Storm Water Panel Report
Deadline: 9/1/06 5pm

Kirk J. Thomson
Director
Environmental Affairs

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September 1, 2006

Ms. Song Her, Clerk to the Board
State Water Resources Control Board
P.O. Box 100
Sacramento, California 95812-0100

BOEING

Re. Additional Comments from The Boeing Company on the Storm Water Panel Experts Report – **"The Feasibility of Numeric Effluent Limits Applicable to Storm Water Discharges"**

Dear Members of the State Board:

The Boeing Company appreciates the opportunity to submit these additional comments on the recommendations contained in the Storm Water Panel's report to improve the National Pollutant Discharge Elimination System Storm Water program. Boeing has facilities throughout California and other states that are covered by the General Industrial Permit or by individual NPDES permits. We are committed to effective and responsible management of storm water discharges from our facilities

Boeing has implemented many best management practices (BMPs) and other storm water control measures, resulting in collection of a large quantity of data in support of these efforts. We believe that these data, and the collective experience we have with storm water compliance, will provide valuable information to the State Board in determining the feasibility of setting and achieving compliance with numeric limits for storm water discharges.

In particular, we believe this information is responsive to three specific requests for information by Board Member Dr. Gary Wolff, as follows:

1. Dr Wolff requested input on what is feasible versus what is infeasible for particular settings or parameters.

2. Dr Wolff asked what is feasible versus infeasible in terms of cost, ability to comply, and other issues associated with implementing/managing the program, and why individual dischargers "view things the way they do," and

3. Dr Wolff asked speakers to address/describe alternatives, including addressing their preferred approaches to storm water regulation, with discussion of why those approaches are superior to the alternatives.

In response to Dr. Wolff's first information request Boeing's data analysis suggests that it is infeasible to determine appropriate water quality based effluent limits (WQBELs). The underlying problem is the high variability of flows and durations associated with typical maritime weather patterns of California. Boeing has also pursuant to Dr Wolff's second information request, examined alternatives storm water management techniques that might achieve WQBELs.

These techniques were found to be very costly, require large amounts of space and involved the use of chemicals that might themselves be considered pollutants. Thus, Boeing's response to Dr. Wolff's third question is that employing Iterative Best Management Practices using benchmarks and action levels to constantly improve performance is the only feasible approach to controlling storm water discharges at this time.

BOEING

Boeing recognizes that controls on storm water discharges are necessary to improve receiving water quality during wet weather events, but the complexity of the data, as discussed in the enclosed document, indicates that development of Technology-Based Effluent Limits (TBELs) and/or WQBELs would be a lengthy, data-intensive process that would require development of appropriate new methodologies. In any case, Boeing believes that it is imperative that dischargers be able to meet whatever criteria are established and to do so in a cost-effective manner. Boeing is also concerned that the environmental impacts of the control measures required for compliance with numeric limits could be excessive, potentially resulting in significant hydromodification, energy and waste disposal requirements, and construction and habitat impacts. These factors need to be considered in setting any standards.

The enclosed document sets forth our detailed comments in response to Dr. Wolff's requests for information.

We look forward to working with the State Board in evaluating options for improving storm water quality. Should you have any questions concerning these comments, please contact Paul Costa, Environmental Services Manager, at (818) 466-8778.

Sincerely,

Kirk J. Thomson
Director, Environmental Affairs
The Boeing Company

Enclosure

COMMENTS OF THE BOEING COMPANY ON THE STATE BOARD'S STORM WATER PANEL OF EXPERTS REPORT

"THE FEASIBILITY OF NUMERIC EFFLUENT LIMITS APPLICABLE TO STORM WATER DISCHARGES"

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3. Dr. Wolff asked speakers to address/describe alternatives, including addressing their preferred approaches to storm water regulation, with discussion of why those approaches are superior to the alternatives.

Over 10 years of monitoring data have been collected as required by Boeing's NPDES permit and Boeing has implemented numerous structural and non-structural BMPs in order to meet numeric discharge limits in its permit at its Santa Susana Field Laboratory (SSFL) facility. Our findings from these efforts and our investigations provide information as requested by Dr. Wolff and are presented below:

As shown in Figure 1, below, and consistent with testimony to the State Board, there are four basic options for regulation of storm flow water quality, as follows:

- Iterative BMPs
- Iterative BMPs with Action Levels (ALs)
- Technology-Based Effluent Limits (TBELs) and
- Water Quality Based Effluent Limits (WQBELs)

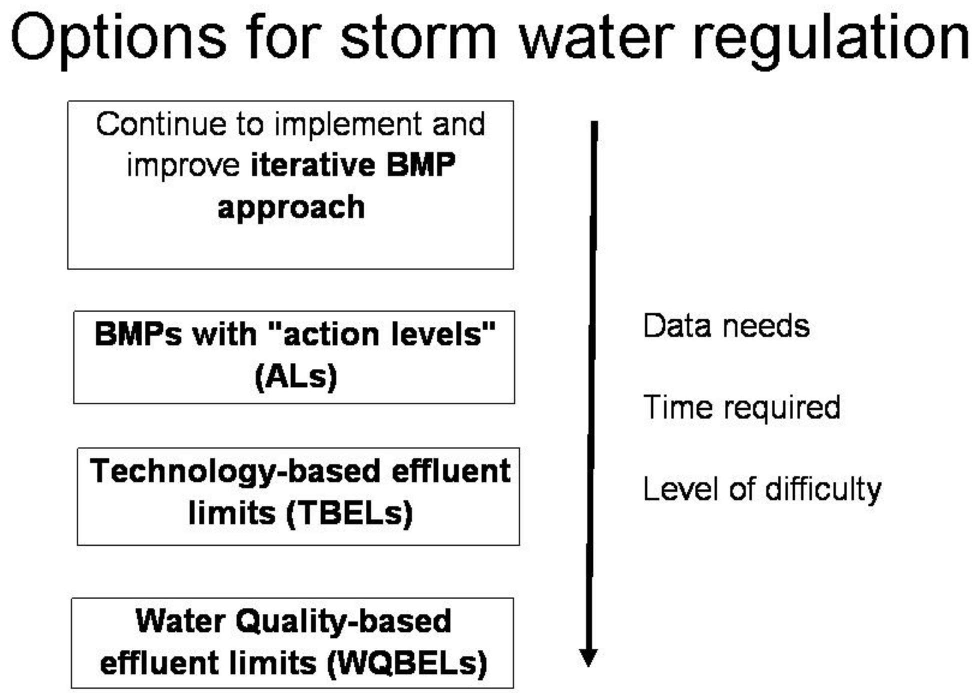


Figure 1: Options for Stormwater Regulation

Permits issued in California to Boeing facilities have employed both an iterative BMP approach (general permit) and WQBELs (individual permit). Thus, our comments focus on these two options.

We believe that one reason there is so much concern regarding the issue of numeric limits is that such limits have been developed and issued by Regional Boards, even in the absence of policy or guidance from the State Board. For example, many permits in the Los Angeles Region contain WQBELs for storm flows that have been calculated using the provisions of the State Implementation Policy (Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California, 2000, revised 2005; also known as the "SIP"). The permit limits developed using the SIP effluent limit derivation procedures, such as those applied to storm water discharges from Boeing's SSFL facility, are almost identical to water quality objectives, and have been applied end-of-pipe as never-to-be-exceeded limits. The procedures contained in the SIP for the development of effluent limits are intended to be applied to steady-state, relatively constant flows, such as discharges from POTWs (publicly owned treatment works) (see SIP at p. 7 et seq.). Because the volumes, flow rates, and constituent concentrations of storm flows are far more variable than for steady-state discharges, the procedures contained in the SIP are generally inappropriate for storm flows.

The variability of storm flows is caused by a number of factors. First, and especially in the arid southwest, storm flows are highly variable in volume, flow rate, and water quality. Storm flow water quality is a complex function of watershed size, slope, soils, vegetation types, rainfall (storm size and intensity), antecedent conditions (a function of the time since last rainfall), and climate. Most of the available data on storm flow quality, both from individual sites and in receiving waters, are in the form of single grab samples for a relatively limited handful of constituents. Thus, it has not been possible to date to develop relationships between these parameters that can be used to predict or explain the full range of variability observed in storm flows. Without such information it is difficult to design measures to control storm water runoff and it is even more difficult to predict how successful such control measures will be in achieving compliance with standards under all storm conditions.

Although they are in the form of grab samples, Boeing has collected a substantial dataset during storm flow conditions from the Santa Susana Field Laboratory. Dr. Gary Lorden, a professor of mathematics at the California Institute of Technology, has reviewed these data to evaluate the statistical approaches that could be used to derive scientifically appropriate numeric limits for storm flows. Dr. Lorden's statistical evaluation of these data (see Attachment A) and a comparison of Boeing's data to other, typical storm flow data demonstrates several key points:

(1) Properly developed WQBELs must consider the probability distribution that storm flow water quality concentrations and mass loadings will fit. Effluent limits that are derived assuming that storm flow data are log-normally distributed are almost certain to be violated, as the distribution described by storm flow data can best be characterized as "heavy-tailed" or as an "extreme value distribution." This means that the highest values in a dataset are far higher than the highest values that would be expected for log-normally distributed data. Comparison of Boeing's data with data from other land use types within the Los Angeles Region, and with constituent concentrations in receiving waters during storm conditions, demonstrates that this variability is not unique to Boeing's site but rather is typical of storm flow conditions within this Region (see Attachment B).

(2) A key concern in the use of available data to set limits is that any dataset will be limited in its ability to describe extreme events, because, by their very nature, extreme events are relatively infrequent occurrences. Extreme events may include unusually large precipitation events, very high rainfall intensities, and changed site conditions, such as fires. If not captured in the dataset upon which numeric limits are based, subsequent extreme events have the potential to result in exceedances of those limits. Thus, any process for establishing numeric limits must address the issue of whether and to what extent extreme events should be regulated. The potential for the occurrence of extreme events also means that large quantities of data, over long periods of time, are required to characterize the full range of expected storm flows and constituent concentrations. Attachment C provides an example of the effects that may be caused by one type of extreme event, wildland fires, showing before and after water quality constituent concentrations for copper, dioxin, and lead at Boeing's Santa Susana Field Laboratory, and demonstrating that the effects of extreme events may persist for long time periods following the precipitating event. Attachment C also provides a comparison of storm water constituent concentrations in flows from the SSFL and in flows from other southern California watersheds that burned during the same fire season. These data demonstrate, again, that fire effects and the variability in storm flow constituent concentrations following fires are typical of the southern California region.

(3) As calculated using the SIP procedures, a WQBEL inherently assumes that exceedances of that limit will occur. In fact, SIP effluent limits are designed to compare measured effluent data to an "acceptable" data distribution. For example, effluent limits calculated using the SIP assume that limits will not be exceeded more than 5% of the time (for chronic limits) or 1% of the time (for acute limits). Although the SIP calculation procedures are designed for steady state flow conditions, the same principles apply to storm flows, which exhibit far more variability than steady state flows. For example, for storm flows, a "design storm" or "design hydrologic condition" would additionally define some probability of exceedance in excess of the frequency of exceedance described above. Properly calculated numeric effluent limits must be developed to allow some clearly-defined frequency of exceedance.

(4) To characterize the probability distribution of storm flows for use in calculating effluent limits will require a large amount of data within any given watershed. For example, Dr. Lorden has calculated that 181 discrete data points for each water quality constituent would be required to determine with 95% confidence whether any specified numerical effluent limit is at the 99^{th} percentile of the data distribution (and therefore is exceeded less than 1% of the time) or at the 95^{th} percentile (therefore exceeded more than 5% of the time).

Considerations in application of BMPs. In addition to data on storm flow constituent concentrations, Boeing has collected data on the concentrations of naturally-occurring constituents in BMP and erosion control materials used at its facilities. Boeing has observed that materials considered for use in structural BMP filtration systems would leach regulated constituents at concentrations that may exceed water quality objectives. Attachment D provides information on concentrations of constituents found in water exposed to various BMP materials considered for use at the site. Sands and gravels were from virgin borrow sources, while hydromulch samples are representative of commercially available hydromulch products. These results further suggest that BMP and erosion control materials themselves may contribute to concentrations of constituents of concern in storm flows, and that careful selection of BMP materials will be important if very low numeric limits such as those in the SSFL permit are to be met consistently. Boeing is willing to provide details on these tests to the State Board, and to assist the State Board in developing a program or database for use by the regulated community statewide to amass relevant information on which BMP and erosion control materials can be selected to be "cleanest" with respect to key constituents. Note that the same considerations will apply to the development of TBELs.

Evaluation of what would be required to achieve strict compliance with WQBELs. Finally, Boeing has been attempting to comply with the WQBELs in its permit for storm water only and storm water dominated discharges for several years and, as such, has installed numerous BMPs and routinely upgraded them. However, despite these efforts Boeing has measured exceedances of WQBELs during this process. Boeing has performed a conceptual evaluation to determine what would be required to meet the current WQBELs under all but the most extreme conditions.

Such considerations are very site-specific. For example, at Boeing's Santa Susana facility, infiltration is not broadly feasible due to concerns with groundwater contamination. Similarly, site slopes and outcropping bedrock make widespread use of wetlands or vegetated BMPs problematic as sole solutions. While BMPs can and do significantly improve water quality, new structural BMPs and non-structural BMP approaches simply do not have sufficient performance data to <u>guarantee</u> their ability to achieve WQBELs at all times and under all conditions, as was stated in the blue ribbon panel's report to the State.

Boeing has determined that containment and treatment measures may be required to achieve compliance with current WQBELs. Boeing's permit contains limits that must be met under all storm conditions, but we do not believe that this is an appropriate standard. We have conducted an analysis of a 10-year 24-hour storm to illustrate what may be required to comply with the permit under such conditions. To have confidence that a 10-year 24-hour storm can be appropriately retained and treated to meet such WQBELs, we have selected necessary retention structures to capture that 10-year 24-hour storm volume with conventional water treatment systems sized to treat that volume within 7 days. Attachment **E** shows the conceptual designs, potential impacts, and estimated costs for such retention and treatment systems.

To capture the 10-year 24-hour storm as predicted with a site-specific hydrology model at three representative regulated outfalls, the following table shows the dams that would be required and the area that would be temporarily inundated during storms due to the construction of the dams.

Detention Dam Characteristic	Outfall 1	Outfall 9	Outfall 11
Tributary Watershed Area (acres)	603	569	300
Maximum Height (ft)	53	98	36
Embankment Volume (cy)	16,000	55,000	14,000
Storage Capacity 3 ft Below Dam Crest (ac-ft)	277	261	138
Storage Capacity at Dam Crest (ac-ft)	330	290	210
Length of Outlet Pipe (ft)	80	120	60
Area of full reservoir (acres)	15.7	12.1	16.5

Note that capturing and treating the 10-year 24-hour storm would not guarantee compliance 100% of the time. There will occasionally be larger storms which can overflow the retention structure. Also, several consecutive storms occurring in a short time period, although each storm may be smaller in volume than the 10-year 24-hour storm, have the potential to overflow a retention structure designed for the 10-year 24-hour storm.

Substantial impacts would be associated with building and maintaining the structures and water treatment systems described in the table above. These impacts include:

- Jurisdictional dams would be required at each outfall, per the criteria established by the State Division of Safety of Dams. Jurisdictional dams require state permits, regular inspections, and must satisfy strict design and construction criteria due to the hazards they present to downstream areas.

- Extensive flooded areas would be created at each detention pond, including riparian areas. Maximum reservoir pool areas are 15.7 acres, 12.1 acres and 16.5 acres for Outfalls 1, 9 and 11, respectively. This could have adverse impacts on local environmental resources, which include threatened and endangered species.

- The required water treatment processes would generate sludge, creating permanent disposal requirements.

- Major construction projects (dams and water treatment plants) would occur in and adjacent to natural channels, creating risks of adverse environmental impacts during construction.

- Building and operating dams and treatment works would result in significant hydromodification, which could potentially have adverse impacts on downstream channel conditions and water quality due to changes in stream flow and velocity profiles created by the hydromodification.

- Construction of dams, treatment works and new or relocated access roads would require significant temporary land disturbance due to grading and construction, and permanent land disturbance associated with new facilities. Land disturbance would occur in currently undisturbed areas, and would increase the potential for erosion until revegetation could occur. These potential impacts for each outfall are summarized in the following table

Type of Land Disturbance	**Outfall 1**	**Outfall 9**	**Outfall 11**
Grading (cy)	45,000	33,000	28,000
Temporary Construction Disturbance (acres)	17	18	17
Permanent Land Disturbance (acres)*	18.3	14.7	19.1
* Includes inundated area, footprints of dam, water treatment works, access roads.			

At this point, these are no more than conceptual plans and very preliminary costs for these storage and treatment options have been estimated below. Actual costs could vary significantly.

Component	**Outfall 1**	**Outfall 9**	**Outfall 11**
Capital Costs CEQA & Permitting	$500,000	$500,000	$500,000
Detention Dam	$3,000,000	$10,400,000	$2,700,000
Treatment Plant	$21,000,000	$20,000,000	$11,000,000
Ancillary Facilities	$627,000	$873,000	$368,000
Total Capital	***$25,100,000***	***$31,800,000***	***$14,600,000***
Annual O&M Costs Detention Dam	$15,000	$52,000	$14,000
Treatment Plant	$260,000	$240,000	$150,000
Ancillary Facilities	$12,000	$18,000	$6,000
Total Annual O&M	***$287,000***	***$310,000***	***$170,000***

Finally, the time needed to plan, permit, design, and construct the retention structures necessary to capture the 10-year 24-hour storm and treat the water to meet WQBELs is on the order of years. The State Department of Safety of Dams has not permitted a new dam structure in the state in many years. Obtaining a permit from them has a high probability of failure. The Army Corps of Engineers and Regional Water Quality Control Board are quite likely to require substantial mitigation under Sections 404 and 401 of the

Clean Water Act, due to the changes in the riparian areas caused by construction of these dams. Negotiating and planning the nature of these mitigation efforts has been known to take years with these agencies. Further, the California Department of Fish and Game will require a Section 1601 streambed alteration agreement, which due to the substantial modification to the streambed and upstream and downstream habitat, may also take years to accomplish. Finally, simply constructing such structures in a remote environment like the SSFL can be expected to be a multi-year project. Lastly, due to the adverse environmental impacts, it is likely that one or more Environmental Impact Reports would be required.

As noted in the expert panel report, the ability of BMPs to produce an effluent of consistent quality, at a variety of different locations, and under all conditions, is unproven. Boeing's experience is consistent with this finding, in that storm water effluent from Boeing's facilities occasionally exceeds current WQBELs, despite an extensive network of BMPs and erosion control measures. Hence, it appears that immediate compliance with current WQBELs (established as they have been by various RWQCBs, based on the CTR water quality objectives assuming a log-normal distribution of concentrations in storm water discharges) is not feasible with the BMP technologies currently available. Even using technologies that the engineering community has historically used to capture and treat water to the levels represented by the current methods used to set WQBELs, such projects can easily take many years to complete because of the environmental impacts, the permitting required, and the time it takes to construct major civil works.

Additional Considerations. Compliance with SIP-based limits for metals in storm water discharges has been especially problematic at SSFL. Sabin et al. (2004) reported data that demonstrate that metals fluxes from atmospheric deposition are a significant source, and perhaps the dominant source, of metals in storm flows. For example, Sabin et al. (2004) found that approximately 16,000 kg/yr of copper were transmitted to the Los Angeles River watershed via atmospheric deposition during the period of August 2002 - June 2003. During the same time period, they found that about 3,000 kg/yr of copper were transmitted via storm flows in the Los Angeles River. After subsequent study in a controlled watershed, Sabin et al. (2005) estimated that approximately 57%-100% of storm water metals loads in a small, predominantly impervious catchment resulted from background urban atmospheric deposition in the San Fernando Valley. The data collected by Sabin et al. (2005) also demonstrate that atmospheric deposition fluxes of metals increase as a result of fires, even at locations distant from those fires. Of course, these sources of metals, and other pollutants, such as dioxin, for which atmospheric deposition is a significant source, are beyond the control of a site operator. These constituents are difficult to remove from storm flows, particularly if they are present in the dissolved phase. The difficulty of treating storm flows is compounded by technical challenges of treating the large volumes of water that are produced over very short time periods by rainfall in arid environments. Additionally, certain treatment processes, such as biological treatment processes, require controlled conditions and thus can be very challenging to maintain and operate for intermittent flows. These factors should be considered when evaluating the suite of constituents for which ALs, TBELs, and/or WQBELs are to be developed, as source control may prove a far more efficient means of control.

Conclusion: Given the complexity of these issues, we recommend that a program for improving the quality of storm water discharges be adopted by the State Board based upon a thorough technical and scientific understanding both of the sources of contaminants in storm water discharges and of the most effective ways to control those sources. As detailed in our previous testimony and written comments, we believe that numeric limits may be appropriate as action levels (ALs) to determine BMP effectiveness. An exceedance of a numeric action level would indicate a potential need to maintain or upgrade BMPs. Boeing recognizes that additional controls on storm water discharges are necessary to improve receiving water quality during wet weather events, but the complexity of the data, as discussed above, indicates that development of TBELs and/or WQBELs would be a lengthy, data-intensive process that would require development of appropriate new methodologies. In any case, Boeing believes that it is imperative that dischargers be able to meet whatever criteria are established and to do so in a cost-effective manner. Boeing does not believe that it is in the public interest to impose numeric limits that may be impossible for dischargers to achieve. Boeing is also concerned that the environmental impacts of the control measures required for compliance with numeric limits, such as those in the SSFL permit, are excessive, potentially resulting in significant hydromodification, energy requirements, waste disposal requirements, and construction and habitat impacts. We look forward to working with the State Board in evaluating options for improving storm water quality.

References:

Flow Science Incorporated, 2006. "Potential Background Constituent Levels in Storm Water at Boeing's Santa Susana Field Laboratory." February 23, 2006.

Sabin, L., Schiff, K., Lim, J., Stolzenbach, K., 2004. "Atmospheric dry deposition of trace metals in the Los Angeles coastal region." Southern California Coastal Water Research Project Biennial Report 2003-2004. SCCWRP: Westminster, CA.

Sabin, L., Lim, J., Stolzenbach, K., Schiff, K., 2005. "Contribution of trace metals from atmospheric deposition to storm water runoff in a small impervious urban catchment." Water Research, Volume 39 (2005), pp. 3929-3937.

Attachments (5)

ATTACHMENT A

COMMMENT LETTER

Comment Letter from Gary Lorden, Ph.D., in regards to "The Feasibility of Numeric Effluent Limits Applicable to Storm Water Discharges"

September 1, 2006

Ms. Song Her, Clerk to the Board
State Water Resources Control Board
P.O. Box 100
Sacramento CA 95812-0100

Re: Attachment to the Boeing Company's comments on the Storm Water Panel of Experts Report – "**The Feasibility of Numeric Effluent Limits Applicable to Storm Water Discharges**"

Dear Ms. Her,

I was retained by MWH to evaluate statistical issues associated with the establishment of numerical limits for pollutants in storm water flows. In that connection I have analyzed a collection of datasets describing constituent concentrations in storm water effluents at outfalls at Boeing's Santa Susana Field Laboratory. I have also been asked to review and comment upon some of the statistical aspects of the report issued by the State Board's Panel of Experts.

My main conclusions, as discussed below, are these:

- as recognized by the panel, there is great variability in stormwater flows and in the measurements of concentrations of constituents in storm flows by grab samples; moreover, from one location to another and from one year to the next there are essential differences that must be considered in setting appropriate numeric limits
- the standard assumption of a lognormal distribution of constituent concentrations, which is relied on heavily in most statistical approaches to the setting of numerical limits on effluents, is likely to be inaccurate (as illustrated by data analyses reported below) in ways that make a substantial difference in establishing limits
- the sample sizes required to determine numerical limits that accurately meet their intended objectives are much larger than reasonably would be expected.

In my opinion, numerical limits on constituents of storm water effluents

- should not be applied to data from storms of "unusual event size and/or pattern", as suggested by the panel of experts
- should not be applied as "never to be exceeded" limits
- must be based on sufficient sample sizes to enable accurate determination of true percentiles of data distributions

- need to be regularly reviewed and updated to incorporate information obtained from storm patterns and severity from year to year
- should be derived from consideration of *all* significant sources of variability, including (for example) influent characteristics, receiving water characteristics, site-specific hydrologic features, treatment characteristics such as flow rate/volume-based capacity limits, and the variability of sample collection and laboratory analysis, particularly for grab samples

To establish a statistically sound basis for setting numerical limits for storm water effluents, I believe it is necessary to carry out a well-designed data collection effort at a representative set of facilities over a period of years sufficient to incorporate the substantial year-to-year variability in the number and severity of storms.

My qualifications.

My professional background as a statistician began with my research specialization in the field for my Ph.D. in mathematics from Cornell in 1966. Since that time, I have been continuously engaged in research and teaching of statistics at Northwestern University, UC Berkeley, and Caltech, where I have been Professor of Mathematics since 1977 and was department chair from 2003 to 2006. I am a fellow of the Institute of Mathematical Statistics, and have been active for the last thirty-five years as a statistical consultant for Caltech colleagues and for various governmental agencies and private companies. I have also served as a statistical expert witness in a variety of legal and regulatory matters, including statistical issues of water quality.

Variability of pollutant concentrations in storm water flows.

It is clear from storm water datasets I have examined in past studies that the pollutant concentrations associated with storm water flows are highly variable, even over short time scales. Within a given hour the measured concentrations of pollutants in grab samples can be expected to vary substantially in relation to the mean for that hour. Therefore the probability that a single-grab-sample-per-storm monitoring system will accurately reflect the true impact of effluents on receiving waters is low. Moreover, the application of numerical effluent limits to grab-sample data is inherently less effective from a statistical point of view than the use of composite samples, for example. Because CTR criteria are specified as one-hour (or longer) average concentrations, it is essential to consider the additional variability of effluent concentrations that occur on a sub-hour basis. In particular, it is important to recognize the fact that any numerical limit applied to grab samples inherently imposes a smaller numerical limit on hourly averages.

Unusual events and exceedance probabilities.

The report of the panel of experts contains repeated acknowledgment of the need to consider that storm water flows are dramatically affected by "unusual events". Here are a few excerpts worth noting:

- "...there is wide variation in storm water quality from place to place, facility to facility, and storm to storm." (p.6)

- "Since the storm-to-storm variation at any outfall can be high, it may be unreasonable to expect all events to be below a numeric value." (p.6)

- "...several to more times each year, the runoff volume or flow rate from a storm will exceed the design volume or rate capacity of the BMP. Storm water agencies should not be held accountable for pollutant removal from storms beyond the size for which a BMP is designed." (p.10)

- "The Panel recommends that Numeric Limits and Action Levels not apply to storms of unusual event size and/or pattern (e.g. flood events)." (p.18)

Even so, regional boards have imposed water quality based effluent limits (WQBELs)—for example, at the Santa Susana facility—as "never to be exceeded limits" in permits! These WQBELs were developed using the procedures in the State Implementation Policy ("SIP"), even though this policy was not developed to apply to storm flow discharges. Effluent limits such as these violate the statistical rationale for numeric limits that underlies the SIP. In that policy, the statistical calculations rely heavily on two foundations:

- the assumption that pollutant concentrations in discharges follow a lognormal distribution, and

- the idea that numeric limits for a facility can be established by considering "exceedance frequencies" based upon calculations using the lognormal distribution.

The latter idea is revealed clearly in the SIP on page 10 in Step 5, which discusses "a factor (multiplier) that adjusts for the averaging periods and exceedance frequencies of the criteria/objectives ..."

Clearly the use of "never to be exceeded" limits for storm water effluents in permits needs to be eliminated. In light of the Panel's discussion and the statistical rationale used in setting limits, provision should be made for two kinds of exceedances—

- exceedances caused by carefully-defined "unusual events"—for example, storms whose severity and/or flow volumes exceed a "design storm" or other pre-defined hydrologic criterion, and events such as wildfires that can radically change site conditions and increase the typical concentrations of certain constituents

- "random" exceedances—resulting from the unavoidable fact that even ideal data, such as data from the assumed "standard" of a lognormal distribution, will have some frequency of exceedance of any specified numerical limit.

Is the assumption of Lognormal Distributions in the SIP valid? Analysis of datasets.

Since the SIP relies heavily on the assumption that lognormal distributions adequately describe data generated by measurement of pollutant concentrations in an effluent, it is very important to address statistically the validity of that assumption—i.e. to test it on actual data.

I was given data sets of storm water grab-sample measurements at 12 outfalls at the Santa Susana facility covering the period from August of 2004 through May of 2006. Data were provided for three constituents: copper (Cu), Total Suspended Solids (TSS), and dioxins, as TCDD equivalent toxicity (TCDD TEQ).

For the purposes of this exercise, I aggregated data for outfalls 1-2, 3-7, and 8-18, resulting in sample sizes as shown in the following table:

Constituent	outfalls 1-2	outfalls 3-7	outfalls 8-18
Cu	60	102	97
TSS	51	69	116
dioxins	51	102	97

Since the SIP-based approach used to establish effluent limits for the facility relies for its statistical calculations upon the assumption that these datasets follow lognormal distributions, I performed statistical hypothesis tests on each of these 9 aggregated samples. Each test was set up to accept or reject the hypothesis that the corresponding dataset constitutes a sample from some lognormal distribution. For each sample, I based the test on a statistic "Z" (defined below) designed to reveal whether my belief from prior examination of similar datasets is true—namely, that storm water constituent concentrations, rather than being well-modeled by a lognormal distribution, actually are too frequently *in the "right-hand tail of the distribution"*. Such "heavy-tailed" behavior in the *actual* data distributions for storm water datasets renders invalid any statistical analysis (e.g., derivation of numerical limits) that is based upon the assumption that the data follow a lognormal distribution. In particular, so-called "exceedance probabilities" will in practice be larger than those specified as criteria and objectives in the "lognormal theory", as is done in the SIP.

Since a data distribution fits a lognormal model if and only if the natural logarithms of the data values fit a normal model (called "Gaussian" by statisticians), one can test the null hypothesis of a lognormal distribution by applying a suitably chosen statistical test to see whether the *logarithms of the data fit a normal model.* Since my interest is in detecting whether the largest values in a sample are often *too large in relation to the sample as a whole* to be described by a lognormal distribution, I based each of the 9 tests on the statistic

$$Z = (M - A)/S,$$

where

M= average of the log-measurements in the largest 5% of the sample,

A= average of all of the log-measurements in the sample,

and S= standard deviation ("sigma") of all of the log-measurements.

(Note: "the largest 5%" of a data distribution can be expected to play a dominant role in determining the frequency that a numeric limit will be exceeded.) Effectively, Z answers the question: How far on the high side of the mean (measured in units of "sigma") are the largest 5% of the log-transformed data? Statistically, the key to the validity of this test is that there is a "correct answer" provided that the data follow a lognormal distribution. That is, the *distribution of Z* is fixed, depending on the sample size, n, *but not depending on the parameters of the lognormal distribution* (e.g., mean, standard deviation, coefficient of variation). On the other hand, if it is indeed true that "the high data values are too high to be explained by a lognormal distribution", then Z will likely be bigger than if the lognormal distribution applies. So the bigger the value of Z calculated from the sample is, the stronger the evidence is that the true distribution of the data is not a lognormal distribution.

The calculated values of Z for each of the 9 samples are summarized in the following table:

Constituent	outfalls 1-2	outfalls 3-7	outfalls 8-18
Cu	3.19	2.06	2.28
TSS	2.79	2.53	2.68
dioxins	2.62	2.72	2.40

Seven of the nine values of Z are substantially too large to be consistent with the assumption that a lognormal distribution describes ("fits") the data at the upper end of the data range—which is clearly the most important part of the distribution for the consideration of setting and enforcing numerical limits. For example, for the copper data at outfalls 1-2 the sample size of 60 implies a median value of Z=1.99 if the lognormal hypothesis is true, and the 95th percentile of the distribution should be Z=2.37, whereas Z=3.19 was calculated from this dataset.

To measure "how large is too large to believe", statisticians use the concept of a "p-value"—*i.e.* what percentage of the time would the value of Z be "this large or larger" *assuming that the lognormal hypothesis is true.* For example, when n=102 data points are sampled and Z is calculated, the percentage of the time that one will find "Z greater than or equal to 2.72" (as obtained in the dioxin sample from outfalls 3-7) is .01%—meaning that at most once in every 10,000 samples would we expect to get such a large value of Z *assuming the lognormal assumption is valid.*

Calculating the same "p-values" for all 9 cases yields the following table (where very small numbers were simplified by "rounding up" – for example, from .008% to .01%).

Constituent	outfalls 1-2	outfalls 3-7	outfalls 8-18
Cu	.001%	43%	5.6%
TSS	.01%	2.1%	.001%
dioxins	.2%	.01%	1.5%

All 3 samples for TSS and all 3 for dioxins show "highly significant p-levels", a term usually applied by statisticians when the p-level is 1-2% or a fraction of 1%. For copper, the result in the first column is highly significant, the one in the second column is not at all significant (43% of the time Z would be at least as big as the calculated value 2.06), and the one in the third column is what would usually be described as "marginally significant"—meaning that the chances (if the lognormal is true) are about "1 in 20" of getting a Z-value as big as the value 2.28 obtained from the sample. This sample, then, suggests that the lognormal hypothesis should be rejected for the copper dataset from outfalls 8-18, but not so strongly as for most of the samples. It is worth noting that if the lognormal hypothesis were true, the results shown in the table should behave like "random numbers in the range 0 to 100". For example, we should expect at most a few of them to be smaller than 10 (meaning a p-level smaller than 10%), whereas this table has 8 of the 9 values smaller than 10.

Taken as a whole, these 9 results are very highly significant. The fact that one of the 9 samples analyzed here does not demonstrate a significant deviation from lognormal—and another is only marginally significant—does *not* suggest to a statistician that if these datasets are typical, then one should regard the lognormal distribution as "sometimes applies to storm water data, sometimes doesn't". On the contrary, even if the true distributions of such data are *always* too "heavy-tailed" to be lognormal and therefore the *true distribution* of Z is always larger than the one prescribed by the lognormal model, these two distributions will still "overlap", and consequently not all individual datasets can be expected to yield a value of Z that is highly significant in rejecting the lognormal hypothesis.

How many data are needed to set numeric limits? An example.

As the SIP lognormal approach makes clear, setting numerical limits is critically related to controlling frequencies of exceedance—i.e., satisfying numerical criteria or objectives. Typical considerations, as seen in Tables 1 and 2 in Section 1.4 of the SIP, involve the 95^{th} percentile and the 99^{th} percentile of the distribution of data measuring pollution concentrations in effluents. Both the process of *setting* numeric limits and the process of monitoring *compliance* with them face the following statistical challenge:

> There is a substantial difference between a data distribution *having* a specified frequency of exceedance and *demonstrating* that it does.

To illustrate this, suppose that we want to choose a sample size, n, and a maximum number of allowable exceedances, k, so that two requirements are met:

1) Obtaining at most k exceedances *demonstrates with 95% confidence* that the 95^{th} percentile of the data distribution is at most L—*i.e.*, that the true frequency of exceeding L is at most 5%.

2) Suppose that the true situation is much better—say that the *99^{th} percentile* of the data distribution is at most L. (The actual frequency of exceedance is 1% or less). Then with 95% confidence the facility should succeed in the demonstration—that is, should get at most k exceedances in a sample of n.

Then the sample size, n, must be at least 181, and in that case k=4.

This result may seem surprising, but it is simply a consequence of what is sometimes called the "law of small numbers". Even though a sample of n=181 data points seems large, we are attempting to learn from these data whether, on average, we will see about 9 exceedances (5% of 181) or about 2 exceedances (1% of 181). The numbers "2 and 9" are small enough so that the chances of being misled by the data—i.e. getting more than 4 exceedances assuming the average number would be 2, or getting 4 or fewer exceedances assuming the average number would be 9-- are (in both cases) about "1 out of 20". This enables us to have 95% confidence that the data will lead us to the right conclusion. For sample sizes *smaller* than 181, the chances of being misled are greater than "1 out of 20", and consequently we cannot have 95% confidence of reaching the right conclusion.

To perform more difficult analyses, such as testing the "fit" of distributions better suited than the lognormal to describe the data, requires even larger sample sizes. Investigation of a large body of data can shed light on the question of whether the lognormal distribution can be replaced by some other shape of distribution that better represents actual data. My expectation is that no *simple* family of distributions can represent adequately the range of behaviors of datasets. Accordingly I expect that the most useful statistical calculations will turn out to be based upon so-called *nonparametric* or *semiparametric* methods, relying more upon estimating from data the actual frequencies of high concentrations rather than upon estimating parameters such as the coefficient of variation.

Sincerely,

Gary Lorden

Gary Lorden

ATTACHMENT B

LOS ANGELES REGIONAL STORM WATER CONCENTRATION SUMMARY STATISTICS COMPARISON

Attachment B Summary Notes

Figure B-1: Copper concentrations in storm flows often exceed CTR limits

Figure B-2: Lead concentrations in storm flows often exceed CTR limits

Figure B-3: Dioxin concentrations in storm flows often exceed CTR limits

Attachment B – Storm Water Comparison Column Charts Data Summary Notes

The following charts display available, relevant, and corresponding storm water data from various sampling database sources. The concentrations of metals in storm water discharges from the SSFL can be compared to storm water runoff from regional catchments affected by wildfires, storm water discharges from other land use types, and from other facilities within the Region. These figures provide a summary of measured copper, lead, and dioxin (TCDD TEQ) concentrations in storm water, including the computed average and observed maximum concentrations. Data sets were collected by Boeing, the Los Angeles County Department of Public Works, and the Los Angeles Regional Water Quality Control Board and are described below.

1) **Boeing SSFL Storm Water Monitoring Data Set (green columns)**: Storm water monitoring data from samples collected from September 2004 to September 2005 have been pooled for storm water only, or storm water dominated outfalls by pooling Outfalls 001-002, and Outfalls 003-010. This data set provides consistent sampling analysis methods under the 2004 SSFL NPDES for metals and TCDD. The table below provides the total number of samples for a given constituent-outfall combination as presented in this figure.

SSFL Outfall	TCDD no DNQ Samples (9/04-9/05)	Copper Samples (9/04-9/05)	Lead Samples (9/04-9/05)
Outfalls 001-002	42	46	47
Outfalls 003-010	150	150	150

2) **LACDPW Land Use Storm Water Data Set (red columns):** The Los Angeles County Department of Public Works (LACDPW) monitored storm water constituent concentrations in samples collected from various land use types from 1994-2000. Catchments representative of the eight dominant land use types within the County were used for these sampling events (see the Los Angeles County 1994-2000 Integrated Receiving Waters Impact Report, on line at http://ladpw.org/wmd/NPDES/IntTC.cfm). LACDPW reports the average and median concentrations and the coefficient of variation for each data set. The graph above presents the average concentration and concentration at plus one standard deviation, assuming data are normally distributed.

3) **LACDPW Receiving Water Data (purple column):** LACDPW collects storm water samples from the Los Angeles River at the Wardlow Gage Station (near the Los Angeles River estuary) and from Sawpit Creek, a catchment that is 98% open space and that is located in the foothills of the San Gabriel Mountains. The plot includes the average and maximum measured concentrations for samples collected from October 1998 to January 2005 (Los Angeles River) and November 1998 to October 2001 (Sawpit Creek). Sampling data were taken from the LACDPW's annual storm water quality reports (on line at http://ladpw.org/wmd/NPDES/report_directory.cfm).

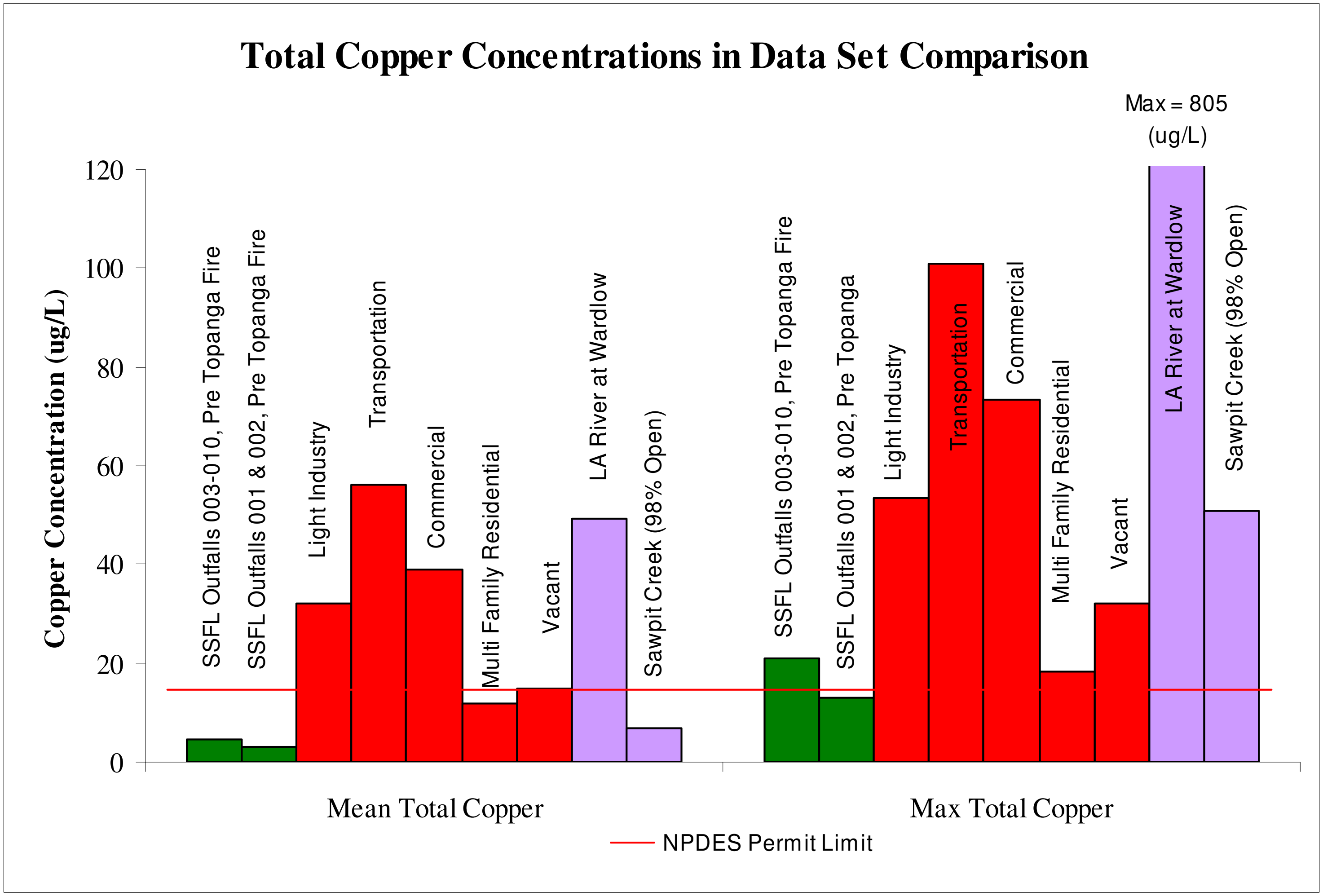
4) **Fisher et al., 1999, data set (red column):** Fisher et al. collected eighteen samples, including 12 dry weather samples and 6 wet weather samples, in 1988-

1989, from 4 sampling sites in the Santa Monica Basin. The average, minimum, and maximum TCDD (TEQ) concentrations from wet weather events are shown in this figure.

5) **Los Angeles Regional Board data set (purple column):** The Los Angeles Regional Board issued a 13267 data request on August 3, 2001 requesting monitoring data for priority pollutants regulated pursuant to the California Toxics Rule, including TCDD (TEQ) ("dioxin"). Preliminary review of records received by the Los Angeles Regional Board for storm water samples collected by ten different permittees and at two nonpermitted sites are shown in Figure 8. This plot shows the preliminary data analysis for the average, minimum, and maximum concentrations from 38 samples collected at 21 sites between September 2001 and March 2005. Samples were collected during both wet and dry weather conditions from industrial process water, storm flow runoff, and receiving waters. (Note that Boeing participated in this survey and submitted data on dioxin concentrations measured in storm water from the SSFL. Samples results from samples collected by Boeing were not included in the data represented by the green triangle.)

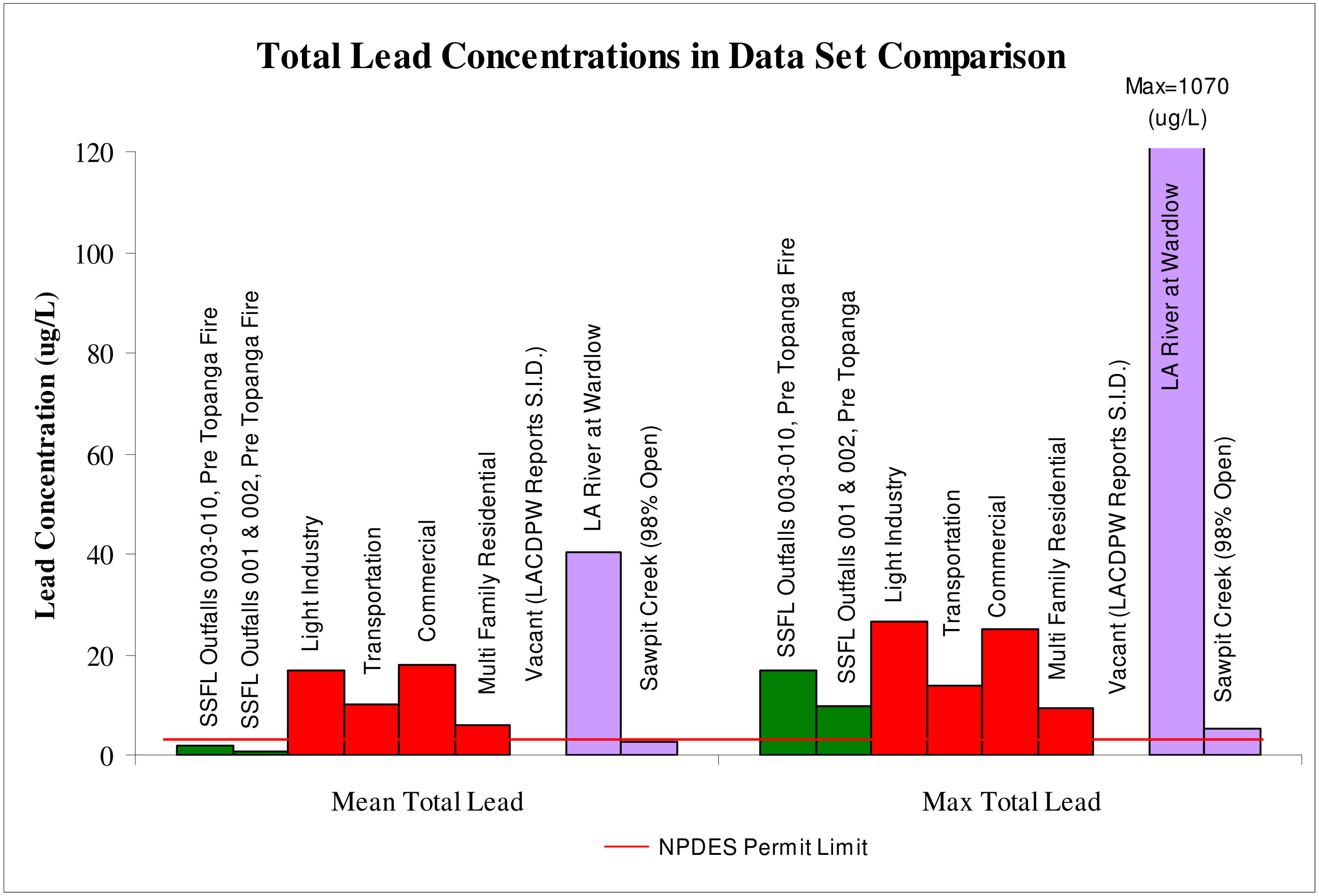
Charts of the data discussed above had the mean calculated by assuming non-detect values for metals equal to half of the reporting limit. [Reporting limit for copper = 5 (µg/L), lead = 5 (µg/L)] and non-detect values for TCDD were equal to 0 (µg/L) for display purposes.

Figure B-1: Copper concentrations in storm flows often exceed CTR limits



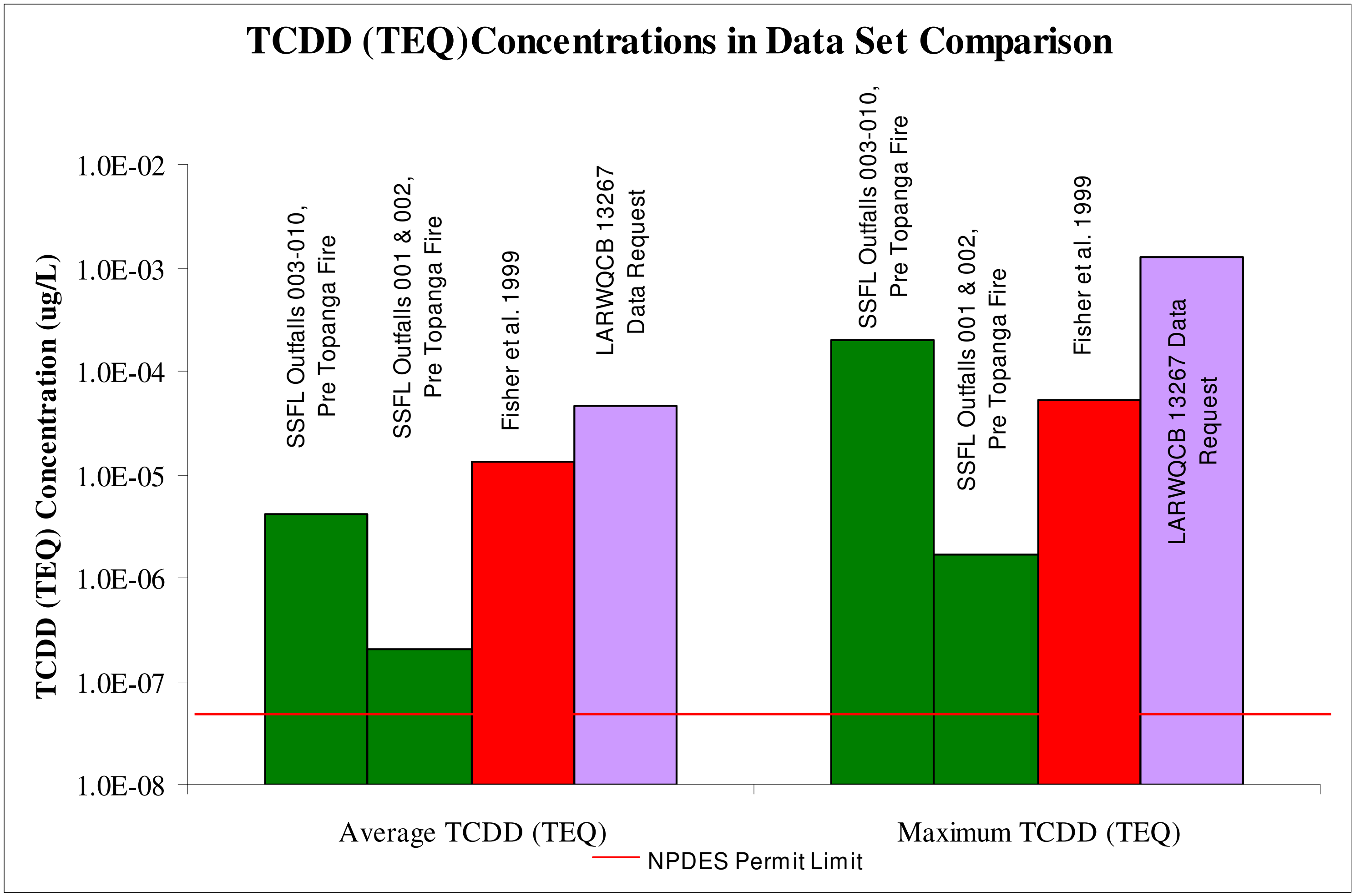
Source: SSFL data (green) from Boeing NPDES monitoring; land use (red) and receiving water data (purple) from Los Angeles County Department of Public Works (1994-2001); CTR-permit limit is 14.1 µg/l.

Figure B-2: Lead concentrations in storm flows often exceed CTR limits



Source: SSFL data (green) from Boeing NPDES monitoring; land use (red) and receiving water data (purple) from Los Angeles County Department of Public Works (1994-2001); CTR-permit limit is 5.2 µg/l.

Figure B-3: Dioxin concentrations in storm flows often exceed CTR limits



Source: SSFL data (green) from Boeing NPDES monitoring; Fischer et al. (1999) (red) includes 6 wet weather samples within LA Basin; LA RWQCB data (purple) from RWQCB database; CTR-permit limit is 2.8×10^{-8} µg/l.

ATTACHMENT C

SSFL Outfalls and Off Site Monitoring Locations
Storm Water Monitoring October 2004 to June 2006

Attachment C Summary Notes

Figure C-1: Post-Fire Reference Soil and Ash Sample Locations

Figure C-2: Boeing SSFL NPDES Permit Monitoring Outfalls

Figures C-3A, C-3B, C-3C: Copper Concentration Scatter Plots

Figures C-4A, C-4B, C-4C: Lead Concentration Scatter Plots

Figures C-5A, C-5B, C-5C: TCDD TEQ Concentration Scatter Plots

Attachment C – Storm Water Scatter Plots Data Summary Notes

The following charts display available, relevant, and corresponding storm water data from various sampling database sources. These sources are explained in detail below. Sampling locations for regional post 2005 fire season monitoring are shown in Figure C-1. Sampling location for SSFL outfall monitoring locations are shown in Figure C-2.

1) **Boeing SSFL Storm Water Monitoring Data Set (Figures C-3A, C-3B, C-4A, C-4B, C-5A, C-5B):** Storm water monitoring data from samples collected from September 2004 to June 2006 at the storm water only, or storm water dominated outfalls, 001, 011, 009 are representative of large drainages at the SSFL.

   Representative SSFL surface water monitoring data used are based on the August 2004 to June 2006 time period. This data set provides consistent sampling analysis methods between the 2004 and 2006 SSFL NPDES for metals and TCDD. The table below provides the total number of samples for a given constituent-outfall combination, along with the Pre-Topanga Fire and Post-Topanga Fire sample numbers.

SSFL Outfall	TCDD no DNQ Total (Pre Fire/Post Fire)	Copper Total (Pre Fire/Post Fire)	Lead Total (Pre Fire/Post Fire)
Outfall 001	21 (16 / 5)	25 (19 / 6)	26 (20 / 6)
Outfall 009	23 (11 / 12)	22 (10 / 12)	23 (11 / 12)
Outfall 011	14 (10 / 4)	15 (11 / 4)	15 (11 / 4)

2) **Boeing Post Chatsworth Topanga Fire Regional Drainage Storm Water Monitoring (Figures C-3C, C-4C, C-5C):** This data set is referred to as Boeing's "Off Site" data set and was originally published in the Flow Science "Potential Background constituent Levels in Storm Water at Boeing's Santa Susana Field Laboratory" Report.[1] The data set is composed of storm water monitoring conducted by Boeing at seven background sites in and around the SSFL from October 2005 to June 2006 and.

Off Site Data Group	TCDD no DNQ	Copper	Lead
CF-1	4	4	4
CRP-1	1	1	1
PCC-1	4	4	4
RP-1	1	1	1
SC-1	2	2	2
SSM-1	3	3	3
WC-1	1	1	1

Charts of the data discussed above plotted with non-detect values for metals equal to half of the reporting limit. [Reporting limit for copper = 5 (µg/L), lead = 5 (µg/L)] and non-detect values for TCDD at the baseline logarithm value of $1x10^{-9}$ (µg/L) for display purposes.

[1] Flow Science, "Potential Background Constituent Levels in Storm Water at Boeing's Santa Susana Field Laboratory." February 23, 2006.

Post-Fire Reference Soil and Ash Sample Locations **Figure C-1**

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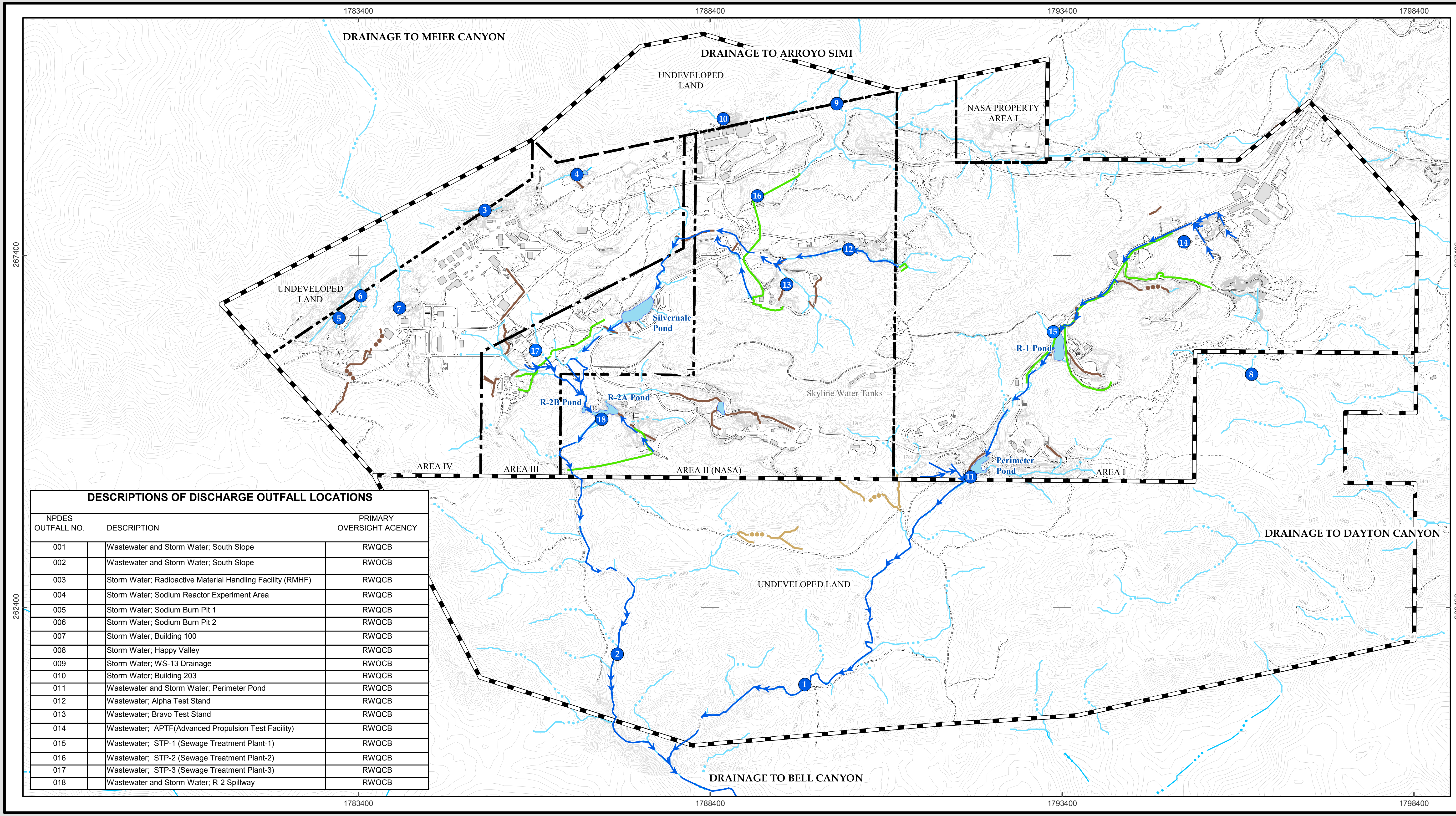
Date: Jan 31, 2006



DESCRIPTIONS OF DISCHARGE OUTFALL LOCATIONS

NPDES OUTFALL NO.	DESCRIPTION	PRIMARY OVERSIGHT AGENCY
001	Wastewater and Storm Water; South Slope	RWQCB
002	Wastewater and Storm Water; South Slope	RWQCB
003	Storm Water; Radioactive Material Handling Facility (RMHF)	RWQCB
004	Storm Water; Sodium Reactor Experiment Area	RWQCB
005	Storm Water; Sodium Burn Pit 1	RWQCB
006	Storm Water; Sodium Burn Pit 2	RWQCB
007	Storm Water; Building 100	RWQCB
008	Storm Water; Happy Valley	RWQCB
009	Storm Water; WS-13 Drainage	RWQCB
010	Storm Water; Building 203	RWQCB
011	Wastewater and Storm Water; Perimeter Pond	RWQCB
012	Wastewater; Alpha Test Stand	RWQCB
013	Wastewater; Bravo Test Stand	RWQCB
014	Wastewater; APTF(Advanced Propulsion Test Facility)	RWQCB
015	Wastewater; STP-1 (Sewage Treatment Plant-1)	RWQCB
016	Wastewater; STP-2 (Sewage Treatment Plant-2)	RWQCB
017	Wastewater; STP-3 (Sewage Treatment Plant-3)	RWQCB
018	Wastewater and Storm Water; R-2 Spillway	RWQCB

N

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FEET

MAP COORDINATES IN STATE PLANE, NAD 27, ZONE V

Legend

- NPDES Outfalls (RWQCB Primary Oversight Authority)
- Treated Effluent Pathways
- HPDE Transmission Pipelines
- Natural Drainage
- Concrete Lined Drainage
- Graded Drainage
- Surface Water Reclamation Ponds

Base Map Legend

- SSFL Property Boundary
- Administrative Area Boundary
- Ground Elevation Contours
- Drainage Pathways
- A/C Curbing
- Dirt Road
- Existing Building or Structure

Storm Water Drainage Systems and Outfall Locations

Date: May 09, 2005

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FIGURE C-2

Attachment C
SSFL Outfalls and Off Site Monitoring Locations Storm Water Monitoring October 2004 to June 2006

Figure C-3A

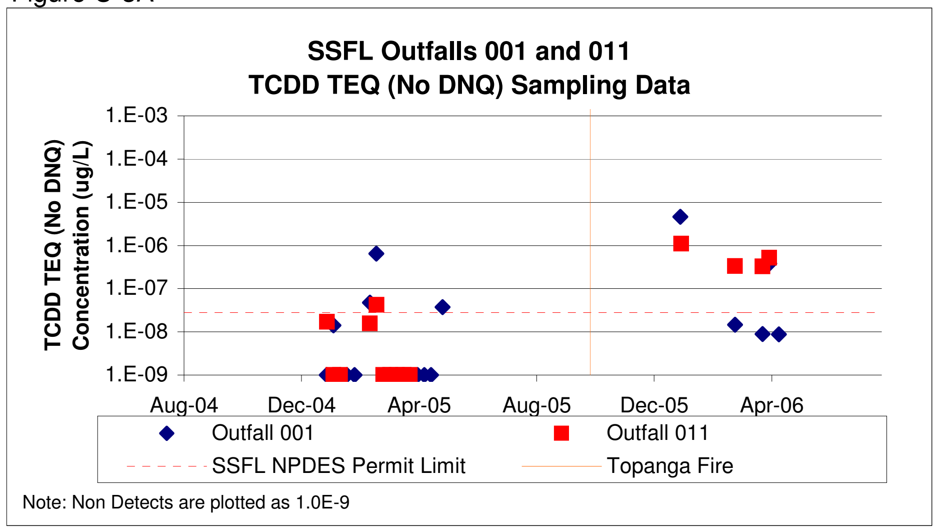


Figure C-3B

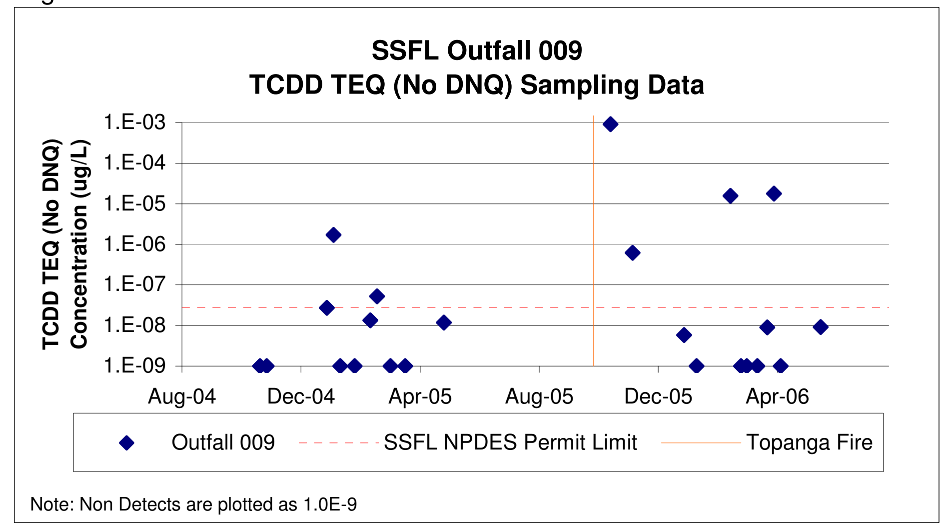


Figure C-3C

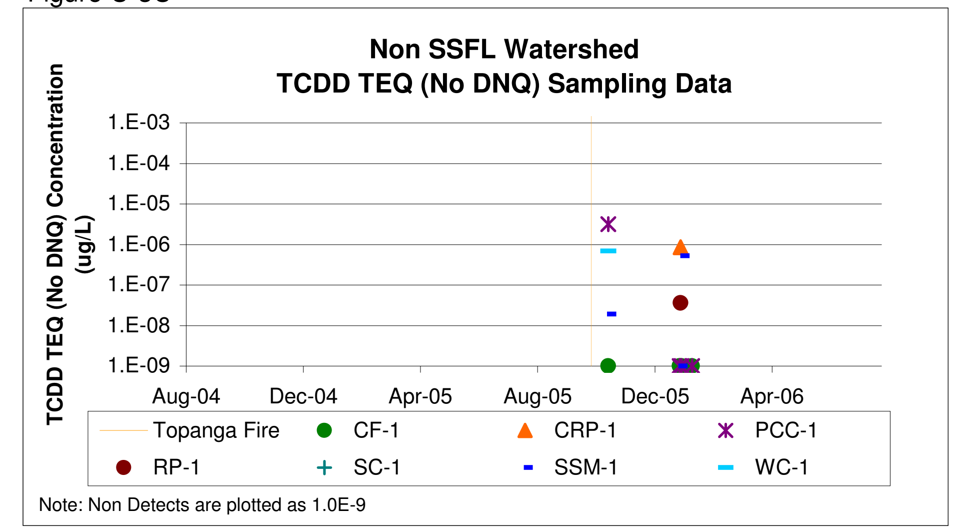


Figure C-4A

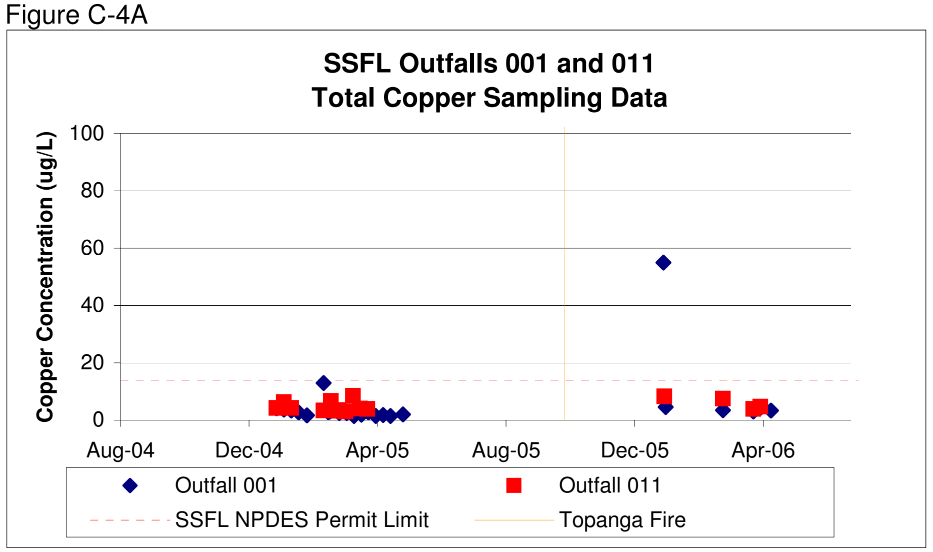


Figure C-4B

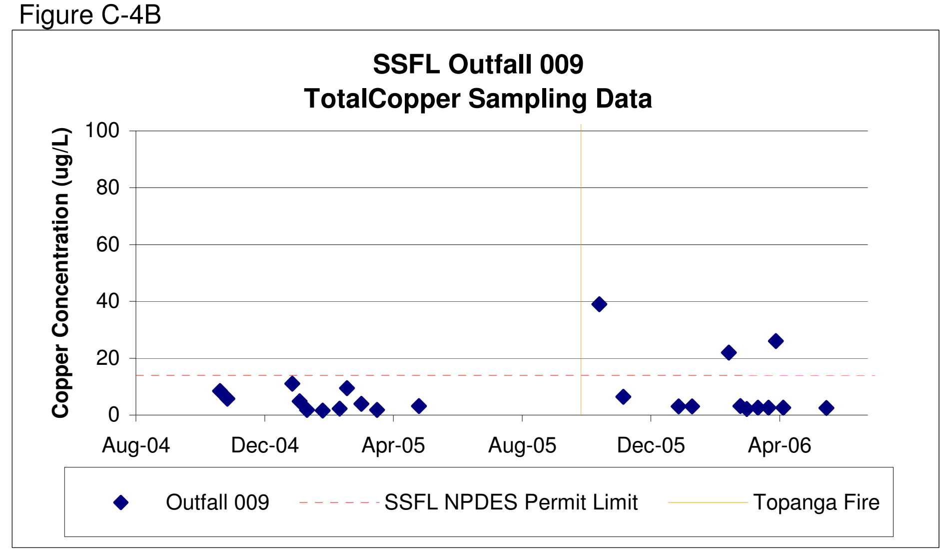


Figure C-4C

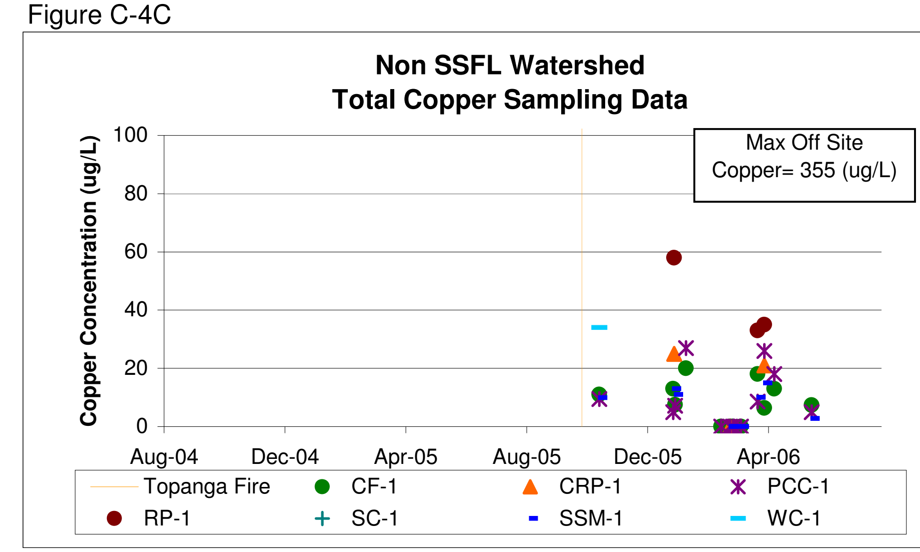


Figure C-5A

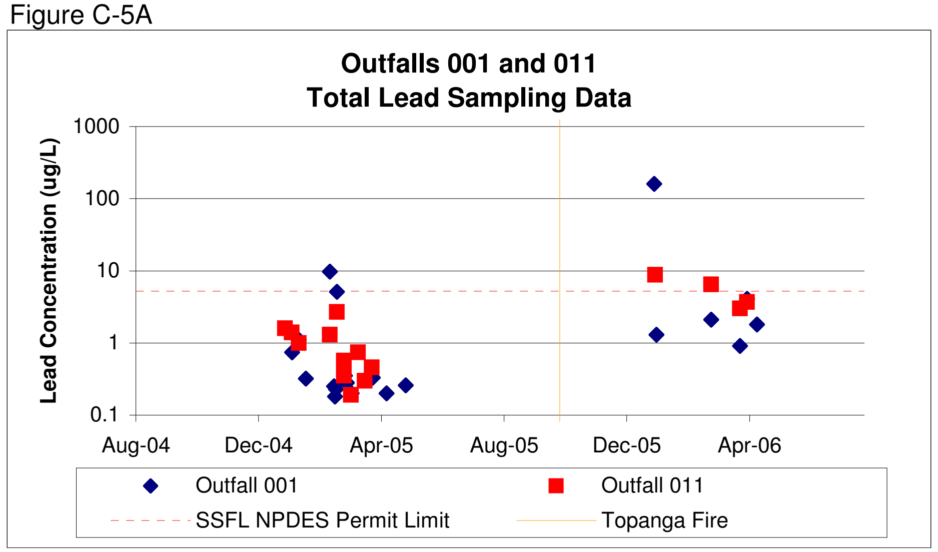


Figure C-5B

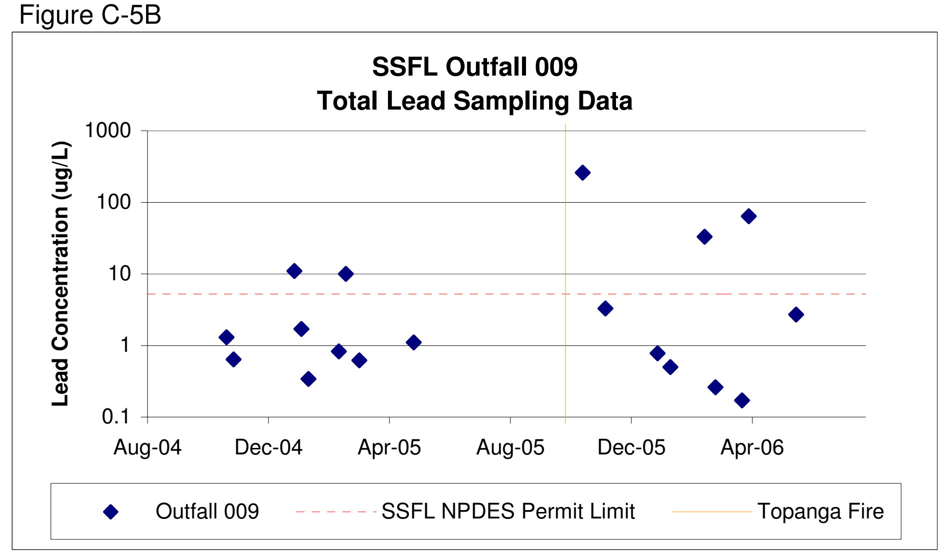
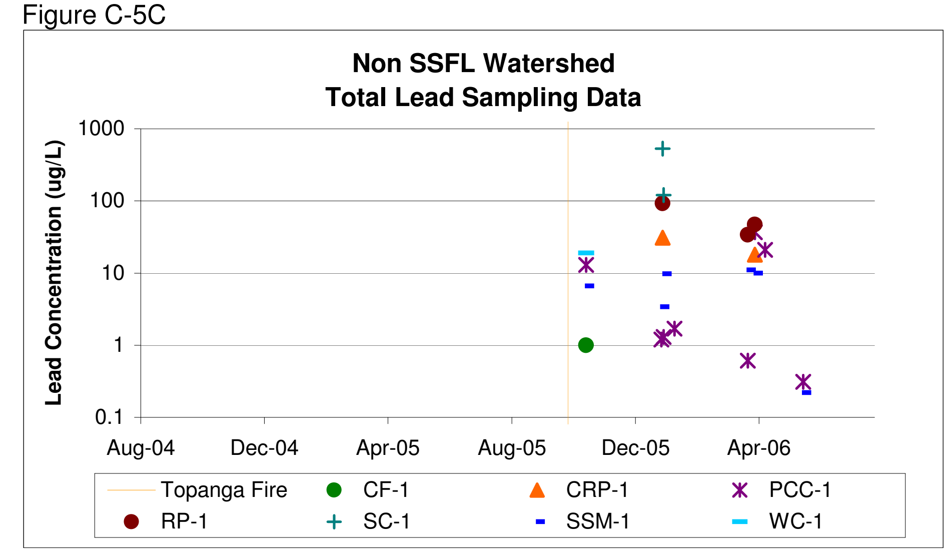


Figure C-5C



ATTACHMENT D

EXCERPT FROM "POTENTIAL BACKGROUND CONSTITUENT LEVELS IN STORM WATER AT BOEING'S SANTA SUSANA FIELD LABORATORY"

Section 4 Results of Tests of BMP and Hydromulch Materials

Reference:

Flow Science Incorporated, "Potential Background Constituent Levels in Storm Water at Boeing's Santa Susana Field Laboratory," February 23, 2006.

4. RESULTS OF TESTS OF BMP AND HYDROMULCH MATERIALS

4.1 BMP AND HYDROMULCH MATERIALS TEST METHODOLOGY

Boeing conducted a series of tests in 2005 to estimate the concentrations of regulated constituents in various best management practice (BMP) materials and to facilitate selection of materials that would minimize the potential for exceedances of permit limits in storm water runoff from the SSFL site. BMP materials are used to manage and filter storm water runoff at multiple locations on the SSFL site.

A wide range of BMP materials were tested, including several types of sand and gravel. Hydromulch materials considered for use following the 2005 Topanga fire were also tested. Several testing procedures were followed for each type of material. For the sands, 200-gram samples were either leached using 200 milliliters of de-ionized water for a certain time period (i.e., the sample was mixed with de-ionized water and continually agitated), or samples were simply combined with the water, stirred once, and set aside to soak for a certain time period, as specified in Table 16. Following either leaching or soaking, the water was decanted and analyzed for a range of metals (both total and dissolved) and dioxin toxicity equivalent (TEQ). In some cases, the sand was rinsed with de-ionized water prior to leaching or soaking.

For the gravels, 200-gram samples were soaked in 200 milliliters of de-ionized water and set aside for a certain time period, decanted, and the water was analyzed for metals and dioxin TEQ. In some cases gravel samples were rinsed prior to soaking, and in some cases the decanted water was filtered prior to analysis, again leaving only dissolved constituents.

For hydromulch samples, generally, 50-gram samples of material were mixed with two liters of water and set aside to soak (for mercury analyses 10-gram samples were mixed with 200 milliliters of water, and for dissolved analyses 20-gram samples were mixed with two liters of water). After soaking, the solid and liquid were separated and each was analyzed individually (see Table 16). One hydromulch material—Soil Set—is a liquid, and so this material was simply analyzed in its liquid state. Table 16 summarizes the specific materials tested and those testing procedures that varied from sample to sample. Table 17 summarizes the specific regulated constituents analyzed for each sample, and corresponding SSFL 2006 NPDES Permit Limits.

Table 16 – BMP and Erosion Control Materials and Testing Procedures

Sample ID	BMP/ Erosion Control Material Group	BMP Material	Variable Testing Procedures
IOJ1924-01 DIWET	Sand	Colorado filter sand	Leached (1 hr.), filtered
IOJ1924-01RE1 DIWET	Sand	Colorado filter sand	Rinsed, leached (1 hr.), filtered
IOJ1924-02	Sand	Colorado filter sand	Rinsed, leached (1 hr.)
IOJ1924-03	Sand	Colorado filter sand	Rinsed, soaked (1 hr.)
IOJ1924-04	Sand	Colorado filter sand	Rinsed, soaked (15 min.)
IOJ1230-01 DIWET	Sand	Corona filter sand	Leached (24 hr.), filtered
IOJ1230-01RE1 DIWET	Sand	Corona filter sand	Leached (1 hr.), filtered
IOJ1230-01RE2 DIWET	Sand	Corona filter sand	Rinsed, leached (1 hr.), filtered
IOJ1230-02	Sand	Corona filter sand	Rinsed, leached (1 hr.)
IOJ1230-03	Sand	Corona filter sand	Rinsed, soaked (1 hr.)
IOJ1230-04	Sand	Corona filter sand	Material from IOJ1230-02 used, soaked (15 min.)
IOK0111-01	Gravel	Road gravel	Rinsed, soaked (15 min.), filtered and unfiltered
IOK0111-02	Gravel	Pea bag gravel	Rinsed, soaked (15 min.), filtered and unfiltered
IOK0111-03	Gravel	Birds eye gravel	Rinsed, soaked (15 min.), filtered and unfiltered
IOK1695-01	Hydromulch	Naka Hydroseed	Leached, soaked (15 min.), filtered and unfiltered
IOK0964-01	Hydromulch	Soil Set	Liquid material analysis
IOK0964-02	Hydromulch	StarTak 600	Water analysis, filtered and unfiltered
IOK0964-03	Hydromulch	Eco Fibre	Water analysis, filtered and unfiltered
IOK0964-04	Hydromulch	Eco Aegis	Water analysis, filtered and unfiltered
IOK0964-05	Hydromulch	Applegate N/D	Water analysis, filtered and unfiltered
IOK0964-06	Hydromulch	Applegate W/D	Water analysis, filtered and unfiltered
IOK0964-07	Hydromulch	Soil Guard	Water analysis, filtered and unfiltered
IOK0964-08	Hydromulch	Mat Fibre	Water analysis, filtered and unfiltered
IOK0964-09	Hydromulch	Eco Blend	Water analysis, filtered and unfiltered
IOK0964-10	Hydromulch	StarTak 600	Solid material analysis
IOK0964-11	Hydromulch	Eco Fibre	Solid material analysis
IOK0964-12	Hydromulch	Eco Aegis	Solid material analysis
IOK0964-13	Hydromulch	Applegate N/D	Solid material analysis
IOK0964-14	Hydromulch	Applegate W/D	Solid material analysis
IOK0964-15	Hydromulch	Soil Guard	Solid material analysis
IOK0964-16	Hydromulch	Mat Fibre	Solid material analysis
IOK0964-17	Hydromulch	Eco Blend	Solid material analysis

Source: Boeing, 2005.

Table 17 – Regulated Constituents Analyzed During BMP and Erosion Control Materials Testing

	Constituent	SSFL 2006 NPDES Permit Limit (Daily Maximum)
	Antimony	6.0 µg/l
	Arsenic*	50 µg/l
	Barium*	1.0 mg/l
	Beryllium	4.0 µg/l
	Boron**	1.0 µg/l
	Cadmium	3.1 µg/l
	Chromium*	16.3 µg/l
	Copper	14.0 µg/l
	Iron*	0.3 mg/l
	Lead	5.2 µg/l
	Manganese*	50 µg/l
	Mercury	0.10 µg/l
	Nickel*	96 µg/l
	Selenium*	5.0 µg/l
	Silver*	4.1 µg/l
	Thallium	2.0 µg/l
	Zinc*	119 µg/l
	Dioxin TEQ	2.8×10^{-8} µg/l

Source: SSFL 2006 NPDES Permit (Order No. R4-2006-008).
* These constituents have permit limits for Outfalls 001, 002, 011, and 018 only.
** This constituent has a permit limit only at Outfalls 003-007, 008, and 010.

4.2 BMP MATERIALS TESTING RESULTS

Given that the BMP materials, once emplaced, function as filters at the site, the passive soaking methodology likely best represents concentrations that would result from contact of storm water with BMP materials emplaced on site. Thus, results presented in this section are a subset of the complete results of Boeing's BMP materials testing program as described above. (Complete results are presented in Appendix B.) The results summarized in Tables 18a through 18q include data from tests where BMP materials were soaked and the supernatant was not filtered. In the sand and gravel cases presented in Table 18, the materials were also rinsed before soaking, mimicking a steady-state, long-term condition of BMP materials at the site. Since SSFL 2004 NPDES Permit Limits are expressed in terms of total, not dissolved, metals, test results from unfiltered samples are presented.

Results for each permitted constituent are presented in Table 18, and include the ratio of the tested concentration to the permit limit for each constituent. Cases where this ratio is greater than 1.0—i.e., where the soak test result for a particular BMP material exceeded the permit limit—are in boldface. Note that as shown in Appendix B, several test methods (particularly the leaching method) produced constituent concentrations far higher than those shown in Table 18. Although these test results are not believed to be as representative of materials emplaced at the SSFL as the results presented in Table 18, they do indicate that the BMP materials themselves contain significant quantities of the constituents regulated in storm water runoff from the SSFL site.

After reviewing the results of these tests, Boeing selected the Corona filter sand and the Bird's eye gravel for use in the BMPs emplaced at the SSFL site. Hydromulch materials used at the site consisted of a mixture of the Applegate, Mat Fiber and the Soil veg parts A and B.

Table 18a – Contributions to ANTIMONY concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Max Permit Limit (µg/L)	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.18	6	0.03
Sand	Corona Filter Sand	0.24	6	0.04
Gravel	Birds Eye Gravel	0.48	6	0.08
Gravel	Pea Bag Gravel	1.7	6	0.28
Gravel	Road Gravel	0.74	6	0.12
Hydromulch	Applegate N/D	76	6	**12.67**
Hydromulch	Applegate W/D	41	6	**6.83**
Hydromulch	Eco Aegis	17000	6	**2833.33**
Hydromulch	Eco Blend	4.4	6	0.73
Hydromulch	Eco Fibre	11	6	**1.83**
Hydromulch	Mat Fibre	5.2	6	0.87
Hydromulch	Naka Hydroseed	590	6	**98.33**
Hydromulch	Soil Guard	9.1	6	**1.52**
Hydromulch	Soil Set	0.68	6	0.11
Hydromulch	Star Tak	0.65	6	0.11

Source: Boeing, 2005.

Table 18b– Contributions to ARSENIC concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Max Permit Limit (µg/L)	Sample Result / Permit Limit
Sand	Colorado Filter Sand	ND	50	0.00
Sand	Corona Filter Sand	14	50	0.28
Gravel	Birds Eye Gravel	13	50	0.26
Gravel	Pea Bag Gravel	70	50	**1.40**
Gravel	Road Gravel	11	50	0.22
Hydromulch	Applegate N/D	ND	50	0.00
Hydromulch	Applegate W/D	ND	50	0.00
Hydromulch	Eco Aegis	12	50	0.24
Hydromulch	Eco Blend	ND	50	0.00
Hydromulch	Eco Fibre	ND	50	0.00
Hydromulch	Mat Fibre	ND	50	0.00
Hydromulch	Naka Hydroseed	6.8	50	0.14
Hydromulch	Soil Guard	ND	50	0.00
Hydromulch	Soil Set	ND	50	0.00
Hydromulch	Star Tak	ND	50	0.00

Source: Boeing, 2005.

Table 18c – Contributions to BARIUM concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (mg/L)	SSFL 2006 NPDES Daily Max Permit Limit (µg/L)	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.056	1	0.06
Sand	Corona Filter Sand	0.052	1	0.05
Gravel	Birds Eye Gravel	0.32	1	0.32
Gravel	Pea Bag Gravel	0.78	1	0.78
Gravel	Road Gravel	0.23	1	0.23
Hydromulch	Applegate N/D	0.024	1	0.02
Hydromulch	Applegate W/D	0.016	1	0.02
Hydromulch	Eco Aegis	0.017	1	0.02
Hydromulch	Eco Blend	0.022	1	0.02
Hydromulch	Eco Fibre	0.029	1	0.03
Hydromulch	Mat Fibre	0.014	1	0.01
Hydromulch	Naka Hydroseed	0.050	1	0.05
Hydromulch	Soil Guard	0.064	1	0.06
Hydromulch	Soil Set	0.028	1	0.03
Hydromulch	Star Tak	ND	1	0.00

Source: Boeing, 2005.

Table 18d – Contributions to BERYLLIUM concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Max Permit Limit (µg/L)	Sample Result / Permit Limit
Sand	Colorado Filter Sand	ND	4	0.00
Sand	Corona Filter Sand	2.8	4	0.70
Gravel	Birds Eye Gravel	ND	4	0.00
Gravel	Pea Bag Gravel	3.3	4	0.83
Gravel	Road Gravel	1.1	4	0.28
Hydromulch	Applegate N/D	ND	4	0.00
Hydromulch	Applegate W/D	ND	4	0.00
Hydromulch	Eco Aegis	ND	4	0.00
Hydromulch	Eco Blend	ND	4	0.00
Hydromulch	Eco Fibre	ND	4	0.00
Hydromulch	Mat Fibre	ND	4	0.00
Hydromulch	Naka Hydroseed	ND	4	0.00
Hydromulch	Soil Guard	ND	4	0.00
Hydromulch	Soil Set	ND	4	0.00
Hydromulch	Star Tak	ND	4	0.00

Source: Boeing, 2005.

Table 18e – Contributions to BORON concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (mg/L)	SSFL 2006 NPDES Daily Max Permit Limit (µg/L)	Sample Result / Permit Limit
Sand	Colorado Filter Sand	ND	1	--
Sand	Corona Filter Sand	ND	1	--
Gravel	Birds Eye Gravel	ND	1	--
Gravel	Pea Bag Gravel	0.064	1	0.06
Gravel	Road Gravel	0.010	1	0.01
Hydromulch	Applegate N/D	0.40	1	0.40
Hydromulch	Applegate W/D	0.17	1	0.17
Hydromulch	Eco Aegis	0.030	1	0.03
Hydromulch	Eco Blend	ND	1	--
Hydromulch	Eco Fibre	0.041	1	0.04
Hydromulch	Mat Fibre	ND	1	--
Hydromulch	Naka Hydroseed	0.057	1	0.06
Hydromulch	Soil Guard	0.012	1	0.01
Hydromulch	Soil Set	0.0084	1	0.01
Hydromulch	Star Tak	ND	1	--

Source: Boeing, 2005.

Table 18e – Contributions to CADMIUM concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.15	3.1	0.04
Sand	Corona Filter Sand	0.045	3.1	0.01
Gravel	Birds Eye Gravel	1.4	3.1	0.35
Gravel	Pea Bag Gravel	0.77	3.1	0.19
Gravel	Road Gravel	0.63	3.1	0.16
Hydromulch	Applegate N/D	0.13	3.1	0.03
Hydromulch	Applegate W/D	0.15	3.1	0.04
Hydromulch	Eco Aegis	0.18	3.1	0.05
Hydromulch	Eco Blend	0.11	3.1	0.03
Hydromulch	Eco Fibre	0.24	3.1	0.06
Hydromulch	Mat Fibre	0.041	3.1	0.01
Hydromulch	Naka Hydroseed	0.31	3.1	0.08
Hydromulch	Soil Guard	0.47	3.1	0.12
Hydromulch	Soil Set	0.70	3.1	0.18
Hydromulch	Star Tak	ND	3.1	0.00

Source: Boeing, 2005.

Table 18f – Contributions to CHROMIUM concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	10	16.3	0.61
Sand	Corona Filter Sand	15	16.3	0.92
Gravel	Birds Eye Gravel	58	16.3	**3.56**
Gravel	Pea Bag Gravel	100	16.3	**6.13**
Gravel	Road Gravel	38	16.3	**2.33**
Hydromulch	Applegate N/D	2.0	16.3	0.12
Hydromulch	Applegate W/D	ND	16.3	0.00
Hydromulch	Eco Aegis	3.3	16.3	0.20
Hydromulch	Eco Blend	2.5	16.3	0.15
Hydromulch	Eco Fibre	4.0	16.3	0.25
Hydromulch	Mat Fibre	ND	16.3	0.00
Hydromulch	Naka Hydroseed	4.3	16.3	0.26
Hydromulch	Soil Guard	ND	16.3	0.00
Hydromulch	Soil Set	ND	16.3	0.00
Hydromulch	Star Tak	ND	16.3	0.00

Source: Boeing, 2005.

Table 18g – Contributions to COPPER concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	17	14	**1.21**
Sand	Corona Filter Sand	22	14	**1.57**
Gravel	Birds Eye Gravel	32	14	**2.29**
Gravel	Pea Bag Gravel	86	14	**6.14**
Gravel	Road Gravel	25	14	**1.79**
Hydromulch	Applegate N/D	7.1	14	0.51
Hydromulch	Applegate W/D	10	14	0.71
Hydromulch	Eco Aegis	8.4	14	0.60
Hydromulch	Eco Blend	4.2	14	0.30
Hydromulch	Eco Fibre	11	14	0.79
Hydromulch	Mat Fibre	2.8	14	0.20
Hydromulch	Naka Hydroseed	9.2	14	0.66
Hydromulch	Soil Guard	5.9	14	0.42
Hydromulch	Soil Set	140	14	**10.00**
Hydromulch	Star Tak	30	14	**2.14**

Source: Boeing, 2005.

Table 18h – Contributions to IRON concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	7	0.3	**22.33**
Sand	Corona Filter Sand	15	0.3	**50.00**
Gravel	Birds Eye Gravel	35	0.3	**116.67**
Gravel	Pea Bag Gravel	160	0.3	**533.33**
Gravel	Road Gravel	35	0.3	**116.67**
Hydromulch	Applegate N/D	0.22	0.3	0.73
Hydromulch	Applegate W/D	0.15	0.3	0.50
Hydromulch	Eco Aegis	0.42	0.3	**1.40**
Hydromulch	Eco Blend	0.057	0.3	0.19
Hydromulch	Eco Fibre	0.38	0.3	**1.27**
Hydromulch	Mat Fibre	0.061	0.3	0.20
Hydromulch	Naka Hydroseed	2.6	0.3	**8.67**
Hydromulch	Soil Guard	0.11	0.3	0.37
Hydromulch	Soil Set	0.46	0.3	**1.53**
Hydromulch	Star Tak	0.11	0.3	0.37

Source: Boeing, 2005.

Table 18i – Contributions to LEAD concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	6	5.2	**1.21**
Sand	Corona Filter Sand	2	5.2	0.29
Gravel	Birds Eye Gravel	8.1	5.2	**1.56**
Gravel	Pea Bag Gravel	87	5.2	**16.73**
Gravel	Road Gravel	19	5.2	**3.65**
Hydromulch	Applegate N/D	0.67	5.2	0.13
Hydromulch	Applegate W/D	0.56	5.2	0.11
Hydromulch	Eco Aegis	5.5	5.2	**1.06**
Hydromulch	Eco Blend	8.9	5.2	**1.71**
Hydromulch	Eco Fibre	2.9	5.2	0.56
Hydromulch	Mat Fibre	0.24	5.2	0.05
Hydromulch	Naka Hydroseed	3.7	5.2	**0.71**
Hydromulch	Soil Guard	0.40	5.2	0.08
Hydromulch	Soil Set	2.5	5.2	0.48
Hydromulch	Star Tak	0.32	5.2	0.06

Source: Boeing, 2005.

Table 18j – Contributions to MANGANESE concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	61	50	**1.22**
Sand	Corona Filter Sand	140	50	**2.80**
Gravel	Birds Eye Gravel	400	50	**8.00**
Gravel	Pea Bag Gravel	3300	50	**66.00**
Gravel	Road Gravel	610	50	**12.20**
Hydromulch	Applegate N/D	65	50	**1.30**
Hydromulch	Applegate W/D	44	50	0.88
Hydromulch	Eco Aegis	300	50	**6.00**
Hydromulch	Eco Blend	63	50	**1.26**
Hydromulch	Eco Fibre	540	50	**10.80**
Hydromulch	Mat Fibre	67	50	**1.34**
Hydromulch	Naka Hydroseed	280	50	**5.60**
Hydromulch	Soil Guard	190	50	**3.80**
Hydromulch	Soil Set	33	50	0.66
Hydromulch	Star Tak	ND	50	0.00

Source: Boeing, 2005.

Table 18k – Contributions to MERCURY concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	ND	0.1	0.00
Sand	Corona Filter Sand	ND	0.1	0.00
Gravel	Birds Eye Gravel	0.086	0.1	0.86
Gravel	Pea Bag Gravel	0.23	0.1	**2.30**
Gravel	Road Gravel	0.12	0.1	**1.20**
Hydromulch	Applegate N/D	ND	0.1	0.00
Hydromulch	Applegate W/D	ND	0.1	0.00
Hydromulch	Eco Aegis	ND	0.1	0.00
Hydromulch	Eco Blend	ND	0.1	0.00
Hydromulch	Eco Fibre	ND	0.1	0.00
Hydromulch	Mat Fibre	ND	0.1	0.00
Hydromulch	Naka Hydroseed	ND	0.1	0.00
Hydromulch	Soil Guard	ND	0.1	0.00
Hydromulch	Soil Set	ND	0.1	0.00
Hydromulch	Star Tak	ND	0.1	0.00

Source: Boeing, 2005.

Table 18l – Contributions to NICKEL concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	4	96	0.05
Sand	Corona Filter Sand	12	96	0.13
Gravel	Birds Eye Gravel	26	96	0.27
Gravel	Pea Bag Gravel	59	96	0.61
Gravel	Road Gravel	27	96	0.28
Hydromulch	Applegate N/D	ND	96	0.00
Hydromulch	Applegate W/D	ND	96	0.00
Hydromulch	Eco Aegis	ND	96	0.00
Hydromulch	Eco Blend	ND	96	0.00
Hydromulch	Eco Fibre	2.2	96	0.02
Hydromulch	Mat Fibre	ND	96	0.00
Hydromulch	Naka Hydroseed	4.1	96	0.04
Hydromulch	Soil Guard	3.4	96	0.04
Hydromulch	Soil Set	7.2	96	0.08
Hydromulch	Star Tak	ND	96	0.00

Source: Boeing, 2005.

Table 18m – Contributions to SELENIUM concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.96	5.0	0.12
Sand	Corona Filter Sand	1.5	5.0	0.18
Gravel	Birds Eye Gravel	12	5.0	**1.46**
Gravel	Pea Bag Gravel	ND	5.0	0.00
Gravel	Road Gravel	1.1	5.0	0.13
Hydromulch	Applegate N/D	ND	5.0	0.00
Hydromulch	Applegate W/D	ND	5.0	0.00
Hydromulch	Eco Aegis	ND	5.0	0.00
Hydromulch	Eco Blend	ND	5.0	0.00
Hydromulch	Eco Fibre	ND	5.0	0.00
Hydromulch	Mat Fibre	ND	5.0	0.00
Hydromulch	Naka Hydroseed	0.51	5.0	0.06
Hydromulch	Soil Guard	ND	5.0	0.00
Hydromulch	Soil Set	1.9	5.0	0.23
Hydromulch	Star Tak	1.9	5.0	0.23

Source: Boeing, 2005.

Table 18n – Contributions to SILVER concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.05	4.1	0.01
Sand	Corona Filter Sand	ND	4.1	0.00
Gravel	Birds Eye Gravel	0.092	4.1	0.02
Gravel	Pea Bag Gravel	0.54	4.1	0.13
Gravel	Road Gravel	0.12	4.1	0.03
Hydromulch	Applegate N/D	0.039	4.1	0.01
Hydromulch	Applegate W/D	0.026	4.1	0.01
Hydromulch	Eco Aegis	0.042	4.1	0.01
Hydromulch	Eco Blend	ND	4.1	0.00
Hydromulch	Eco Fibre	0.038	4.1	0.01
Hydromulch	Mat Fibre	ND	4.1	0.00
Hydromulch	Naka Hydroseed	0.052	4.1	0.01
Hydromulch	Soil Guard	ND	4.1	0.00
Hydromulch	Soil Set	ND	4.1	0.00
Hydromulch	Star Tak	ND	4.1	0.00

Source: Boeing, 2005.

Table 18o – Contributions to THALLIUM concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.22	2	0.11
Sand	Corona Filter Sand	0.15	2	0.08
Gravel	Birds Eye Gravel	0.42	2	0.21
Gravel	Pea Bag Gravel	1.7	2	0.85
Gravel	Road Gravel	0.46	2	0.23
Hydromulch	Applegate N/D	ND	2	0.00
Hydromulch	Applegate W/D	ND	2	0.00
Hydromulch	Eco Aegis	ND	2	0.00
Hydromulch	Eco Blend	ND	2	0.00
Hydromulch	Eco Fibre	ND	2	0.00
Hydromulch	Mat Fibre	ND	2	0.00
Hydromulch	Naka Hydroseed	ND	2	0.00
Hydromulch	Soil Guard	ND	2	0.00
Hydromulch	Soil Set	ND	2	0.00
Hydromulch	Star Tak	ND	2	0.00

Source: Boeing, 2005.

Table 18p – Contributions to ZINC concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	38	119	0.32
Sand	Corona Filter Sand	88	119	0.74
Gravel	Birds Eye Gravel	83	119	0.70
Gravel	Pea Bag Gravel	590	119	**4.96**
Gravel	Road Gravel	110	119	0.92
Hydromulch	Applegate N/D	48	119	0.40
Hydromulch	Applegate W/D	22	119	0.18
Hydromulch	Eco Aegis	32	119	0.27
Hydromulch	Eco Blend	26	119	0.22
Hydromulch	Eco Fibre	41	119	0.34
Hydromulch	Mat Fibre	15	119	0.13
Hydromulch	Naka Hydroseed	51	119	0.43
Hydromulch	Soil Guard	67	119	0.56
Hydromulch	Soil Set	54	119	0.45
Hydromulch	Star Tak	ND	119	0.00

Source: Boeing, 2005.

Table 18q – Contributions to DIOXIN TEQ concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Hydromulch	Star Tak	0.000012	0.000000028	**429**
Hydromulch	Eco Fibre	0.0000013	0.000000028	**46**
Hydromulch	Eco Aegis	0.0000077	0.000000028	**275**
Hydromulch	Applegate N/D	0.0000012	0.000000028	**43**
Hydromulch	Applegate W/D	0.0000021	0.000000028	**75**
Hydromulch	Soil Guard	0.0000033	0.000000028	**118**
Hydromulch	Mat Fibre	0.00000027	0.000000028	**10**
Hydromulch	Eco Blend	0.0000018	0.000000028	**64**

Source: Boeing, 2005.

ATTACHMENT E

TECHNICAL MEMORANDUM: SANTA SUSANA FIELD LABORATORY STORM WATER MANAGEMENT – CONCEPTUAL DESIGN OF CAPTURE, STORAGE AND TREATMENT MEASURES

TECHNICAL MEMORANDUM

To:	Paul Costa	**Date:**	September 1, 2006
From:	Richard Haimann, P.E./MWH, Chip Paulson, P.E./MWH	**Reference:**	1891168.017508
Subject:	**Santa Susana Field Laboratory Stormwater Management - Conceptual Design of Capture, Storage and Treatment Measures**		

1.0 EXECUTIVE SUMMARY

This technical memorandum presents the results of a study to assess feasible conceptual designs for capture, storage and treatment measures (CSTMs) to capture and treat runoff from selected stormwater outfalls on the Santa Susana Field Laboratory (SSFL) site so that permit conditions are likely to be met. CSTMs were designed to control the 10-year, 24-hour storm such that all numerical discharge limits listed in the industrial stormwater permit for the SSFL site would be likely to be met for all occurrences of the design storm or lesser events. CSTMs were designed for Outfall 1 (South Slope), Outfall 11 (Perimeter Pond), and Outfall 9 (Well WS13), as representative of the typical outfalls on the SSFL property.

A rainfall-runoff model was developed for the SSFL site using the SWMM platform and Los Angeles County Hydrology Manual criteria. The model was used to compute 10-year, 24-hour peak flows and runoff volumes for the three outfall watersheds of interest for a single, isolated storm event.

Conceptual designs of CSTMs were prepared to target metals and TCDD (dioxin) for removal, and consist of the following components at each outfall:

- Roller compacted concrete dam sized to store the full 10-year, 24-hour storm runoff volume.
- Water treatment plant consisting of high-rate clarification with pH adjustment and coagulant feed following by granular activated carbon.
- Pump station to deliver water from storage to the water treatment plant.
- Ancillary facilities including discharge pipeline from the water treatment plant to the stream, dirt access roads, SCADA, and electrical power supply.

Capital and operation and maintenance costs for the runoff capture and treatment facilities at each outfall are summarized in **Table ES-1**.

Table ES-1
Cost of Capture, Storage and Treatment Measures

Component	Outfall 1	Outfall 9	Outfall 11
Capital Costs			
CEQA & Permitting	$500,000	$500,000	$500,000
Detention Dam	$3,000,000	$10,400,000	$2,700,000
Treatment Plant	$26,500,000	$25,200,000	$13,100,000
Ancillary Facilities	$600,000	$900,000	$400,000
Total	$30,600,000	$37,000,000	$16,700,000
Annual O&M Costs			
Detention Dam	$15,000	$52,000	$14,000
Treatment Plant	$320,000	$300,000	$190,000
Ancillary Facilities	$12,000	$18,000	$6,000
Total	$347,000	$370,000	$210,000

Note: Costs are rounded to reflect level of accuracy of estimates.

Implementing the CSTMs would require obtaining a number of permits and approvals, including CEQA compliance, a Corps of Engineers 404 Permit, a Stream Alteration Agreement from the California Department of Fish and Game, and 401 certification and a stormwater construction permit from the Regional Board.

Implementing CSTMs at the selected outfalls would have the following results.

- Stormwater WQBELs as specified in the SSFL stormwater permit would likely be met 100 percent of the time for all storms up to the 10-yr, 24-hr event, provided that storms are spaced at least 7 days apart.
- Treated stormwater would meet non-potable water quality standards and could be reused onsite as non-potable water supply. Potable standards may be attainable with sufficient incremental treatment to meet the Surface Water Treatment Rule.

Implementing CSTMs at the selected outfalls would have the following impacts.

- Jurisdictional dams would be required at each outfall, per the criteria established by the State Division of Safety of Dams.
- Extensive flooded areas would be created at each detention pond, including riparian areas.
- Transport, use and storage of chemicals at the water treatment plants would create risks of spills of these chemicals into the permitted outfall waterways.
- The required water treatment processes would generate sludge, creating permanent disposal requirements.
- Major construction projects (dams and water treatment plants) would occur in and adjacent to natural channels, creating risks of adverse environmental impacts during construction.
- Building dams and treatment works represents significant hydromodifications, which can potentially have adverse impacts on downstream channel conditions and water quality due to changes in stream flow and velocity profiles created by the hydromodification.

- Construction of dams, treatment works and new or relocated access roads would require significant temporary and permanent land disturbance in currently undisturbed areas.

It is anticipated that design, permitting and construction for CSTMs at a given outfall, under best case conditions, if allowable by resource agencies and the Department of Safety of Dams could potentially be implemented in approximately 48 months from notice to proceed. There is uncertainty in this estimate. Should there be controversy associated with the impacts from the projects, this schedule can increase by many years.

2.0 INTRODUCTION

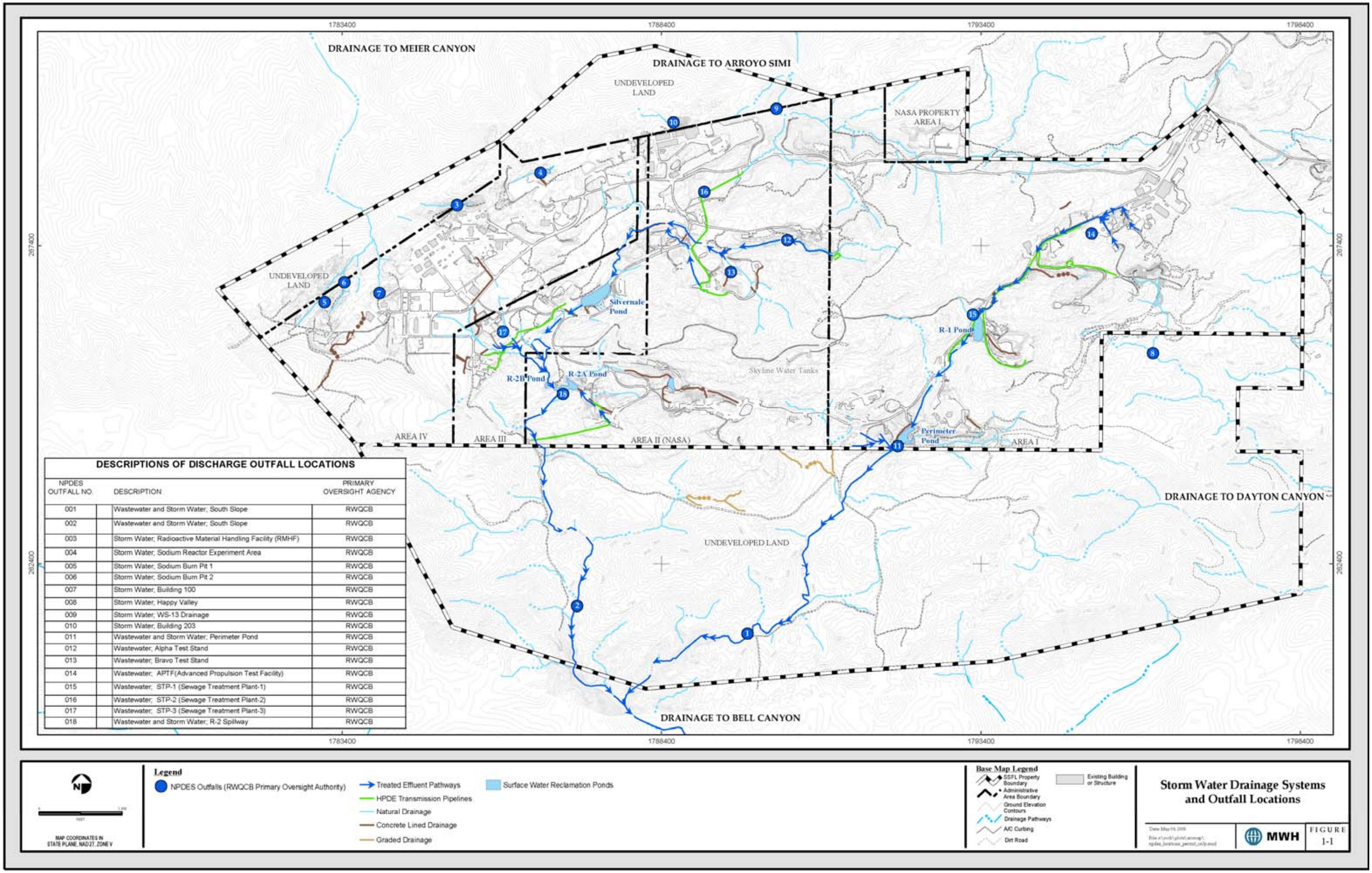
This technical memorandum presents the results of a study to assess feasible conceptual designs for capture, storage and treatment measures (CSTMs) to completely capture and treat runoff from selected stormwater outfalls on the Santa Susana Field Laboratory (SSFL) site. This work was conducted to support activities associated with the SSFL industrial stormwater discharge permit.

2.1 Project Objectives

The objectives of this analysis were to:

- Develop 10-year, 24-hour design peak discharges and hydrographs for use in sizing CSTM facilities.
- Develop conceptual designs for CSTMs that would be capable of treating design storm runoff such that it would be likely to meet numerical water quality standards established in the SSFL stormwater permit.
- Develop conceptual level cost estimates for the CSTM designs.
- Identify benefits and impacts of implementing the CSTM projects.

Based on discussions with SSFL staff, conceptual CSTM designs were prepared for Outfall 1 (South Slope), Outfall 11 (Perimeter Pond), and Outfall 9 (Well WS13). **Figure 1-1** shows the locations of these outfalls on the SSFL site. These outfalls were considered to be representative of the types of outfalls present at the SSFL site, and would provide a reasonable range of costs of fully treating the 10 year 24 hour stormwater volume to meet water quality based effluent limits (WQBELs).



DESCRIPTIONS OF DISCHARGE OUTFALL LOCATIONS

NPDES OUTFALL NO.	DESCRIPTION	PRIMARY OVERSIGHT AGENCY
001	Wastewater and Storm Water; South Slope	RWQCB
002	Wastewater and Storm Water; South Slope	RWQCB
003	Storm Water; Radioactive Material Handling Facility (RMHF)	RWQCB
004	Storm Water; Sodium Reactor Experiment Area	RWQCB
005	Storm Water; Sodium Burn Pit 1	RWQCB
006	Storm Water; Sodium Burn Pit 2	RWQCB
007	Storm Water; Building 100	RWQCB
008	Storm Water; Happy Valley	RWQCB
009	Storm Water; WS-13 Drainage	RWQCB
010	Storm Water; Building 203	RWQCB
011	Wastewater and Storm Water; Perimeter Pond	RWQCB
012	Wastewater; Alpha Test Stand	RWQCB
013	Wastewater; Bravo Test Stand	RWQCB
014	Wastewater; APTF(Advanced Propulsion Test Facility)	RWQCB
015	Wastewater; STP-1 (Sewage Treatment Plant-1)	RWQCB
016	Wastewater; STP-2 (Sewage Treatment Plant-2)	RWQCB
017	Wastewater; STP-3 (Sewage Treatment Plant-3)	RWQCB
018	Wastewater and Storm Water; R-2 Spillway	RWQCB

2.2 Project Background

The Regional Water Quality Control Board administer an Individual Industrial Storm Water Permit for the SSFL site. The Boeing Company, which owns and operates facilities on the SSFL property, is responsible for complying with pertinent permit requirements. The permit defines numerical water quality based effluent limits for various constituents, and requires implementation of BMPs to reduce constituent concentrations in stormwater runoff to meet those objectives. A Storm Water Pollution Prevention Plan was prepared for the site by MWH in November 2004 and revised several times since.

An extensive BMP implementation program has been implemented by Boeing at outfalls defined in the stormwater permit. This program has taken an adaptive management approach, in which a variety of types of BMPs have been implemented and monitored, and designs have been modified over time to improve performance and constructability.

Although the BMPs that have been implemented and investigated to date result in significant water quality improvements, to date they have not been effective 100 percent of the time in producing discharge water quality that meets the numerical WQBELs in the stormwater permit. Boeing requested a study to determine, at a conceptual level, the type, size and cost of facilities that would be required to fully capture and treat the design storm runoff such that the WQBELs would be likely to be satisfied.

To limit the study to a manageable schedule, capture and treatment requirements were investigated for three representative outfalls.

- Outfall 1 was selected because it drains a large area on the south side of the SSFL site.
- Outfall 9 was selected because it drains a large area on the north side of the SSFL site.
- Outfall 11 was selected because there is an existing storage pond (Perimeter Pond) at this site, which could be integrated into a permanent CSTM solution.

3.0 HYDROLOGIC ANALYSIS

Peak discharges and runoff hydrographs were developed for the three outfalls of interest in this study. The 10-year, 24-hour storm was adopted as the design storm, as this storm is noted in the current stormwater permit for the SSFL site. Peak flows are needed to size conveyance facilities, and runoff volumes are needed to size storage facilities.

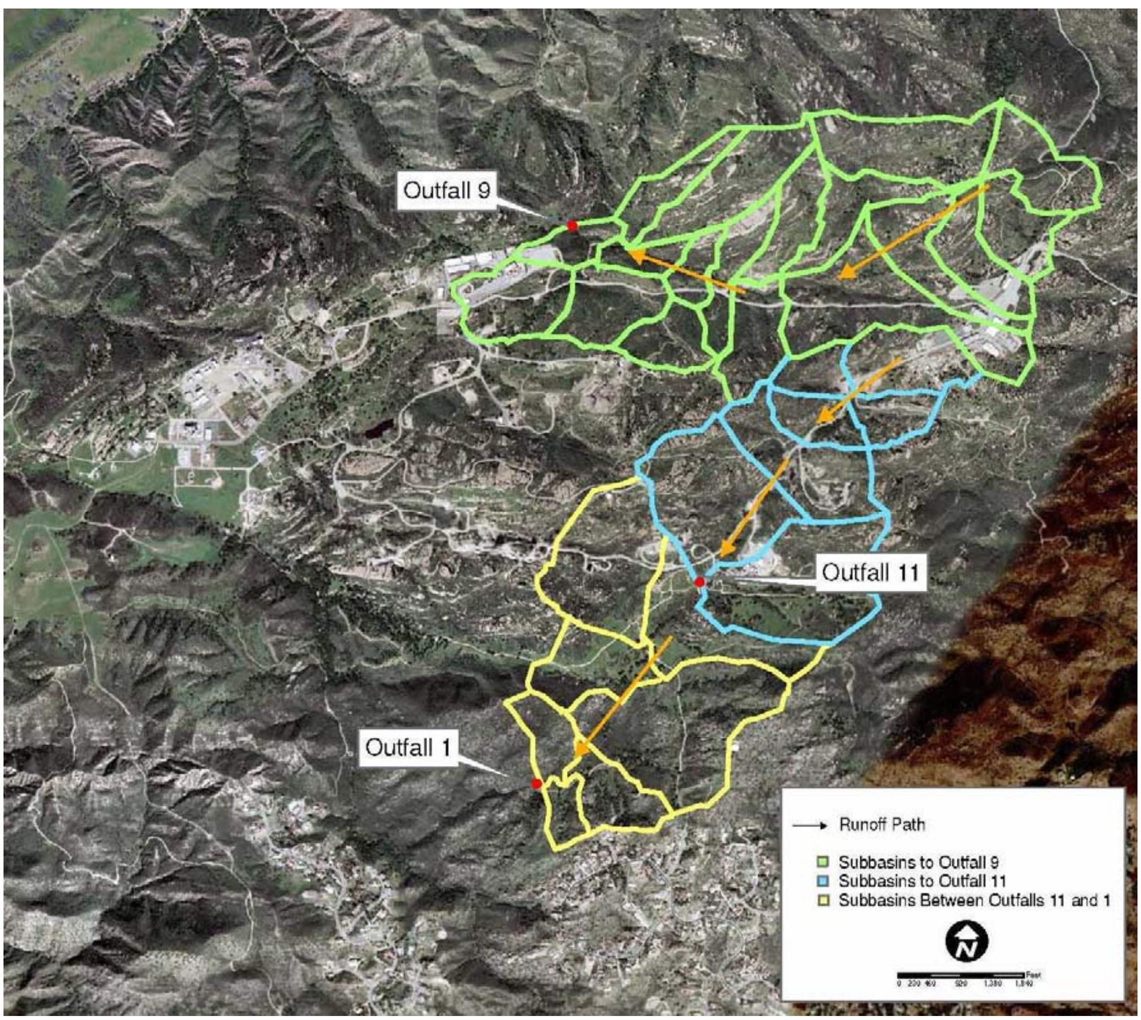
The SWMM model was selected for use in computing 10-year, 24-hour runoff hydrographs for Outfalls 1, 9 and 11. The following sections describe development of the hydrologic model and the results for the selected outfalls.

3.1 Hydrologic Model Development

To support various stormwater management activities on the SSFL site, a rainfall-runoff simulation model was developed using the SWMM software. The model was developed for the entire site; results for the three selected outfalls were used in this conceptual CSTM design study. This section summarizes the model data developed for the overall SSFL watershed area.

The SSFL watershed and sub-basins tributary to each outfall were delineated using topographic contours processed from aerial photos taken prior to 1996. These contours were supplemented and updated recently from field surveying data. The SSFL watersheds were delineated and subdivided into 72 sub-basins. The entire delineated area covers an area of 2,173 acres, and the average sub-basin size is 30 acres. Figure 3-1 shows the tributary drainage areas and sub-basins for Outfalls 1, 9 and 11. Topography is generally hilly; the slope of the sub-basins ranges from 2% to 41%.

Figure 3-1
Location of Study Outfalls and Tributary Sub-basins



The amount of impervious surface in each sub-basin strongly affects the volume of runoff that the sub-basin generates. Values of percent imperviousness range from 2% (undeveloped land) to 40% (built-up and/or rocky outcrops adjacent to the streams).

In the model simulation, each sub-basin generates runoff from rainfall after the model accounts for initial losses (e.g., interception storage, depression storage) and uniform losses (e.g., infiltration) throughout the storm event. A depression storage value of 0.10 inch was adopted for the impervious portion of the sub-basins, while the equivalent value for the pervious portion was 0.20 inch. Losses due to infiltration were calculated using the Natural Resources Conservation Service (NRCS) Curve Number method. This approach assumes that the soil type and vegetation cover determine the rate at which water infiltrates into the ground. The soil on the SSFL site belongs to NRCS hydrologic soil group D. This soil type has a high runoff potential with an average saturated hydraulic conductivity of 0.025 in/hr. The site is predominantly open space, with grass cover on 50-75% of the area. This soil type and ground cover combination translates to a Curve Number of 84.

Direct runoff flows overland to stream channels that are modeled as conduits. A total of 8.8 miles of stream were modeled assuming a typical trapezoidal channel of 4 ft wide (at the bottom) by 10 ft deep with a 2:1 side slope, using a Manning’s roughness coefficient of 0.07. Overland flow from both types of surfaces was also taken into account. The Manning's coefficient for the impervious surface portion is 0.024 (cement rubble surface), while for the pervious portion, it is 0.24 (dense grass).

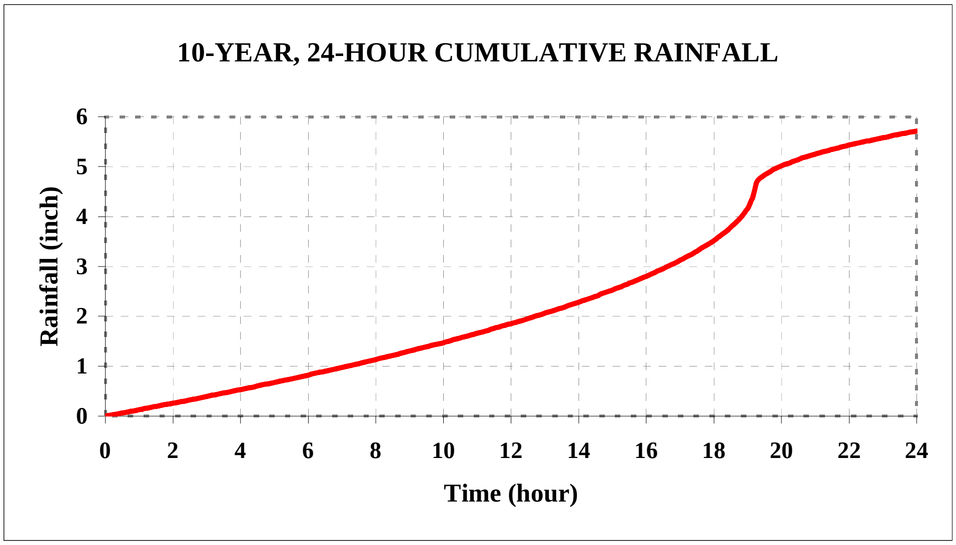
The SSFL site is located in Ventura County, but it is immediately adjacent to Los Angeles County. The 10-year, 24-hour design storm was developed using criteria presented in the hydrology manual published by Los Angeles County. This manual includes more updated information than the Ventura County Hydrology Manual. The Ventura County Hydrology Manual is focused on calculating runoff from new development, while the Los Angeles County Hydrology Manual has more information for currently developed sites. The Los Angeles County manual also allows calculation of a wider range of more frequent storm events. These smaller storms are more relevant for the water quality facilities that will be designed using the model results. Because of these advantages, the Los Angeles County manual was used to develop the design storm.

The Los Angeles County Hydrology Manual includes maps showing isohyetals for the 50-year, 24-hour storm. The SSFL site is on the Calabasas map, but the isohyetals do not extend over the site because it is not in Los Angeles County. By extrapolating the isohyetals it was concluded that the 50-year, 24-hour storm produces a rainfall of 8.0 inches over the SSFL site. This estimate is based on the isohyetals for neighboring areas in Los Angeles County, and on the fact that NOAA Atlas 2, Volume XI shows a 50-year, 24-hour rainfall of 8.0 inches for the site.

The Los Angeles County Hydrology Manual includes a series of multipliers to obtain the 24-hour rainfall totals for other storm frequencies as a function of the 50-year rainfall depth. For the 10-year storm, the multiplier is 0.714, which gives an equivalent rainfall depth of 5.71 inches. The manual includes a unit hyetograph for a typical storm distribution over a 24-hour period.

Figure 3-2 shows the temporal rainfall pattern for the design storm. Using the calculated depth and the hyetograph, the 24-hour design storm was created for the 10-year event.

Figure 3-2
Cumulative 10-year, 24-hour Storm Pattern for SSFL Site



The effect of existing storage ponds on runoff hydrology was investigated in the simulations. There are five existing ponds in the site - R-1, Perimeter, Silvernale, R-2A, and R-2B - which provide storage for stormwater. The Perimeter Pond, located immediately upstream of Outfall 11 and also in the Outfall 1 watershed, was included in the simulations to capture runoff. However, the pond did not produce a significant attenuation effect on the final flow results (i.e., peak discharge, total runoff volume) because its storage volume is small compared to the 10-year, 24-hour runoff volume.

New sets of flow monitoring equipment are currently being installed to provide data to calibrate the rainfall-runoff model. Flow data will be collected during the next rainy season, which will run from mid-October 2006 through mid-April 2007.

The model simulation was run for 72 hours to assure that the entire hydrograph volume was computed.

3.2 Hydrologic Results

Peak discharges and runoff volumes for the design storm at the selected outfalls are presented in **Table 3-1**. **Figures 3-3, 3-4** and **3-5** present the computed runoff hydrographs at these locations.

Table 3-1
10-Year, 24-Hour Peak Discharge and Runoff Volume at SSFL Outfalls

SSFL Outfall	Drainage Area (acres)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
Outfall 1	603	553	277
Outfall 9	569	525	261
Outfall 11	300	286	138

Figure 3-3
10-Year, 24-Hour Runoff Hydrograph at Outfall 1

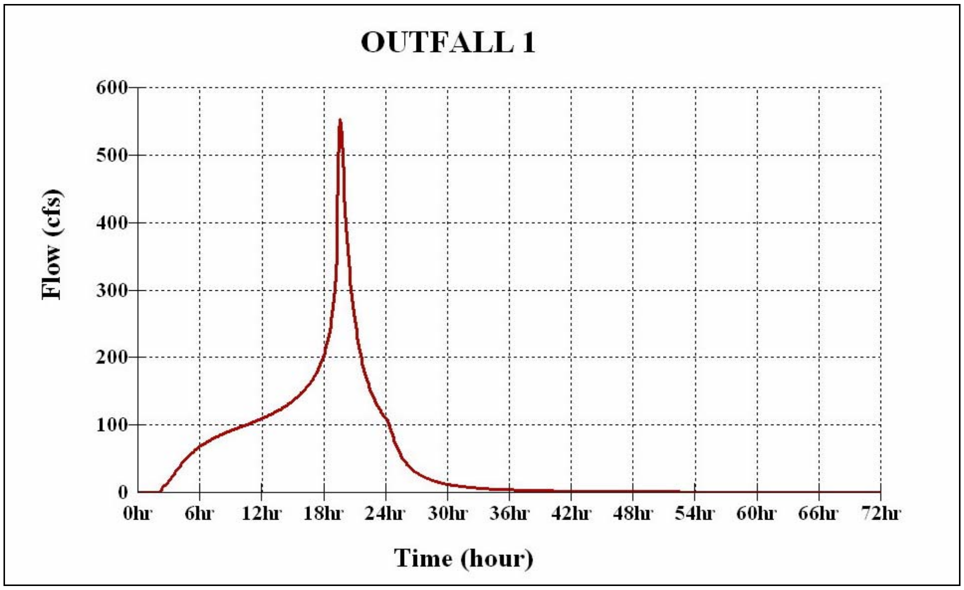


Figure 3-4
10-Year, 24-Hour Runoff Hydrograph at Outfall 9

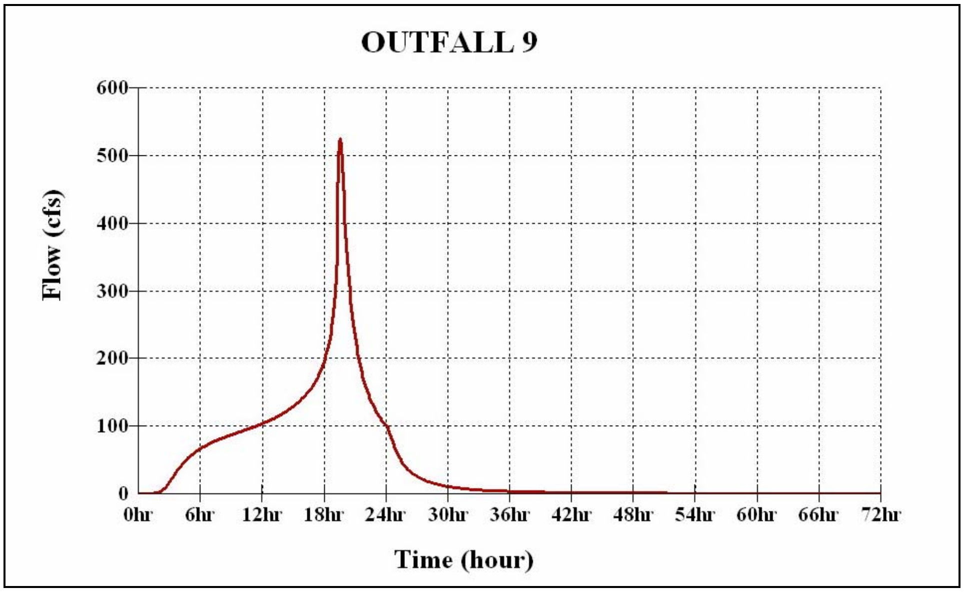
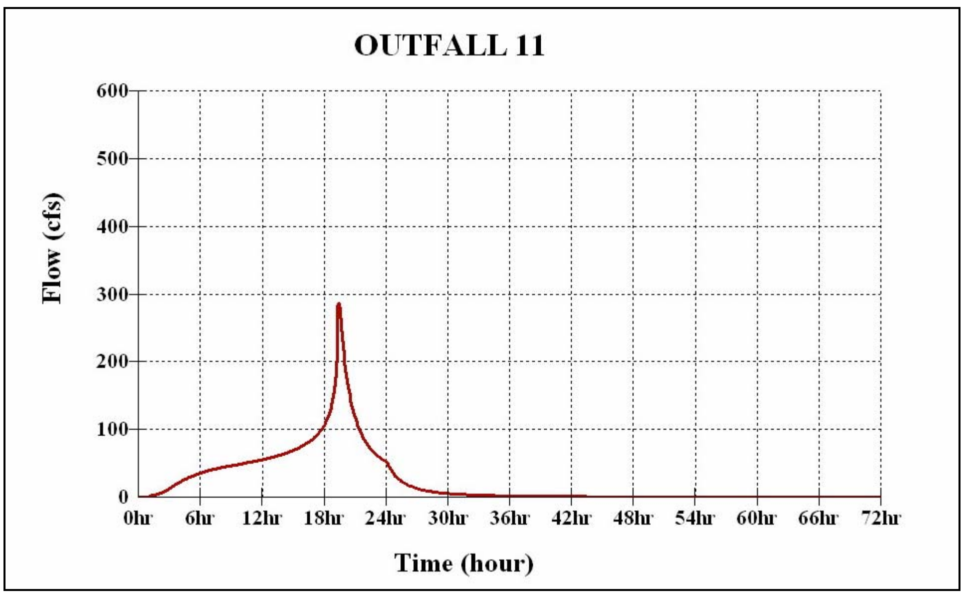


Figure 3-5
10-Year, 24-Hour Runoff Hydrograph at Outfall 11



4.0 CONCEPTUAL CSTM DESIGN

The objective of the CSTM system is to fully capture and treat the design storm runoff to meet the numerical WQBELs specified by the Regional Board. Thus the CSTMs at each outfall consist of the following components:

- Detention storage sized to retain the full 10-year, 24-hour runoff volume
- Water treatment process to treat the full runoff volume in 7 days from the beginning of the storm event
- Ancillary facilities required to implement the CSTM (e.g., pump from detention storage to water treatment; release of treated water back to outfall channel; access roads; power)

Each of these components is described below.

The conceptual design components are sized to accommodate capture, storage and treatment of a single design storm in 7 days. Storms in Southern California can occur with less than 7 days between events. However, it is very unlikely that two 10-year, 24-hour storms would occur within 7 days. Sizing facilities to fully store the 10-year, 24-hour storm runoff volume and treat it over 7 days produces facilities that would also be capable of storing and treating back-to-back 2-year, 24-hour storms that occur within 3 days of each other. This is a reasonable factor of safety at this conceptual level. For design it would be appropriate to simulate operation of the proposed CSTMs over several critical historical wet periods involving multiple storms to assure that facilities would function as desired.

4.1 Detention Storage

Conceptual design criteria for detention storage at each outfall were selected based on common engineering practice. Conservative assumptions were made at this level of analysis wherever necessary. Detention storage design criteria are summarized as follows.

- Roller compacted concrete dam
- 20 ft wide dam crest
- 0.8:1 side slope for downstream embankment face and vertical upstream face
- Minimum 3 ft of freeboard between the maximum 10-year, 24-hour water level and the dam crest
- 24-inch reinforced concrete pipe low level outlet to drain detention storage when necessary
- Minimum pool of 5 ft deep (about 1 ac-ft of storage volume) at the end of each storm to provide enhanced stormwater treatment for subsequent storms.

A roller compacted concrete (RCC) design was selected based on spillway considerations. If an earthfill embankment dam were used, a spillway structure would be required to pass at least the 100-year peak discharge. Preliminary sizing of typical spillway configurations resulted in either wide spillways compared to the width of the channels in which the detention basins are located, or significantly higher dams. Use of RCC for the dam material allows the entire dam crest to serve as the spillway, eliminating the need for a separate spillway and reducing the required height of the dam. This approach was considered to be the most cost effective design at this conceptual level.

Based on these design criteria and site conditions defined by the best available topographic mapping, detention dam characteristics as shown in **Table 4-1** were determined.

Table 4-1
Detention Dam Characteristics for Conceptual Design

Detention Dam Characteristic	Outfall 1	Outfall 9	Outfall 11
Maximum Height (ft)	53	98	36
Embankment Volume (cy)	16,000	55,000	14,000
Storage Capacity 3 ft Below Dam Crest (ac-ft)	277	261	138
Storage Capacity at Dam Crest (ac-ft)	330	290	210
Length of Outlet Pipe (ft)	80	120	60
Area of full reservoir (acres)	15.7	12.1	16.5

Figures 4-1, 4-2 and **4-3** show the locations of the potential detention storage sites on a topographic base, and **Figures 4-4, 4-5** and **4-6** show the detention sites on an aerial photograph.

The detention storage sizing for Outfall 1 in **Table 4-1** assumed that no storage is provided at Outfall 11 (which is upstream in the same watershed). This is conservative for storage requirements at Outfall 1.

At Outfall 11 the possibility of providing the required flood storage by raising the dam forming the Perimeter Pond was investigated. At the necessary dam height and storage volume, existing infrastructure would be inundated during a 10-year storm. Thus this option was shown to be infeasible, and a new dam site downstream of the existing Perimeter Pond dam was selected. The existing pond would be completely inundated by the new facility during any significant storm events.

Providing 3 feet of freeboard between the 10-year, 24-hour water level and the top of the dam at each detention pond provides a factor of safety against hydrologic uncertainty, the possibility of back-to-back storms (which were not evaluated quantitatively), and the possibility of treatment capacity limitations due to plant problems or power outages.

The detention ponds would trap sediment from the upstream watershed. This would especially be a factor at Outfall 9 since there is no existing upstream storage in that subwatershed. The existing Perimeter Pond at Outfall 11 currently traps all sediment tributary to the Outfall 11 CSTM, and controls most of the area upstream of Outfall 1. Portions of the SSFL site could contribute heavy sediment loads during high intensity runoff events due to steep slopes and exposed soils. Periodic maintenance would be required to remove accumulated sediment from the detention basins to preserve the required design capacity. Material removed from the detention basins would have to be tested to assure that it could be disposed onsite or in a conventional landfill.

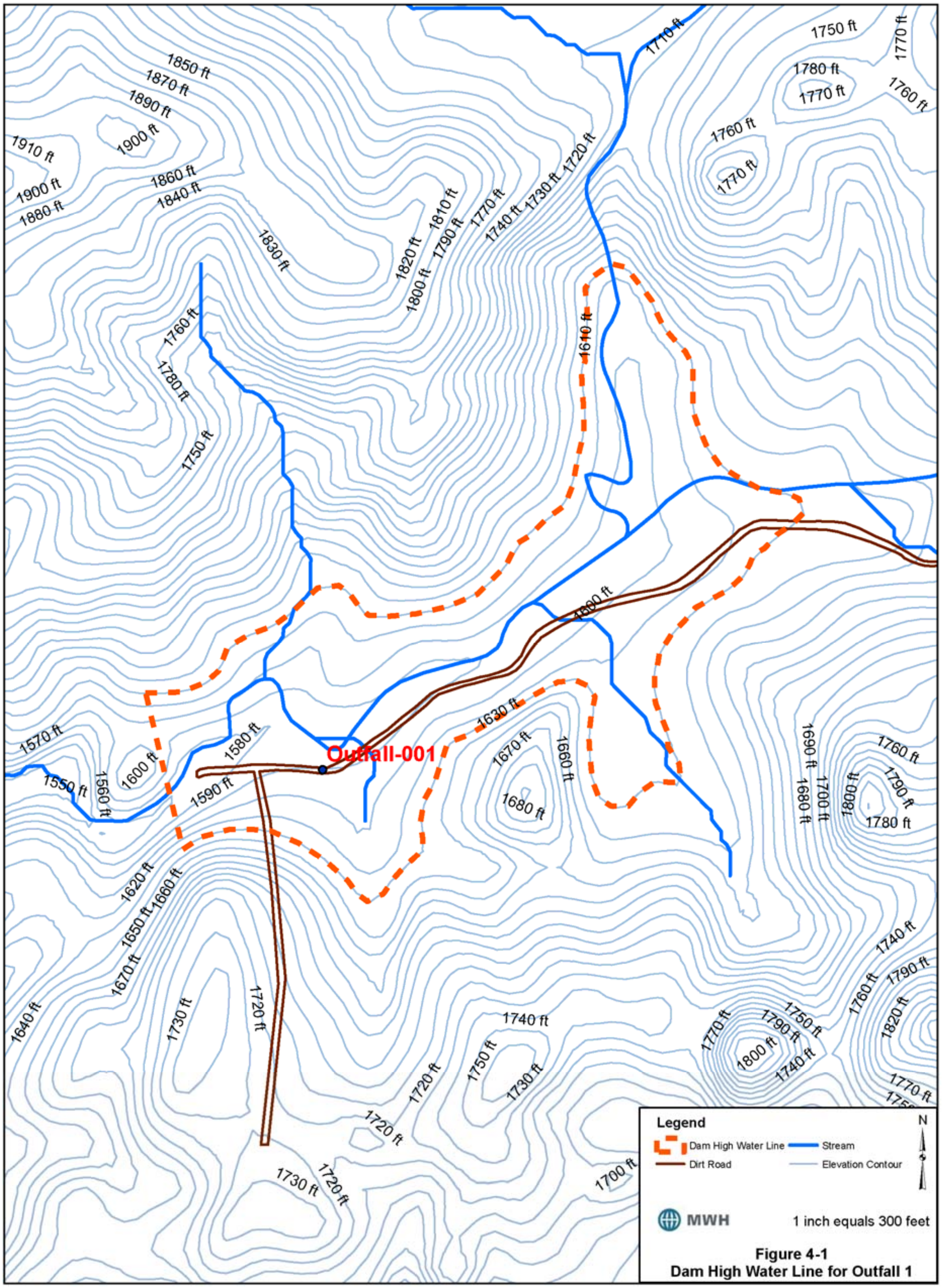


Figure 4-1
Dam High Water Line for Outfall 1

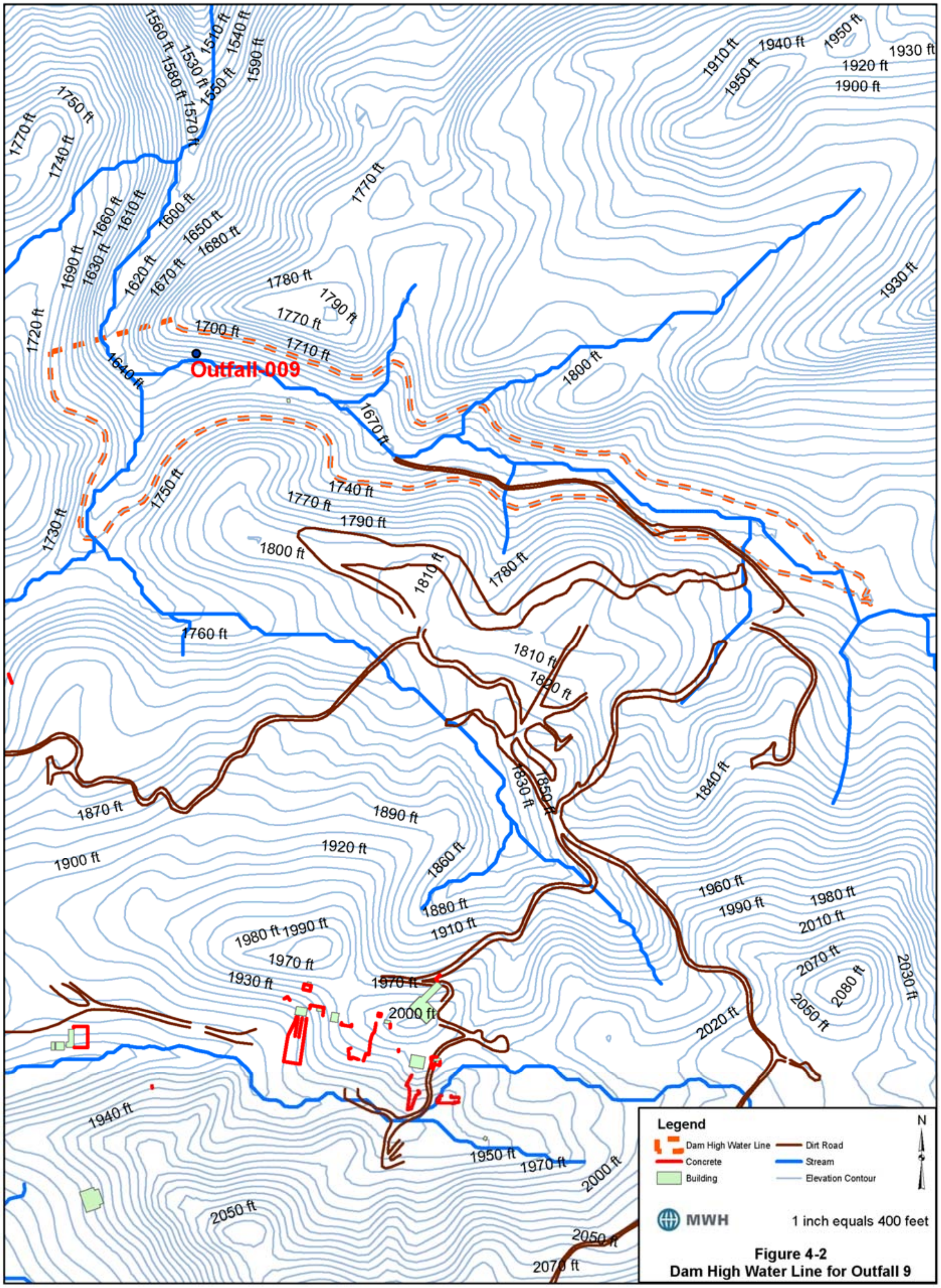


Figure 4-2
Dam High Water Line for Outfall 9

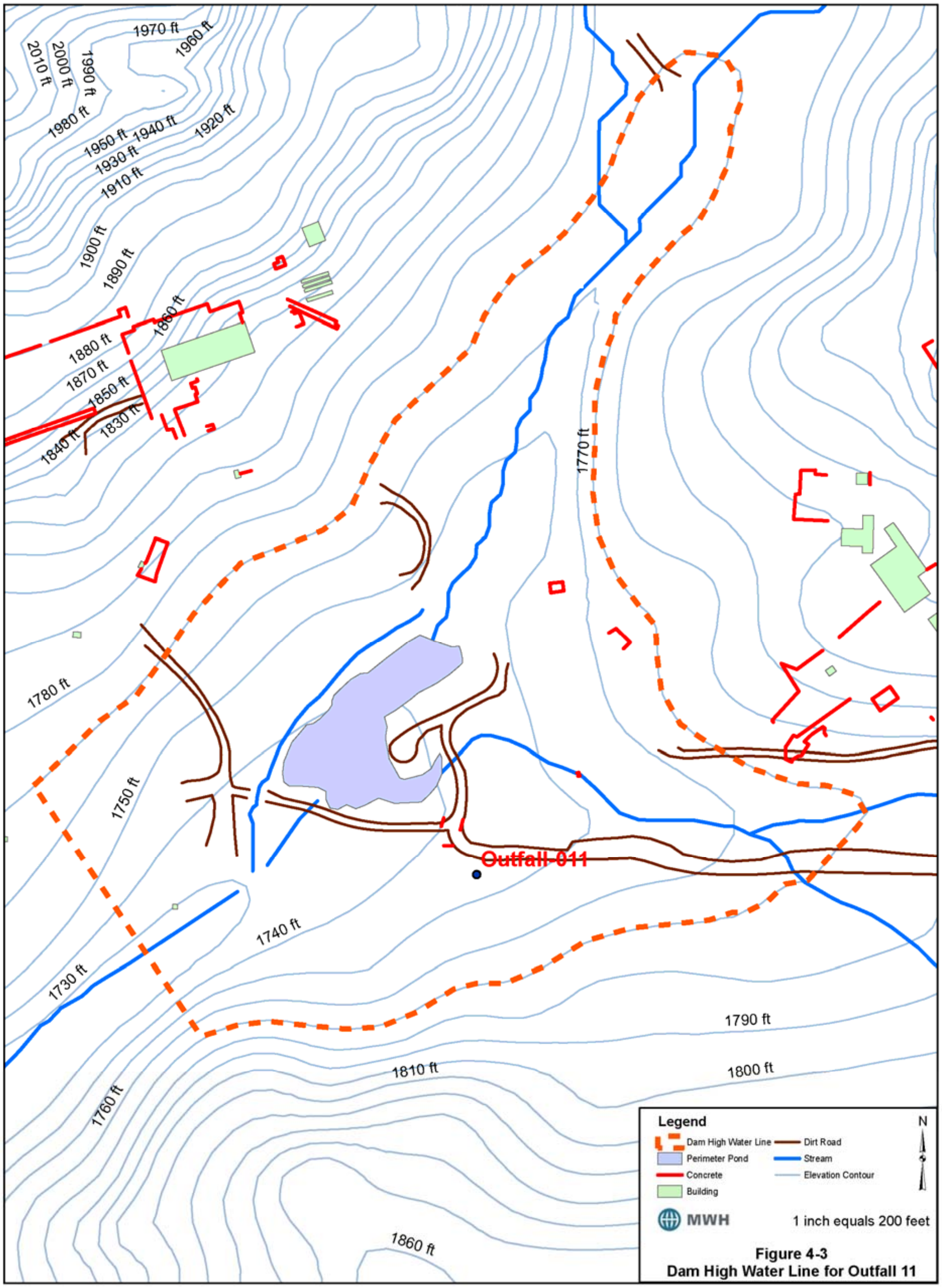


Figure 4-3
Dam High Water Line for Outfall 11

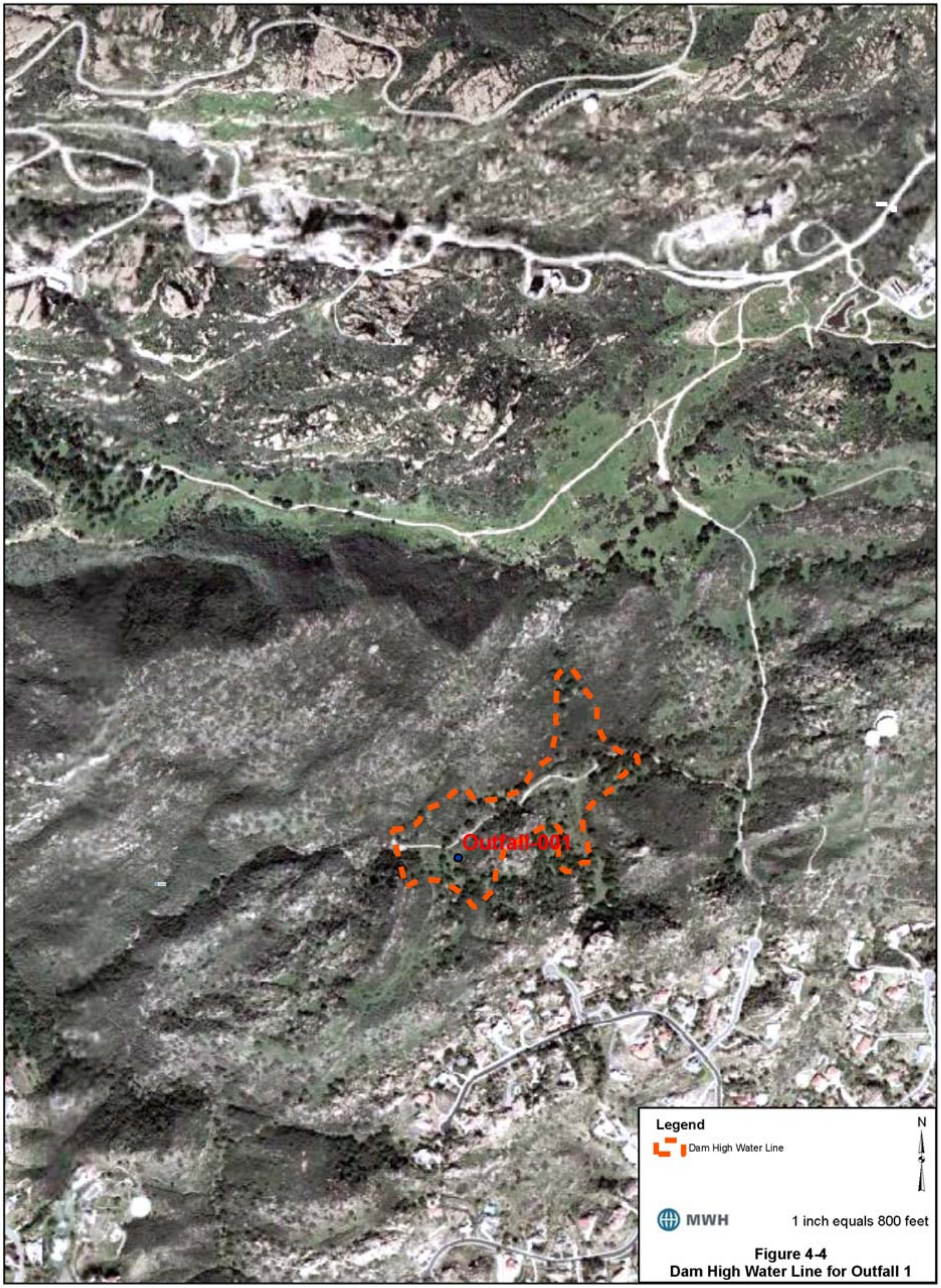


Figure 4-4
Dam High Water Line for Outfall 1

Figure 4-5
Dam High Water Line for Outfall 9

Figure 4-6
Dam High Water Line for Outfall 11

4.2 Water Treatment

Required water treatment processes are dependent on the constituents to be removed and the numerical discharge limits to be achieved. The SSFL stormwater permit (RWQCB Order 24-2006-0036) provides numerical water quality discharge limits for a broad range of constituents. Limits are expressed as either a daily maximum or a daily maximum plus a monthly average maximum. The objective of this full control CSTM investigation is to provide treatment such that no exceedances to the permit limits occur during wet weather for events up to and including the 10-yr, 24-hr storm. Thus the daily limits are of primary concern.

Recent water quality monitoring data for runoff events from August 2004 to May 2006 was reviewed and compared to the numerical discharge limits. Sampling data from this period represents results of analyzing grab samples collected during runoff events, and does not necessarily represent the event mean concentration. The historical grab samples provide the best available characterization of site runoff water quality.

Table 4-2 summarizes the results of this comparison for constituents having exceedances of WQBELs for the three outfalls of interest. In some cases, stormwater samples were collected prior to establishment of specific discharge limits. In these cases, average and maximum analytical results are shown for the full data set, and the number of samples and permit limit exceedances are shown both for the period during which the permit limits were in force and for the full August 2004 to May 2006 data set. Not all outfalls have the same permit limits, and not all outfalls had limits established at the same time.

Depending on the storm and outfall, as many as 200 constituents were analyzed. For most constituents analyzed, concentrations were within compliance limits for all the samples collected. **Table 4-2** only provides data for those constituents that had one or more samples exceeding the WQBEL.

Iron, total lead and TCCD (dioxin) have average values exceeding the numerical discharge limits at one or more outfalls. For all other constituents in **Table 4-2** it is only samples in which the concentration was at or near the maximum concentration recorded in the period of record that failed to meet the numerical limit. The strong influence of isolated high concentrations suggests that there is a good probability that providing equalization storage in the detention ponds will greatly improve the ability to meet discharge limits, and may be sufficient to meet limits in many storm events. However, because there is no way to determine when these extreme concentrations will occur, all runoff events would have to be treated to assure compliance with the WQBELs.

Based on the data summarized in **Table 4-2**, target constituents for treatment are metals and TCDD. Metals (particulate-bound fraction) can be removed relatively effectively using solids removal processes. Settling of solids in the detention basins may assist in removing metals and other constituents adsorbed to the solids.

Table 4-2
Constituents Exceeding Current Stormwater Permit Discharge Limits, August 2004 – May 2006

Constituent	Permit Limit(1)	Unit	Average	Maximum	No. of Samples(2)	No. of Exceedances(2)
Outfall 1						
Chromium (total)	16.3/8.1	ug/L	12.9	100	16	2
Copper (total)	14.0/7.1	ug/L	5.34	55	25	1
Iron	0.3/-	mg/L	8.58	92	16	10
Lead (total)	5.2/2.6	ug/L	7.35	160	26	2
Manganese (total)	50/0	ug/L	76.9	370	8	3
Mercury (total)	0.10/0.05	ug/L	0.06	0.26	22	1
Surfactants	0.5/-	mg/L	0.086	1	21	1
TCDD	2.80E-08 / 1.40E-08	ug/L	2.74E-07	4.60E-06	21	5
Outfall 9						
Cadmium (total)	4.0/-	ug/L	0.50	9/2	5/23	0/1
Copper (total)	14.0/-	ug/L	7.36	39	5/23	1/3
Lead (total)	5.2/-	ug/L	19.6	260	5/23	1/5
Mercury (total)	0.13/-	ug/L	0.06	0.16	5/23	0/4
Oil and Grease	15/-	mg/L	1.33	16	23/23	1/1
pH (field)	8.5/-	pH units	7.26	8.8	19/19	1/1
TCDD	2.80E-08/-	ug/L	8.9E-06	1.77E-05	5/23	1/6
Outfall 11						
Lead (total)	5.2/2.6	ug/L	1.84	8.8	2/21	0/2
Mercury (total)	0.10/0.05	ug/L	0.08	0.25	2/21	0/9
TCDD	2.80E-08 / 1.40E-08	ug/L	1.13E-07	1.10E-06	2/21	2/5

(1) Daily/Monthly Average
(2) During period of permit limits/For entire data set
(3) Highlighted cells denote exceedance of Daily permit limit

Although the equalization storage in the detention basins is expected to improve water quality, there is no assurance that this equalization alone will be capable of meeting the specified discharge limits under all flow conditions and for all runoff events less than or equal to the 10-year 24-hour storm, particularly for TCDD. Therefore, a water treatment process consisting of high-rate clarification with pH adjustment and coagulant feed (such as the Actiflo package plant) to address total metals, following by granular activated carbon (GAC) to remove TCDD, is proposed at each outfall. Actiflo units have small footprints, and have been found to be successful in other stormwater treatment applications. The GAC process would involve high temperature thermal treatment to destroy the TCDD chemical. Bench testing and pilot testing would be required to determine site-specific removal efficiencies and assure that numerical limits could be met. Although the limited water quality data shows some differences in permit limit exceedances at the three outfalls, to reduce risks of exceedances, it was assumed that the same two-phase treatment process would be installed at each outfall.

For purposes of this analysis it is assumed that all water captured in the detention ponds would be treated prior to discharge back to the drainage-way. Collection and immediate analysis of water quality samples from the detention pond discharges could allow the treatment plant to be bypassed whenever pond releases would meet all the numerical limits. However, in practice this would not be feasible due to the turnaround times required for laboratory analyses of the constituents of concern. The assumption of full treatment of all runoff is appropriate for this conceptual analysis since it minimizes risks of exceedances.

Treatment system design criteria have been adopted to allow for system sizing and costing. System sizing for capacity is based on treating the full 10-year, 24-hour runoff volume at a constant rate over a treatment duration of 7 days. **Table 4-3** summarizes the basic design parameters for the three designated outfalls.

Table 4-3
Basis of Water Treatment Plant Design Criteria

Treatment Parameter	Unit	Outfall 1	Outfall 9	Outfall 11
Total Runoff Volume	mg	90	85	45
Required Treatment Duration	days	7		
Required Treatment Capacity	cfs	20	19	10
	mgd	12.9	12.3	6.5
	gpm	9,000	8,500	4,500

MG: million gallons; cfs: cubic feet per second; mgd: million gallons per day; gpm: gallons per minute.

It is assumed that the treatment facility would be located adjacent to the detention pond. The area required for Actiflo and GAC equipment, chemical storage, O&M activities, vehicle access, and a pump station from the detention pond (see section on Ancillary Facilities) is conservatively estimated to be approximately 1.0 acre (200 feet by 200 feet). A possible treatment plant site for each outfall is shown in **Figures 4-1** through **4-6**.

Sludge disposal from the treatment plants would be required. Sludge disposal would most likely be accomplished by hauling the sludge to an appropriate offsite landfill. The GAC process would require regular exhaustion and regeneration of the carbon media. Regeneration would occur offsite at a commercial regeneration facility.

4.3 Ancillary Facilities

A number of ancillary facilities would be required to implement the CSTMs. These are briefly described below.

- **Access roads for construction and O&M.** It is assumed new access roads to accommodate construction and future maintenance would be graded dirt roads with some gravel bedding as necessary to allow access. The proposed detention ponds would require relocation of existing onsite roads either because of the dam fill or the reservoir inundation. Existing roads would be relocated around the detention sites using as short a route as possible.

- **Conveyance system from the detention pond to the treatment facility.** It is assumed that the treatment facility would be located adjacent to the detention pond, and that water would be pumped from the pond to the water treatment facility. Preliminary investigation of the most feasible dam sites indicated that it would not be practicable to locate the water treatment facility at a downstream location such that water could be released from the pond by gravity. It is assumed that the pump station would be located at the water treatment plant. **Figures 4-1** through **4-6** show the potential water treatment plant/pump station location at each outfall, and the alignment of an intake pipeline from the reservoir to the pump station.

- **Conveyance system from the treatment facility back to the outfall channel**. Treated water would be returned to the stream below the detention pond through a gravity pipeline. **Figures 4-1** through **4-6** show a conceptual alignment for the discharge pipeline at each outfall.

- **SCADA controls.** SCADA controls would allow remote operation of the treatment, pumping and piping systems. It is assumed that existing central SCADA operations of other facilities on the SSFL site can be expanded to handle the new facilities.

- **Power.** The water treatment facility, pump station and SCADA controls would require power at the outfall sites. It is assumed that power lines (either overhead or buried) would be extended from the nearest feasible onsite locations for each outfall. For Outfalls 9 and 11, power could be extended from existing facilities close to the plant sites. For Outfall 1, power would have to be brought in from the existing facilities in the vicinity of Perimeter Pond approximately 4,500 feet away.

5.0 COSTS

An engineer's opinion of probable costs was developed for the capture, storage and treatment facilities at each outfall. The purpose of the estimate is to provide an opinion of order-of-magnitude capital and operation and maintenance (O&M) costs for the CSTM plan. Cost opinions at the conceptual level of project development have an expected accuracy of +50 percent to –30 percent. Capital costs include engineering and construction management services. Permitting costs of $500,000 per outfall have been assumed for all state and federal environmental permits.

5.1 Detention Dam Capital and O&M Costs

Costs for detention dams and related appurtenances were based on the following unit cost assumptions.

- Roller Compacted Concrete (RCC) for detention dams was assumed to cost $125/cy in place.
- 24-inch RCP outlet pipes were assumed to cost $100/ft, plus $20,000 for headwalls and gates.
- A contingency of 50 percent was applied to capital cost estimates for the dams to account for unlisted items, unknown site conditions, and uncertainties in material quantities and costs.
- O&M costs for civil facilities were estimated at 0.5 percent of capital cost.

Table 5-1 summarizes detention dam costs for the three outfalls.

Table 5-1
Detention Dam Capital and O&M Costs

Component	Outfall 1	Outfall 9	Outfall 11
RCC Dam	$2,000,000	$6,900,000	$1,800,000
Outlet Pipe	$8,000	$12,000	$6,000
Headwalls, Gates	$20,000	$20,000	$20,000
Contingency	$1,000,000	$3,500,000	$910,000
Capital Cost	$3,000,000	$10,400,000	$2,700,000
Annual O&M	$15,000	$52,000	$14,000

Note: Costs are rounded to reflect accuracy of estimates.

5.2 Water Treatment Capital and O&M Costs

Capital and O&M costs for the water treatment components are summarized in **Table 5-2**. Cost estimates were based on unit factors commonly used for each process based on engineering experience. Treatment costs for the clarification step were estimated assuming a unit cost of $1.5 million per mgd capacity, including plant design and construction, site work, and contingencies. O&M costs were estimated using a unit cost of $400 per year per million gallons treated. This covers equipment maintenance, chemicals, staffing and sludge disposal. Costs for the GAC step were estimated assuming $120,000-$140,000/mgd for capital cost and $140-$170 per year per million gallons treated for annual O&M costs. A capital cost contingency factor of 25 percent for the water treatment systems was added to account for site work and other unlisted items. To determine annual O&M costs it was assumed that the mean annual runoff occurs from 10 storms with an average volume of one-half the 10-year runoff volume calculated by the InfoSWMM model. An O&M cost contingency factor of 25 percent was added to account for offsite sludge disposal and other general administrative and site maintenance functions.

Table 5-2
Water Treatment Capital and O&M Costs

Description	Outfall 1	Outfall 9	Outfall 11
Capital Cost			
Treatment Capacity (mgd)	12.9	12.3	6.5
Actiflo ($/mgd)	$1,500,000	$1,500,000	$1,500,000
GAC ($/mgd)	$140,000	$140,000	$120,000
Subtotal	$21,200,000	$20,200,000	$10,500,000
Contingency (25%)	$5,300,000	$5,000,000	$2,600,000
Capital Cost	$26,500,000	$25,200,000	$13,100,000
Annual O&M Cost			
Annual Runoff Volume (mg)	451	425	274
Actiflo Unit Cost ($/mg)	400	400	400
GAC Unit Cost ($/mg)	170	170	140
Subtotal	$260,000	$240,000	$150,000
Contingency (25%)	$60,000	$60,000	$40,000
Annual O&M Cost	$320,000	$300,000	$190,000

5.3 Ancillary Facility Capital and O&M Costs

Capital costs for ancillary facilities associated with the storage and treatment systems at each outfall are summarized in **Table 5-3**. Costs were developed using unit cost factors based on engineering experience and a 50 percent contingency for unlisted items and uncertainties.

Table 5-3
Ancillary Facility Capital Costs

Component	Quantity	Units	Unit Cost ($)	Component Cost
Outfall 1				
Intake pump station	200	hp	1,300.00	$260,000
Intake pipe + Return pipe	800	ft	60.00	$48,000
Access road	2000	ft	20.00	$40,000
Relocated roads	0	ft	20.00	$0
SCADA		LS		$30,000
Power		LS		$40,000
Subtotal				$418,000
Contingency			50%	$209,000
			Total	**$627,000**
Outfall 9				
Intake pump station	317	hp	1,300.00	$412,100
Intake pipe + Return pipe	1300	ft	60.00	$78,000
Access road	100	ft	20.00	$2,000
Relocated roads	2000	ft	20.00	$40,000
SCADA		LS		$30,000
Power		LS		$20,000
Subtotal				$582,100
Contingency			50%	$291,050
			Total	**$873,150**
Outfall 11				
Intake pump station	87	hp	1,300.00	$113,100
Intake pipe + Return pipe	700	ft	60.00	$42,000
Access road	0	ft	20.00	$0
Relocated roads	2000	ft	20.00	$40,000
SCADA		LS		$30,000
Power		LS		$20,000
Subtotal				$245,100
Contingency			50%	$122,550
			Total	**$367,650**

O&M costs consist of maintenance costs for the civil and mechanical facilities, which were estimated at 1 percent of the capital cost, and power costs for the pump stations. Power costs were estimated assuming an average of 10 storms per year that fill the pond volume to one-half of capacity, and a power cost of $0.05/kwh. **Table 5-4** summarizes annual O&M costs for ancillary facilities.

Table 5-4
O&M Costs for Ancillary Facilities

Component	Outfall 1	Outfall 9	Outfall 11
Total Capital Cost	$627,000	$873,000	$368,000
Annual Maintenance Cost	$6,000	$9,000	$4,000
Annual Power Cost	$6,000	$10,000	$3,000
Total Annual O&M	$12,000	$18,000	$6,000

5.4 Summary of CSTM Costs

Table 5-5 summarizes the total costs of complete storage, treatment and disposal to meet the requirements of the SSFL stormwater permit at Outfalls 1, 9 and 11. Notes that costs for Outfall 1 facilities assume no control measures are implemented at Outfall 11.

Table 5-5
Cost of Complete Control CSTMs

Component	Outfall 1	Outfall 9	Outfall 11
Capital Costs			
CEQA & Permitting	$500,000	$500,000	$500,000
Detention Dam	$3,000,000	$10,400,000	$2,700,000
Treatment Plant	$26,500,000	$25,200,000	$13,100,000
Ancillary Facilities	$600,000	$900,000	$400,000
Total	$30,600,000	$37,000,000	$16,700,000
Annual O&M Costs			
Detention Dam	$15,000	$52,000	$14,000
Treatment Plant	$320,000	$300,000	$190,000
Ancillary Facilities	$12,000	$18,000	$6,000
Total	$347,000	$370,000	$210,000

Note: Costs are rounded to reflect level of accuracy of estimates.

5.5 Environmental Permitting Requirements

A number of environmental permits and approvals would be required to implement the CSTMs described in this technical memorandum. The primary environmental permits and approvals that would be required include:

- CEQA compliance, possibly consisting of a full EIR/EIS; coordination with the Regional Board, EPA, U.S. Fish and Wildlife Service and California Department of Fish and Game
- Section 404 wetlands permit for construction in the channels, from the Corps of Engineers
- Stream Alteration Agreement for construction in the channels, from California Department of Fish and Game
- Section 401 certification for discharge potentially affecting water quality, from the Regional Board
- Permits for grading and construction, from Ventura County

- General stormwater discharge permit covering construction activities, from the Regional Board
- Permit for construction of jurisdictional dams, from California Division of Safety of Dams

This is a partial list of permits and approvals that would be required; other regulations involving air quality, construction, and other disciplines would have to be satisfied.

5.6 Project Results and Impacts

Implementing CSTMs at the selected outfalls would have the following results.

- Stormwater WQBELs as specified in the SSFL stormwater permit would be likely to be met 100 percent of the time for all storms up to the 10-yr, 24-hr event. For larger storms partial treatment would be provided, which would improve the quality of stormwater discharged to downstream channels.

- Treated stormwater would meet non-potable water quality standards and could be reused onsite as non-potable water supply. This would, of course, require a system for distributing treated water to the onsite demand points. Additional incremental treatment may produce water of potable quality that meets the Surface Water Treatment Rule.

Implementing CSTMs at the selected outfalls would have the following impacts.

- Jurisdictional dams would be required at each outfall, per the criteria established by the State Division of Safety of Dams. Jurisdictional dams require state permits, regular inspections, and must satisfy strict design and construction criteria due to the hazards they present to downstream areas.

- Extensive flooded areas would be created at each detention pond, including riparian areas. Maximum reservoir pool areas are 15.7 acres, 12.1 acres and 16.5 acres for Outfalls 1, 9 and 11, respectively, and are shown in **Figures 4-4, 4-5** and **4-6**. This could have adverse impacts on local environmental resources, which include threatened and endangered species.

- Transport, use and storage of chemicals at the water treatment plants would create risks of spills of these chemicals into the permitted outfall waterways.

- The required water treatment processes would generate sludge, creating permanent disposal requirements.

- Major construction projects (dams and water treatment plants) would occur in and adjacent to natural channels, creating risks of adverse environmental impacts during construction.

- Building and operating dams and treatment works would result in significant hydromodification, which could potentially have adverse impacts on downstream channel conditions and water quality due to changes in stream flow and velocity profiles created by the hydromodification.

- Construction of dams, treatment works and new or relocated access roads would require significant temporary land disturbance due to grading and construction, and permanent land disturbance associated with footprints of new facilities (dams, treatment plants, access roads) and the reservoir pool areas. Land disturbance would occur primarily in currently undisturbed areas, and would increase the potential for erosion until revegetation could occur. These potential impacts for each outfall are summarized in **Table 6-1**.

Table 6-1
Land Disturbance Impacts for All Facilities Associated With Each Outfall

Type of Land Disturbance	Outfall 1	Outfall 9	Outfall 11
Grading (cy)	45,000	33,000	28,000
Temporary Construction Disturbance (acres)	17	18	17
Permanent Land Disturbance (acres)(1)	18	15	19

(1) Includes surface footprints of new infrastructure and reservoir pool areas.

5.7 Implementation Schedule

A conceptual schedule for implementing the CSTMs at a representative outfall is provided in **Table 6-2**. The schedule includes design, permitting and construction, and assumes typical times for approval of permits, etc. It is assumed that if multiple outfalls were addressed simultaneously, adequate resources would be supplied such that activities could proceed concurrently without delaying the overall schedule. The schedule is conceptual at this stage, and would have to be refined after selection of final components, completion of preliminary design, and discussions with regulatory agencies. It is anticipated that design, permitting and construction for CSTMs at a given outfall, under best case conditions, if allowable by resource agencies and the Department of Safety of Dams could potentially be implemented in approximately 48 months from notice to proceed. There is uncertainty in this estimate. Should there be controversy associated with the impacts from the projects, this schedule can increased by many years.

Table 6-2
Conceptual CSTM Implementation Schedule

Implementation Milestone	Months from Notice to Proceed
Complete Preliminary Design	3
Complete Permitting (assumes EIR for CEQA)	30
Complete Final Design	33
Complete Bidding, Select Contractor	36
Complete Construction	48