimum amount of water over the next 10 years at prices at or below the cost to purchase treated water from Metropolitan. While this incremental capacity could be provided by a number of other options available to the Authority, this option is competitive with the cost to purchase from Metropolitan and will require no capital participation by the Authority for the WTP expansion. However, costs for the connection to the Authority's aqueduct will be recovered through the treated-water purchase agreement with Olivenhain. Implementation of this project is assumed to take place before 2005.

The second project to be constructed by 2007 is the construction of approximately 50 mgd of treatment capacity, either by building an entirely new facility or by expanding an existing treatment plant by 50 mgd. For cost purposes only, this expansion is assumed to be at the Olivenhain WTP, which can accommodate an expansion of about 44 mgd at their existing site.

Project	Design Flow (cfs)	Length (ft)	Diameter (inches)	TDH (ft)	Power (hp)	Volume (mg)
Table 7-2. Description of Projects Common to All Alternatives						
2000-2005						
Flow control facility and power supply for Olivenhain Connection	TBD	–	–	–	–	–
Expand regional water treatment capacity	TBD	–	–	–	–	–
Expand Padre Dam Pump Station	43	–	–	50	325	–
2005-2010						
Additional San Vicente Dam Raise (100,000 ac-ft)	–	–	–	–	–	32,585
Increase untreated water capacity						
Mission Trails Flow Regulatory Structure	–	–	–	–	–	18
Tunnel pipeline and demolition of existing vents (10 vent structures)	400	5,000	96	–	–	–
Reactivate 72-inch pipeline near Miramar WTP	TBD	–	72	–	–	–
San Diego 24/25/26 (Miramar WTP)	TBD	–	–	–	–	–
San Diego 12 Expansion (Alvarado WTP)	TBD					
Poway treated water connection and pump station	9	2,500	–	50	100	–
Lower Otay Pump Station	–	–	–	375	1,000	–
2010-2015						
Construct new Crossover Pipeline No. 2	200	52,000	72	–	–	–
Pipeline from Otay WD Flow Control Facility 14 to regulatory reservoir	18	26,300	30	–	–	–
Hubbard Hill Flow Regulatory Structure	–	–	–	–	–	3.5
Restore untreated-water delivery in La Mesa–Sweetwater Extension to Sweetwater Lake	–	–	72	–	–	–
Slaughterhouse Terminal Reservoir	–	–	–	–	–	10
North County Distribution Pipeline (NCDP) Flow Regulatory Structure	–	–	–	–	–	5
2015-2020						
None						
2020-2025						
None						
2025-2030						
None						

Other options exist for obtaining an additional 50 mgd, including the expansion of the Weese WTP or a new plant at the Twin Oaks Valley Diversion Structure. The Olivenhain Phase II expansion is included only for modeling purposes and should be seen as representative of the additional 50 mgd capacity, wherever it might be placed in the northern portion of the Authority's Second Aqueduct.

The third project is associated with the Levy WTP and is intended to take advantage of the peak capacity available at that plant to meet regional needs. Delivery to Padre Dam MWD and Otay WD would be increased to 28 and 12 mgd, respectively, with an expanded pump station to Padre Dam and an expanded Otay 14 FCF. These capacities are greater than those specified in the current contractual agreement between the Authority and Helix (the agreement provides a capacity guarantee of 26 mgd from Levy WTP to the Authority, approximately 18 mgd to Padre MWD and 8 mgd to Otay WD). The increase in total delivery from 26 to 40 mgd would take advantage of the excess capacity available at the Levy WTP. As demands in Helix grow and utilize the currently available excess capacity, the potential exists to expand the capacity of the WTP to 120 mgd, adding another 14 mgd to the Authority's current capacity right. This would allow the Authority to continue to provide up to 40 mgd to Padre Dam and Otay well into the future.

Seven projects are shown in the 2005-2010 period.

There is a need to improve untreated-water delivery capacity and operational efficiency on the Second Aqueduct, south of the Miramar Vents. It is envisioned that the project would consist of reactivation of a 72-inch pipeline near the Miramar WTP, a new FRS and replacement of Pipelines 3 and 4 from Elliot Vent 1 to Vent 5 with a single, large-diameter pipeline installed in a tunnel. The proposed Mission Trails Flow Regulatory Structure (FRS) II would be an 18- to 20-mg storage facility that would change the way the untreated-water pipelines are operated in much the same way that the existing Mission Trails FRS has impacted the operation of the treated-water system. The existing Elliot Vents would not be required and could be removed from Mission Trails Regional Park.

Carryover storage is needed to increase supply reliability for the region. As will be seen later in this chapter, a volume of approximately 100,000 ac-ft provides a substantial increase in regional water supply reliability. This volume could be provided at a single site or multiple sites. However, single sites are seen as more cost-effective. Based on the number of sites reviewed for the ESP, there are only two sites that can be identified as having sufficient potential to provide the needed volume. These are San Vicente Reservoir as part of the already-approved San Vicente dam raise project for the ESP or at the North County site (Moosa Canyon) analyzed during the ESP planning phase. The San Vicente site has been assumed for this *Master Plan* analysis based upon the cheaper unit cost anticipated and the fact that the pipelines and pump station needed to utilize the storage are now being designed as part of ESP.

A new pipeline delivering water from Helix's new flume pipeline to Otay's Regulatory Reservoir would allow a conversion of the La Mesa–Sweetwater Extension pipeline back to untreated-water service from the First Aqueduct to Sweetwater Reservoir. This would provide additional untreated-water reliability for the South County during the relining projects on the untreated-water pipelines of the Second Aqueduct. It is noted that this conversion may require Helix WD projects for full project implementation.

New flow control facilities (FCFs) to the Miramar and Alvarado WTP are required to meet the increased demand for treated water resulting from the planned WTP expansions. The Authority will continue to maintain the ability to supplement the treated-water pipeline by pumping from the Miramar WTP clearwell, allowing the Authority to purchase treated water when excess treatment capacity is available during peak regional demand periods.

A final project in the period 2005-2010 is construction of a connection between Poway's Berglund WTP and the Ramona Pipeline that serves treated water to Ramona and the Rancho Bernardo area of San Diego. To supply up to 6 mgd of treated water from Berglund, a small 100-hp pumping station would be required. The size of this pumping station could be increased if there were an agreement between the City of Poway and the Authority to expand Berglund and make additional treatment capacity available to the region. An additional benefit of this project would be the ability to supply treated water to Poway when the treatment plant might be taken out of service for scheduled maintenance or in the event of an emergency.

There are six projects needed between 2010 and 2015. Three of these projects are flow-regulating structures (reservoirs) that provide operational enhancements. The reservoirs recommended are at critical locations in the system, giving operations staff the ability to operate more efficiently and to avoid spills. These facilities are located at the terminus of the First Aqueduct's treated-water pipelines at Hubbard Hill in Escondido, at the end of the First Aqueduct near San Vicente Reservoir (Slaughterhouse Canyon), and at the head of the North County Distribution Pipeline (NCDP).

The final project in this period is the Crossover Pipeline No. 2. The existing Crossover Pipeline will need to be replaced or relined during the study period. Relining will reduce the capacity of the existing Crossover Pipeline to below what is needed to serve the Escondido-Vista WTP, the Berglund WTP and other uses on the First Aqueduct south of Escondido. A new Crossover Pipeline would allow continued service to the member agencies served by the existing pipeline while it is being relined. Once relined, the existing Crossover Pipeline could be converted to treated water service, which would be beneficial if the Escondido-Vista WTP is re-rated back up to 90 mgd.

There are no common projects in the periods beyond 2015.

Results of Reliability Simulation for Alternatives 1 through 3

This section describes the additional facilities required for each alternative that, when combined with the previously described facilities common to all alternatives, provide a full and complete "system." Each alternative is also analyzed for the level of reliability provided under the array of supply and demand conditions discussed earlier. As will be seen, the reliability of the alternatives are substantially different from one another. These results do not reflect the probability of occurrence of duration events that might impact system reliability, such as pipeline breaks or power failures, since these are typically of such short durations that they have little impact on overall system reliability in comparison to the reliability impacts of water supply or system capacity.

Alternative 1 – Conveyance of Additional Supply from the North, Pipeline 6, and Skinner WTP Expansion

Alternative 1 Facilities

The facilities comprising Alternative 1 are presented in **Table 7-3**. The table shows project name, time period for the facility to come online, and a size or capacity. This table does not list the projects common to each alternative shown in Table 7-2. The common projects were discussed earlier in this chapter.

Table 7-3. Description of Projects Required for Alternative 1, Supply from the North

Project	Design Flow (cfs)	Length (ft)	Diameter (inches)	TDH (ft)	Power (hp)	Volume (mg)
2000-2005						
None.						
2005-2010						
Convert Pipeline 3 to untreated water from Crossover to Miramar	TBD	–	–	–	–	–
2010-2015						
Pipeline 6 (Authority reach)	520	61,776	108	–	–	–
2015-2020						
None						
2020-2025						
None.						
2025-2030						
None						

The primary new facilities for this alternative are:

- Pipeline 6 – Authority's portion
- Conversion of Pipeline 3 to untreated water from Crossover to Miramar

The treated capacity within Metropolitan's Skinner Service Area available to serve the Authority will increase to 570 mgd for this alternative. Certain assumptions also need to be made for purposes of estimating the impact on the cost of treated water from Metropolitan as a result of providing treatment capacity beyond the expansion of Skinner to 640 mgd. The assumption is that a new treatment plant of approximately 150 mgd will be constructed by 2015 to serve southern Riverside County. To convey the full 570 mgd from Metropolitan will require Pipeline 3 be converted from untreated-water to treated-water delivery from Skinner to the Twin Oaks Valley Diversion Structure after Pipeline 6 is constructed. Pipelines 1, 2, and 4 would continue delivering treated water. Pipeline 6 would deliver untreated water in conjunction with Pipeline 5. This combination of pipelines will provide a total untreated water capacity of 646 mgd (1000 cfs) to the Authority, based upon a preliminary capacity of 336 mgd (520 cfs) for Pipeline 6, and a total treated water capacity of 572 mgd (885 cfs). This treated water capacity assumes that Pipeline 4 will operate at its original design capacity of 425 cfs and Pipeline 3 will operate at 280 cfs after Pipeline 6 is completed.

With the construction of the Olivenhain WTP and expansions of the Miramar and Alvarado WTPs, there is a need to convert Pipeline 3 to untreated water service south of the Twin Oaks Valley Diversion Structure. Pipeline 4 provided untreated water through this stretch until the San Marcos and Rancho Penasquitos Pipelines (Pipeline 5 Extension) were completed. Once the new untreated-water pipeline was in place, Pipeline 4 was converted to treated water to facilitate scheduling of relining of both Pipelines 3 and 4 through this stretch. With two treated water pipelines, one can be taken out of service for an extended period for relining. Once relining work is completed on both pipelines in this stretch, Pipeline 3 can be converted to untreated-water service to supply the treatment plants south of San Marcos.

Finally, no specific projects have been defined for the 2025-30 period.

Alternative 1 Supply

Table 7-1 shows the most probable supply and demand projections used in the reliability analyses for Alternative 1. An annual import supply of 673,889 ac-ft is required by the year 2030 for average demands. Pipelines 1 through 5 are capable of delivering this amount; however, depending on the mix of supplies selected, Pipeline 6 will need to be in service sometime after 2015 to allow for years of below-average, local surface runoff; years of higher than average demand, and years of less-than-planned quantities of recycled and groundwater supply.

The reliability analyses performed utilize the facilities in place in each year through 2030 for this alternative. Through this system, the available supplies and demands are varied across the full range of demands and supplies for each year. Any instances of demands not being fully met are recorded by location, year and amount, as are key system operations information. Summary reliability information is graphed to provide visibility for overall system reliability by year.

Alternative 1 Overall Reliability

The results of the reliability analyses are presented below for the two probabilistic demand forecasts for Alternative 1.

Weather Variability Only. **Figure 7-3** shows the reliability of Alternative 1 for the range of demand conditions shown previously in **Figure 7-1,** without Carryover Storage. All

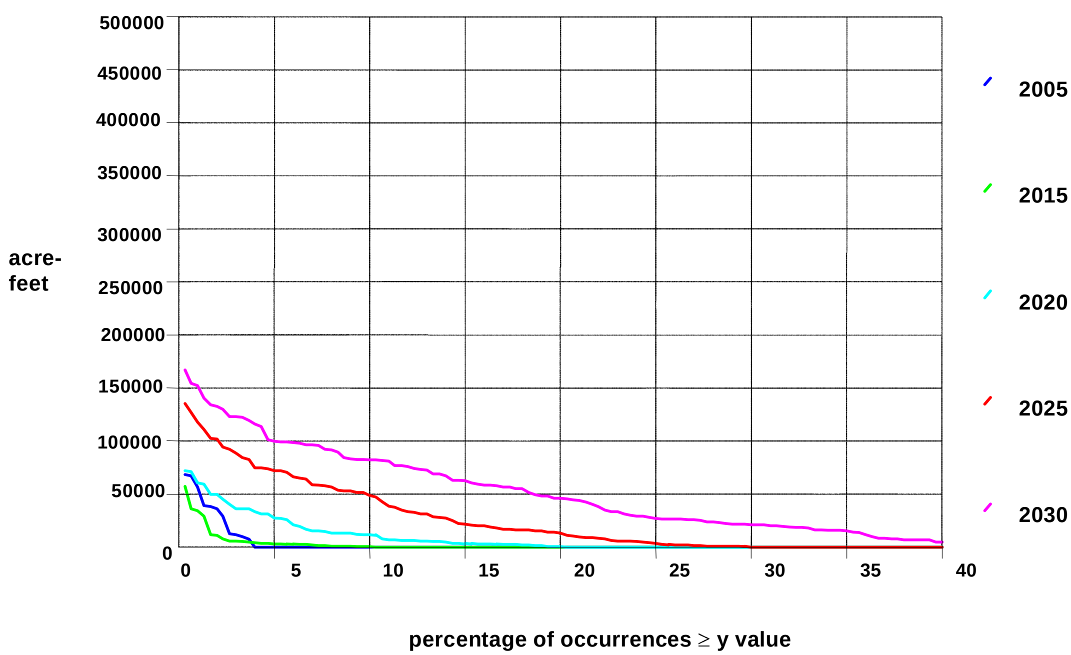

Figure 7-3. Annual Unserved Demand Duration Curves Analyzed for Weather Variability – Alternative 1

reliability results presented in the figures within this chapter are based upon a hydrologically limited supply with a floor set to the Authority's preferential right. Reliability is illustrated by the probability of shortages, expressed as "annual unserved demand". Examination of the figure shows, for the year 2030, a 5 percent probability of a shortage of 100,000 ac-ft or more. The highest point on the curve is a 0.3 percent probability that the shortage would be 170,000 acre feet or more. In the year 2020, the magnitudes are significantly less, with the 5 percent probability at 27,000 ac-ft or more and the 1 percent probability at 60,000 ac-ft or more. The highest shortage in 2005 is approximately 70,000 acre feet. The highest shortage in 2015 is less, about 55,000 acre feet as the ESP and local treatment projects are completed.

All of the predicted shortages in the year 2030 are due to a shortage in import supply. None are due to capacity limitations in the regional delivery system. The estimated reliability of imported supplies is based on current planning efforts by Metropolitan and does not reflect uncertainty in demands caused by anything other than variations in weather. This and other key issues are discussed in depth in Chapter 8.

If Carryover Storage is added in the region, then the magnitude of the shortage is substantially decreased. **Figure 7-4** is the resulting reliability plot for the same conditions, except for the addition of 100,000 ac-ft of Carryover Storage at San Vicente. For the year 2030, the 5 percent probability is reduced to a shortage threshold of 64,000 ac-ft. The addition of Carryover Storage reduced the 5 percent probability of occurrence for the 2015 shortage from approximately 70,000 acre feet to a threshold of about 25,000 acre feet.

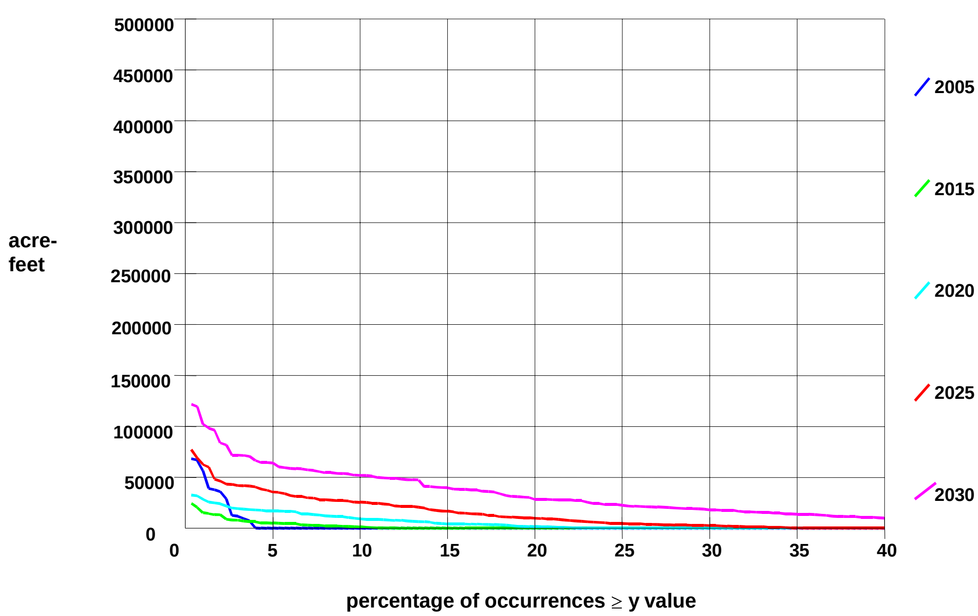

Figure 7-4. Annual Unserved Demand Duration Curves Analyzed for Weather Variability with Carryover Storage – Alternative 1

The simulation program also assesses the amount of the Carryover Storage volume that is used. **Figure 7-5** shows the probability that the range of volume will be used in the year 2030. For example, there is about a 25 percent probability that 40,000 ac-ft would be used, 10 percent that 75,000 ac-ft and a 3 percent probability that almost the entire 100,000 feet would be required. Significant increases in Carryover Storage above 100,000 ac-ft did not yield significant improvements in the average occurrence of shortage.

Weather and Demographic Variability. When demographic variability is included in developing the demand forecast (see **Figure 7-2** for the full range of demands), the reliability of the system proposed for this alternative is highly impacted, especially in the latter years of the study period. **Figure 7-6** presents the results of the simulations. The magnitude of the shortage is significantly higher when a much wider range of potential demands is considered given that the range of supply is the same. Thus the maximum shortage shown in **Figure 7-6** is about 430,000 ac-ft compared to a maximum of about 170,000 ac-ft in **Figure 7-3** where the demographic variability is not included.

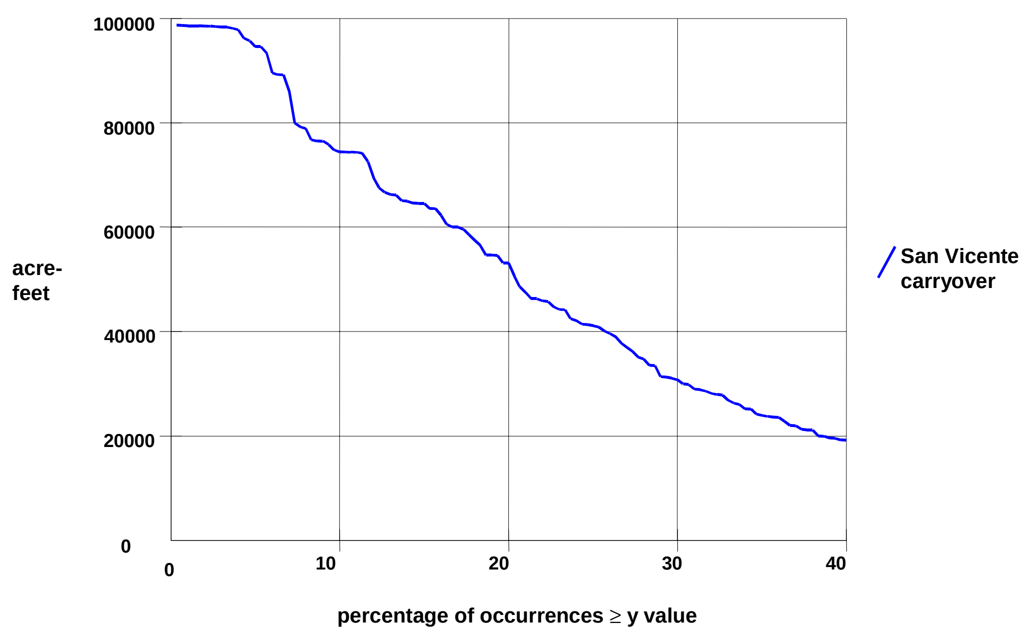

Figure 7-5. Annual Production Duration Curve for 2030 Analyzed for Weather Variability – Alternative 1, San Vicente Carryover Storage

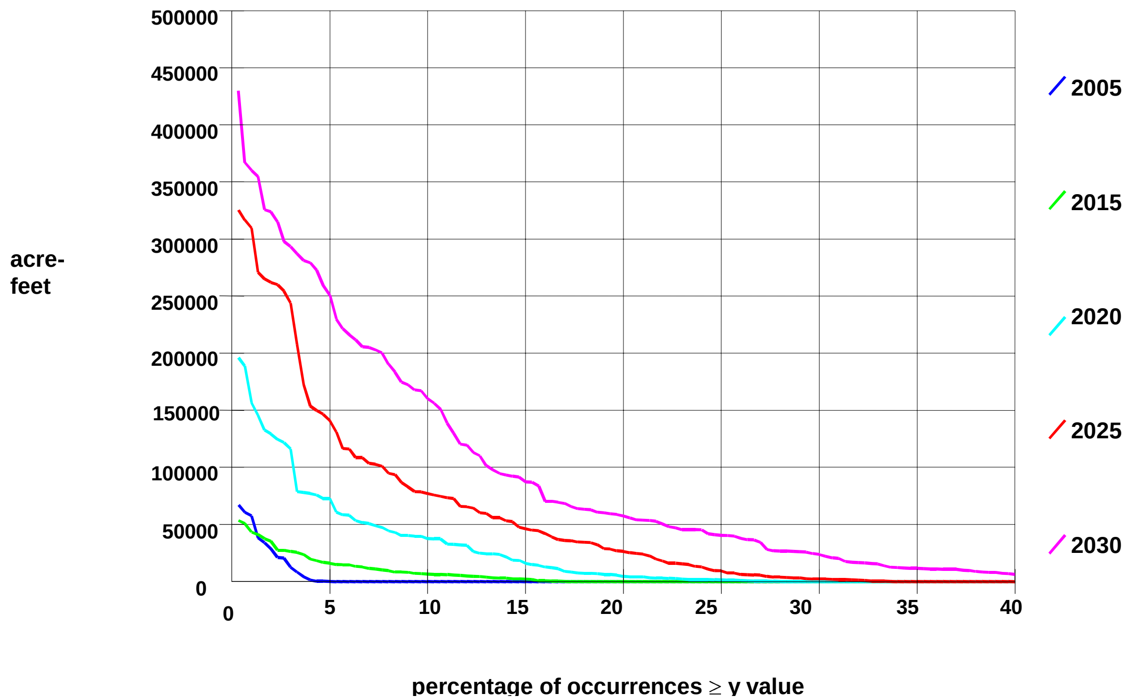

Figure 7-6. Annual Unserved Demand Duration Curves Analyzed for Weather and Demographic Variability with Carryover Storage – Alternative 1

It is interesting to note that the reliability through the year 2015 is very good for either case (i.e., with and without demographic variability). For the year 2015, the impact of using the full range of demands rather than just weather variability, is an increase in the shortage (at a 0.3 percent probability) from 25,000 acre feet **(Figure 7-4)** to 50,000 acre feet **(Figure 7-6)**. This is a rather small amount for such a low-probability event. By 2030, the shortage of 430,000 acre feet for both weather and demographic variability is significantly higher than the 130,000 acre feet for weather variability only.

This suggests that the demographic variability beyond 15 years is the largest driver of overall reliability in the later years. Since the range of demographic variability grows substantially beyond the 15th year, a strategy that could be employed to manage this variability is to monitor the demographic projections for a 15- or 20-year time horizon on an annual or biennial basis and adjust the reliability analyses to reflect any changes. This would provide a 20-year warning for any unusually high demographic trends that would require adjustments to the Authority's water supply and facility plans.

Alternative 2 – Additional Supply from the West, Seawater Desalination Plant

Alternative 2 Facilities

The facilities comprising Alternative 2 are presented in **Table 7-4**. The table shows project name, time period for the facility to come online, and a size or capacity. These tables do not list the projects common to each alternative shown in **Table 7-2**. The common projects were discussed earlier in this chapter.

The primary new facilities for this alternative are:

- Seawater desalination plant at Encina (a minimum of 80-mgd in two phases)
- Pipelines and pump stations to deliver water from the Encina Seawater Desalination Plant to the aqueduct system
- Conversion of Pipeline 3 to untreated water from Crossover to Miramar

For Alternatives 2 and 3, it was assumed that 420 mgd would be available from Skinner WTP in 2007 for delivery through Pipelines 1, 2 and 4 (a combined capacity of 650 cfs or 420 mgd) through 2009. It was further assumed that 391 mgd would be available beginning in 2010, which reflects a reduction of 53 cfs in the capacity of Pipeline 4. This is based on recent suggestions by Metropolitan that the capacity of Pipeline 4 should be reduced.

With the assumption that the capacity of Skinner WTP allocated to the Authority service area would be maintained at 420 mgd, Pipelines 1, 2, and 4 would be delivering treated water and the total treated-water delivery capacity would be 650 cfs. Pipelines 3 and 5 would be used to deliver untreated water. The combined capacity of these two pipelines is 760 cfs. If Pipeline 6 were required, it would deliver untreated water in conjunction with Pipelines 3 and 5.

Alternative 2 assumes that the Authority would first build regional facilities to provide supply from seawater desalination and then build other treatment and conveyance facilities when needed. The date that these new facilities would be required depends primarily upon the capacity of desalination developed.

As mentioned above, Alternative 2 includes a new treatment plant. The Encina Seawater Desalination Plant would be constructed and in service by 2010 at an initial capacity of 50 mgd. It would then be expanded in a 30-mgd increment to a total capacity of 80 mgd by 2015. All of the 80-mgd capacity would be pumped to the Maerkle Reservoir (elevation of 500 feet) in Carlsbad. It was assumed that Carlsbad and Oceanside would receive a base load of 10 mgd each from this facility and that the remaining 60 mgd would be pumped into the aqueduct system and into Pipeline 4. Preliminary analyses indicate that there is enough demand in winter to use the plant's full capacity. However, it may be necessary to take the water to the Twin Oaks Valley Diversion Structure to serve enough demand in the winter months to keep the desalting plant at an efficient production level. From the Twin Oaks Valley Diversion Structure, the water could flow both north and south in Pipeline 4 and, thus, provide at least a blend of desalinated seawater to all agencies now relying on Pipeline 4.

As shown in **Table 7-4**, the only changes from Alternative 1 are the elimination of Pipeline 6 (Authority reach) and the inclusion of the Encina Desalination Plant. It was assumed that the Encina facility would be built in stages so that it can operate at a high production efficiency year round. Thus, it becomes operational in the 2005-2010 period as a 50-mgd facility with pump stations and pipelines sized for an ultimate expansion to 100 mgd. The plant will serve water directly to Carlsbad, Oceanside, and others via a connection to the Second Aqueduct through the existing Tri-Agency Pipeline (TAP). The TAP will limit the amount that can be delivered, so the expansion of the desalting plant will require that the TAP be replaced (or paralleled) with a larger capacity line.

The expansion of the Encina facility to 80 mgd is shown in the 2010-2015 period.

Alternative 2 Supply

The most probable forecast of demand and supply for average weather conditions is presented in **Table 7-5** for Alternative 2. Seawater desalination plant production is assumed to start at an initial capacity of 56,000 ac-ft/yr by 2008 (50 mgd), increasing to 89,000 ac-ft (80 mgd) annually by the year 2015. Further expansion beyond 80 mgd would depend upon the success of the facility, the base load market for the water, and whether other local treatment facilities are completed as planned.

The total delivery through the Metropolitan and Authority aqueducts would include both IID transfer water and the Metropolitan-supplied water. The total would be about 594,000 ac-ft by the year 2030. This quantity is well within the

Table 7-4. Description of Projects Required for Alternative 2, Supply from the West

Project	Design Flow (cfs)	Length (ft)	Diameter (inches)	TDH (ft)	Power (hp)	Volume (mg)
2000-2005						
None.						
2005-2010						
Convert Pipeline 3 to untreated water from Crossover to Miramar	TBD	–	–	–	–	–
Encina Desalination Plant (initial 50 mgd)						
Desalination Plant	78	–				
Pipeline from plant to Maerkle Reservoir	155	34,262	72	–	–	–
Pipeline from Maerkle Reservoir to Tri-Agency Pipeline	120	5,345	48	–	–	–
Pump Station from plant and Maerkle Reservoir	155	–	–	557	14,000	–
Pump Station from Maerkle Reservoir and Tri-Agency Pipeline	120	–	–	262	6,000	–
2010-2015						
Expand Encina Desalination Plant (30 mgd expansion to 80 mgd)						
Desalination plant expansion	125	–	–	–	–	–
Replace Tri-Agencies Pipeline	120	22,423	48	–	–	–
2015-2020						
None.						
2020-2025						
None.						
2025-2030						
None.						

delivery capacity of the five aqueduct pipelines. Even a reduction of 100,000 ac-ft of local supply in any given year (point forecast) would not increase the import demand beyond the total capacity limit of Pipelines 1 through 5.

Alternative 2 Overall Reliability

Reliability results are presented for Alternative 2 for the two demand conditions, namely:

- Demand forecast with weather variability
- Demand forecast with weather and demographic variability

This alternative provides a new source of water to the region. The 80-mgd desalination facility envisioned produces about 80,000 ac-ft/year of new water. In the reliability analyses, it was assumed that the supply available to the Authority was increased by this amount and that Metropolitan would not include that amount in the total supply to be allocated to Metropolitan's member agencies.

Weather Variability Only. **Figure 7-7** shows the resulting reliability for the demand condition with only weather variability. These results show that the potential shortage is very small for all planning years after the desalination plant is expected to

Table 7-5. Summary of Demand and Supply
Alternative 2, Supply from the West (ac-ft/yr)

	2005	2010	2015	2020	2025	2030
DEMAND[(a)]						
M&I	589,002	619,245	663,695	712,569	759,529	793,606
Agriculture	108,324	102,859	97,100	89,174	83,594	78,783
Total demand	**697,326**	**722,104**	**760,795**	**801,743**	**843,123**	**872,389**
SUPPLY						
Local supply						
Average local surface runoff[(b)]	85,600	85,600	85,600	85,600	85,600	85,600
Planned local recycled water	33,400	45,100	51,800	53,400	53,400	53,400
Planned local groundwater	31,100	53,500	57,500	59,500	59,500	59,500
Total local supply	150,100	184,200	194,900	198,500	198,500	198,500
Seawater desalination						
Encina	0	50,000	80,000	80,000	80,000	80,000
South Bay	0	0	0	0	0	0
Imported water						
Imported water (Metropolitan)[(c)]	344,800	368,100	345,895	313,243	364,623	393,889
Imported water (IID transfer)[(d)]	30,000	110,000	140,000	190,000	200,000	200,000
Additional supply required (imported or other)	172,426	9,804				
Total imported plus additional supply required	547,226	487,904	485,895	523,243	564,623	593,889
Total supply	**697,326**	**722,104**	**760,795**	**801,743**	**843,123**	**872,389**

[(a)]Deterministic demand forecast for average weather conditions (point forecast).

[(b)]Numbers shown represent long-term average production.

[(c)]Based on estimated preferential right.

[(d)]Includes both Imperial Irrigation District (IID) and Palo Verde Irrigation District (PVID) transfer water, based on October 2002 Term Sheet.

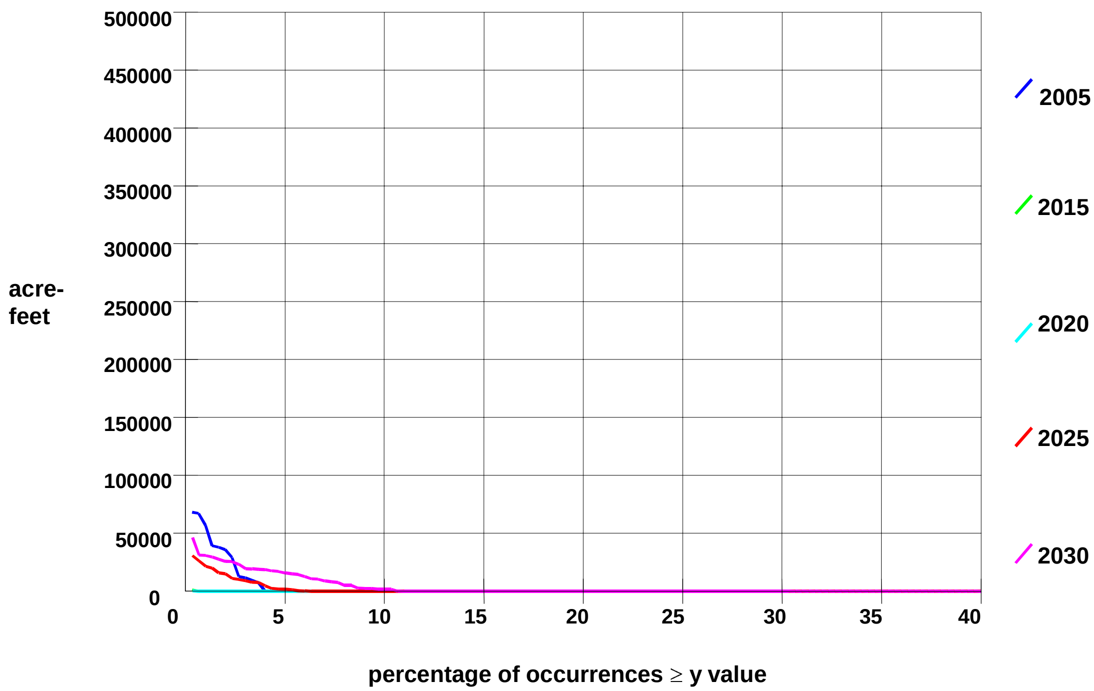

Figure 7-7. Annual Unserved Demand Duration Curves Analyzed for Weather Variability – Alternative 2

become operational (2010). In the year 2030, a shortage of 16,000 ac-ft, or greater, has a probability of 5 percent. At a 1 percent probability level the shortage is 31,000 ac-ft. This increased reliability over the first alternative is due to the additional resource (desalinated seawater) that is part of the supply mix for Alternative 2.

Carryover storage reduces the amount of shortage essentially to zero (see **Figure 7-8**), except for the 2005 planning year that occurs prior to the construction of either the desalination plant or the carryover storage reservoir. **Figure 7-9** illustrates the amount of carryover storage that is used near the end of the planning period. In this case, a total of 10,000 ac-ft or more of carryover storage being used has a probability of occurrence of 5 percent.

Weather and Demographic Variability. When demographic variability is included, the potential for shortages in later planning years is far more significant. **Figure 7-10** shows that the year 2030 shortage level increases to greater than 350,000 ac-ft compared to the less than 50,000 ac-ft shown earlier in **Figure 7-7.** The wide variation in potential demand, resulting from the potentially wide variation of demographic factors in the later planning years, is significant. Actual growth on the upper portion of the range could overwhelm the facilities planned. Either more desalination capacity would have to be provided or import supplies would have to become more certain, along with the construction of Pipeline 6.

If the seawater plant is limited to 80 mgd, it should be adequate to 2030 if the region stays on a demand growth path represented by **Figure 7-1**. Should demographic changes drive that demand growth higher or faster, then more desalinated seawater capacity, or other supplies, would be necessary.

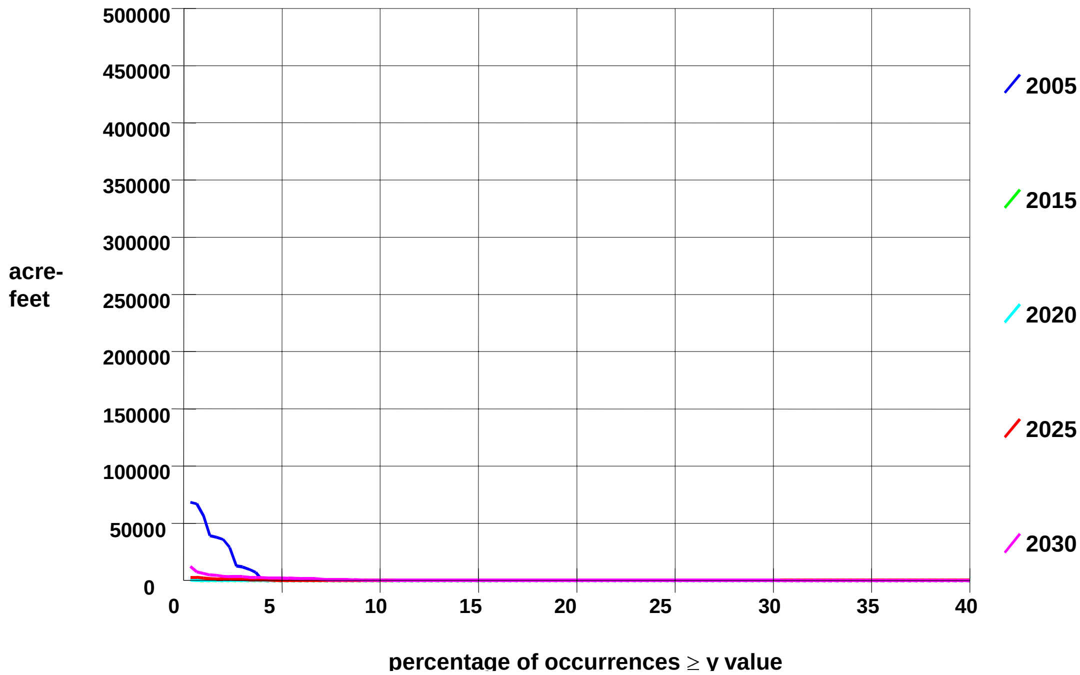

Figure 7-8. Annual Unserved Demand Duration Curves Analyzed for Weather Variability with Carryover Storage – Alternative 2

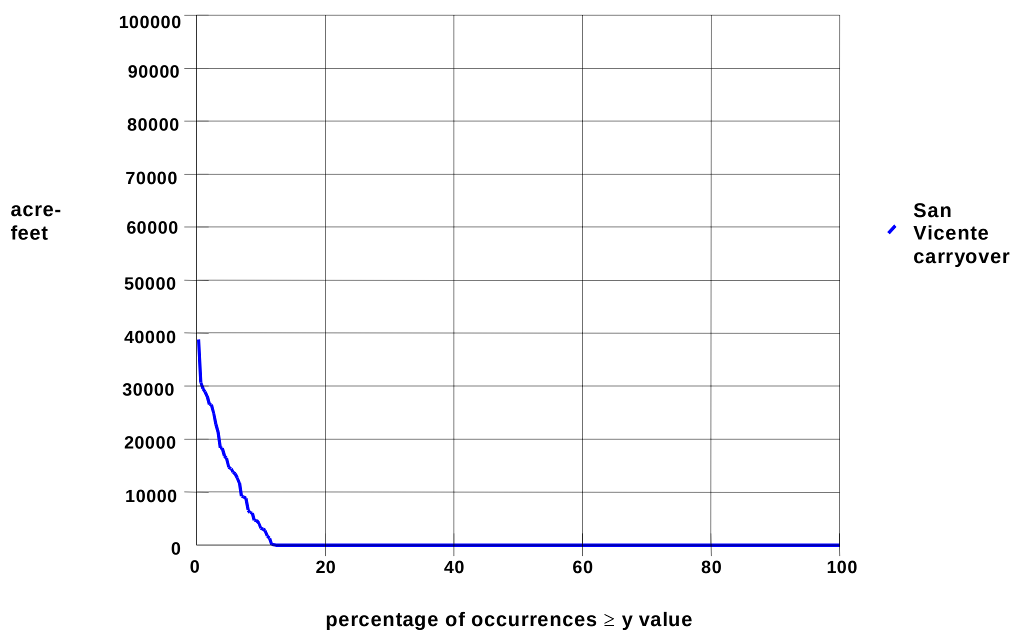

Figure 7-9. Source Annual Production Duration Curve for 2030 Analyzed for Weather Variability – Alternative 2, San Vicente Carryover Storage

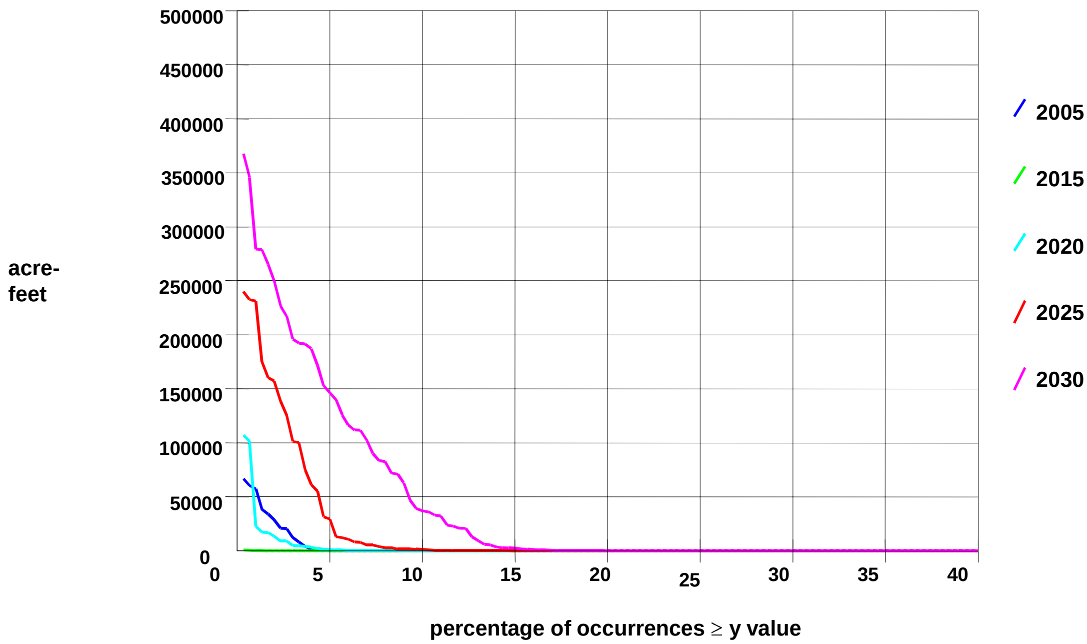

Figure 7-10. Annual Unserved Demand Duration Curves Analyzed for Weather and Demographic Variability with Carryover Storage – Alternative 2

Alternative 3 – Supply from the East, Regional Colorado River Conveyance Facility

Alternative 3 Facilities

The facilities that comprise Alternative 3 are presented in **Table 7-6.** This alternative has the same projects as Alternative 1 through 2010. In 2010-2015, the Colorado River Conveyance Facility is shown rather than the Authority's reach of Pipeline 6. Also, a 65-mgd Crossover WTP is shown rather than needing to depend on an expansion of Skinner WTP.

The primary new facilities for this alternative are:

- Regional Colorado River Conveyance Facility (RCRCF)
- New Crossover WTP

Alternative 3 is based on the concept that the Authority would build a conveyance facility to deliver up to 300,000 ac-ft/yr of water from the Colorado River. The specified amount in the agreement between IID and the Authority is 200,000 ac-ft/yr, so the extra conveyance capacity allows for additional transfers. Because of the salinity of the water at the point of delivery, total dissolved solids (TDS) reduction will be required, reducing the transferred amount by 5 percent. Of the total 200,000 ac-ft/yr specified in the transfer agreement, 190,000 ac-ft/yr would be realized.

An engineering feasibility study of various alignments for the RCRCF was prepared in 1995 by Black and Veatch. A joint study was recently completed to refine and update the costs presented in the Black and Veatch study and to study alignments on the Mexico side of the border. For this *Master Plan* it has been assumed that an alignment on the U. S. side of the border would be constructed (alignment 5C from the Black and Veatch study).

For Alternative 3, it was assumed that the capacity of Skinner WTP allocated to the Authority service area would continue at 420 mgd. Thus, treated water would continue in Pipelines 1, 2, and 4 for a total delivery capacity of 650 cfs (420 mgd). Untreated-water delivery would occur in Pipelines 3 and 5, with a combined capacity of 760 cfs. In addition, untreated water would be delivered in the RCRCF. For the purposes of this analysis, it was assumed

Table 7-6. Description of Projects Required for Alternative 3, Supply from the East

Project	Design Flow (cfs)	Length (ft)	Diameter (inches)	TDH (ft)	Power (hp)	Volume (mg)
2000-2005						
None.						
2005-2010						
None.						
2010-2015						
Regional Colorado River Conveyance Facility (RCRCF)						
Pipeline, pump stations, hydro-electric facilities	415	475,200	96	–	–	–
Reverse osmosis treatment plant (118 mgd for 300,000 ac-ft)	183	–	–	–	–	–
Brine disposal (conveyance from Miramar and Alvarado WTPs, 39 mgd)	60	156,000	–	–	–	–
Brine disposal (capacity in South Bay International Outfall, 39 mgd)	60	–	–	–	–	–
Crossover WTP (65 mgd)	100	–	–	–	–	–
Untreated water connection (Pipelines 3, 5, and Crossover)	–	–	–	–	–	–
Treated water connection (Pipeline 4)	–	–	–	–	–	–
2015-2020						
None						
2020-2025						
None						
2025-2030						
None.						

that the annual delivery capacity is 190,000 ac-ft/yr through San Vicente Reservoir.

With the construction of the Olivenhain WTP and expansions of the Miramar and Alvarado WTPs, there is a need to convert Pipeline 3 to untreated-water service south of the Twin Oaks Valley Diversion Structure. Pipeline 4 provided untreated water through this stretch until the San Marcos and Rancho Penasquitos Pipelines (Pipeline 5 Extension) were completed. Once the new untreated-water pipeline was in place, Pipeline 4 was converted to treated water to facilitate scheduling of relining of both Pipelines 3 and 4 through this stretch. With two treated-water pipelines, one can be taken out of service for an extended period for relining. Once relining work is completed on both pipelines in this stretch, Pipeline 3 can be converted to untreated-water service to supply the treatment plants south of San Marcos.

Alternative 3 Supply

The point forecast of demand and supply for average weather conditions is presented in **Table 7-7** for Alternative 3.

The construction of a new conveyance facility to bring the IID transfer water to the region would reduce the total delivery that is supplied from the north through Metropolitan and Authority facilities. The total delivery through Metropolitan and Authority aqueducts would include the Metropolitan-supplied water, plus any transfer water for the Authority other than the IID transfer water.

In **Table 7-7**, the delivery from Metropolitan and other supplies would be about 674,000 ac-ft/yr in 2030, which is well within the estimated annual capacity of the existing aqueduct system of about 700,000 to 750,000 ac-ft/yr. Even a reduction of 100,000 ac-ft of local supply in any given year (point forecast) would not increase the import demand to the total capacity limit of Pipelines 1 through 5.

Alternative 3 Overall Reliability

Results will again be presented for the two demand conditions, namely

- Demand forecast with weather variability
- Demand forecast with weather and demographic variability

Weather Variability. **Figure 7-11** shows the resulting reliability for the demand condition with only weather variability. The results are virtually the same as those presented for Alternative 1. Examination of the data used to create the figure shows, for the year 2030, a 5 percent probability of a shortage of 104,000 ac-ft or more and a 1 percent probability that the shortage would be 146,000 ac-ft or more. In the year 2020, the magnitudes are significantly less, with the 5 percent probability at 40,000 ac-ft or more and the 1 percent probability at 66,000 ac-ft or more. All of the predicted shortages are due to a shortage in import supply, none are due to capacity limitations in the regional delivery system.

The results of adding carryover storage in the simulation are presented in **Figure 7-12**. The impact is not as beneficial as shown for Alternative 1, where the overall reliability was significantly increased. At an occurrence of 5 percent, the reduction in the shortage is only about 20,000 ac-ft in 2030 (105,000 ac-ft without carryover storage to a shortage of 85,000 ac-ft with carryover storage). The reduction in shortage was 36,000 ac-ft for Alternative 1. **Figure 7-13** shows the simulated probability of the carryover storage utilization. There is a 5 percent probability that the carryover storage used will be 38,000 ac-ft or greater in 2030. The maximum used would be about 56,000 ac-ft.

Table 7-7. Summary of Demand and Supply for Alternative 3, Supply from the East (ac-ft/yr)

	2005	2010	2015	2020	2025	2030
DEMAND[a]						
M&I	589,002	619,245	663,695	712,569	759,529	793,606
Agriculture	108,324	102,859	97,100	89,174	83,594	78,783
Total demand	697,326	722,104	760,795	801,743	843,123	872,389
SUPPLY						
Local supply						
Average local surface runoff[b]	85,600	85,600	85,600	85,600	85,600	85,600
Planned local recycled water	33,400	45,100	51,800	53,400	53,400	53,400
Planned local groundwater	31,100	53,500	57,500	59,500	59,500	59,500
Total local subtotal	150,100	184,200	194,900	198,500	198,500	198,500
Imported water						
Imported water (Metropolitan) [c]	344,800	366,904	386,400	403,400	418,400	431,400
Regional Colorado River Conveyance Facility (IID Transfer)[d]	28,500	104,500	133,000	180,500	190,000	190,000
Additional supply required (imported or other)	173,926	66,500	46,495	19,343	36,223	52,489
Total imported plus additional supply required	547,226	537,904	565,895	603,243	644,623	673,889
Total supply	**697,326**	**722,104**	**760,795**	**801,743**	**843,123**	**872,389**

[a] Deterministic demand forecast for average weather conditions (point forecast).

[b] Numbers shown represent long-term average production.

[c] Based on estimated preferential right:

[d] Assume a loss of 5 percent of the total as brine during TDS reduction.

Weather and Demographic Variability. The results for the analysis using both demographic and weather variability were similar to those shown for Alternative 1 (**Figure 7-6**). **Figure 7-14** presents the reliability for the full range of demand for the case where carryover storage is provided.

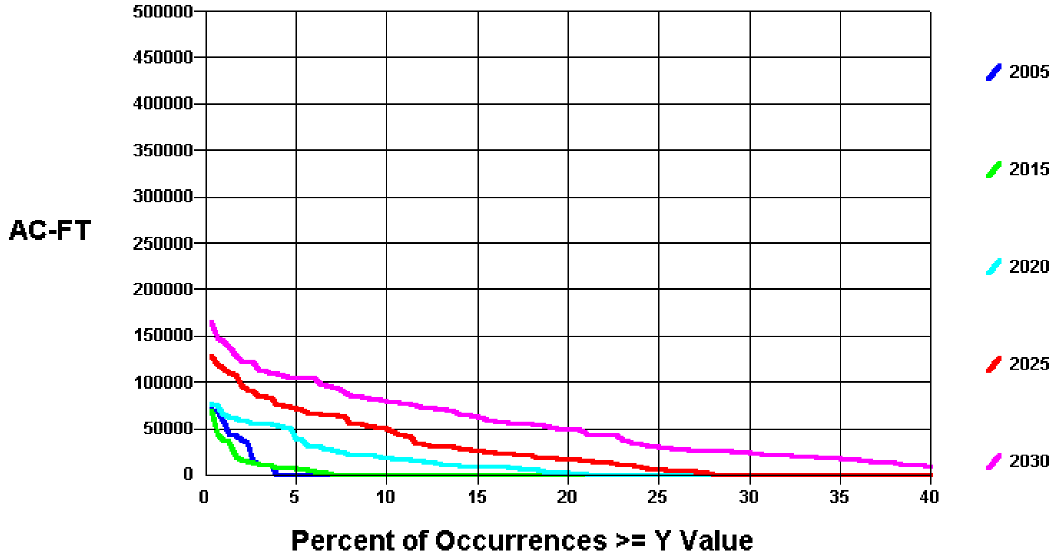

Figure 7-11. Annual Unserved Demand Duration Curves Analyzed for Weather Variability – Alternative 3

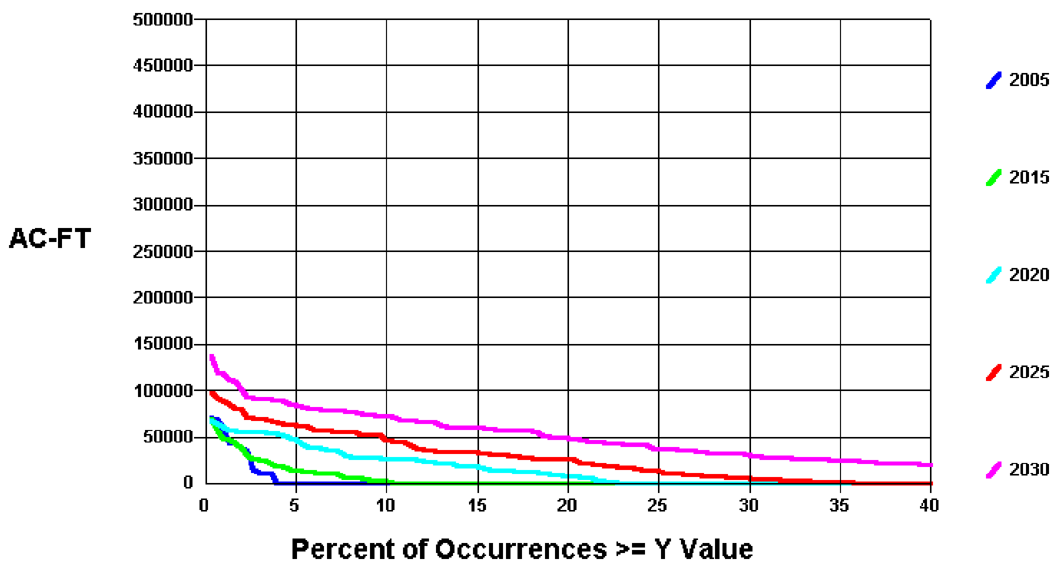

Figure 7-12. Annual Unserved Demand Duration Curves Analyzed for Weather Variability with Carryover Storage – Alternative 3

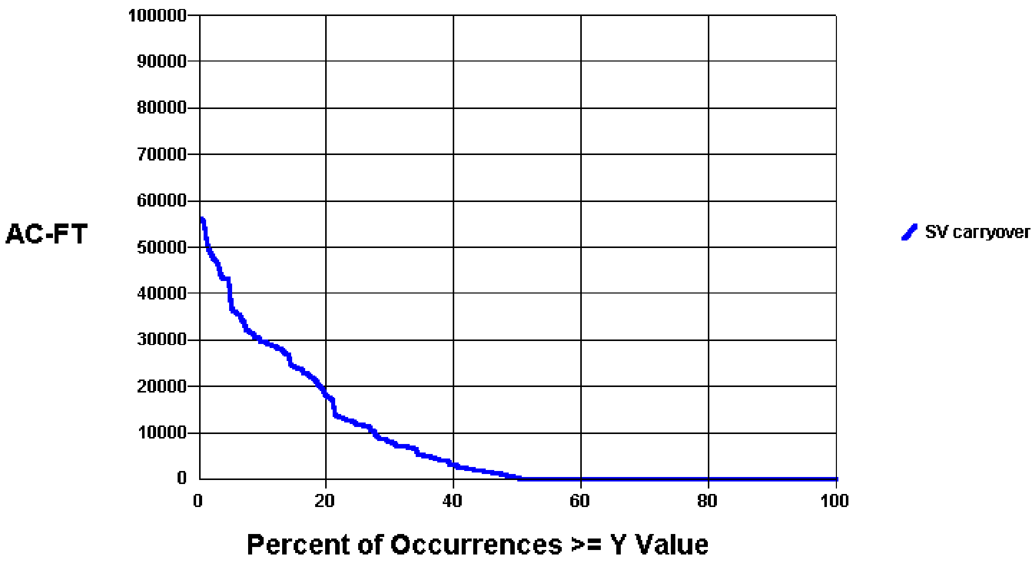

Figure 7-13. Source Annual Production Duration Curve for 2030 Analyzed for Weather Variability – Alternative 3, San Vicente Carryover Storage

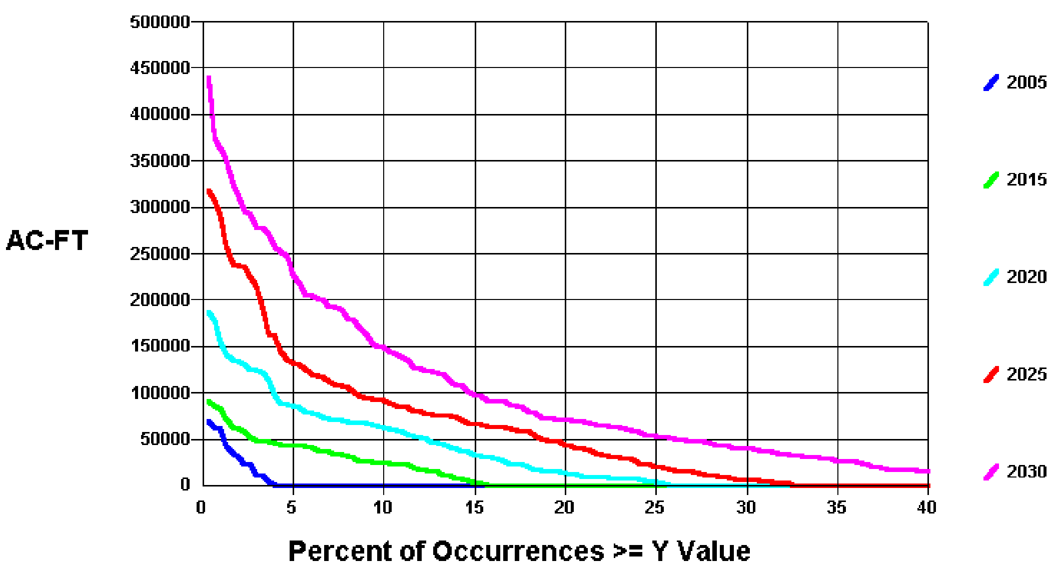

Figure 7-14. Annual Unserved Demand Duration Curves Analyzed for Weather and Demographic Variability with Carryover Storage – Alternative 3

Summary Comparison of Reliability

Under the Constrained Demand forecast, only Alternative 2, Supply from the West with Seawater Desalination, can deliver a fully reliable water supply to the Authority's member agencies through 2030 (see **Figure 7-15**). The Constrained Demand forecast reflects the most probable demand projection, consistent with the *Urban Water Management Plan,* allowing for variations in weather. The key reason for this is that only Alternative 2 brings a substantial, new water supply to the Authority that is essentially 100 percent reliable. The import water supplies that must be more heavily utilized in Alternatives 1 and 3 are substantially less reliable than desalinated seawater.

Options to enhance the reliability of Alternatives 1 and 3 under a constrained demand forecast were pursued, but none of these options produced enough of a reliability enhancement to merit further effort in consideration of the cost to implement them. When analyzing the uncertainties associated with changes in currently forecasted demographics under the Unconstrained Demand forecast as shown in **Figure 7-16,** Alternative 2, as would be suspected, was the most reliable of the three alternatives.

One of the factors that must be taken into account in analyzing the Unconstrained Demand reliability results is the very low likelihood that the conditions reflected in the extreme shortage events would occur. These low probability conditions include substantially greater population growth and employment, and lower housing densities (reference the discussion in Chapter 3 on Demand Forecasts for Facilities Master Plan). This is especially true as the planning horizon of 2030 is approached where the uncertainties in the forecast are most pronounced. Even if such conditions were to exist in the later years, the demographic trends would be

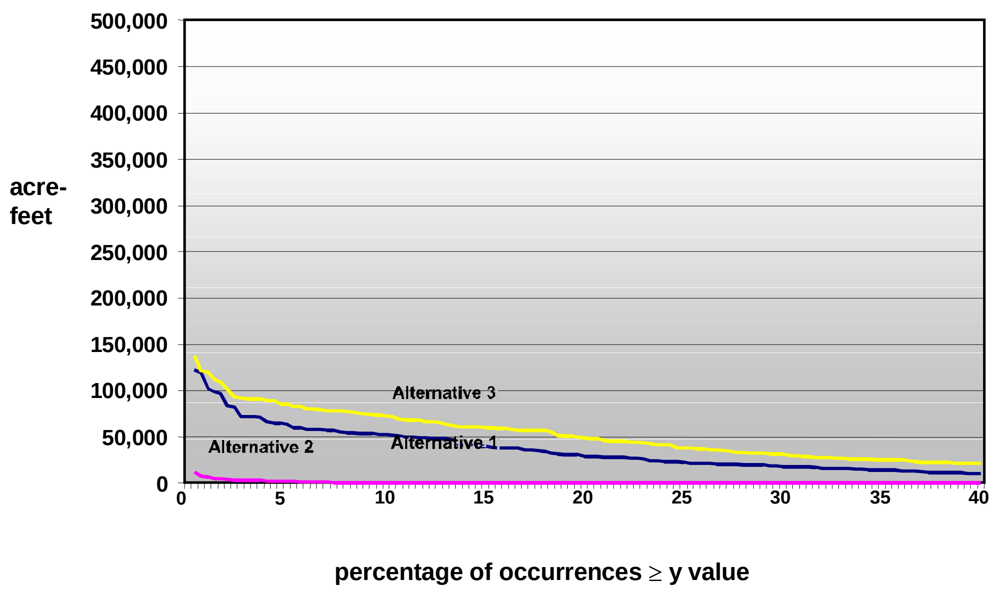

Figure 7-15. Comparison of Annual Unserved Demand Duration Curves for 2030, Analyzed for Weather Variability with Carryover Storage – Alternatives 1, 2, and 3

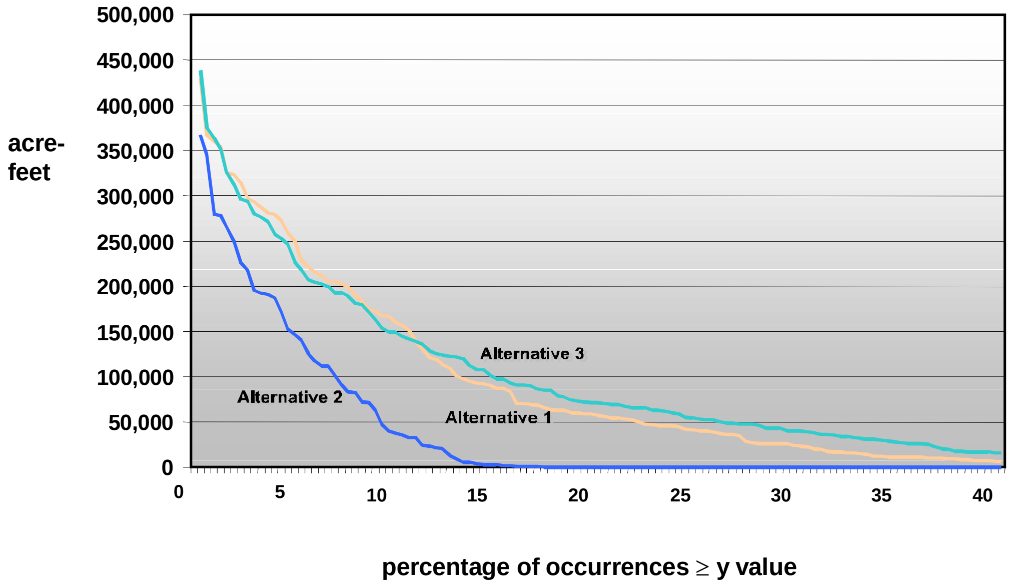

Figure 7-16. Comparison of Annual Unserved Demand Duration Curves for 2030, Analyzed for Weather and Demographic Variability with Carryover Storage – Alternatives 1, 2, and 3

evident in sufficient time for the Authority to respond by implementing further demand-side management, pursuing new supplies and constructing additional facilities. For this reason the *Master Plan* alternatives have not been designed to meet demands under the most extreme, low-probability conditions, as that approach is both cost prohibitive and unwarranted at this time. Instead, the *Master Plan* seeks to compare alternatives that take into account a reasonable measure of the uncertainties that drive demand, weather, and demographics, and offer a prudent capital investment strategy that enhances reliability in a cost-effective manner. This will be further explored in Chapter 8, Conclusions and Recommendations.

Economic Comparison

The economic comparison of the three alternatives is based on a present value comparison of capital and operations and maintenance costs, including the cost to purchase water from the various sources. Capital costs include replacement costs for facilities components of various useful lives to provide a true lifecycle cost estimate. This section summarizes this economic comparison of the three alternatives.

Capital Costs

Tables 7-8 through 7-10 present the capital costs for Alternatives 1 through 3, respectively. The tables include project name, anticipated completion date, type of project, and total project capital cost. Projects listed in the tables are grouped into three categories:

Table 7-8. Capital Costs for Alternative 1 Facilities, Supply from the North			
Project	**Anticipated Completion Date**	**Type of Project**	**Total Project Capital Cost (2001 Dollars)[(a)]**
Rehabilitation of Existing Facilities			
Three pipeline relining projects	2005	PL (reline)	29,606,000
Three pipeline relining projects	2010	PL (reline)	40,994,000
Two pipeline relining projects	2015	PL (reline)	24,724,000
Five pipeline relining projects	2020	PL (reline)	55,013,000
Five pipeline relining projects	2025	PL (reline)	52,945,000
Five pipeline relining projects	2030	PL (reline)	39,464,000
Total			**242,746,000**
Expansion of Internal System Capacity and Addition of Water Treatment Capacity			
Flow control facility and power supply to Olivenhain Connection	2004	FCF	1,200,000
Expand regional treatment plant capacity	2005	WTP	123,711,000
San Diego 24/25/26	2007	FCF	3,780,000
San Diego 12 expansion	2007	FCF	3,780,000
Increase untreated water capacity			
Mission Trails Flow Regulatory Structure	2007	Res	23,672,000
Tunnel pipeline and demolition of 10 existing vent structures	2007	PL	34,760,000
Reactivate 72-inch pipeline near Miramar WTP	2009	PL	1,911,000
Lower Otay Pump Station	2008	PS	9,217,000
Padre Dam Pump Station Expansion	2009	PS	3,149,000
Poway Pump Station and treated water connection	2010	PS/FCF	2,280,000
Pipeline from Otay WD Flow Control Facility 4 to regulatory reservoir	2013	PL	24,812,000
Restore untreated-water delivery in LMSE to Sweetwater Lake	2014	PL	744,000
Hubbard Hill Flow Regulatory Structure	2015	Res	4,772,000
Slaughterhouse Terminal Reservoir	2015	Res	12,970,000
NCDP Flow Regulatory Structure	2015	Res	6,762,000
Construct new Crossover Pipeline No. 2	2015	PL	102,006,000
Total			**359,526,000**

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Table 7-8. Capital Costs for Alternative 1 Facilities, Supply from the North (continued)			
Project	**Anticipated Completion Date**	**Type of Project**	**Total Project Capital Cost (2001 Dollars)[(a)]**
Additional Seasonal/Carryover Storage and New Conveyance and Supply Projects			
Additional San Vicente Dam Raise (100,000 acre-feet)	2010	Res	189,866,000
Convert Pipeline 3 to untreated water from Crossover to Miramar	2010	PL	2,126,000
Pipeline 6 (Authority Reach)	2015	PL	121,900,000
Total			**313,892,000**
Total for Alternative 1			**916,164,000**

[(a)] Total project capital costs were calculated as the estimated construction cost, plus contingencies, engineering, environmental, and administration costs added as a percentage. Land acquisition and right-of-way costs were also included, based on a unit cost per acre or per linear foot.

Table 7-9. Capital Costs for Alternative 2 Facilities, Supply from the West			
Project	**Anticipated Completion Date**	**Type of Project**	**Total Project Capital Cost (2001 Dollars)[(a)]**
Rehabilitation of Existing Facilities			
Three pipeline relining projects	2005	PL (reline)	29,606,000
Three pipeline relining projects	2010	PL (reline)	40,994,000
Two pipeline relining projects	2015	PL (reline)	24,724,000
Five pipeline relining projects	2020	PL (reline)	55,013,000
Five pipeline relining projects	2025	PL (reline)	52,945,000
Five pipeline relining projects	2030	PL (reline)	39,464,000
Total			**242,746,000**
Expansion of Internal System Capacity and Additional Water Treatment Capacity			
Flow control facility and power supply to Olivenhain Connection	2004	FCF	1,200,000
Expand regional treatment plant capacity	2005	WTP	123,711,000
San Diego 24/25/26	2007	FCF	3,780,000
San Diego 12 expansion	2007	FCF	3,780,000

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Table 7-9. Capital Costs for Alternative 2 Facilities, Supply from the West (continued)

Project	Anticipated Completion Date	Type of Project	Total Project Capital Cost (2001 Dollars)[a]
Expansion of Internal System Capacity and Additional Water Treatment Capacity (cont'd)			
Increase untreated water capacity			
Mission Trails Flow Regulatory Structure	2007	Res	23,672,000
Tunnel pipeline and demolition of 10 existing vent structures	2007	PL	34,760,000
Reactivate 72-inch pipeline near Miramar WTP	2009	PL	1,911,000
Lower Otay Pump Station	2008	PS	9,217,000
Padre Dam Pump Station Expansion	2009	PS	3,149,000
Poway Pump Station and treated water connection	2010	PS/FCF	2,280,000
Pipeline from Otay WD Flow Control Facility 4 to regulatory reservoir	2013	PL	24,812,000
Restore untreated-water delivery in LMSE to Sweetwater Lake	2014	PL	744,000
Hubbard Hill Flow Regulatory Structure	2015	Res	4,772,000
Slaughterhouse Terminal Reservoir	2015	Res	12,970,000
NCDP Flow Regulatory Structure	2015	Res	6,762,000
Construct new Crossover Pipeline No. 2	2015	PL	102,006,000
Total			**359,526,000**
Additional Seasonal/Carryover Storage and New Conveyance and Supply Projects			
Additional San Vicente Dam Raise (100,000 ac-ft)	2010	Res	189,866,000
Convert Pipeline 3 to untreated water from Crossover to Miramar	2010	PL	2,126,000
Encina Desalination Plant (initial 50 mgd)		Desal	213,901,000
Desalination Plant	2007		
Pipeline from plant to Maerkle Reservoir	2007	PL	72,863,000
Pipeline from Maerkle Reservoir to Tri-Agency Pipeline	2007	PL	6,757,000
Pump station from plant to Maerkle Reservoir	2007	PS	129,342,000
Pump station from Maerkle Reservoir to Tri-Agency Pipeline	2007	PS	55,454,000
Encina Desalination Plant (30 mgd expansion to 80 mgd)	2015	Desal	128,340,000
Desalination plant expansion			
Replace Tri-Agencies Pipeline	2015	PL	28,348,000
Total			**826,997,000**
Total for Alternative 2			**1,429,269,000**

[a] Total project capital costs were calculated as the estimated construction cost, plus contingencies, engineering, environmental, and administration costs added as a percentage. Land acquisition and right-of-way costs were also included, based on a unit cost per acre or per linear foot.

Table 7-10. Capital Costs for Alternative 3 Facilities, Supply from the East			
Project	**Anticipated Completion Date**	**Type of Project**	**Total Project Capital Cost (2001 Dollars)[(a)]**
Rehabilitation of Existing Facilities			
Three pipeline relining projects	2005	PL (reline)	29,606,000
Three pipeline relining projects	2010	PL (reline)	40,994,000
Two pipeline relining projects	2015	PL (reline)	24,724,000
Five pipeline relining projects	2020	PL (reline)	55,013,000
Five pipeline relining projects	2025	PL (reline)	52,945,000
Five pipeline relining projects	2030	PL (reline)	39,464,000
Total			**242,746,000**
Expansion of Internal System Capacity and Additional Water Treatment Capacity			
Flow control facility and power supply to Olivenhain Connection	2004	FCF	1,200,000
Expand regional treatment plant capacity	2005	WTP	123,711,000
San Diego 24/25/26	2007	FCF	3,780,000
San Diego 12 expansion	2007	FCF	3,780,000
Increase untreated water capacity			
Mission Trails Flow Regulatory Structure	2007	Res	23,672,000
Tunnel pipeline and demolition of 10 existing vent structures	2007	PL	34,760,000
Reactivate 72-inch pipeline near Miramar WTP	2009	PL	1,911,000
Lower Otay Pump Station	2008	PS	9,217,000
Padre Dam Pump Station Expansion	2009	PS	3,149,000
Poway Pump Station and treated water connection	2010	PS/FCF	2,280,000
Pipeline from Otay WD Flow Control Facility 4 to regulatory reservoir	2013	PL	24,812,000
Restore untreated-water delivery in LMSE to Sweetwater Lake	2014	PL	744,000
Hubbard Hill Flow Regulatory Structure	2015	Res	4,772,000
Slaughterhouse Terminal Reservoir	2015	Res	12,970,000
NCDP Flow Regulatory Structure	2015	Res	6,762,000
Construct new Crossover Pipeline No. 2	2015	PL	102,006,000
Total			**359,526,000**

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Table 7-10. Capital Costs for Alternative 3 Facilities, Supply from the East (continued)

Project	Anticipated Completion Date	Type of Project	Total Project Capital Cost (2001 Dollars)[a]
Additional Seasonal/Carryover Storage and New Conveyance and Supply Projects			
Additional San Vicente Dam Raise (100,000 ac-ft)	2010	Res	189,866,000
Regional Colorado River Conveyance Facility			
Pipeline, pump stations, hydroelectric facilities (300,000 ac-ft)	2015	PL, PS	2,221,904,000
Reverse osmosis treatment plant (118 mgd for 300,000 ac-ft)	2015	WTP	161,590,000
Brine disposal (conveyance from Miramar and Alvarado WTPs, 39 mgd)	2015	PL, PS	141,735,000
Brine disposal (capacity in South Bay International Outfall, 39 mgd)	2015	Other	89,681,000
Crossover WTP (65 mgd)	2015	WTP	97,807,000
Untreated water connection (Pipelines 3, 5, and Crossover)	2015	PL	2,552,000
Treated water connection (Pipeline 4)	2015	PL	851,000
Total			**2,905,986,000**
Total for Alternative 3			**3,508,258,000**

[a] Total project capital costs were calculated as the estimated construction cost, plus contingencies, engineering, environmental, and administration costs added as a percentage. Land acquisition and right-of-way costs were also included, based on a unit cost per acre or per linear foot.

1. ***Rehabilitation of Existing Facilities.*** These are the relining projects that have been developed in the Authority's RRP. For convenience, all of the relining projects within each 5-year planning period have been lumped together. It is anticipated that some variations in these groupings may be required as planning and implementation of the RRP continues.
2. ***Expansion of Internal System Capacity and Additional Water Treatment Capacity Projects.*** These are the *Master Plan* base projects. They are grouped together as they are common to each alternative.
3. ***Additional Seasonal/Carryover Storage and New Conveyance and Supply Projects.*** These are the specific projects for each alternative.

The capital costs shown are for Authority projects only and do not include the costs associated with new Metropolitan projects that are needed to supply or treat the water to make the alternative work. For example, the capital cost of Metropolitan's portion of Pipeline 6 and the capital cost of the Skinner WTP expansion are not included in the tables. The method chosen to account for the Authority's share of Metropolitan's capital costs is in the projection of Metropolitan's rates that are included in the present value tables later in this chapter.

Capital costs include the estimated construction cost plus contingencies, engineering, environmental and administration costs added as a percentage. Land acquisition and right-of-way costs are also included, based on unit costs per acre.

Present Value of Facilities

A present value comparison of alternatives requires that facility construction costs be inflated to the time of construction, that the value of money (discount rate) be considered, and that the useful life of each facility be accounted for in the comparison.

Each facility has been assigned a useful life as follows:

- Pipelines 75 years
- Pump stations 40 years
- Flow regulatory structures 40 years
- Water treatment plants 40 years
- Dams 100 years

Capital costs were presented in the previous section in 2001 dollars **(in Tables 7-8 through 7-10)**. For the present value analysis, an escalation rate of 3 percent was used to inflate the capital cost of each project to the year of construction. In addition, the year 2090 was selected as the planning horizon for the present value analyses, since two of the alternatives consist primarily of a major pipeline project, which is to be constructed in 2015 with a useful life ending in 2090.

Two discount rates were considered. First, a discount rate of 5.5 percent was used, since this is consistent with current Authority financial planning for bond interest rates. The impact of a lower interest rate, where interest is equal to inflation, was then derived as a comparison.

For two groups of projects, the application of the useful life parameter and the calculation of future replacement costs would be identical for all three alternatives and were therefore omitted in the calculation of the present value. The present value of these projects was simply assumed to be the one-time, escalated capital cost brought back to the year 2001. These projects fall into the first two categories in the previous capital cost tables ("Rehabilitation of Existing Facilities" and the "Expansion of Internal System Capacity and Additional Water Treatment Capacity").

Useful life and future replacement costs are not identical for projects in the third group, when comparing the alternatives, and therefore were included in the calculation of present value. Facilities were assumed to be replaced at the end of their useful life as shown in the bullets above. The escalated replacement cost was then brought back to 2001, using each of the two discount rates (3 percent and 5.5 percent). Projects in this group fall into the category labeled "Additional Seasonal/Carryover Storage and New Conveyance and Supply Projects" in the previous capital cost tables.

One additional cost element was included for the alternative-specific projects: repairs. Repairs were valued at 20 percent of the original capital cost. For convenience, the repair costs were assigned as a lump sum at the 20th year of the facility's life.

Table 7-11 lists the present value of the capital costs for each alternative, for each discount rate. The calculations assume a 3 percent inflation rate and include a remaining value for projects whose useful life extends beyond 2090.

Annual Costs

Annual costs of concern are water purchases (or production costs in the case of seawater desalination), pumping energy, wheeling charges, and labor and materials for any facilities that increase personnel needs for the Authority. For convenience, the annual costs were grouped into the following categories:

- IID transfer water purchase
- Payments to Metropolitan
- Annual operating costs

IID Transfer Water Purchase

The only costs included are the payment to IID for conserved water. Costs to convey the water to the Authority's service area are included as either the wheeling charge to Metropolitan (Alternatives 1 and 2) or as Authority annual operating costs (Alternative 3).

The transfer was assumed to begin in the year 2003 at 10,000 ac-ft, ramping up to the full delivery of 200,000 ac-ft in the year 2021 according to the schedule in Chapter 4. The rate for the transfer water was anticipated to be $258 per ac-ft in 2003. This rate is increased by 3 percent per year. The term of the agreement with IID is assumed to be 75 years.

The resulting cost to the Authority is the same for each alternative.

Payments to Metropolitan

Annual payments for treated and untreated water were estimated using a modified Metropolitan rate model. The model was used to estimate the impact on Metropolitan rates of constructing and operating the various facilities needed to serve the Authority under each alternative. For Alternative 1 (Supply from the North), Pipeline 6 and a new 150 mgd WTP were also included in determining the rate out to 2030. Since the rate model contains no projects beyond 2030, the resulting rate in 2030 from the Metropolitan model was escalated at 3 percent per year from 2030 through 2090.

Wheeling charges for the IID transfer water were included in the payment to Metropolitan. This charge was assumed to be $97.50 per ac-ft in 2003 and escalated at 3 percent per year through 2090.

Annual Operating Costs

Annual operating costs include the incremental, direct operating costs for the Authority. Included are:

- Pumping power
- Pumping from carryover storage (all three alternatives)
- Pumping from the desalination plant (Alternative 2)
- Net pumping from the east (Alternative 3)
- Pumping of IID transfer water from San Vicente Reservoir (Alternative 3)
- Operation and maintenance (labor, chemicals, and power) of the desalination plant (Alternative 2)

Table 7-11. Present Value of Capital Costs (in dollars)

Alternative	Discount Rate of 5.5 Percent	Discount Rate of 3.0 Percent
Alternative 1, Supply from the North	671,232,000	1,450,358,000
Alternative 2, Supply from the West	1,500,921,000	3,086,459,000
Alternative 3, Supply from the East	2,799,191,000	5,373,438,000

(a) Including repair, replacement, and depreciated value, for a 2090 planning horizon.

- Operation and maintenance (labor, power, and chemicals) of the Cross-over WTP (Alternative 3)
- Treatment to reduce the TDS of the IID transfer water (Alternative 3 only)
- Annual maintenance of the Regional Colorado Regional Conveyance Facility (Alternative 3)

The annual costs for each alternative were calculated to the year 2090, as was done for the present value of capital costs, to complete the life cycle of the major pipelines. In general, unit costs were escalated at 3 percent per year.

Table 7-12 presents the net present value (NPV) of each category of annual costs for each alternative. These results are for a discount rate of 5.5 percent. Since the analyses include all purchase of water, the payments to Metropolitan dominate the annual cost comparison. The exception is Alternative 3, since the annual operating costs to the Authority are high due to pumping the IID transfer water through the new conveyance facility. The present value comparisons show that Alternatives 1 and 2 are very similar while Alternative 3 (Supply from the East) is significantly more costly.

Table 7-13 presents the NPV of the annual costs for a discount rate of 3 percent. In this case, inflation and interest rate are identical. The relative results among the alternatives are the same as for the 5.5 percent discount rate used in the previous table.

Table 7-12. Net Present Value of Annual Costs for a Discount Rate of 5.5 Percent (in dollars)[(a)]

Alternative	Operation and Maintenance	Metropolitan Payments	ImperiaL Irrigation District Purchase	Total
Alternative 1, Supply from the North	28,857,000	9,160,567,000	1,289,390,000	**10,478,814,000**
Alternative 2, Supply from the West	1,582,537,000	8,074,858,000	1,289,390,000	**10.946,785,000**
Alternative 3, Supply from the East	2,097,415,000	6,956,079,000	1,289,390,000	**10,342,884,000**

(a) For a 2090 planning horizon.

Table 7-13. Net Present Value of Annual Costs for a Discount Rate of 3.0 Percent (in dollars)[(a)]

Alternative	Operation and Maintenance	Metropolitan Payments	ImperiaL Irrigation District Purchase	Total
Alternative 1, Supply from the North	88,524,000	24,138,102,000	3,275,766,000	**27,502,392,000**
Alternative 2, Supply from the West	4,386,536,000	20,888,663,000	3,275,766,000	**28,550,965,000**
Alternative 3, Supply from the East	6,304,811,000	17,385,201,000	3,275,766,000	**26,965,778,000**

(a) For a 2090 planning horizon.

Table 7-14 summarizes the present value comparison for each alternative and includes both capital and annual costs. This table is for a discount rate of 5.5 percent. Again, the total present value is relatively close between Alternatives 1 and 2. Alternative 3 (Supply from the East) is higher than either in this economic comparison.

Table 7-15 summarizes the present value comparison for each alternative for a discount rate of 3.0 percent. Again, the total present value is relatively close for Alternatives 1 and 2.

Table 7-14. Comparison of Present Value Costs for Alternatives 1, 2, and 3 at a 5.5 Percent Discount Rate (in dollars)[(a)]

Alternative	Capital	Operation and Maintenance	Metropolitan Payments	Imperial Irrigation District Purchase	Total
Alternative 1, Supply from the North	671,232,000	28,857,000	9,160,567,000	1,289,390,000	**11,150,047,000**
Alternative 2, Supply from the West	1,500,921,000	1,582,537,000	8,074,858,000	1,289,390,000	**12,447,706,000**
Alternative 3, Supply from the East	2,799,191,000	2,097,415,000	6,956,079,000	1,289,390,000	**13,142,075,000**

(a) For a 2090 planning horizon.

Table 7-15. Comparison of Present Value Costs for Alternatives 1, 2, and 3 (3.0 Percent Discount Rate) (in dollars) [(a)]

Alternative	Capital	Operation and Maintenance	Metropolitan Payments	Imperial Irrigation District Purchase	Total
Alternative 1, Supply from the North	1,450,358,000	88,524,000	24,138,102,000	3,275,766,000	**28,952,750,000**
Alternative 2, Supply from the West	3,086,459,000	4,386,536,000	20,888,663,000	3,275,766,000	**31,637,424,000**
Alternative 3, Supply from the East	5,373,438,000	6,304,811,000	17,385,201,000	3,275,766,000	**32,339,216,000**

(a) For a 2090 planning horizon.

Comparison Summary

The reliability and economic analyses from the previous sections are carried forward in this section and combined with five additional qualitative evaluation criteria. Each of the alternatives was compared qualitatively based on seven criteria as shown in **Table 7-16**.

The net present value and reliability comparisons are based on the evaluations summarized earlier in this chapter. Generally speaking, present value analyses showed that Alternatives 1 and 2 would be very similar, and Alternative 3 would be significantly higher. With regard to reliability, Alternative 2 is better than Alternatives 1 and 3.

The online date criterion reflects the date the new supply alternative and associated conveyance could be completed. It is anticipated that Alternative 1, Supply from the North would be online by 2015. Alternative 3, Supply from the East, has the potential to be online by 2015, but there are significant issues beyond the normal control of the Authority that need to be taken into account, such as the response of the other six Colorado River Basin States to the concept of a second conveyance from the Colorado River to urban Southern California. The potential for Issues like this to require a substantial amount of time to find resolution will make it unlikely that the Alternative 3 facilities could be in operation by 2015. Alternative 2, Supply from the West, would be online by 2010. Both Alternatives 1 and 2 are ranked equally in the table, since the schedule for either can meet the needed online date of 2015. The unresolved issues regarding Alternative 3 is the reason it is ranked lower in the table.

The new supply criterion measures the potential of the alternative to provide a new Authority supply and the facilities needed to convey that supply. Alternative 2 provides the only real new supply to the Authority and is therefore ranked as the best alternative. However, Alternative 3 also provides some potential for new supply since more delivery capacity results without having to parallel portions of Metropolitan's system, and it comes from an independent source. It is ranked lower than Alternative 2, but higher than Alternative 1.

The evaluation of the permitting criterion is based on the stage the project is in with respect to the CEQA process. Alternative 1, Supply from the North, has a certified EIR for Pipeline 6, but the EIR will require some revisions. The other two alternatives have not yet begun the EIR permitting process. In addition, it is anticipated the EIR process for Alternative 3, Supply from the East, will be significantly more difficult and require more time to complete than Alternative 2, Supply from the West.

The potential for outside funding criterion measures the alternative's potential to obtain external funding and reduce Authority expenditures. It is anticipated that Alternative 2 offers the best potential for outside funding, because it provides a new supply to California and assists in reducing the demand on the Colorado River and the Sacramento-San Joaquin Delta. At a minimum, the desalination plant has been identified by Metropolitan as a good candidate for funding under their desalination program. It is anticipated some external funding may be available for Alternative 3, because it provides a supply to a critical border area.

The criterion, "Improvement of Water Quality," measures the alternative's ability to provide a better overall water quality than existing supplies. With the exception of chlorides, the water quality supplied by Alternative 2 will be better than the existing supplies. The supplies from the north (Alternative 1) and east (Alternative 3, which includes TDS reduction) would provide the same water quality as the existing supplies.

The potential to phase the implementation of an alternative is also considered as a criterion. The ability to phase a project could result in steadier rate increases and overall project flexibility to changes in planning assumptions.

Based upon all the factors considered, Alternative 2, Supply from the West, appears to provide more advantages to the Authority, while still being fairly cost competitive with Alternative 1, Supply from the North, which is the least costly for the set of assumptions used in our economic comparisons.

Table 7-16. Comparison Summary of Alternatives 1, 2, and 3 – Net Present Value, Reliability, and Qualitative Criteria

Alternative	Net Present Value (billions of dollars)	Online Date	New Supply	Reliability	Permitting	Potential for Outside Funding	Improve Water Quality	Potential for Phasing
North	$28.95	◉	○	◓	◉	○	○	○
West	$31.64	◉	◉	◉	◓	◉	◉	◉
East	$32.34	○	◓	◓	○	◓	○	○

○ = Sufficient ◓ = Better ◉ = Best

8 Conclusions and Recommendations

The purpose of the *Regional Water Facilities Master Plan* is to evaluate the ability of the Authority to continue to meet its mission based on current plans for water supply and facility improvements, and to recommend new facilities or improvements to existing facilities needed to meet the Authority's mission through 2030. The *Master Plan* is intended to function as the roadmap for implementing the major capital improvements the Authority needs to serve projected water demands.

This *Master Plan* has reviewed both treated and untreated projected demands of the region and analyzed different alternatives to convey supplies to meet customer demands. The results in Chapter 5 and Chapter 7 are the basis for the recommendations of future facility needs. The focus of Chapter 5 is an analysis of the reliability of a baseline system, which assumes the use of existing facilities and the completion of the 2002-03 Capital Improvement Program. This analysis demonstrated that additional facilities should be constructed to meet reasonable expectations of reliability, both in the short term (between now and year 2010) and over the long term, 2015 and beyond. Chapters 5 and 7 provide a detailed discussion of the needs for these facilities.

The most important conclusion reached by this plan is that the Authority should aggressively pursue the West alternative (seawater desalination) for a major portion of the Authority's supply portfolio. Seawater desalination provides many benefits, including the provision of a new supply with price certainty, new treatment capacity, and enhanced water quality. The other two alternatives reviewed (the North and East alternatives) offered relatively reduced levels of reliability, largely because neither provides a comparable independent water supply as reliable as seawater desalination. Benefits offered by the recommended seawater desalination alternative include:

- A regional seawater desalination plant provides a new regional supply source.
- The seawater desalination process produces treated water.
- With seawater desalination plants, the ocean effectively becomes a storage reservoir.
- The Pacific Ocean is a supply for which the region does not have to compete.
- The supply is always available and not subject to hydrologic cycles.
- The costs for desalinated seawater are more certain than the cost of new imported water supplies.
- The main cost uncertainty for seawater desalination is the cost of electric-

ity; however, cost variations in electricity are as likely to impact the cost of new imported supplies as seawater desalination.

- Additional advances in technology are likely to continue to push the future cost of seawater desalination downward in the same way that technology advances have caused a significant decline in unit costs over the last ten years, thereby providing less upside cost risk.
- Diversification of supply sources, similar to diversification of investments, guard against exposure to unknown and undefined future risks.

Meeting Reliability Needs

One of the major goals of the master planning process is to achieve region-wide agreement on what it means for the Authority to provide a reliable water supply. Decisions regarding reliability must encompass both near-term strategies for matters that are fairly well understood, such as the need to develop additional regional water treatment capacity, and long-term strategies that of necessity must use information that is less well understood, such as the total water demand that will actually occur in 2030. By their nature, long-term forecasts cannot precisely predict the future. But long-range analysis, as used in this plan, is useful for comparing alternatives for measures of reliability in light of varying uncertainties in the future and a quantification of the risk associated with those uncertainties.

Each of the three alternatives considered in this plan were analyzed for reliability of service. An underlying fundamental principle in the development of this plan is the acknowledgement that diversification of supply sources is a positive approach for improving reliability. The alternative with the highest apparent degree of reliability, seawater desalination, is recommended for use as the starting point for discussing a standard of reliability for the Authority.

Establishment of a reliability standard should be based upon an analysis that includes the frequency, magnitude, and duration of estimated delivery shortages within a projected range of weather and demographic variability. As stated in previous chapters, when taking into account varying levels of uncertainty in both weather and demographics it is important to understand that a prudent standard for reliability should not seek to address potential conditions that have extremely low probabilities of occurrence, as that is not a cost-effective approach to long term facilities planning. Neither should the reliability measurement be constrained to measuring a single variable, such as weather. The recommended alternative provides a capital investment strategy that is commensurate with a realistic assessment of both the short-term and long-term risks of not meeting member agency demands.

The recommended alternative also preserves the Authority's ability to respond to changed conditions in the long term without making investments in the near term that may prove unwarranted. A reasonable timeframe to consider in making future adjustments to the recommended alternative is the first 15 years of the 30-year planning horizon. This allows the Authority to make adjustments to its facilities and water supply plans to accommodate the changing conditions..

Recommendations for Near-Term Actions to Maintain and Enhance Reliability

A review of near-term needs to improve reliability results in the following recommendations:

- Addition of facilities to connect to existing treatment plants with available peak capacity

- Addition of 50-100 million gallons per day (mgd) of treatment capacity within the region
- Constructing a minimum 50 mgd seawater desalination plant in Carlsbad by Year 2010, including the pump stations and pipelines sized for 100 mgd plant capacity to convey the water to the Authority's Second Aqueduct
- Completing the highest priority replacement/relining projects
- Constructing the Second Aqueduct untreated water flow regulatory structure project at Mission Trails
- Constructing other internal system projects needed to increase delivery capacity and operational efficiency
- Addition of 100,000 acre-feet of carryover storage by 2010

The additional treatment capacity is the highest priority for maintaining regional water delivery reliability. The additional treatment can be met in a variety of ways. Of the 50-100 mgd of capacity needed by 2010, approximately 50 mgd of this will be needed by 2006. Expanding existing member agency water treatment plants, construction of a new regional plant, or a combination of the two, can provide this 50 mgd. A first phase of a seawater desalination plant in Carlsbad could provide the remaining 50 mgd of treatment capacity needed, and can be online prior to year 2010. Recent action by the Authority's Board has authorized solicitation of design-build-operate (DBO) proposals from public and private entities to provide some or all of this additional treatment capacity for ownership by the Authority.

There are other initiatives, including demand-side management, which can be undertaken or continued in addition to the structural/facility solutions discussed in the preceding paragraph to help with the treated water capacity issues:

- Continued close coordination between MWD, Authority and member agency operation staffs to maximize the efficient use of treatment capacity and minimize simultaneous peaking
- Continued extensive public outreach concerning the need for conservation
- Developing an incentive program to encourage large treated water users to reduce peak water demand during high regional demand periods

These demand-side management actions should be considered in conjunction with the structural/facility solutions, not viewed as an alternative to these solutions.

Recommendations for Long-Term Actions to Maintain and Enhance Reliability

Analysis of the region's long-term reliability focused chiefly on the projected availability of future water supplies and the diversification of the Authority's water supply portfolio. Long-term projections used in the analysis of reliability are intended as a planning exercise to make informed judgments and decisions about potential resources alternatives. The West alternative, featuring large-scale seawater desalination, was found to offer a significant improvement in reliability at a relatively slight additional cost (approximately seven percent higher in present value costs than the least costly North alternative). This option also improves the diversification of Authority water sources by introducing a new supply that is independent of the Authority's current source of imported water.

The recommended seawater desalination plant(s) must complete the environmental permitting process before design and construction can go forward. Until the environmental permitting process on the first phase of seawater desalination is completed, there is some level of uncertainty today as to what extent and what volume seawater desalination can be implemented. While it is not believed that the level of uncertainty over the feasibility of seawater desalination is as great as that for other new water supplies, it would be prudent to proceed cautiously with this alternative until the environmental review and permitting process nears completion. Therefore, it is important that all three alternatives remain in the analysis during the environmental review and permitting period. The alternatives are not mutually exclusive and combinations of the alternatives may be needed in the future. For example if there is a limitation on seawater desalination that is not seen today, Pipeline 6 may need to be built sooner than the 2030 planning horizon, if some additional certainty develops over new imported water supplies.

Reliability Standards for Planning Purposes

As stated in Chapter 1, there is a need to establish a set of reliability standards for the Authority. One of the major goals of the master planning process is to achieve region-wide agreement on what it means for the Authority to provide a reliable water supply.

Each of the three alternatives were analyzed for their reliability of service, and it is proposed that the estimated reliability of the best apparent alternative, Seawater Desalination, be used as the starting point for the discussion of reliability standards.

One of the major benefits of Alternative 2 is its scalability. That is, it can be adjusted in size to meet whatever levels of reliability may be determined to be appropriate. The current recommendation is to implement an initial 50 mgd desalination facility, with a second phase of an additional 30 mgd. This second phase can be increased in size, and additional phases can be added by investigating other potential seawater desalination sites.

The reliability standards should establish the frequency, magnitude, and duration of estimated delivery shortages within the projected range of weather and demographic variability.

The seawater desalination alternative provides the estimated level of reliability shown in **Table 8-1** in the years 2005, 2015 and 2020. As indicated, the probability of some level of shortage during elevated demand conditions will remain high through 2007 due to insufficient treatment capacity. This produces a lower level of reliability in 2005 than in 2015, after a number of treatment plant expansions are completed.

Recent Changes to SANDAG Forecasts

As this draft of the *Master Plan* was being prepared for release, SANDAG released revisions to its region-wide population forecast. The revised forecast projects a slower rate of population growth than the previous forecast, with the previous estimate for the 2020 population being roughly equal to the revised 2030 population estimate. At this point, it is difficult to assess the impact of this change, as population is only one of several drivers of future demand projections. For this reason, it will be necessary to evaluate any new forecast information from SANDAG to determine whether it will be necessary to revise the current water demand projections to take into account the revised SANDAG growth forecast.

Power Supplies

During the preparation of this *Master Plan* study, the availability and cost of electricity and natural gas to the San Diego region became a significant issue. The Authority has been involved in discussions seeking solutions to this complex issue. Currently there are no recommendations for the Authority to increase its role in energy production beyond the already-approved

Table 8-1
Estimated Annual Reliability for the Best Apparent Alternative – Seawater Desalination

Frequency of Shortage[(a)]	Magnitude of Yearly Shortage (acre-feet)
2005	
93.8	100
97.1	1,000
97.8	10,000
98.3	25,000
99.8	75,000
2015	
97.8	100
98.2	1,000
99.0	10,000
99.6	25,000
99.97	75,000
2020	
93.2	100
94.0	1,000
97.0	10,000
99.1	25,000
99.7	75,000

[(a)] Expressed as the probability that the shortage will not exceed the indicated magnitude.

hydroelectric projects. A regional energy office has been established to work with the various public agencies and private companies to grapple with the region's energy needs, and a regional energy study is being prepared to address these issues. The Authority has co-funded this study along with other regional entities.

Energy availability and cost are important factors for operating seawater desalination plants. These costs have been incorporated into the projected cost of the seawater desalination alternative. Regional energy issues will continue to be monitored closely for potential impacts to the implementation of this alternative.

Financial Impacts

There are options available to the region to build facilities to meet 100 percent of any demands in the future. However, the cost of some of these options may be cost prohibitive. The approach used for the *Master Plan* has been to schedule construction of facilities as demands dictate. This allows phasing of projects to minimize increases in water rates by spreading expenditures over a longer period of time.

Finite financial resources require prioritizing projects to first invest in those projects that provide the greatest increase in reliability for the least cost. Additional financial analyses and rate modeling will be needed further refine the prioritizing and scheduling of the various proposed projects, and to support adoption of a final *Master Plan* and a preferred alternative in the Program EIR.

Policy Issues

As discussed in Chapter 1, there are potential policy issues that the *Master Plan* study raises that will require discussion and resolution by the Board of Directors prior to certifying a Programmatic Environmental Impact Report (PEIR) and approving the final *Master Plan.* These include:

- Establishing a planning standard for reliability
- Establishing an operating standard for reliability
- Determining whether changes should be made to operational levels of service to member agencies for water deliveries and what policies or pricing structures should be established to manage those water deliveries.
- Establishing an annexation policy regarding lands generally beyond the existing boundaries of the Authority's member agencies (i.e., not considered "in-fill")
- Establishing a policy for serving demands of entities outside of the Authority's boundaries
- Establishing a policy regarding service to member agencies that do not complete capital improvements according to schedules upon which the Authority has relied for planning regional facilities

Final decisions about the size, location, and types of facilities will be affected by decisions the Board makes. The *Master Plan* report outlines a roadmap for facility development for the future, allowing for the flexibility to respond to changing circumstances, while maintaining and enhancing water reliability for the region, meeting the Authority's mission.

Summary of Recommendations

A summary of the *Master Plan* recommendations for facilities and policies is given below.

Facilities

Rehabilitation of Existing Facilities

- These projects are the replacement and relining projects needed to rehabilitate the existing Authority pipelines. These projects are described in Chapter 6 of the report. The schedule for relining is being further refined as part of the Replacement and Relining PCCP project.

Internal System Improvements

- The recommended internal system improvement projects are described in Chapter 7. These projects provide additional operating flexibility and capacity to the existing Authority system. Further discussion with the member agencies affected by these facilities is required. For instance, the Mission Trails Flow Regulatory Structure and Mission Trails Tunnel are required to provide additional untreated-water conveyance capacity to the existing reservoirs and water treatment plants south of Lake Miramar. Currently the Authority does not provide 100 percent of water treatment capacity to all the plants simultaneously. The agencies that own these plants supply some water from local storage to meet the needs of the plants. The *Master Plan* analysis did not provide this level of conveyance capacity. Further discussions with the treatment agencies is required to determine if a higher level of delivery capacity will be needed in the future.

Increase Regional Water Treatment Capacity

- As stated earlier in this section, this is the highest priority for maintaining regional water delivery reliability. The Authority Board of Directors recently adopted new policies allowing the Authority to be more involved in the treatment business. The Authority in conjunction with Metropolitan and Member Agency treatment capacity will provide for sufficient capacity in the region. The Authority's approach will be to review the possibility of meeting the future treatment capacity need with connections to existing member agency facilities, expansion of existing member agency owned water treatment plants, and construction of an Authority owned plant. These options individually or in combination will be investigated in studies subsequent to the *Master Plan*. Additional meetings with the Authority member agencies will be held once options to meet the treated water capacity need are analyzed.

Addition of 100,000 acre-feet of Carryover Storage

- Carryover storage provides a number of benefits described in Chapter 6. A specific environmental impact report will be prepared for this potential facility and will analyze alternatives for locating this storage.

Seawater Desalination

- The Board of Directors has authorized Authority staff to investigate the development of 50 million gallons a day of seawater desalination capacity at the Encina power plant site in Carlsbad. The Board has also directed staff to investigate additional development of seawater desalination at other sites along the San Diego County coastline. The *Master Plan* recommendation calls for the implementation of seawater desalination to meet demands in the future. This is based on the assumption that seawater desalination will be permitted and that operating costs are in the range currently projected. If seawater desalination is not as viable as assumed today, the Authority Board of Directors has committed to the Pipeline 6 project. This pipeline could be built sooner if additional supplies are needed beyond the full implementation of seawater desalination.

The *Master Plan* has not attempted to describe every project in detail but rather describe the types of projects needed to meet the needs of the region in the future. There are follow-on studies in the permitting and EIR stages for each of these projects to further define them. The Master Plan is the first step in determining the facilities needed to provide a reliable supply of water to San Diego County.

Policies

- Establish a planning standard for reliability consistent with the results indicated in Table 8-1, which are equivalent to the estimated reliability expected from implementing Alternative 2, Seawater Desalination.
- Direct staff to continue to explore methods of managing water deliveries through peak demand management policies and pricing structures

that provide a facilities benefit to the Authority.

- Establish a policy that no allowance for additional annexations will be included in any water supply or facility planning, other than for infill within the current general boundaries of the Authority.
- Establish a policy that the Authority will not plan for the facilities needed to serve water outside of its boundaries unless the entity being served pays the full cost for the use of existing Authority facilities and the construction of any new facilities that may be required.
- Establish a policy that member agencies shall be served on a capacity available basis when such agencies: 1) fail to place into operation facilities assumed to be in place by the Authority according to the schedules indicated in the member agencies' facilities plans or have otherwise provided information to the Authority regarding their plans, and 2) at any time request service from the Authority which would have otherwise been unnecessary had their planned facilities been in operation.