Scoping Document

to Support Development of

Total Maximum Daily Loads Addressing Nutrients and Algal Toxins

in

Waterbodies of the Pinto Lake Catchment

Pinto Lake

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Pinto Lake TMDL Project

Scoping Document

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State Water Resources Control Board

prepared by

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1. Preface

The purpose of this scoping document is to outline the nature and scope of a project to develop total maximum daily loads (TMDLs) for the Pinto Lake catchment. Practically speaking, TMDL projects are plans or strategies to restore clean water, and thus a TMDL report is a type of planning document. The California Water Plan characterizes TMDLs as *"action plans…to improve water quality."* This scoping document includes a description of the TMDL project area, a description of the identified water quality problems, a description of the physical setting of the Pinto Lake catchment, a description of currently known and available data sources, and a description of potential sources causing or contributing to the water quality impairments in Pinto Lake. As a result of this TMDL project, it is anticipated that a TMDL report and an associated basin plan amendment to incorporate Pinto Lake TMDLs into the Water Quality Control Plan for the Central Coastal Basin will ultimately be presented for the Central Coast Water Board's consideration. Data, information and narrative contained in this document are a draft work in progress, and thus are subject to revision and change during the course of TMDL development.

2. TMDL Project Location

The anticipated TMDL project includes Pinto Lake and the surrounding areas that drain to the lake. Based on GIS spatial analysis, Pinto Lake drains a 1,486 acre (2.3 square miles) catchment of southern Santa Cruz County, north of the city of Watsonville (see Figure 1). Pinto Lake is a natural, perennial lake that has existed for at least 8,000 years as a result of a tectonically-driven local topographic depression (Plater et al., 2006).

Figure 1. Location map, Pinto Lake catchment, Santa Cruz County, California.

Delineation of watershed drainage boundaries is a necessary part of TMDL development. Drainage boundaries of the conterminous United States are delineated on the basis of the Watershed Boundary Dataset[1], which contain digital hydrologic unit boundary layers organized on the basis of Hydrologic Unit Codes. Hydrologic Unit Codes (HUCs) were developed by the United States Geological Survey to identify all the drainage basins of the United States. Watersheds range in all sizes depending on how the drainage area of interest is spatially defined, if drainage areas are nested, and on the nature and focus of a particular hydrologic study. Watersheds can be characterized by a hierarchy as presented in Table 1.

Table 1. Watershed hierarchy (basins, subbasins, watersheds, subwatersheds, catchments).

Hydrologic Unit	**Approx. Drainage Area (square miles, unless otherwise noted)**	**Example(s)**	**Spatial Data Reference (USGS Hydrologic Unit Code shapefiles)**
basin	≥ 1,000	Pajaro River basin	Watershed Boundary Dataset HUC-8 shapefiles
subbasin	> 250 to < 1,000	San Benito River subbasin	2 or 3 HUC-10s [B] *(spatial dissolve)*
watershed	~ 100 to ~ 250	Llagas Creek watershed Uvas Creek watershed	Watershed Boundary Dataset HUC-10 shapefiles
subwatershed	> 10 to < 100	Salsipuedes Creek subwatershed Corrilitos Creek subwatershed	Watershed Boundary Dataset HUC-12 shapefiles
catchment	~ 1 to < 10	Pinto Lake catchment	National Hydrography Dataset catchment shapefiles *in conjunction with* ArcMap® 10.1 spatial analyst hydrology tool
subcatchment	≤ 1,000 acres	Pinto Lake, northern subcatchment Pinto Lake, southern subcatchment	Delineated on the basis of Pioneer Road, an east to west road which bisects the Pinto Lake catchment.

[A] Based on adaptation from Jonathan Brant, PhD, and Gerald J. Kauffman, MPA, PE (2011) Water Resources and Environmental Depth Reference Manual for the Civil Professional Engineer Exam.
[B] This is approximately equivalent to "Hydrologic Area" in the CalWater 2.2 watershed convention,

The Pinto Lake catchment was delineated by Central Coast Water Board staff on the basis of a digital elevation model used in conjunction with the Esri® ArcMap™ 10.1 spatial analyst extension hydrology tool. Notable is that staff's digital lake catchment delineation comports quite well with a Pinto Lake catchment delineation independently developed and published by university researchers (Plater et al., 2006) – see Figure 2 – thus providing additional confidence in our catchment delineation.

Elevations in the Pinto Lake catchment range from 112 feet above mean sea level (MSL) at the City of Watsonville's Pinto Lake Park located at the southeastern margin of the lake, to 513 feet above MSL in the northwestern, upland reaches of the lake catchment. In addition, two subcatchment–scale drainages can be defined on the basis of Pioneer Road. Pioneer Road is an east-west road which bisects the lake catchment into a southern subcatchment which includes land areas in closer proximity to the lake, and a northern subcatchment which includes upland areas relatively farther away from Pinto Lake (see Figure 4 in report Section 4.1 for a map view illustration of the location of the subcatchments). According to Plater et al. (2006), lake bathymetry is generally in the range of 2 to 6 meters; maximum depths range to 8 meters in the central part of the lake.

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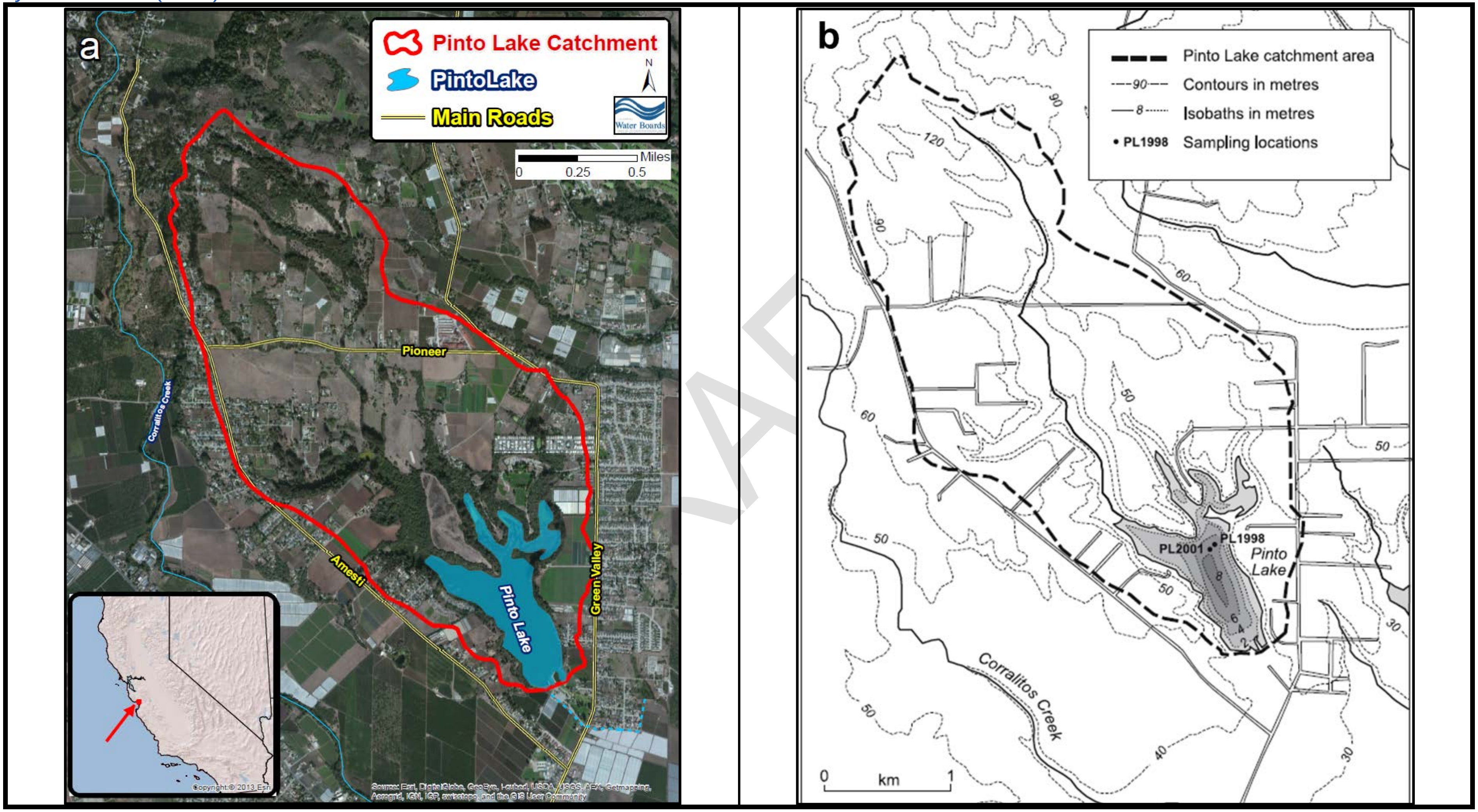
[1] The Watershed Boundary Dataset (WBD) is developed by federal agencies and national associations. WBD contains watershed boundaries that define the areal extent of surface water drainage to a downstream outlet. WBD watershed boundaries are determined solely upon science-based principles, not favoring any administrative boundaries.

Figure 2. (a) Central Coast Water Board staff's digital delineation of the Pinto Lake catchment drainage area derived from application of the Esri® ArcMap™ 10.1 spatial analyst hydrology tool extension; and compare to: (b) a delineation of the Pinto Lake catchment drainage area published by Plater et al. (2006).



3. Description of the Water Quality Problem

Pinto Lake is listed on the Clean Water Act 303(d) list of impaired waterbodies due to impairments associated with harmful algal blooms. This type of water quality impairment is a biological response to excessive loading of nutrients to the lake. While nutrients - specifically nitrogen and phosphorus – are essential for plant growth and are naturally present and ubiquitous in the environment, they are considered pollutants when they occur at levels which have adverse impacts on water quality. According to the 2010 Clean Water Act Section 303(d) report, the listed water quality impairments in Pinto Lake include unacceptable amounts of cyanobacteria microcystins (i.e.., algal toxins), low dissolved oxygen, and scum/floating material. In the past, Pinto Lake was not subject to episodic and intense cyanobacteria algal blooms based on interviews with long term lake-side residents, knowledgeable locals, or inferred from sediment core data (CSUMB and Resource Conservation District of Santa Cruz County, 2013).

Episodic algal blooms in Pinto Lake, resulting from nutrient-driven biostimulation[2] constitute a potential health risk and public nuisance to humans, to their pets, and to wildlife. The majority of freshwater harmful algal blooms (HABs) reported in the United States and worldwide is due to one group of algae, cyanobacteria (CyanoHABs, or blue-green algae). University of California-Santa Cruz researchers report that Pinto Lake is one of the most toxic lakes ever recorded in the scientific literature on the basis of episodic high levels of algal cyanotoxins[3]. An illustration of an algae bloom in Pinto Lake is presented in Figure 3.

Figure 3. Aerial photo of algae bloom in Pinto Lake (photo submitted by City of Watsonville staff).

[2] As used herein, “biostimulation” refers to a state of excess growth of aquatic vegetation due to anthrophogenic nutrient inputs into an aquatic system. Biostimulation is characterized by a number of other factors in addition to nitrogen and phosphours inputs; for example, dissolved oxygen levels, chlorophyll *a*, sunlight availability, and pH.

[3] The National Wildlife Federation recently reported that Pinto Lake “contains some of the most toxic water in the nation.”

A description of the water quality-related problems associated with Pinto Lake was recently articulated by the office of California Assembly Member Luis A. Alejo:

Freshwater blue green algae toxins caused the deaths of over 31 endangered southern sea otters in Monterey Bay. In 2012 a blue green algal bloom at Pinto Lake, just 4 miles from the Monterey Bay, resulted in the death of countless waterfowl. "The birds were convulsing on the ground and flying into buildings and cars all across town" states Robert Ketley, Water Quality Program Manager for Watsonville.

From: Press Release dated February 12, 2015 from California Assembly Member Luis A. Alejo

Possible health effects of exposure to blue-green algae blooms and their toxins can include rashes, skin and eye irritation, allergic reactions, gastrointestinal upset, and other effects. At high levels, exposure can result serious illness or death. These effects are not theoretical; worldwide animal poisonings and adverse human health effects have been reported by the World Health Organization (WHO, 1999). The California Department of Public Health and various County Health Departments have documented cases of dog die-offs throughout the state and the nation due to blue-green algae. Dogs can die when their owners allow them to swim or wade in waterbodies with algal blooms. Dogs are also attracted to fermenting mats of cyanobacteria near shorelines of waterbodies (Carmichael, 2011). Dogs reportedly die due to ingestion associated with licking algae and associated toxins from their coats.

Also noteworthy is that algal toxins originating from freshwater sources, such as coastal lakes and streams, have been implicated in the deaths of central California southern sea otters (Miller et al., 2010). Furthermore, City of Watsonville staff has reported anecdotal cases of people contracting skin rashes or flu-like symptoms associated with contact with algal blooms in Pinto Lake. Currently, there have been no confirmations of human deaths in the United States from exposure to algal toxins, however many people have become ill from exposure, and acute human poisoning is a distinct risk (Dr. Wayne Carmichael of the Wright State University-Department of Biological Sciences, as reported in NBC News, 2009).

4. Pinto Lake Catchment Setting

This section of the document presents brief and cursory highlights of the physical, climatic, and hydrologic setting of the Pinto Lake catchment. As appropriate, further information will be compiled during TMDL development.

4.1 Land Use–Land Cover

Land use and land cover in the Pinto Lake catchment was evaluated from digital data provided by the California Department of Conservation's Farmland Mapping & Monitoring Program. The Farmland Mapping and Monitoring Program maps are updated every two years with the use of aerial photographs, a computer mapping system, public review, and field reconnaissance. For this TMDL Project Scoping Document, the 2012 Farmland Mapping and Monitoring Program mapping data were used.

Central Coast Water Board staff conducted a brief and cursory review of land use–land cover data for this scoping document. Estimations of land use–land cover in the Pinto Creek catchment, and the northern and southern subcatchments are presented in Figure 4 and Figure 5. Land cover in the catchment is comprised largely of residential areas and cultivated cropland. Upland reaches on the northern subcatchment contain significant amounts of mixed woodland and grasslands.

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Figure 4. Land use–land cover (year 2012) in the Pinto Lake catchment on the basis of data from the Farmland Mapping and Monitoring Program. Two subcatchments are also included: a northern subcatchment (drainage areas north of Pioneer Road) and a southern subcatchment (drainage areas south of Pioneer Road).

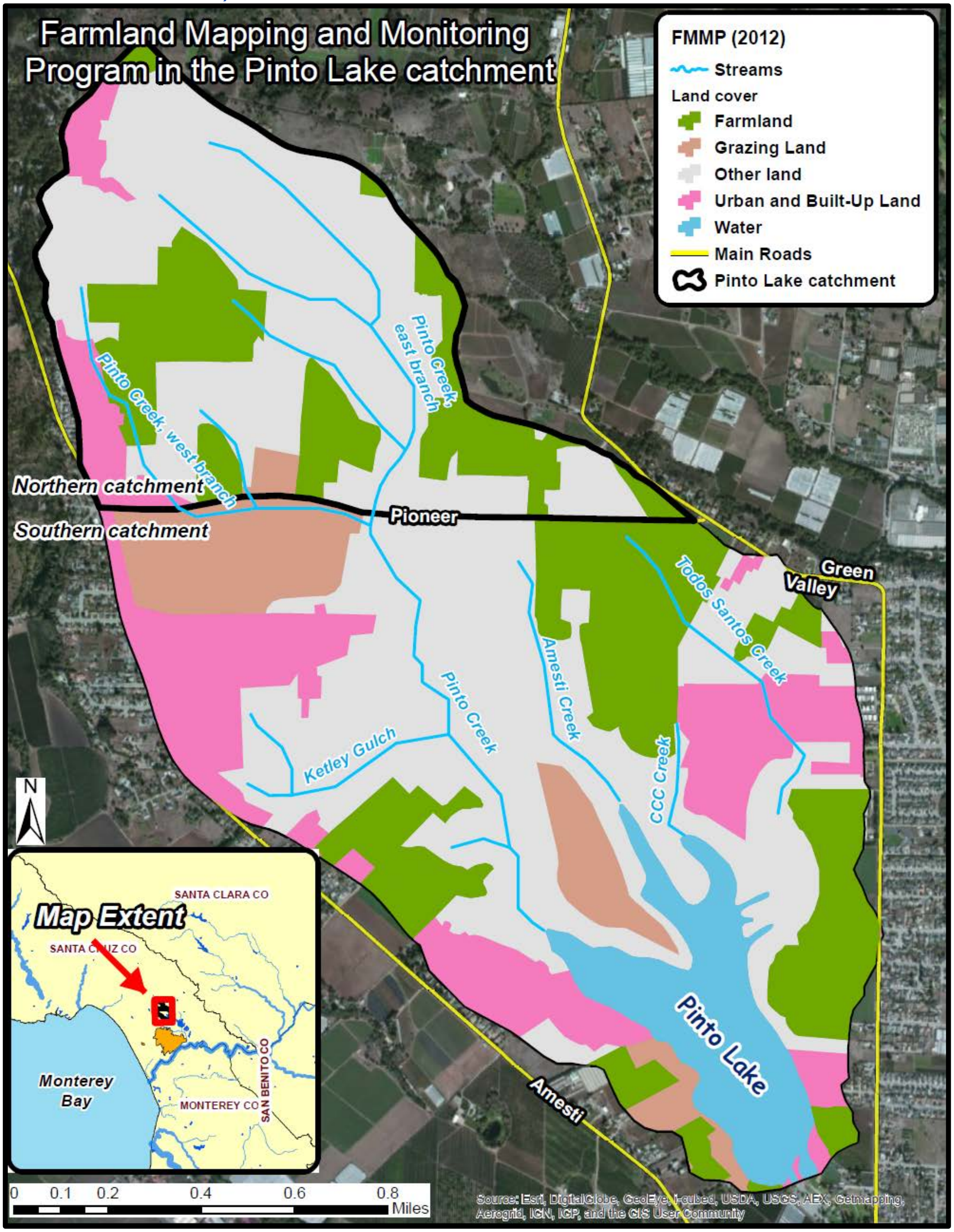
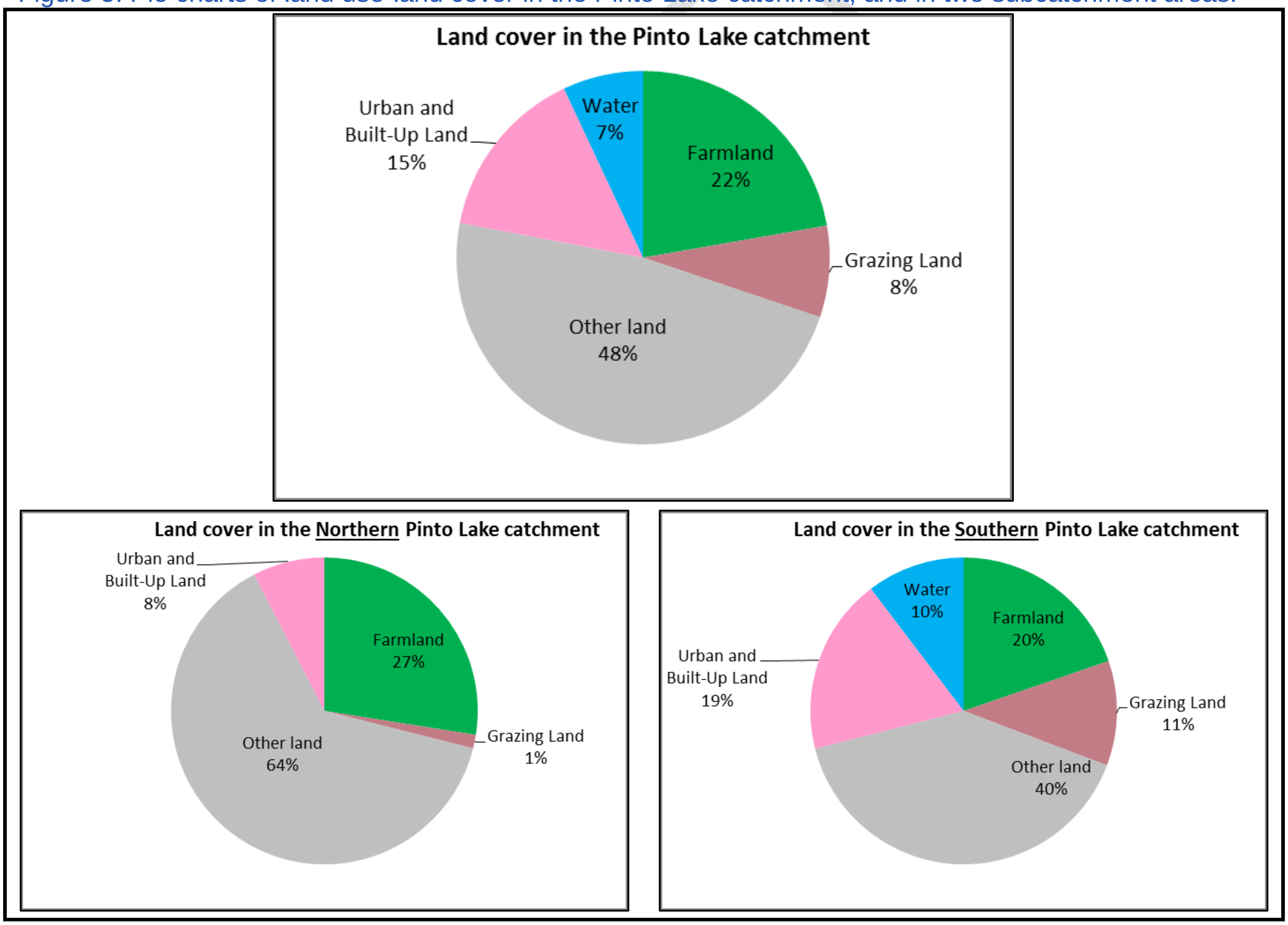


Table 2. Land use–land cover in the Pinto Lake catchment (year 2012), on the basis of Farmland Mapping and Monitoring Program data. The table includes the total Pinto Lake catchment area and two subcatchment areas (the northern subcatchment and the southern subcatchment).

		Farmland *Acres & Percent of catchment*	Urban or Built Up *Acres & Percent of catchment*	Grazing land Grassland *Acres & Percent of catchment*	Undeveloped, Woodlands or Restricted *Acres & Percent of catchment*	Open Water *Acres & Percent of catchment*	Total
Pinto Creek catchment	**Total (all catchment)**	330.7 acres	223.5 acres	117.7 acres	710.7 acres	103.8 acres	1,486 acres
		22%	15%	8%	48%	7%	100%
	Northern subcatchment (north of Pioneer Rd.)	132.6 acres	36.6 acres	6.8 acres	306.3 acres	0	482
		27%	8%	1%	64%	0%	100%
	Southern subcatchment (south of Pioneer Rd.)	198.1acres	187.0 acres	110.9 acres	404.4 acres	103.8 acres	1,004 acres
		20%	19%	11%	40%	10%	100%

Data source: Department of Conservation, Farmland Mapping and Monitoring Program, 2012.

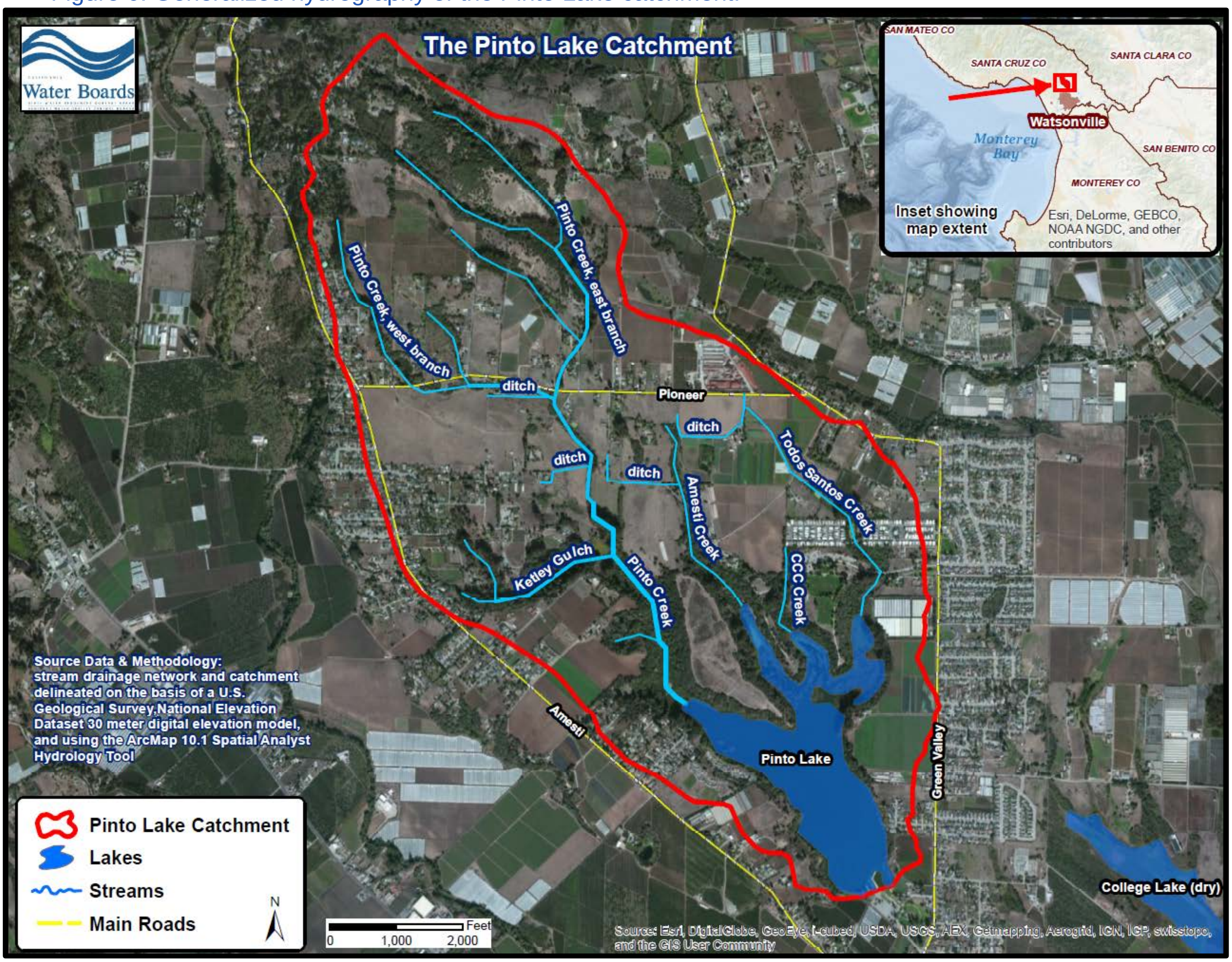
Figure 5. Pie charts of land use-land cover in the Pinto Lake catchment, and in two subcatchment areas.



4.2 Hydrography

Assessing the hydrology of any given watershed or catchment is an important step in evaluating the magnitude and nature of pollutant transport and loading in waterbodies. Central Coast Water Board staff conducted a brief and cursory review of hydrologic data for this scoping document. This section of the report outlines a cursory review and assessment of the hydrography of the Pinto Lake catchment. The entire drainage area of the Pinto Lake catchment encompasses over 1,400 acres with a network of creeks draining to Pinto Lake. A generalized illustration of the hydrography of the Pinto Lake catchment is presented in Figure 6. The stream network shown in Figure 6 was delineated using the ArcMap™ 10.1 spatial analyst hydrology tool extension. The main lake tributary is called Pinto Creek, a third order stream on the basis of the Strahler stream classification convention. Pinto Creek drains the northern and western areas of the Pinto Lake catchment. A number of other informally named creeks[4] drain parts of the central and eastern margins of the lake catchment.

Figure 6. Generalized hydrography of the Pinto Lake catchment.



[4] The informal tributary creek names are used by local researchers and stakeholders working in the lake catchment and were provided to Central Coast Water Board staff by City of Watsonville staff.

Table 3 presents an outline of known or presumed hydrologic conditions associated with the tributary creeks of Pinto Lake. More information on the hydrography of the Pinto Lake catchment will be compiled during TMDL development.

Table 3. Hydrologic conditions of tributary creeks of Pinto Lake.

Stream Reach	Strahler Stream Order	Mean Annual Flow (cubic ft./sec.)	Flow Regime
Pinto Creek	3rd order	unknown	Intermittent (source: NHDplus)
Pinto Creek, east branch	2nd order	unknown	Unknown, presumed intermittent
Pinto Creek, west branch	1st order	unknown	Unknown, presumed intermittent
Amesti Creek	1st order	unknown	Unknown, presumed intermittent
CCC Creek	1st order	unknown	Unknown, presumed intermittent
Todos Santos Creek	1st order	unknown	Unknown, presumed intermittent

4.3 Climate

Central Coast Water Board staff conducted a brief and cursory review of climatic data for this scoping document. Precipitation is often considered in the development of TMDLs. Precipitation is directly related to a number of watershed hydrologic functions, such as surface runoff, groundwater recharge, and water table elevations.

The Pinto Lake catchment, and California's central coast are characterized by a Mediterranean–type climate, with the vast majority of precipitation falling between November and April (see Table 4).

Table 4. Precipitation records in the vicinity of Pinto Lake.

Station	Elevation (ft.)	Climatic Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Watsonville Waterworks[A] **(1938-2013)**	95	Average Precipitation (inches)	4.52	3.89	3.02	1.52	0.49	0.14	0.04	0.05	0.30	0.99	2.39	4.18	**21.52**
Corralitos (COR)[B]	450	Average Precipitation (inches)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	**27.05**
Burrell Station (BRL)[B, C]	1,850	Average Precipitation (inches)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	**42.60**

A: Western U.S. COOP weather station (Source: NOAA Western Regional Climate Center).
B: Calif. Dept. of Forestry weather station – data published in the California Natural Resources Agency CERES database.
C: Located in Soquel Creek watershed of Santa Cruz mountains, northwest of the Pinto Lake catchment.
NR = not reported

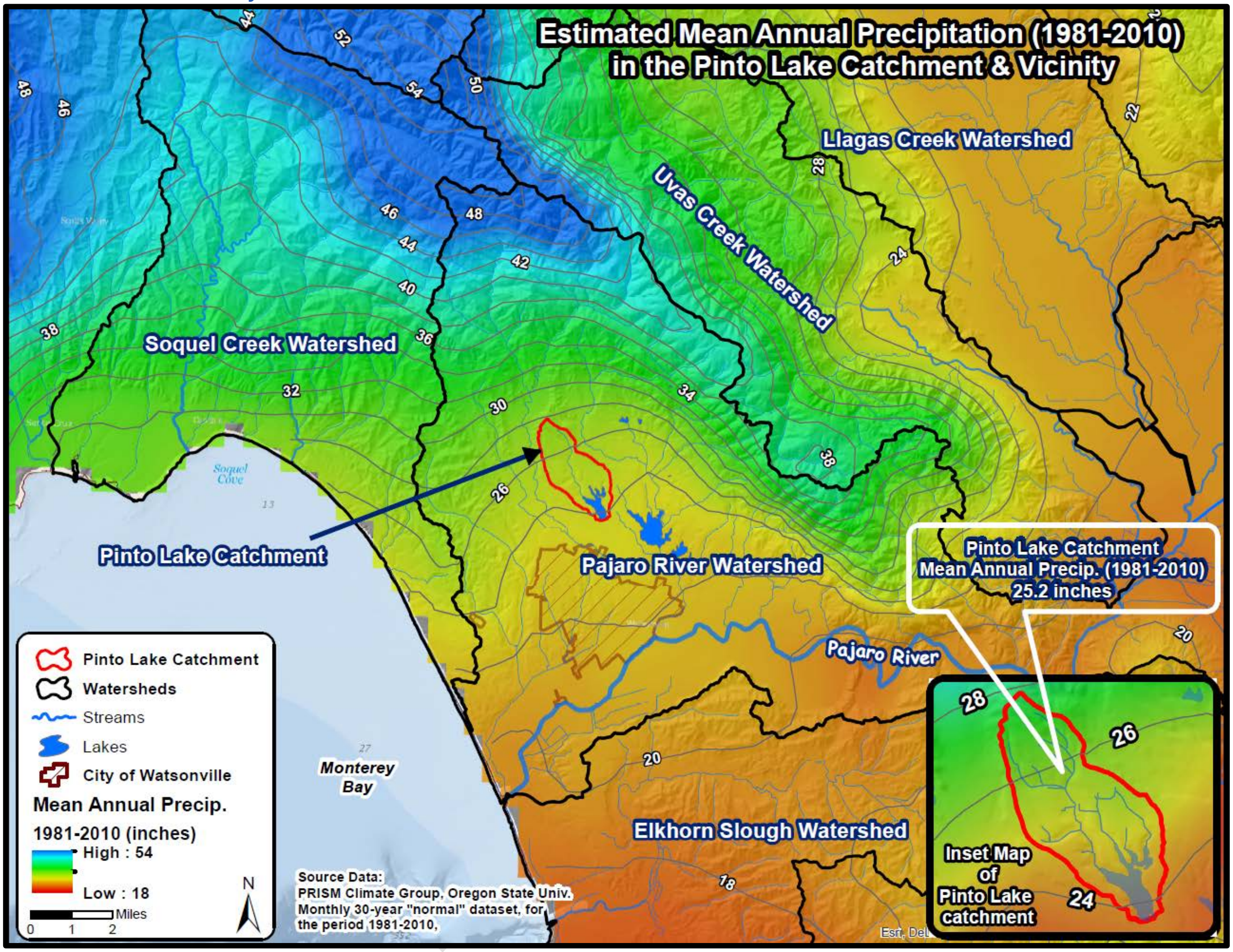
Mean annual precipitation estimates for the Pinto Lake catchment may be assessed using the Parameter-elevation Regressions on Independent Slopes Model (PRISM)[5]. PRISM is a climate mapping system that accounts for orographic climatic effects and is widely used in watershed studies and TMDL projects to make projections of precipitation into rural or mountainous areas where rain gage data is often absent, or sparse.

An isohyetal map for estimated mean annual precipitation (1981-2010) in the Pinto Lake catchment and vicinity is presented in Figure 7. Estimated mean annual precipitation within the Pinto Lake catchment is summarized in Text Box 1.

[5] The PRISM dataset was developed by researchers at Oregon State University, and uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of climatic parameters. The dataset incorporates a digital elevation model, and expert knowledge of climatic variation, including rain shadows, coastal effects, and orographic effects.

As warranted, more information on climatic conditions and atmosphere deposition of nutrients in the Pinto Lake catchment will be compiled during TMDL development.

Figure 7. Estimated mean annual precipitation for the 30 year period of 1981-2010 in the Pinto Lake catchment and vicinity.



Text Box 1. Estimated mean annual precipitation (1981-2010) in the Pinto Lake catchment.

On the basis of the PRISM data, estimated mean annual precipitation within the Pinto Lake catchment for the period 1981-2010 was **25.2 inches per year**.

It should be reiterated that the aforementioned PRISM data represent average precipitation conditions over a 30 year period, while currently California is experiencing extreme drought conditions. Consequently, solutions and timeframes for improvements and monitoring aimed at achieving pollutant load reductions may need to consider assumptions about water quality conditions under extreme drought conditions.

4.4 Groundwater

Central Coast Water Board staff conducted a brief and cursory review of groundwater data for this scoping document. TMDLs do not directly address pollution of groundwater by controllable sources. However, shallow groundwater inflow to lakes and streams may be considered in the context of TMDL development. Groundwaters and surface waters are not closed systems that act independently from each other; it is well known that groundwater inflow to surface waters can be a source of nutrients or salts to any given surface waterbody. The physical interconnectedness of surface waters and groundwater is widely recognized by scientific agencies, researchers, and resource professionals, as highlighted below:

"Traditionally, management of water resources has focused on surface water or ground water as separate entities….Nearly all surface-water features (streams, lakes reservoirs, wetlands, and estuaries) interact with groundwater. Pollution of surface water can cause degradation of ground-water quality and conversely pollution of ground water can degrade surface water. Thus, effective land and water management requires a clear understanding of the linkages between ground water and surface water as it applies to any given hydrologic setting."

From: U.S. Geological Survey, 1998. Circular 1139: "Groundwater and Surface Water – A Single Resource"

"While ground water and surface water are often treated as separate systems, they are in reality highly interdependent components of the hydrologic cycle. Subsurface interactions with surface waters occur in a variety of ways. Therefore, the potential pollutant contributions from ground water to surface waters should be investigated when developing TMDLs."

From: U.S. Environmental Protection Agency, Guidance for Water Quality-Based Decisions: The TMDL Process – Appendix B. EPA 440/4-91-001.

"Although surface water and groundwater appear to be two distinct sources of water, they are not. Surface water and groundwater are basically one singular source of water connected physically in the hydrologic cycle...Effective management requires consideration of both water sources as one resource."

From: California Department of Water Resources: Relationship between Groundwater and Surface Water
http://www.water.ca.gov/groundwater/groundwater_basics/gw_sw_interaction.cfm.

"Surface water and ground water are increasingly viewed as a single resource within linked reservoirs. The movement of water from streams to aquifers and from aquifers to streams influences both the quantity and quality of available water within both reservoirs"

From: C. Ruehl, A. Fisher, C. Hatch, M. Los Huertos, G. Stemler, and C. Shennan (2006), *Differential gauging and tracer tests resolve seepage fluxes in a strongly-losing stream.* Journal of Hydrology, volume 330, pp. 235-248.

"It's a myth that groundwater is separate from surface water and also a myth that it's difficult to legally integrate the two….California's groundwater and surface water are often closely interconnected and sometimes managed jointly."

From: Buzz Thompson, Professor of Natural Resources Law, Stanford University Law School, quoted in *Managing California's Groundwater*, by Gary Pitzer in Western Water January/February 2014, *and* from Public Policy Institute of California, *California Water Myths*, www.ppic.org.

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Also worth noting, a clear and concise description about the nature of hydrologic interactions between lakes and groundwater was published by the U.S. Geological Survey, as shown below:

"Lakes interact with groundwater in three basic ways: some receive groundwater inflow throughout their entire bed; some have seepage loss to ground water throughout their entire bed; but perhaps most lakes receive groundwater inflow through part of their bed and have seepage loss to ground water through other parts."

From: U.S. Geological Survey, 1998. Circular 1139: "Groundwater and Surface Water – A Single Resource"

The range of information discussed above is illustrated conceptually in Figure 8.

Figure 8. Lakes are intimately connected to the groundwater system.

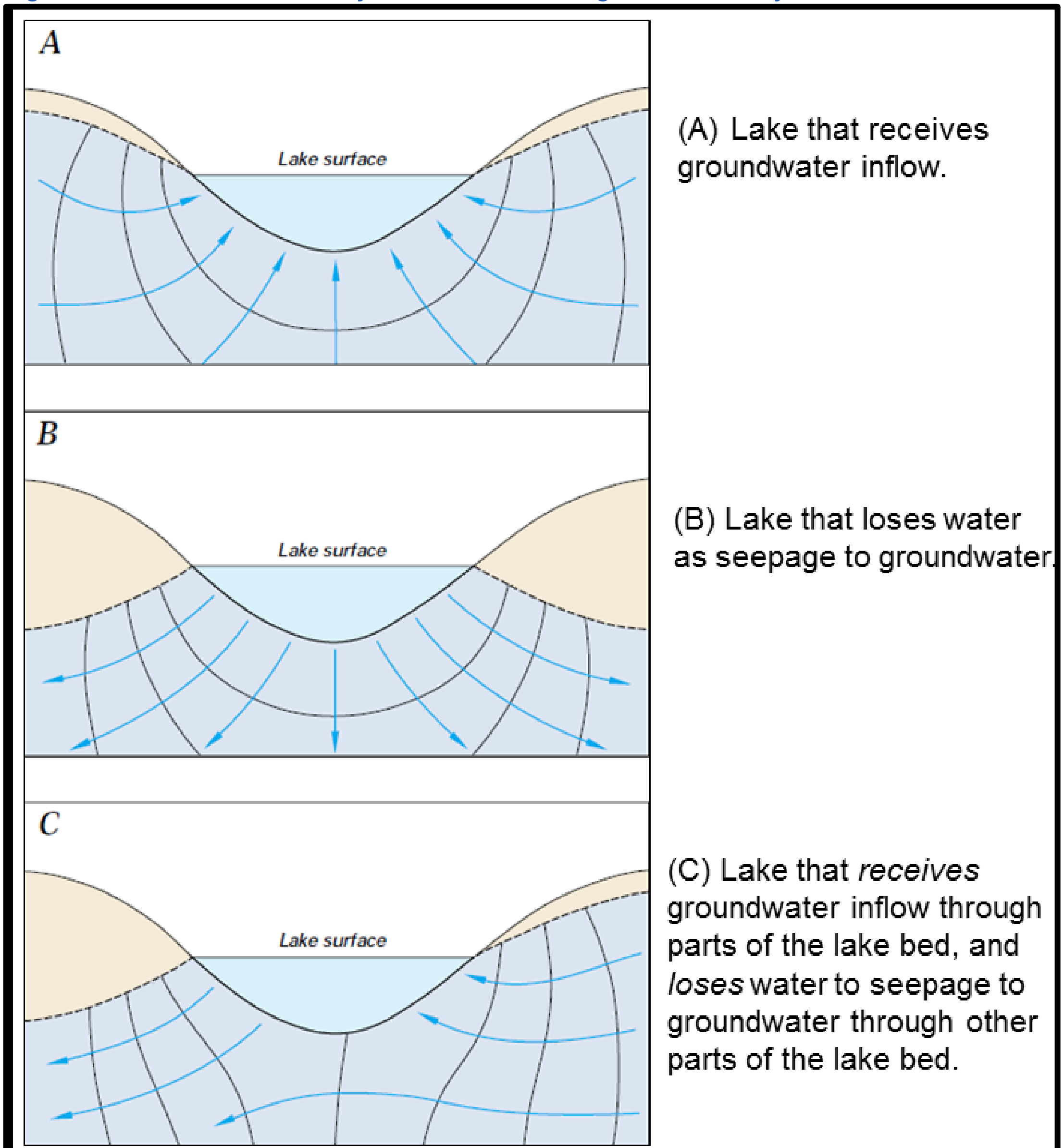
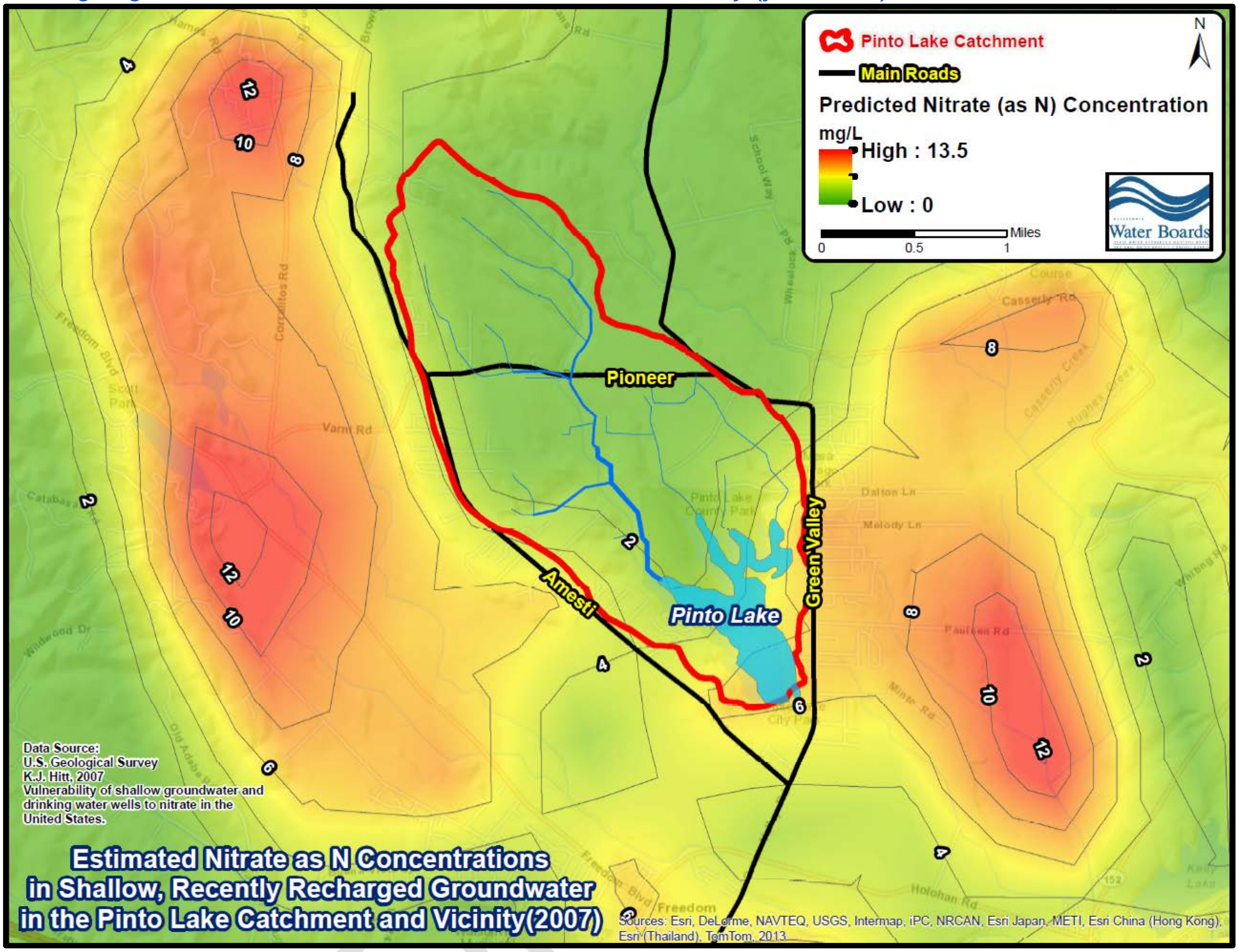


Figure credits: U.S. Geological Survey Circular 1139 (1998)

Figure 9 illustrates the estimated nitrate as nitrogen concentration in project area shallow, recently-recharged groundwater (data source: U.S. Geological Survey GWAVA model[6]). Shallow, recently recharged groundwater is defined by the U.S. Geological Survey in the GWAVA dataset as groundwaters less than 15 meters below ground surface. The dataset indicates that in some areas around the lake catchment, nitrate concentrations in shallow groundwater are elevated well above what would be expected in natural background conditions. At this time, groundwater flow conditions in the shallow subsurface around Pinto Lake are unknown. In general, regional groundwater flow in drinking water aquifers in this part of the Pajaro River valley is expected to be towards the south and west. However, groundwater flow directions can be quite variable depending on local hydrogeologic conditions, groundwater pumping, and percolation of irrigation waters and other surface waters.

[6] The GWAVA dataset represents predicted nitrate concentration in shallow, recently recharged groundwater in the conterminous United States, and was generated by a national nonlinear regression model based on 14 input parameters.

Figure 9. U.S. Geological Survey estimates of nitrate (as N) concentrations in shallow, recently recharged groundwater in the Pinto Lake catchment and vicinity (year 2007).



Groundwater has been recognized by local researchers as a potential and perhaps important source of nutrient loading to Pinto Lake (Ketley, Rettinger, and Los Huertos, 2013). However, there is currently insufficient data to estimate potential groundwater loads to the lake without further research.

4.5 Soils

Soils have physical and hydrologic characteristics which may have a significant influence on the transport and fate of nutrients. Watershed researchers and TMDL projects often assess soil characteristics in conjunction with other physical watershed parameters to estimate the risk and magnitude of nutrient loading to waterbodies (Mitsova-Boneva and Wang, 2008; McMahon and Roessler, 2002; Kellog et al., 2006). The relationship between nutrient export (loads) and soil texture is illustrated in Figure 10 and Figure 11. Generally, fine-textured soils with lower capacity for infiltration of precipitation/water are more prone to runoff and are consequently typically associated with a higher risk of nutrient loads to surface waters.

Figure 10. Median annual Total N and Total P export for various soil textures.

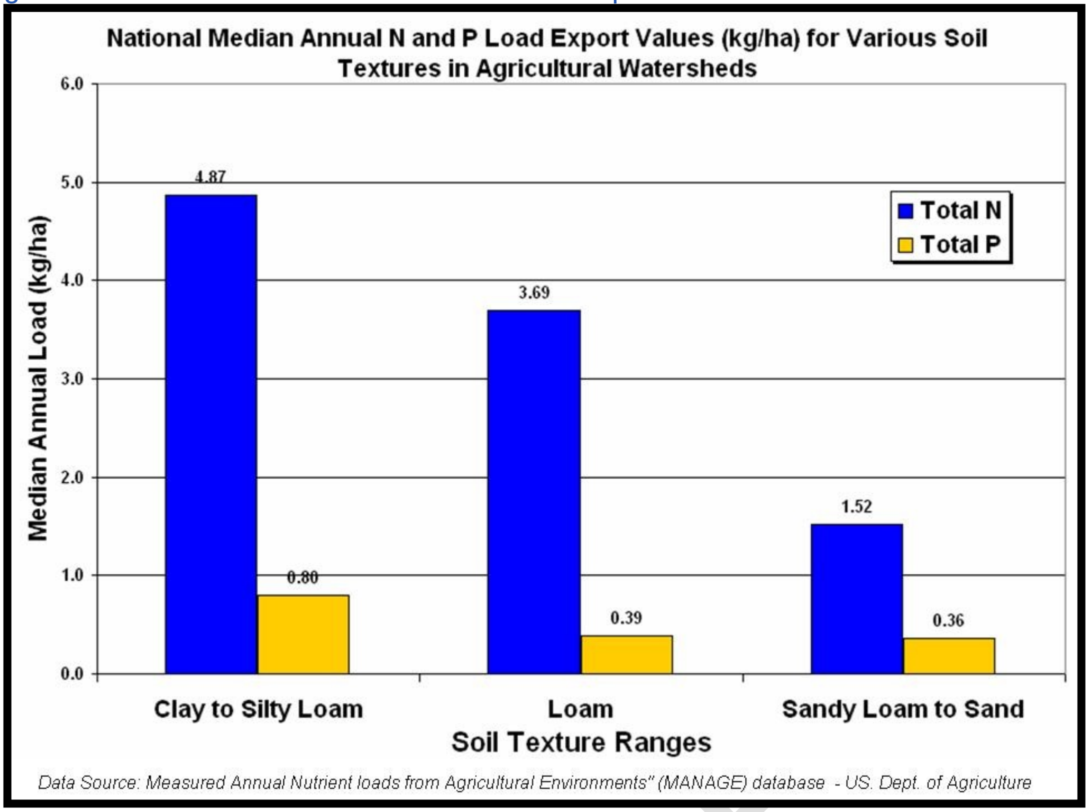
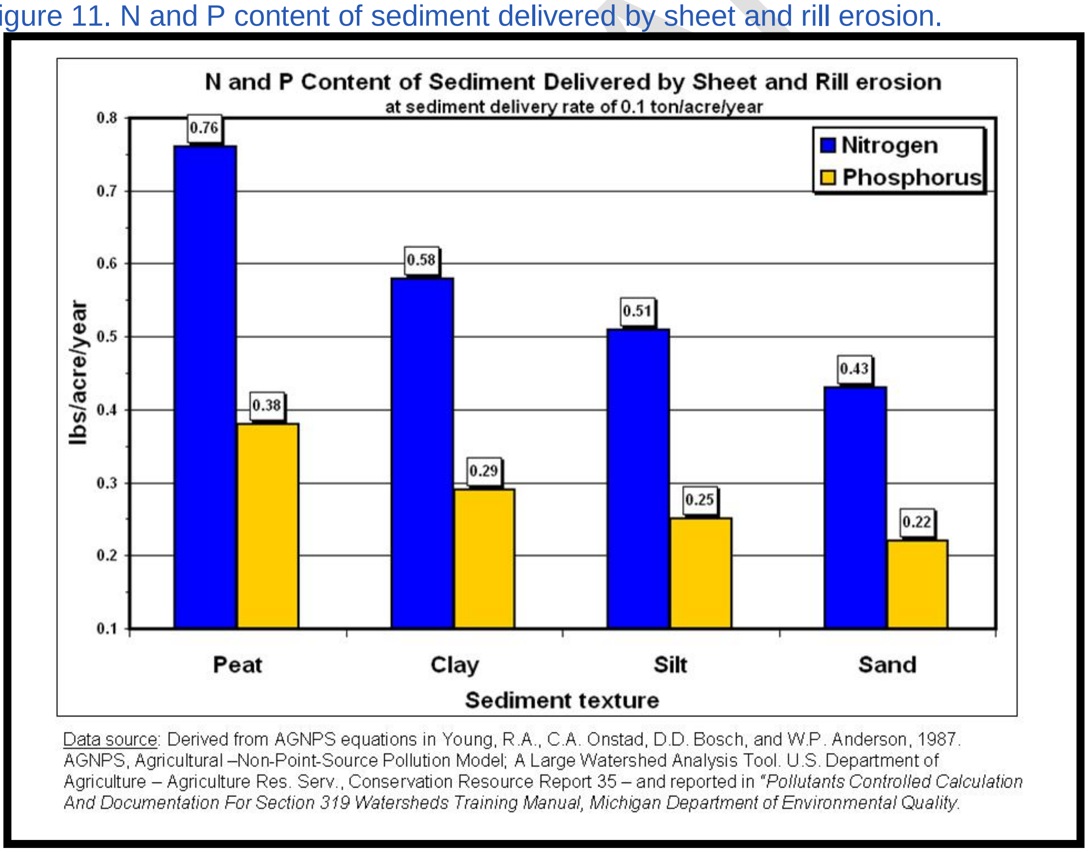
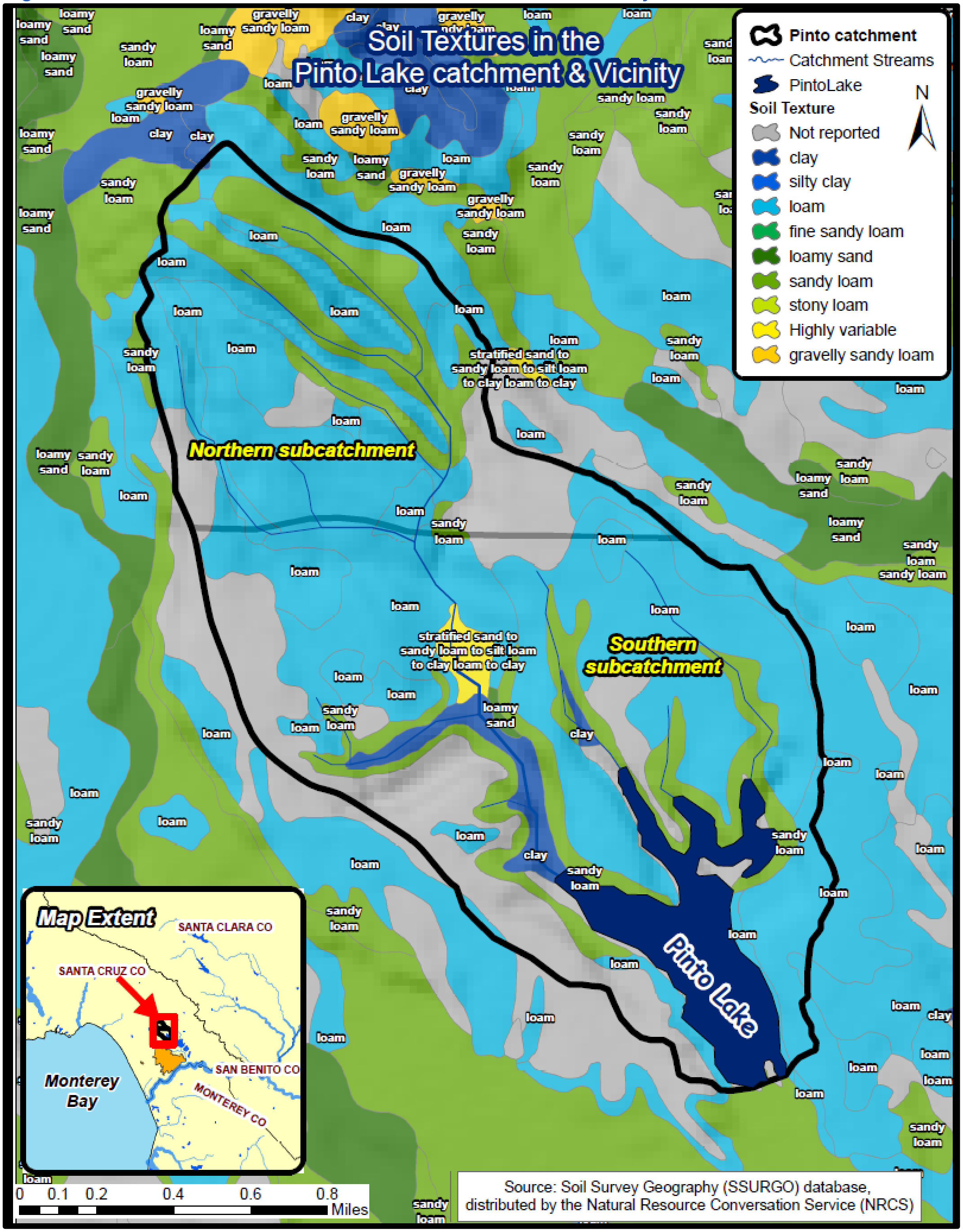


Figure 11. N and P content of sediment delivered by sheet and rill erosion.



Soil data for the Pinto Lake catchment are available from the U.S. Department of Agriculture National Resources Conservation Service's Soil Survey Geographic (SSURGO) Database. Soils of the Pinto Lake catchment are predominantly loams, with subsidiary amounts of sandy loams and clays (see Figure 12). In the southern subcatchment, surficial materials of the Pinto Creek riparian corridor (the westernmost lake tributary) are characterized by fine-grained clays, while lake tributary stream corridors to the east of Pinto Creek are generally characterized by relatively coarser-grained surficial materials such as sandy loams (refer again to Figure 12). It should be noted that many SSURGO soil attributes are based on county-level and regional soil survey mapping, and thus site-specific and localized soil variation can be expected.

Figure 12. Soil textures in the Pinto Lake catchment and vicinity.



Also worth noting, some areas in and around the Pinto Lake catchment are characterized shallow (~two feet below ground surface) clay hardpan layers, and thus these subsurface conditions can cause perched groundwater horizons and horizontal flow of shallow perched groundwater (personal communication Richard Casale, District Conservationist, U.S. Dept. of Agriculture Natural Resources Conservation Service, July 22, 2014). This type of shallow groundwater lateral flow therefore has the potential to result in hydraulic communication locally with surface waterbodies.

4.6 Geology

Geology can have a significant influence on natural, background concentrations of nutrients and other inorganic constituents in stream waters. The linkage between geologic conditions and stream water chemistry has long been recognized (for example, U.S. Geological Survey, 1910 and U.S. Geological Survey, 1985). Stein and Kyonga-Yoon (2007) reported that catchment geology was the most influential environmental factor on water quality variability from undeveloped stream reaches in lightly-disturbed, natural areas located in Ventura, Los Angeles, and Orange counties, California. Stein and Kyonga-Yoon (2007) concluded that catchments underlain by sedimentary rock had higher stream flow concentrations of metals, nutrients, and total suspended solids, as compared to areas underlain by igneous rock. Additionally, the Utah Geological Survey hypothesized that organic-rich marine sedimentary rocks in the Cedar Valley of southern Utah may locally contribute to elevated nitrate observed in groundwater (Utah Geological Survey, 2001). Nitrogen found in the organic material of these rock strata are presumed by the Utah Geological Survey researchers to be capable of oxidizing to nitrate and may subsequently leach to groundwater. Further, the Las Virgenes Municipal Water District (LVMWD, 2012) recently reported that high background levels of biostimulatory substances (nitrogen and phosphate) in the Malibu Creek Watershed appear to be associated with exposures of the Monterey/Modelo Formation. Also worth noting, Domagalski (2013) states that knowledge about natural and geologic sources of phosphorus in watersheds are important for developing nutrient management strategies.

Consequently, in evaluating the effect of anthropogenic activities on nutrient loading to waterbodies in a TMDL project, it may also be relevant to consider the potential impact on nutrient water quality which might result from local geology.

Central Coast Water Board staff conducted a brief and cursory review of geologic data for this scoping document. Figure 13 presents an illustration of the geology of the Pinto Lake catchment and vicinity. Figure 13 is supplemented by a detailed geologic legend which is shown in Figure 14. Riparian creek corridors in the lake catchment are characterized by fine-grained Holocene[7] alluvium[8], while surficial geologic materials located outside the riparian corridors and in the uplands of the lake catchment are characterized by older, late Pleistocene[9] alluvium.

Phosphorus-prone geologic materials may be associated with Upper Tertiary (Miocene) mudstones of the Santa Cruz mountains (geologic unit number 500, as illustrated on Figure 13). Whether or not detrital materials from these Miocene mudstones were ever deposited in the Pinto Lake catchment is uncertain. There is currently no direct surface water hydrologic connection between the lake catchment and Miocene strata of the Santa Cruz mountains. There may have been historical hydrologic connectivity between the lake catchment and the Miocene strata of the Santa Cruz mountains during flood stages, or due to migrations and changes in depositional patterns and stream networks in the recent geologic past.

If warranted, further review of geologic information may occur during TMDL development.

[7] The Holocene is a geologic epoch which began 11,700 years ago at the end of the Pleistocene epoch and includes the present day. Thus, Holocene geologic materials include sediments and detrital matter that are currently being deposited on the land surface by air and water, as well as materials that have been deposited in the very recent geologic past.

[8] Sedimentary material deposited by rivers and streams is commonly referred to as alluvium, or alluvial deposits.

[9] The Pleistocene epoch is a relatively young geologic era which lasted from about 2.6 million years ago to 11,700 years ago.

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Figure 13. Detailed map of geologic units and geologic materials (with associated numeric identifiers) in the Pinto Lake catchment and vicinity. A legend for the geologic units and their associated numeric identifiers shown on this map is presented in Figure 14.

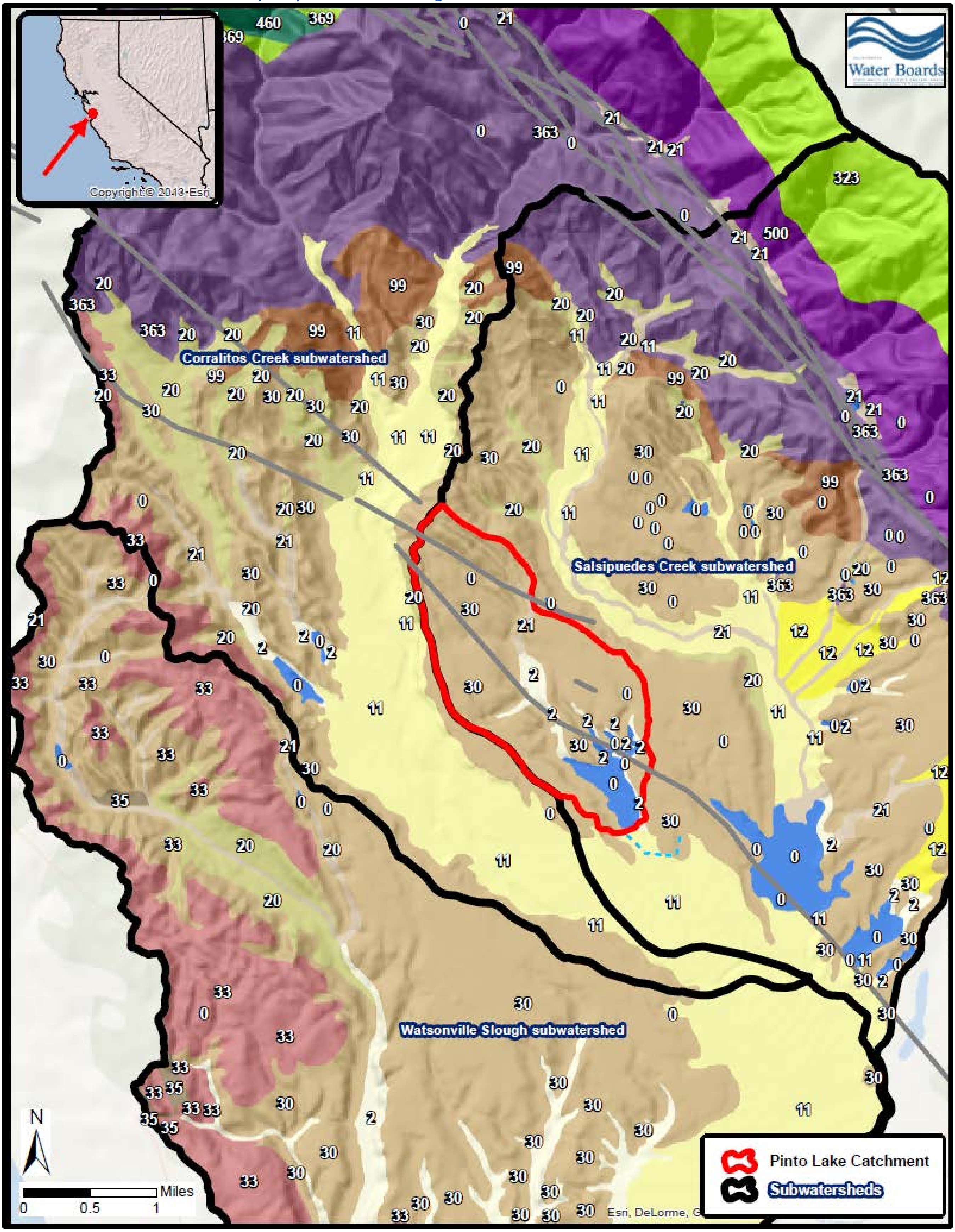
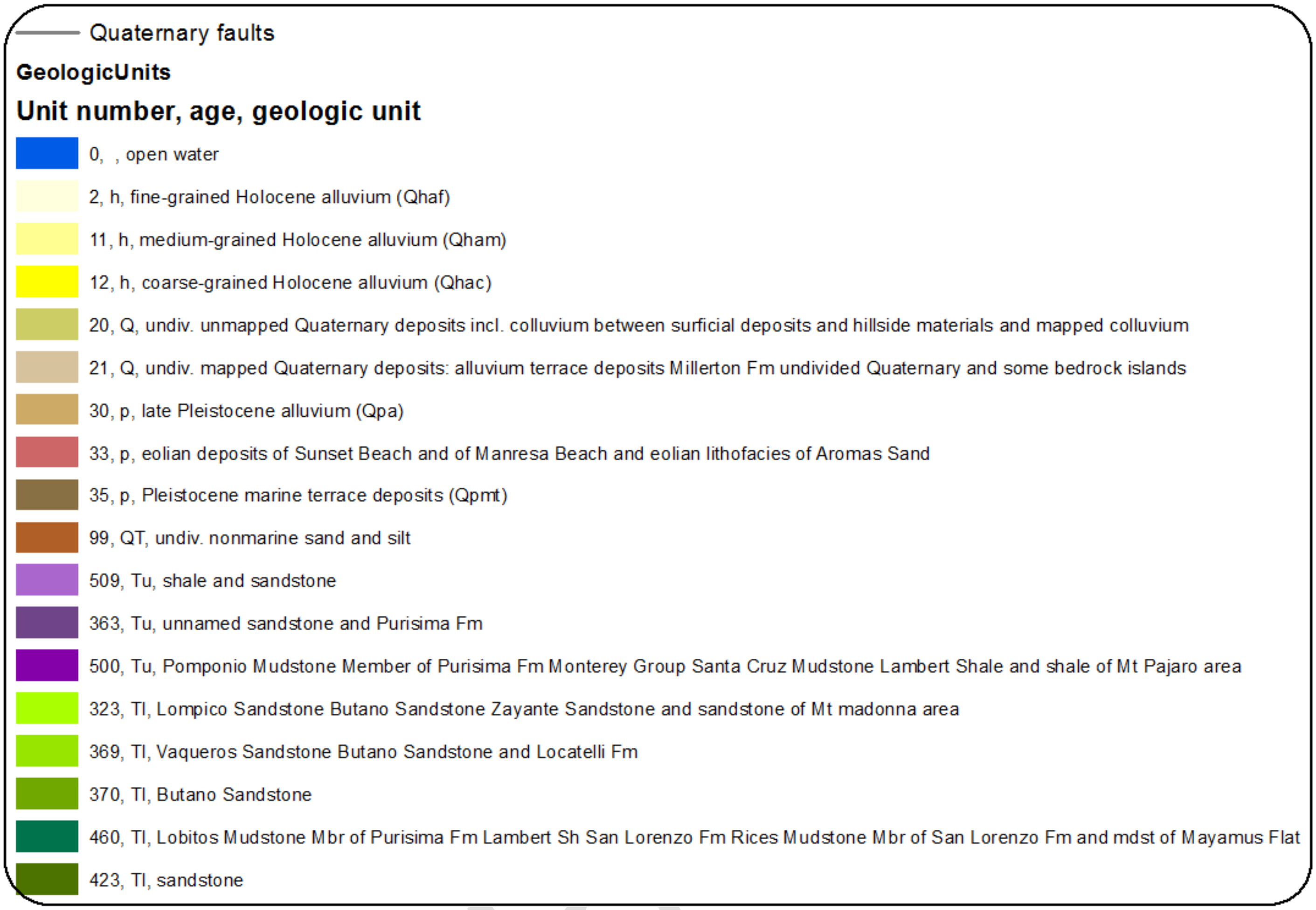


Figure 14. Legend for the geologic map previously shown in Figure 13.



5. Data Sources

The following is a preliminary list of anticipated data sources that could be used in TMDL development. As appropriate, Central Coast Water Board staff will work with stakeholders to identify additional sources of data.

1. City of Watsonville water quality data
2. County of Santa Cruz water quality data.
3. Water quality data collected by researchers from University of California, Santa Cruz and California State University, Monterey Bay.

Key stakeholders that are expected to be knowledgeable about the available water quality data for Pinto Lake include Mr. Robert Ketley, city of Watsonville staff, and John Ricker, County of Santa Cruz staff.

Stakeholders and interested members of the public have been informed that they may submit any information and data to Central Coast Water Board staff which they think would be relevant to a TMDL study for Pinto Lake. Examples include, but are not limited to:

1. Data, photos, personal knowledge about the lake, about the algae blooms, and/or about recent or historic land use practices;
2. Environmental success stories, such as improvement of management practices to reduce nutrient loading to the watershed;
3. Alert Central Coast Water Board staff to previous studies or reports that may be relevant to Pinto Lake
4. Provide feedback, written or informal, on draft reports Central Coast Water Board staff make available;

5. Anything else stakeholders and interested parties think would be relevant or helpful.

6. Potential Pollutant Sources

Elevated nutrients in a waterbody can contribute to biostimulation, such as algal blooms. There are many possible nutrient sources within any given watershed; in general the following can potentially be significant sources of nutrient loads:

- Urban runoff
- Wastewater treatment plants
- Fertilizer applications
- Livestock manure
- Septic systems
- Natural background
- Atmospheric deposition
- Shallow groundwater inflow into streams and lakes

Table 5 and Text Box 2 outline inferred sources of nutrient loading to Pinto Lake based on recent research (Ketley, Rettinger, and Los Huertos, 2013 and CSUMB and Resource Conservation District of Santa Cruz County, 2013). As warranted, more information regarding nutrient sources to Pinto Lake will be compiled and assessed during TMDL implementation.

Table 5. Estimated nutrient loads to Pinto Lake (table from CSUMB and Resource Conservation District of Santa Cruz County, 2013).

Source	Estimated 2011 load lbs
Lake sediments	1100 – 2645 pounds (mean 1650 pounds)
Watershed	220-660 pounds (mean 286 pounds)
Ground Water	Unknown without further research

Text Box 2. Inferred sources of controllable nutrient pollution to Pinto Lake.

Based on recent research (Ketley, Rettinger, and Los Huertos, 2013) inferred sources of controllable nutrient sources to Pinto Lake include agricultural operations, residential septic systems, and increased erosion and discharge of phosphorus-rich sediment to the lake as a result of the removal of historic native vegetation.

7. Public Outreach & Public Participation

Public outreach is a part of the TMDL development process. Leveraging knowledge about the Pinto Lake catchment from local residents, resource professionals, public agency staff, land owners, and land operators is very helpful to the Central Coast Water Board. Public outreach and public participation will be an ongoing element of TMDL development activities. A Lyris email distribution list has been created for this TMDL project and is used to notify interested parties of public meeting and progress regarding this TMDL project. Currently, there are 124 email subscribers on the Pinto Lake Lyris database.

Central Coast Water Board staff held a TMDL "kick off" meeting in Watsonville in July 2014. At the meeting, staff met with and identified stakeholders who are interested in water quality issues associated with Pinto Lake, and those whom have knowledge about lake data, lake conditions, and lake history. Attendees of the meeting included growers, representatives of public agencies, interested local residents, resource professionals, representatives of environmental groups, and representatives of the agricultural industry. Central Coast Water Board staff often finds meetings like this to be quite useful from the perspective of information-sharing, which ultimately benefits TMDL development. An example of the usefulness of TMDL meetings like this was articulated by a meeting attendee:

> *"Your power point presentation was excellent and it was very nice of you to provide all of us with the power point slides for our information. The discussion after your presentation was excellent too. It was great that you opened up the meeting and encouraged everyone to add to the discussion. We had a lot of very valuable and interesting input from the people there."*
>
> From: email to Central Coast Water Board staff from a meeting participant at the July 2014 Pinto Lake TMDL meeting in Watsonville.

8. Existing Plans to Improve Water Quality

In 2013, resource professionals from the California State University, Monterey Bay and the Resource Conservation District of Santa Cruz County prepared the Implementation Strategies for Restoring Water Quality in Pinto Lake. This report outlined the causes of algal cyanobacteria blooms in Pinto Lake and identified management practices and measures which could be taken to reduce nitrogen and phosphorus loading to lake waters, and to eliminate or substantially reduce these algal blooms and their toxins. The management measures identified can generally be outlined as follows:

- In- lake treatments to limit release of phosphorus from lake sediments.
- Erosion control/sediment capture practices to reduce nutrient loadings from agricultural and/or urban properties in the watershed.
- Irrigation and nutrient management programs for agricultural, commercial and residential properties in the watershed.
- Public education regarding management of on-site wastewater systems, gray water disposal and landscaping practices.
- Investigating options for sewer system extensions.

Text Box 3. Pinto Lake Watershed Implementation Strategies Report (2013).

> Note that TMDLs adopted in California need to have associated implementation strategies to improve water quality and provide for the attainment of water quality standards. Therefore, for reference purposes, **Attachment A** to this scoping document contains the entire *Pinto Lake Watershed: Implementation Strategies for Restoring Water Quality in Pinto Lake* report (CSUMB and Resource Conservation District of Santa Cruz County, 2013). This report could potentially serve as an informational tool and guidance document for a future TMDL implementation plan adopted through the Central Coast Water Board's basin plan amendment process.

9. Anticipated Next Steps

As stated previously, Pinto Lake currently has unacceptable levels of cyanobacteria microcystins (e.g., algal toxins), low dissolved oxygen, unacceptable pH levels, and scum/floating material. In the past, Pinto Lake was not subject to episodic and intense cyanobacteria algal blooms based on historical data and interviews with long term lake-side residents, thus indicating that controllable conditions are causing or contributing to these water quality problems in recent years.

Consequently, Central Coast Water Board staff anticipates developing a total maximum daily loads report, and associated implementation strategy with the goal of improving water quality and attaining applicable water quality standards in Pinto Lake. Consistent with guidance from the State Water Resources Control Board's Water Quality Control Policy for Addressing Impaired Waters, staff anticipates that a Pinto Lake TMDL project will need to be adopted through a basin plan amendment process in which the Water Quality Control Plan for the Central Coastal Basin would be amended to include any adopted TMDLs for the lake. The basin plan amendment process requires TMDLs to be approved by the Central Coast Water Board, as well as to receive approvals from the State Water Resources Control Board and the California Office of Administrative Law.

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Attachment A

Pinto Lake Watershed: Implementation Strategies for Restoring Water Quality in Pinto Lake

Prepared March 2013

California State University, Monterey Bay
Resource Conservation District of Santa Cruz County

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Pinto Lake Watershed

Implementation Strategies for Restoring Water Quality in Pinto Lake

Prepared March 2013

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Executive Summary

Pinto Lake is a 126 acre, natural lake located just outside of Watsonville, California. The lake typically develops heavy cyanobacteria blooms from May through December. These blooms frequently produce toxins with concentrations above the state health limit of 0.8 ppb. Pinto's cyanobacteria blooms have been implicated in fish kills, bird deaths and the death of several southern sea otters in Monterey Bay. The purpose of this project was to determine what environmental factors are causing these blooms and identify what management measures and practices could be taken to eliminate or substantially reduce the blooms and their toxins.

Water quality sampling in the lake and its tributaries was conducted by the California State University Monterey Bay (CSUMB). This sampling covered basic water quality parameters, such as dissolved oxygen, pH and nutrients as well as identifying cyanobacteria species. Sampling of cyanotoxins was conducted by the University of California at Santa Cruz (UCSC). Water quality and bloom toxicity data were analyzed by UCSC using a statistical predictive model. Based on this analysis, it was determined that phosphorus, and to a lesser degree nitrogen, were the principal drivers of Pinto's toxic cyanobacteria blooms.

Based on the findings of the water quality study, CSUMB and the Resource Conservation District of Santa Cruz County (RCD) identified a number of management measures and practices that would help reduce nutrient loadings (phosphorus and nitrogen). These management measures include:

- In- lake treatments to limit release of phosphorus from lake sediments.
- Erosion control/sediment capture practices to reduce nutrient loadings from agricultural and/or urban properties in the watershed.
- Irrigation and nutrient management programs for agricultural, commercial and residential properties in the watershed.
- Public education regarding management of on-site wastewater systems, gray water disposal and landscaping practices.
- Investigating options for sewer system extensions .

Three public workshops were organized by the RCD to inform and engage key stakeholders and residents in the Pinto Lake watershed. The workshops were well attended and helped facilitate critical dialogue with community members.

While the project was successful in its purpose of identifying the principal drivers of the lake's cyanobacteria blooms and selecting management measures to address those drivers, more work is needed to determine the efficacy of specific management measures. For example, in- lake treatments range from simple water mixing systems (such as aeration) to the addition of chemicals (such as alum) which effectively lock phosphorus in lake sediments. The effectiveness of these management measures should be determined through pilot scale studies before commitment to full-scale implementation. In addition, more water quality sampling needs to occur within the watershed, to determine if there are nutrient contributing hotspots where focused management measures could be most effective.

Background, Need & Purpose

Pinto Lake is a shallow, 126-acre hyper-eutrophic lake located within the Pajaro River watershed in Santa Cruz County. The lake is bordered by two public parks and private lands. Land use in the lake's 1,484 acre watershed outside of the park is primarily agricultural and ranch land, with some suburban and rural residential areas and businesses including stables, kennels and a composting facility.

The lake poses a health risk to humans and animals from frequent cyanobacteria algal blooms (CHABs), which currently dominate the lake's aquatic ecosystem. Freshwater CHABs create an array of potent cyanotoxins through both direct ingestion and bioaccumulation. The family of hepatotoxic microcystins , produced by several cyanobacteria taxa, are some of the most pervasive and potent cyanotoxins identified worldwide. While acute microcystin exposure through direct ingestion can lead to liver failure and death within 24-48 hours, lower level exposure through recreational contact or accidental ingestion can result in less severe symptoms such as nausea, vomiting, and diarrhea. Chronic low-level exposure to microcystin has also been associated with the long-term development of liver and gastrointestinal cancers in mammals (Ueno et al. 1996). In 2010 researchers documented 21 sea otter deaths in the Monterey Bay National Marine Sanctuary (MBNMS) that were linked to microcystin poisoning emanating from land-based freshwater cyanobacteria (Miller et al. 2010). Pinto Lake drains seasonally into the Monterey Bay, and is a potential source of CHAB biomass and cyanotoxins for the MBNMS. Pinto Lake demonstrates seasonal CHABs with microcystin toxin levels measuring at an average of 183 ppb, during blooms, in 2007 through 2011. These toxin levels exceed the safe recreational exposure limit of 0.8 ppb established by the State of California (Cal EPA 2012).

Over 100,000 people visit Pinto Lake's two parks each year enjoying activities such as boating, fishing, lakeside picnics and camping. Many visitors include local low income families with young children. A low-income housing project for farm workers is located on the lake's western shore. Health risks to park visitors and the community that are linked to water contact would be significantly reduced through eradication of the cyanobacteria and associated toxins.

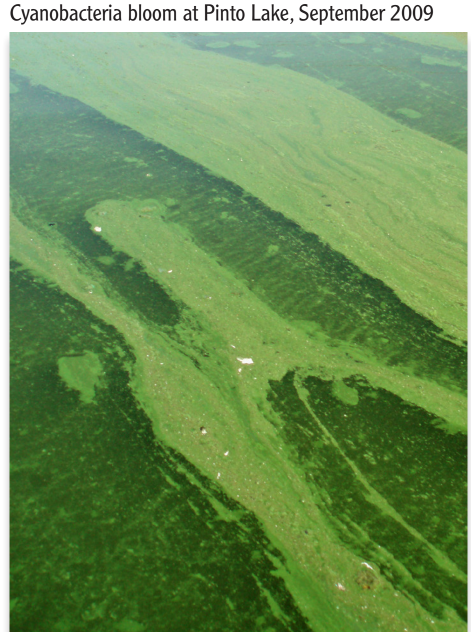
In 2006, the Pajaro Nitrate TMDL implementation plan recommended 1) additional monitoring to address biostimulatory substances, algal growth, and low DO, and 2) revisiting, and revising or developing subsequent Pajaro Nutrient TMDLs (TN, Nitrate, or TP) as needed to correct the impairments. In addition, Pinto Lake was placed on the California Impaired Water Bodies 303(d) list in 2009. In 2010, the City of Watsonville was awarded funding through an EPA Clean Water Act Section 319(h) grant to identify the environmental drivers of the blooms (temperature, nutrients, and/or sediments) and develop an implementation strategy to mitigate and restore Pinto Lake water quality based on the results of the water quality sampling data and modeling. The strategy was required to include a summary of MMs/MPs, an implementation sequence of actions needed to minimize and/or eliminate the cyanobacteria blooms, actions related to minimizing the loading of nutrients into the lake, treatments recommended for the nutrients in the lake itself, and/or any other action or treatment required at the lake water outflow. The Pinto Lake Total Maximum Daily Load Planning and Assessment Project (Project) provided the first analysis of the potential sources (Pinto Creek and its tributaries, shallow groundwater, or the lake's sediments) of pollutants and conditions that initiate and support toxic cyanobacteria blooms in Pinto Lake and recommendations for an implementation strategy that can be used in current TMDL implementation efforts as well as in the development of future TMDLs.

This project was designed to encompass an array of factors most commonly associated with CHABs and cyanotoxins. Because several studies have reported distinct spatial patterns associated with CHAB inception and development, the focus of this Project was on monitoring the spatial and temporal variation in CHAB development across Pinto Lake in association with environmental factors. Monitoring of potential sources of nutrient flow to the lake included monitoring of surface flow from the watershed via Pinto Lake tributaries, from groundwater through groundwater monitoring wells and from the lake sediments though sampling and incubating Pinto Lake sediments.

The major outcome of this project is the establishment of a consistent dataset of cyanobacteria bloom development and toxicity in relation to lake nutrient and temperature dynamics. Using this dataset, models were developed describing the associations between the environmental variables and the presence and abundance of seasonal CHABs and microcystins.

This information can be used to adapt outreach activities to target sources of nutrients that stimulate CHABs as well as shape interim and long-term strategies for controlling Pinto Lake cyanobacteria. The project team also identified specific management measures and practices that may be used to reduce the factors associated with promoting the development of toxic CHABs.

Cyanobacteria bloom at Pinto Lake, September 2009



History & Current Land Use

Through the examination of records, older maps of the area, and researching the establishment of changes in the watershed, we sought to understand any shifts in the watershed, land use, or projects that might have contributed to the development of regular cyanobacteria harmful algal blooms (Table 1).

The limnological record of human impact on watershed land cover and on lake sedimentation during the historical period has been well established for Pinto Lake in Central Coastal California. In addition, the sedimentary record of the 'pre-impact' condition provides evidence of a climatic control on the nature of lake sedimentation. The impact of immigrants and their 'imported' land-use practices was clearly reflected in an order of magnitude increase in the rate of lake sedimentation. In addition, the occurrence of exotic plant species in the sedimentary record indicates disturbance as early as c. 1769–1797, whilst redwood deforestation between 1844 and 1860 represents the most significant human impact (Plater et al. 2006) In 1844, Jose Amesti deeded 15,400 acres to his wife which included the Pinto Lake area. The north portion of Pinto Lake was sold to George S.P. Cleveland in 1862 and he constructed a set of buildings and developed his 164 acre parcel as a ranch. Residential subdivisions and additional urban development occurred during the 1950s and through the 1970s. In 1974, the County of Santa Cruz purchased the north portion of Pinto Lake "to protect the lake while providing recreation."

Interviews with Pinto Lake watershed residents and Santa Cruz County community members have described Pinto Lake shifting from a largely swimmable recreational resource in the late 1960s to early 1970s to the current cyanobacteria-dominated lake we see today, suggesting that the blooms began to be a problem sometime in the late 70s- early 80s. Knowledgeable lakeside residents mentioned draining of the lake in the 1960s (in an attempt to eradicate carp) and conversion of apple orchards to berry crops as potentially significant changes in the lake and its watershed.

ArcGIS map analysis, descriptions in the scientific literature, and on-foot observation were used to estimate the current land uses in the Pinto Lake watershed. The watershed was found to be dominantly covered by agriculture land (ranch land, rural single family dwellings with large properties) and suburban development, with parkland constituting the rest of the area surrounding the lake (Table 2).

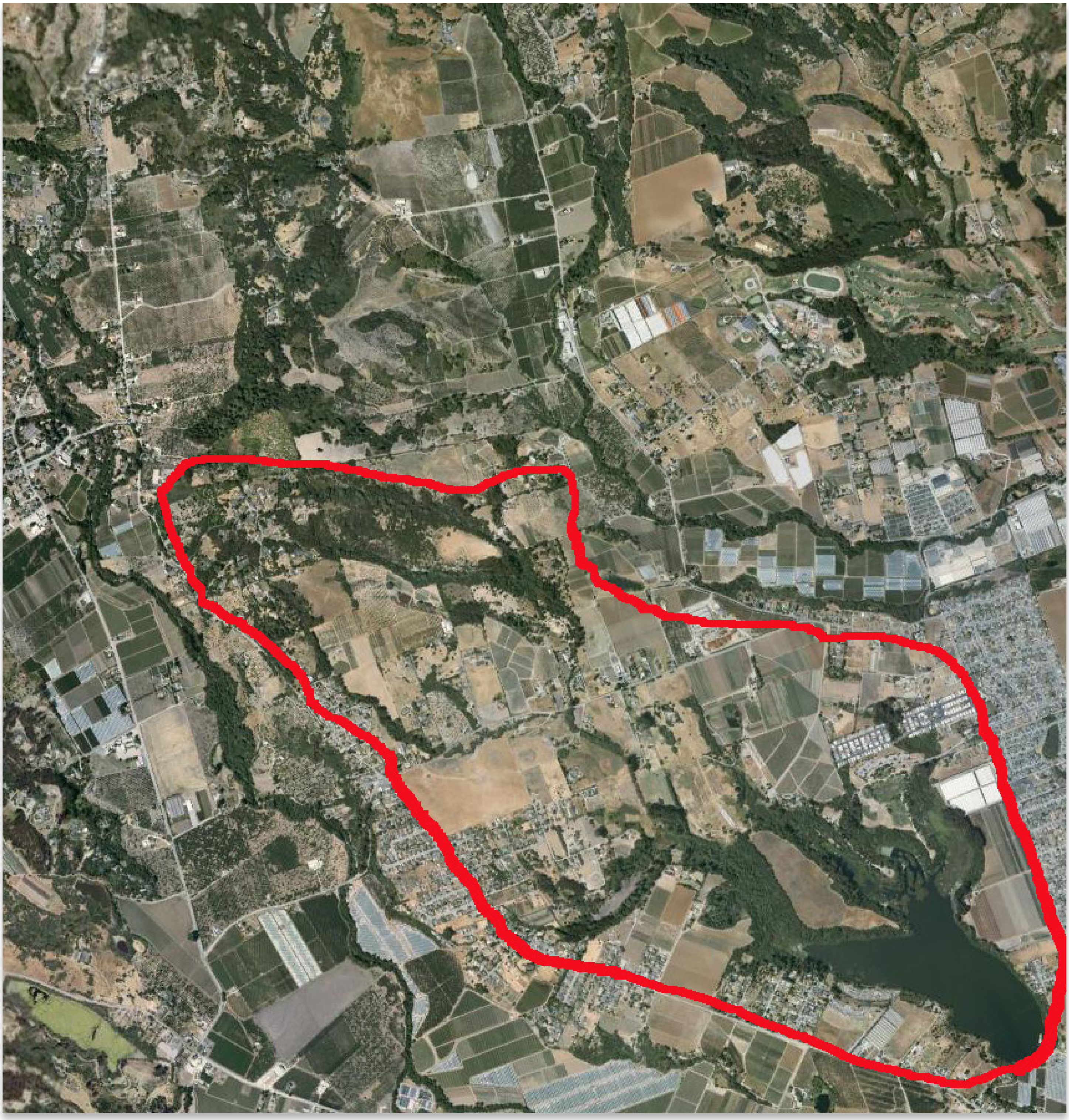
Table 1. Key Historical Land Use Changes

Event	Time Period	Potential Effect	Evidence	Associated Lake Sediment Depth
Landscape clearance and agricultural development	Late 18th to mid 19th century	Changed sediment and nutrient flux rates.	Increases in sedimentation for this period as documented by radio and pollen dating (Plater et al. 2006).	11.5 feet
Reductions of riparian vegetation in the watershed	18th century to present	Reduction of nutrient and sediment retention in watershed.	Changes in pollen in the lake sediments (Plater et al. 2006) and aerial photography.	7.5 feet
Impounding of the Lake, building of Green Valley Road	Late 1950	Increase of lake water level and increase in eutrophic status.	Evidence of increase in eutrophic phytoplankton from lake sediments (Plater et al. 2006).	3.1 feet
Residential subdivisions and development in the area with septic systems	1950s and 1970s	Septic systems can contribute nutrients to Pinto lake via surface failures or subsurface flow through groundwater, although the subsurface movement of nitrate and particularly phosphate is usually limited in clay soils. Surface discharge of greater volumes may also contribute phosphate as many detergents contain phosphate.	There is evidence of nutrients from surrounding land uses being transported to the lake, however, there is currently no evidence showing a link directly to septic systems versus other land uses.	N/A
Drawdown of lake elevation	1960s & 1970s	Decrease in eutrophic status with drawdown, but increased eutrophication with rise after drawdown.	Evidence in sediment diatom/ dinoflagelate record of 1960s and 1970s decrease in eutrophication followed by increase (Plater et al. 2006).	1 foot

Table 2: Land Use/Land Cover

Land Use Categories	Area-Acres	% Total watershed area
Agriculture	422	35
Row Crop	374	25
Orchard	148	10
Commercial/ Residential	281	19
Grazing	267	18
Scrub/Shrub/ Forest	252	17
Open Water	89	6
Wetland	74	5
Total	**1485**	**100**

Aerial view of the Pinto Lake Watershed



Water Quality Monitoring Results & Findings

The Pinto Lake Project succeeded in confirming that the combination of high nutrient levels in the lake and seasonal warm water were driving toxic cyanobacterial blooms. Because the lake becomes thermally stratified, the processes that influence cyanobacteria blooms are seasonally distinct. Nutrients released from lake sediments, referred to as internal loading, are the dominant source of nutrients for cyanobacterial growth, and therefore should be a management priority. However, watershed nutrient inputs cannot be ignored and must also be controlled. Management of in-lake sediments alone will not be enough to rectify the problem.

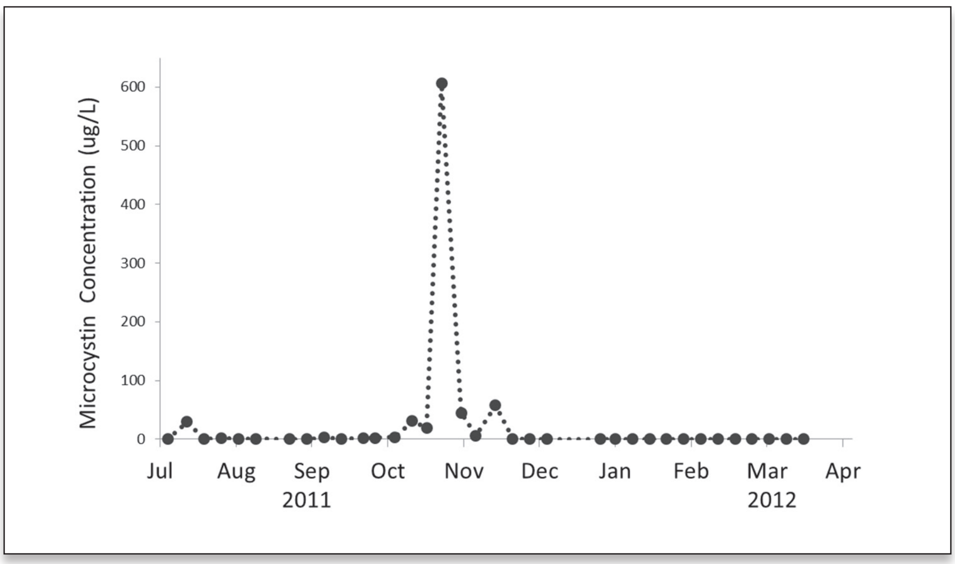
Lake Inputs

Samples and testing were conducted by California State University Monterey Bay. At every sampling visit, samples were collected to measure cyanotoxins, cyanobacteria, and nutrient concentrations. In situ water quality and physical lake parameters including water temperature, pH, dissolved oxygen and water clarity were also measured. To evaluate internal loading, sediment cores were collected from Pinto Lake sediments and incubated to estimate nutrient flux to the water column from the sediments.

Cyanotoxins - Microcystins

The cyanotoxin microcystin was detected throughout the year above the safe recreational exposure limit established by the State of California (0.8 ug/L) with peaks in July and again during a more sustained toxic period in the autumn (Figure 1). Besides posing immediate health risks for the public engaging in recreational contact with the lake, the documented high levels of microcystin may also pose health risks to nearby communities through aerosolization of the toxins at high concentrations (Cheng et al. 2007).

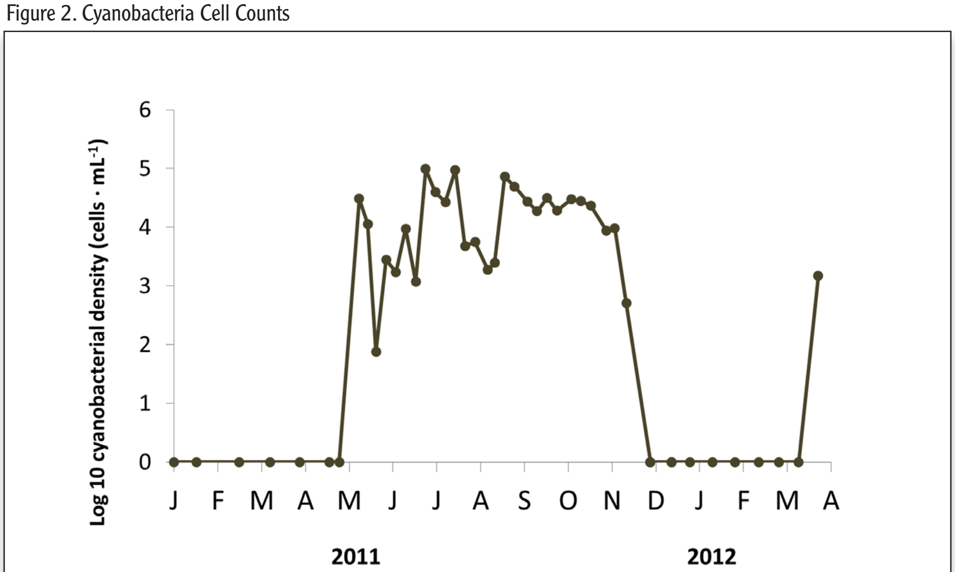
Figure 1. Microcystins



Cyanobacteria Monitoring

Cyanobacteria cells increased in Pinto Lake from undetectable levels in January through March to above 100,000 cells/ml in July (Figure 2). The mass accumulation of cyanobacterial cells (CHABs), including several cyanobacteria capable of producing cyanotoxins, continued through late autumn. Cyanobacterial cell densities decreased in December and remained undetectable until the following March. This is most likely due to seasonal decrease in solar radiation and temperature as well as the turbulent mixing of winter weather.

Figure 2. Cyanobacteria Cell Counts



Nutrients

Nutrient concentrations varied with depth based on the season. Nitrogen and phosphorus increased in the water column in the winter and spring months associated with seasonal stream flows from rainfall . However, the flux of dissolved nitrogen and phosphorous to the water column in summer/fall from the sediments was even more pronounced. This suggests that the lake is dominated by internal loading of nutrients (e.g. dissolved inorganic phosphorus and ammonium) that are released from the lake sediments which is then available to surface waters with the seasonal mixing of the lake water column (Figures 3-4).

The results from the nutrient flux experiments (Table 3) support the importance of internal loading of nutrients and explain the high concentrations of nitrogen and phosphorus in the water below the thermocline prior to the autumn mixing (Figure 3-4).

Temperature, Dissolved Oxygen, pH

In the winter months the lake surface water was cool with an average temperature of less than 57˚F and the lake was neutral with an average pH of 7. There was low saturated dissolved oxygen with an average between 40-60% and the lake was well-mixed with the water column consistent throughout (Figure 3).

As air temperature and the amount of solar radiation increased in the spring and summer, the temperature of the surface water (epilimnion) increased substantially with a summer average of 72˚F (Figure 5), while the bottom waters (hypolimnion) increased only moderately to an average of 55˚F and at a slower rate. With the differences in water temperatures (which causes a difference in the density of lake water), Pinto Lake became stratified—with a distinct thermocline demarcating a warm, oxygen-rich upper layer and a cooler, oxygen-depleted lower layer (Figure 4). Dissolved oxygen concentrations and pH increased in the surface waters as a product of the photosynthetic activity of algae growth, while dissolved oxygen below the thermocline was consumed by respiratory activity in the lake bottom. As the summer progressed into autumn, the entire water column warmed and the difference in density disappeared. Without a difference in density between the upper and lower lake depths, the lake mixed, with continuation of high dissolved oxygen at the surface and low-dissolved oxygen in much of the underlying water column. By early winter the water column cooled and there was a decline of the cyanobacterial bloom.

Figure 3. Winter Nutrients, Temperature and Dissolved Oxygen

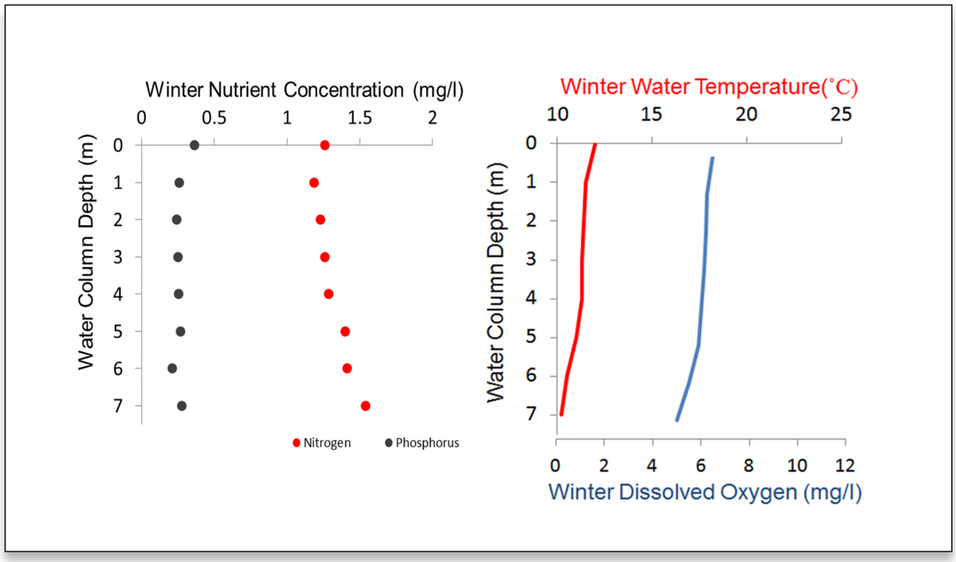


Figure 4. Summer Nutrients, Temperature and Dissolved Oxygen

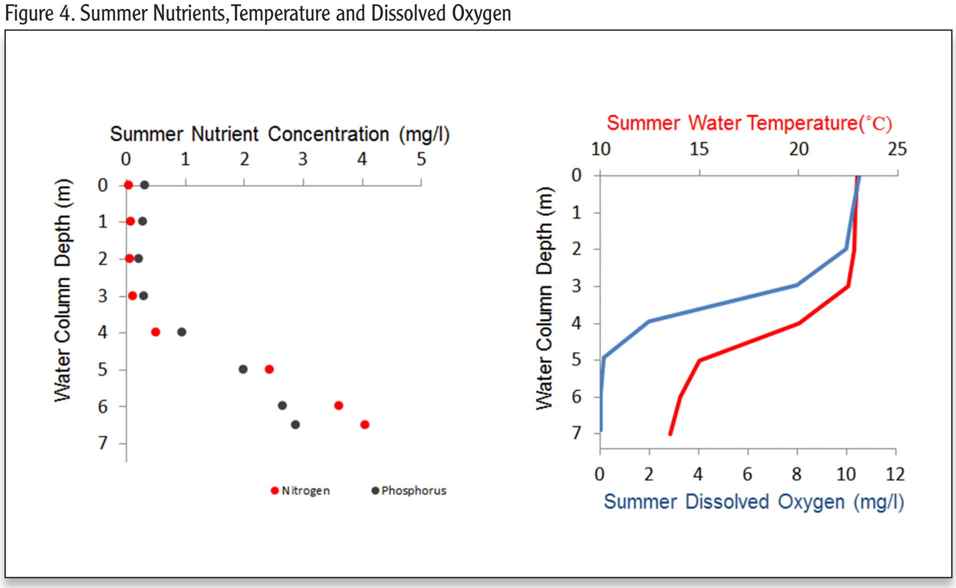


Figure 5. Surface Water Temperatures

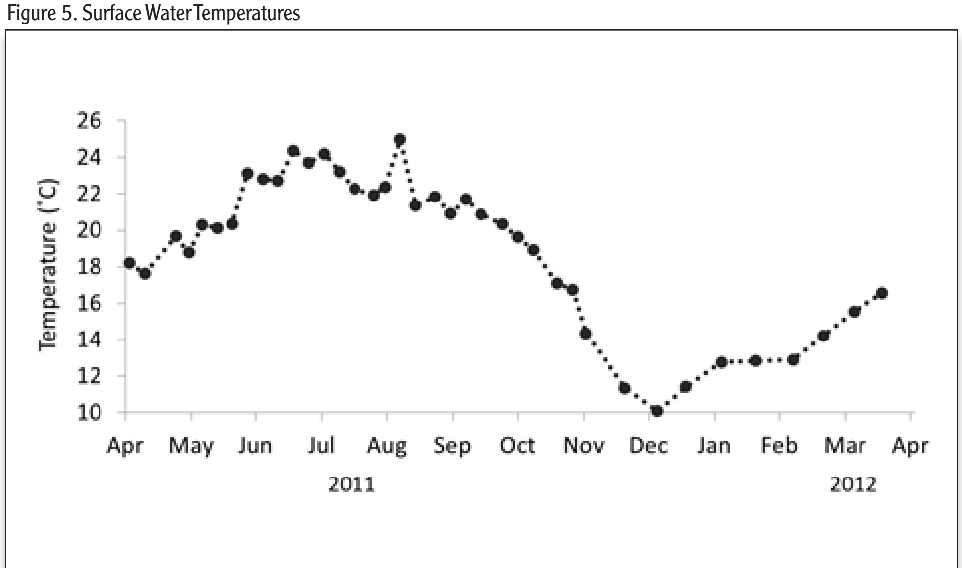


Table 3. Pinto Lake Nutrient Flux

	Phosphorus as phosphate	Nitrogen as ammonium
Nutrient flux range	0–0.172 mg/ft²/sec	0–1.29 mg/ft²/sec
Average nutrient flux	0.067 mg/ft²/sec	0.570 mg/ft²/sec
Estimated average monthly flux	200 kg (440 pounds)	1700 kg (3740 pounds)

Watershed Inputs

The streams that flow into Pinto Lake were monitored at various locations and times for in-situ water quality parameters (temperature, pH, and dissolved oxygen) and nutrient concentrations. The sampling sites included several locations on the main lake tributary, Pinto Creek (leading to the upper left lake finger) and also on the tributary leading to the middle lake finger and the smaller tributary flowing to the upper right lake finger (Table 4).

Because the catchment area is small and rainfall was below average (17 inches of precipitation for January through December 2011; with an average precipitation of 23 inches), discharge and load estimates have high levels of uncertainty. Nevertheless, we estimated an annual load of between 200-660 pounds phosphorus (total) and 330- 660 pounds nitrogen (dissolved ammonium + nitrate).

Table 4: Pinto Lake Tributary Water Quality.
(Results are range of observations and average values)

Parameter	Range	Average
Temperature (°C)	12.51–13.64	(13.25)
pH	6.93–7.15	(7.01)
Dissolved oxygen (mg/L)	8.61–9.79	(9.31)
Dissolved oxygen (% Saturation)	73.3–88.7	(84.0)
Nitrogen (mg/L)	0.2–1.4	(0.59)
Phosphorus (mg/L)	0.15–0.8	(0.45)

Ground Water Well Nutrient Concentrations

Two ground water monitoring wells were constructed in early autumn 2011 to monitor and quantify the nutrient concentrations of groundwater and estimated loading of nutrients to the lake from groundwater. The intent was to look at potential nutrient seepage from residential septic systems on Amesti Road and leaching from the application of agricultural fertilizers from properties above Pinto Lake County Park.

The wells are located just north of the Santa Cruz County Pinto Lake Park and immediately to the west of the lake in the Villas del Paraiso residential development. Groundwater well water quality monitoring began in November 2011 and continued through December 2012. Depth to water ranged from 1.6 feet to 6.5 feet and an elevation of 5–28.7 feet above the average lake level. Ground water samples were taken after wells were purged of their volumes three times and collected monthly. Between November 2011 and December 2012 nutrient concentrations ranged from 0.057 to 3.95 mg/L of phosphorus and between 0.12 to 1.47 mg/L of nitrogen, which suggests somewhat high concentrations. However, high sediment concentrations in the well samples suggest caution in their interpretation because water-particle interactions may have biased these values. In addition, without nested wells and some estimate of ground water flow, it is difficult to gauge the potential load to the lake. However, these data suggest that ground water inputs into the lake should be further evaluated.

Summary of Water Quality Factors Promoting Toxic Cyanobacteria in Pinto Lake

Statistical analysis was conducted by the University of California at Santa Cruz.

In 2011, the development of a toxic cyanobacterial bloom in Pinto Lake was documented with cyanobacterial cell densities and the concentration of microcystin increasing in the warm summer and autumn months. In this period, together with the seasonal increase in temperature and sunlight, there were levels of phosphorus and nitrogen sufficient to promote the development of the toxic cyanobacterial bloom. Statistical analyses of collected water quality data show strong positive relationships between phosphorus and both cyanobacterial cell density and microcystin concentrations. The data show a weaker association with ammonium-nitrogen and both cyanobacterial cell density and microcystin. The data also show a negative relationship between nitrate-nitrogen and both cyanobacterial density and microcystins. The strong relationship between phosphorus and toxic cyanobacteria suggests that management efforts should focus on reducing phosphorus as a primary goal.

Internal loading from the lake sediments and seasonal runoff from the watershed were both found to contribute nutrients to Pinto Lake. However it was evident from the 2011 data, the nutrients derived from the lake sediments accounted for a much higher load of the lake's nutrients (Table 5). Atmospheric deposition was not considered as part of this study.

Table 5: Comparing Nutrient Loads to Pinto Lake

Source	Estimated 2011 load lbs
Lake sediments	1100 – 2645 pounds (mean 1650 pounds)
Watershed	220-660 pounds (mean 286 pounds)
Ground Water	Unknown without further research

The historical lake record (obtained through interviews with long term lakeside residents and knowledgeable locals or inferred from sediment core data) indicates that Pinto Lake has not always demonstrated such regular and intense cyanobacterial blooms. Cyanobacteria blooms appear to have started n the late 1970s/early 1980s. The appearance of the blooms is possibly due to impounding of the lake and the subsequent alteration of the lake water level (Table 1) associated with the paving of Green Valley Road circa 1950 and/or increases in watershed nutrient loadings in response to changes in watershed land use. However, it is unlikely that these factors would have instigated cyanobacterial blooms in Pinto Lake without the increase in sediments documented in the Pinto Lake sediment cores beginning with European land development in the 18th century and continuing to the present day.

Current & Historic Management Measures

The project team conducted research on management measures currently and historically implemented in the Pinto Lake Watershed (Table 6). Data was collected through surveys and by speaking with landowners and various agencies who work in the watershed. All implemented management practices that focus on reduction of the pollutants that drive CHABs are listed. Existing outreach, education, technical and financial assistance programs that target pollutants contributing to CHABs and are available to Pinto Lake Watershed residents and growers are also listed.

In-Lake

The City has begun implementation of a carp eradication program (Carpageddon). Carp feed on small organisms by sucking up lake sediments and filtering out the animals. This behavior disturbs lake sediments and releases phosphorous, which is one of the drivers of CHABs.

Furthermore, to reduce risk to humans and other mammals, the California Department of Fish and Wildlife has stopped trout releases into Pinto Lake. This is in response to the recent documented presence of microcystins in trout caught at the lake. The impact on CHABs from the discontinuation of trout releases and carp removal is currently unknown.

Lake Outflow Study

In 2012, a small laboratory was set up at Pinto Lake to study potential cyanotoxin treatment technologies for the waters exiting Pinto Lake that continue to the Pajaro River and eventually Monterey Bay. This project was funded through SWRCB cleanup and abatement funds. Technologies included slow sand filtration, alum, granular activated carbon, ozonation and resin beads. The goal of this study was to determine if any of the treatment technologies could provide a cost-effective treatment system for managing toxins at Pinto Lake's outfall. Analysis of the data from this project is currently underway.

Parks

The County of Santa Cruz Parks Department has an active Integrated Pest and Nutrient Management Program that includes only necessary removal of poison oak and invasive plants to minimize bare soil and erosion and using slow-release fertilizer and irrigation management to reduce any potential runoff, thus reducing nutrients to the lake. The park maintenance personnel have also attended erosion control workshops and the park has an active stormwater management plan to assist in reducing erosion and sediment transport to the lake.

Residential

The County of Santa Cruz currently has ordinances in place to reduce nutrient loading from erosion, vegetation clearing, and septic systems, although many of the residential septic systems predate current requirements. Existing facilities are required to comply with current requirements when new additions or substantial changes are made to properties. Residential subdivisions and development occurred in the area in the 1950s and 1970s. It is known that septic systems can contribute nutrients to Pinto Lake via surface failures or subsurface flow through groundwater, although the subsurface movement of nitrate and particularly phosphate is usually limited in clay soils such as those surrounding Pinto Lake. While ground water wells were monitored as part of the Pinto Lake study, the data was not reliable enough to conclude input of nutrients to Pinto Lake from septic systems. Surface discharge (due to leachfield saturation in winter and spring months) may also contribute phosphate as many detergents contain phosphate. Surface water monitoring would be needed to determine the significance of theses input into Pinto Lake.

The County implemented an effort in 1995-97 to evaluate septic system performance along the Amesti Road corridor. Installation information was compiled, water quality samples were collected from roadside ditches and parcels were inspected for signs of failure. Findings showed that 82% of the septic systems were functioning properly, 16% had grey water discharge and 2% were failing. Corrections were made. Much of that area is challenged by small lots, clay soils and perched groundwater during the winter. Many of the systems utilize seepage pits, which discharge effluent at depths below the perching clay layer. Seepage pits are no longer allowed for new development, but can be used for septic system repairs if adequate separation (5 feet) from the regional water table can be maintained. More recently, new development and repairs have utilized alternative technologies which provide for a higher level of treatment and nutrient removal prior to shallow effluent disposal.

During the site surveys in the mid 1990s, it was discovered that a standard practice in the neighborhood surveyed was to discharge washing machine water to the street gutters in order to reduce the load on the septic systems. Property owners were required to cease that practice and connect their washing machines to their septic systems or install approved grey water sumps for subsurface disposal. During the time period, the County also conducted broad outreach and education to septic owners and queried them about level of interest in replacing septic systems with a sewer system for which there was very little interest.

Currently, the County provides the same level of septic system oversight as is provided in other areas of the County. A database is maintained of all septic system permits, complaints, inspections, and septic tank pumping activities. Occasionally samples are collected from some roadside ditches during late winter/early spring. Records of septic tanks pumping have been maintained since 1989. A recent review in late 2012 showed that 13% of the septic systems in the Pinto Lake Watershed did not report records of pumping to the County. This is important, because depending on how a septic system is managed a lack of pumping could result in movement of solids into the leachfield and failure of the system.

Residents made comments at the April 30, 2013 workshop regarding leachfields that are saturated year-round, the pervasive smell of septic wastes during winter and spring and obvious signs of greywater discharge to ditches. These comments suggest management of septic systems in the Amesti area continue to be challenging.

Agricultural

Five known agricultural management practices have been installed by agricultural operations in the Pinto Lake Watershed through assistance from the programs listed below (also see Table 6).

Local Farm Bill Programs

Over the last 38 years the Natural Resources Conservation Service (NRCS) has worked on numerous properties that drain to Pinto Lake. In the last 5-7 years the

Table 6. Management Practices Implemented in Pinto Lake Watershed

Management Practice	Practice Size	Pollutant Addressed	Benefit	Creek	Land Use
Cover Crop	< 1 acre	Sediment and sediment bound nutrients	Erosion control, Fertility Management (Legumes can add substantial amounts of available nitrogen to the soil. Non-legumes can be used to take up excess nitrogen from previous crops and recycle the nitrogen as well as available phosphorus and potassium to the following crop), rand educes leaching of nutrients	Pinto Creek	Agriculture
Critical Area Planting	1 acre	Sediments and some nutrients in runoff	Erosion control	Pinto Creek	Agriculture
Sediment basin	1 basin	Sediment and sediment bound nutrients	Retains soil on property and some sediment that may contain pesticides and nutrients, potential for lowering peak tributary discharge rates and protect stream banks and drainage perimeters from erosion.	Pinto Creek	Agriculture
Grassed Waterway	< 1 acre	Dissolved nutrients in runoff and sediments	Reduces gully erosion. Vegetation within the waterway may also trap sediment washed from cropland, absorb some chemicals and nutrients in the runoff water and provide cover for small birds and animals.	Pinto Creek	Agriculture
Irrigation Reservoir (water catchment and reuse)	10,000 gallon tank storage	Sediments and some nutrients in runoff	Reduces runoff from pervious surface thus reducing erosion. Conserves water requiring less groundwater use.	Pinto Creek	Agriculture
Irrigation and Nutrient Management	> 1 acre	Sediment and sediment bound nutrients, dissolved nutrients	Reduces water use and nutrient runoff to Pinto Lake. Can also reduce cost of park operations.	Pinto Lake	Park
Landscape Maintenance (less toxic or limited fertilizers and weed controls)	6 residential properties	Nutrients in runoff and groundwater	Reduces volume of excess nutrients thus reducing potential for runoff.	Pinto Lake Watershed	Residential
Manages car wash runoff or uses commercial car wash	3 residential properties	Phosphate surface flow	Reduces volume of phosphates in stormwater runoff.	Pinto Lake Watershed	Residential
Septic tank pumping or repairs	5 residential properties	subsurface nitrate, phosphate and ammonium	Reduction of nitrate, phosphate and ammonium from subsurface flow and system failures.	Pinto Lake Watershed	Residential
Stormwater Management (including erosion control)	4 residential properties	Nutrients and sediments from surface flow	Reduction of stormwater runoff and sediment about nutrients to Pinto Lake.	Pinto Lake Watershed	Residential

NRCS has had at least 5 EQIP (Environmental Quality Incentive Program) contracts on farms in the drainage area. Those farms have or are currently in the process of installing a number of conservation practices that will benefit both surface and/or groundwater supplies and quality . These practices include cover crops, hedgerow, sediment basin, irrigation reservoir (tanked), runoff control, road seeding, irrigation systems, irrigation pipelines, flow meters, roof runoff structure and irrigation water management.

During the same time period, both the RCD and NRCS have provided onsite technical assistance to other properties that do not have EQIP contracts, providing consultations on erosion, sediment and runoff control measures, and various management, vegetative and structural conservation practices including underground pipe outlets , water control structure, critical area planting, wildlife enhancement, pond management and more. The benefits and intent of all of these practices is to protect and improve the quality of soil and water resources in the drainage areas surrounding the farms. The majority of the practices reduce erosion

Assistance provided by the NRCS has helped agricultural operators to;

- » Reduce runoff by installing practices the improve water intake and the soil's ability to hold water for plant use
- » Reduce soil erosion and resulting sedimentation affecting on and offsite surface water quality
- » Improve irrigation water efficiencies so that there is less dependence on groundwater supplies and less opportunity for irrigation runoff
- » Reduce nutrient rich runoff with the use of grassed roads, filter strips, permanent cover, cover crops and other vegetative practices.

RCD Programs

Irrigation and Nutrient Management Program: In 2011, the RCD launched the Irrigation and Nutrient Management (INM) Program, focused initially on the Pajaro River Watershed, which includes Pinto Lake. The INM program is funded by the California State Water Resources Control Board (SWRCB) and the Natural Resources Conservation Service (NRCS), and is designed to address rising concerns of declining water quality and water supply in the region.

Through the INM program, RCD Staff and regional agronomists work cooperatively with growers to assess current irrigation and nutrient delivery practices and equipment, in order to find ways to increase water and nutrient efficiency while maximizing production and crop quality. Building on a long history of conservation efforts in the Pajaro Watershed, the INM program is conducting on-site irrigation evaluations and collecting data to monitor fertilizer inputs and make recommendations on how systems can be improved to conserve grower resources and mitigate impacts of agricultural run-off. So far, the program has identified many small low-cost management changes. One example is modifying irrigation scheduling that will improve system efficiency, thus reducing potential runoff of phosphorus and sediments.

MANA Program: In 2010 the RCD was awarded funding from the US Department of Agriculture's Outreach and Assistance for Socially Disadvantaged Farmers and Ranchers Program. For the past three years, this program, called Manejo Agricola con Nuevos Amigos (MANA) has been supporting the Resource Conservation District of Santa Cruz County (RCD) initiative to provide better conservation and education assistance to Spanish speaking growers.

The MANA program has three main goals. First, the program seeks to improve RCD and Natural Resources Conservation Service (NRCS) relationships with Spanish speaking growers. Second, MANA aims to reduce barriers farmers may have with putting conservation measures into practice due to language or economic factors. The third goal of the MANA program is to improve economic outcomes for Spanish speaking growers, by designing programs that improve access to markets and help implement cost saving conservation measures.

The MANA program has developed tools and resources specifically targeted to Spanish speaking farmers in Santa Cruz County, including: erosion control assistance, farm water quality and compliance assistance, and irrigation and nutrient management assistance. Although services have been provided across all of Santa Cruz County, Pinto Lake Watershed has not been specifically targeted. By focusing future efforts in this watershed, these services would assist in the delivery of projects associated with TMDL implementation for Pinto Lake Watershed.

Recommended Management Measures/Practices

This section includes all management measures and practices that address the identified pollutants driving CHABs at Pinto Lake. The first two key management measures, Stakeholder engagement and the recommended additional studies, will be key to addressing the challenges of the watershed based transport of nutrients to Pinto Lake.

The implementation strategy (see next section), includes priority immediate, short-term and long-term recommendations based on the results of this project.

Watershed Management Approach

We propose a multi-pronged watershed management approach, which relies on promoting stakeholder efforts to improve water quality. These efforts must include the following strategies to reduce the identified nutrients contributing to CHABs:

- » Stakeholder engagement, outreach and education.
- » Additional monitoring to better understand how different land use types are contributing (fate and transport) and adaptive monitoring.
- » Direct treatment of the lake to reduce CHABs.
- » Watershed-wide implementation of management measures and practices to reduce input of those factors driving CHABs.

Because of the relatively small scale of the Pinto Lake watershed, and the limited number of stakeholders, implementation of management measures and practices to improve Pinto Lake water quality and reduce toxic blooms seems reasonably likely. Furthermore, this success will also result in reduced risk from the discharge of lake-originating cyanotoxins to the Pajaro River and ultimately into the Monterey Bay coastal area.

Finally, adaptive management will have to be a key component of any implementation solutions, due to the limited and emerging information on the biology of CHABs. The monitoring data provided vital information on the conditions that initiate and drive the blooms and toxins. This information can be used to adapt outreach activities to target key sources of pollutants as they become better understood, as well as help shape interim and long-term strategies for controlling cyanobacteria.

1. Stakeholder Engagement

The first mode of watershed management is working with community stakeholders. By connecting with stakeholders the plan will be a collaborative approach, which will be critical to its ultimate success. Spearheaded by the Resource Conservation District of Santa Cruz County (RCD), the current and future stakeholders include but are not limited to:

- » County Public Works and County Parks
- » City of Watsonville Parks and Recreation
- » Private Land Owners and Residents
- » Irrigated Row Crops Growers
- » Orchard, Vineyard and Caneberry Growers
- » Grazing/Rangeland Operators
- » Compost Facilities
- » Recreational Stakeholders

Community members and stakeholders who attended the first public outreach event recommended the development of the 'Friends of Pinto Lake.' Friends of Pinto Lake had their first meeting in May 2013 and are working to establish a leadership role in organizing the community.

Collaboration with local recreational groups that rely on Pinto Lake such as the Rod and Gun Club, Disc Golf Club, and birding and other recreational clubs.

Management target/outcome: Reduction of sediments, nutrients and sediment-bound nutrients from runoff.

Other Benefits: Higher likelihood of projects completed with a collaborative approach and a greater understanding of potential management measures.

Costs: Principle costs include time for managing meetings and disseminating information and assisting with the formation of the volunteer group.

2. Watershed Studies

The Pinto Lake project succeeded in confirming that high nutrient levels in Pinto Lake were driving toxic cyanobacterial blooms and that the watershed and the lake sediments are both significant sources of nutrients. Additional study is needed to characterize and monitor the fate and transport of nutrients and sediments in the Pinto Lake watershed. This study would include nutrient and sediment monitoring of the Pinto Lake tributaries above and below specific land covers and uses. An additional element would be the installation of some of the recommended structural management measures at specific locations in the watershed with monitoring of the surface flow above and below the installation and along the flow path. This approach will allow for precise accounting of sediment and nutrient loads from all the Pinto Lake tributaries and how each sub-watershed (and associated land use/ type of land cover) contributes to the overall sediment loadings. It will also provide data on the efficacy of the implemented measures at reducing the nutrients and sediments in Pinto Lake. The results will point to further locations and scale for implementation of similar measures in the watershed and give a better sense of how to further prioritize MM/MP efforts.

Restoration of degraded wetlands and riparian areas has been show to be beneficial for nutrient uptake and sediment capture. An inventory and study of condition of existing Pinto Lake watershed wetland and riparian resources and measures needed to restore them is recommended.

Finally, additional information on contributions from septic systems if needed to accurately determine the scale and scope of management practices for septic based nutrients.

This information is crucial for designing the most functional and appropriate MM/MPs for successful management of the toxic CHABs plaguing Pinto Lake.

Management target/outcome: Precise quantitative understanding of nutrient and sediment loads associated with discrete and specific land uses and land cover categories. This will provide a better understanding of the fate of nutrients and sediments moving through the existing watershed and through the proposed pilot-scale structural reduction measures. Reduction of nutrients and sediments associated with pilot-scale structural reduction practices.

Other Benefits: More complete accounting of the fate and transport of nutrients and sediment through the watershed, to guide effective, efficient and properly scaled MM/MP and recommendations for private and public land.

Costs: Principle costs include the construction of structural MM/MPs within the riparian areas, water and sediment monitoring in the watershed and specifically above, along and below the structural MM/MPs.

3. In-Lake Treatments

The lake-based approaches will need to be multi-pronged and adaptive to changing conditions. The main potential treatments/approaches include alum treatment to control benthic phosphorus flux, carp removal for reduction of phosphorus from bioturbation, implementation of floating island technology for in-lake nutrient removal and experimental plots for pilot study investigation of other treatment options .

Non-Structural Practices

Carp Removal

Fish removal has been found to be very effective for reducing P and for decreasing blooms in review of treatments (Sondergaard et al. 2007). Besides inherent improvements from the removal of benthivorous fish, fish removal also enhances alum treatment efficacy. Carp removal program, sponsored by the City of Watsonville has already begun at Pinto Lake through incentivized fishing and could be increased through winter gill-netting/seining

Management target/outcome: Reduction of loss of phosphorus and ammonium from the sediments.

Other Benefits: Can be implemented alone or to enhance other treatment modalities.

Costs: Principle costs include reimbursement of fisherman and disposal of carp biomass. For enhanced removal, increased efforts could include gill-netting or seining to remove additional fish.

Structural Practices

Alum Treatment of Lake Sediments

Alum treatment of lake sediments has been shown to be highly effective trapping of an estimated 50–80% reduction of internal P loading for a median 5-years and can also help slow migration of cyanobacteria from the sediments (Welch & Schreive 1994, Kennedy and Cooke 2007). The efficacy of this treatment involves several caveats including reduction of relevant external loading (Hullebusch et al. 2007), removal/reduction of bioturbation of sediments and tracking efficacy through regular sediment phosphorus analyses. The removal of benthivorus carp would be the major contributor to the success of alum treatment (Sondergaard et al. 2007). The load of alum applied depends on P but also on the properties of the sediments (Rydin and Welch 1998). Fractionating P into mobile and bound forms in the sediments is important for tracking alum treatment efficacy (Reitzel et al. 2005). Potential negative effects on aquatic life should be considered and dosing must be measured so as to avoid toxicity (Gensemer and Playle 1999)

Management target/outcome: Estimated 50–80% potential reduction of internally-loaded phosphorus from the sediments for a 3–10 year period.

Other Benefits: Alum treatment has shown additional benefit of reducing/slowing migration of cyanobacteria from the sediments to the water column

Costs: Principle costs include initial application (which requires further speciation of the phosphorus content and lake sediment characterization by the contractor to estimate alum load required) and monitoring and maintenance to continue efficacy. Other significant costs would be the simultaneous or previous reduction of watershed-originating phosphorus and removal of benthivorus carp that would otherwise render the alum treatment ineffective.

Floating Treatment Wetland Technology

This technology, referred to as FTW, consists of a floating mat or mesh, onto which plants are established. The mat or mesh is porous enough to allow the roots of the plants to penetrate into the water column below, permitting the plants to be grown hydroponically, sequestering the nutrients they need for growth such as phosphorous and/or nitrogen from the water itself. The resulting competition for nutrients reduces the growth of non-desirable species such as algae. Floating islands also block sunlight from penetrating into the water leading to a further reduction in the growth rates of algae.

The extensive root mass which develops below the mat provides an excellent refuge for aquatic life (such as small fish), as it simultaneously offers both food (in the form of invertebrates such as insect larvae) and cover. The root mass and its associated biofilm also assist in tying up and removing tiny suspended particles in the water column, enhancing the water clarity of the pond. The plant material can even be harvested from the islands as an effective means of mining either nutrients or contaminants from aquatic ecosystems (FTW description by C&M Aquatic Management Group Ltd).

Management target/outcome: Reduction of sediments and nutrients through bioaccumulation.

Other Benefits: Can also increase dissolved oxygen, decrease water temperature around the installations and provide habitat for aquatic species.

Costs: Principle costs include installation, some monitoring and maintenance to ensure continued function over time.

Dredging

Dredging of sediments as a way of controlling internal loading has been considered. While such a technique is technically feasible, the practical and fiscal aspects of such an approach are significant. Sediment DDT levels would need to be assessed to determine suitability for disposal. Disposal of dredge materials at a landfill would require drying the sediments to less than 50% moisture. This would require staging large volumes of sulfide-rich dredge material (with associated air quality issues) on appropriate nearby land. Local landfill disposal costs range from $25- $60/ ton. Even if the materials can be disposed of as "clean fill" at $25/ton, disposal costs would exceed $2.4M for the removal of the top foot of sediment. Total cradle-to- grave project costs would likely exceed $3.5M with no guarantee that remaining sediments would not release phosphorous and perpetuate the cyanobacteria blooms..

4. Watershed Treatments

Like the lake-based approaches, the watershed based treatments will also be multi-pronged and adaptive to changing conditions. The practices include options for various land use types. Some are simple management practices that can be installed by homeowners, while others are at a larger scale, requiring collaboration between local government, agricultural operators, and small business. Being able to install several demonstration projects (that include monitoring) would be beneficial in determining the efficacy of different practices under the conditions that exist in the Pinto Lake Watershed.

Incentive Programs

Incentive programs include rebates or incentives to landowners for implementing specific management practices/measure. Some countywide programs already exist but none specific to Pinto Lake. Recommendations include developing a rebate program for both domestic and agriculture land uses. Additionally, a long-term goal should be to develop or implement a Performance Based Incentive Program for agricultural, public, and commercial land uses.

Management target/outcome: Reduction of watershed based nutrients and sediments.

Other Benefits: Performance Based Incentives are paid out based on actual measured reduction in pollutants providing a greater probability of success in reducing CHABs.

Costs: Principle costs include installation, some monitoring and maintenance to ensure continued function over time.

Domestic Non-Structural Practices

Septic Tank Maintenance:

Although the contribution of subsurface nutrient flow into the lake is poorly understood, septic tank maintenance may have benefits to the lake. Currently 13% of the septic systems in the watershed have no record of being pumped in the last 20 years. Inadequate maintenance can lead to surface failure and overland flow of untreated sewage to the ditches and eventually the lake. Illicit grey water discharge to the ground surface can also contribute nutrient loading to the lake. In the meantime, property owners should be encouraged to upgrade their septic systems to handle the grey water, install a properly designed and permitted grey water sump, or do their laundry at a laundromat when soils are saturated and the septic system is not accepting effluent. We recommend an educational campaign focusing on proper septic maintenance and alternative mechanisms for managing grey water and how to identify septic problems. Public outreach on this subject could include informative door hangers. If findings show a significant subsurface contribution of nutrients from otherwise properly functioning septic systems, further consideration should be given to extending sewers to the area. Comments made by residents at the April 2013 workshop suggest that extending sewer services on Amesti Road (where most of the septic system in the watershed are located) may provide residents with a fiscally and aesthetically viable alternative to upgrading septic systems and installing graywater systems. Homeowners described problems with chronically saturated leachfields and obvious greywater flows (from disconnected washing machines) leading to local drainage ditches. There were concerns raised about public health, when odors associated with septic wastes were common throughout the area during the winter, spring and early summer months. They also cited the high cost ($>20K) of installing the currently required onsite waste treatment technologies and the fact that these technologies would have a finite life and need to be replaced with similar, if not more advanced, systems. By comparison, the estimated (2013) cost of installing a sanitary sewer is about $1.5M. Assuming a sewer extension serving 100 homes, the per-home cost would be about $20K for main and lateral hookup. These factors suggest that sewering could represent a more financially and aesthetically attractive option for residents than continuing to make septic systems work in this challenging environment.

Management target/outcome: Reduction of nitrate, phosphate and ammonium from subsurface flow and system failures.

Other Benefits: Community involvement, participation and education. Health and safety benefits from potential reductions of septic-associated bacteria within neighborhoods. Reduction of soluble nutrients entering Pinto Lake watershed will help reduce the overall trophic status of the lake.

Costs: Principle costs include staff time for outreach and public education components, some of which could be defrayed by creation of the "Friends of Pinto Lake" group to manage outreach activities. There would be additional cost for monitoring and evaluation. Extension of the sewer line on Amesti Road is estimated at $1.5M

Vehicle Washing and Grey Water Management

While seemingly minimal, the effect of vehicle washing and grey water management can have significant impacts on the nutrient load to watershed from suburban development. Recommendations to control these loads include designating an area for community or onsite vehicle washing and potentially subsidizing septic pumping for those who forgo pumping grey water to avoid septic overfill. In addition, a solution may be to have a community "Car Wash Day" in a designated area that limits grey water runoff or provide one time vouchers to local car wash facilities as an educational tool about the effects of car wash runoff on the lake. Other option includes a grey water workshop or site visits to determine if a properly designed grey water system could be installed or if connection to a treatment system is preferred.

Management target/outcome: Reduction of phosphate surface and subsurface flow.

Other Benefits: Community involvement, participation and education

Costs: Principle costs include staff time for outreach and public education components, some of which could be defrayed by creation of the "Friends of Pinto Lake." Cost-share for car wash vouchers.

Landscape Maintenance and Stormwater Management

While its effects are unknown, household nutrients from landscape care are potential sources of nutrients transported through stormwater runoff. We recommend providing information to landowners on proper use of nutrient and pest landscape management along with best management practices for domestic stormwater. Distribution of the RCD publication "Slow it, Spread it, Sink it! contains user friends information for homeowners on both structural and non-structural practices for managing stormwater around homes and small business.

Management target/outcome: Reduction of nitrate, phosphate and ammonium subsurface flow from septic systems and domestic stormwater.

Other Benefits: Community involvement, participation and education.

Costs: Principle costs include staff time for outreach and public education components, some of which could be defrayed by creation of the "Friends of Pinto Lake" group to manage outreach activities.

Additional cost could include rebate funds for landowners who reduce stormwater runoff using various MMs/MPs. Rebates could pay for practices such as rain catchment, downspout disconnects, rain gardens and swales.

Street Cleaning

The establishment of a regular street cleaning of the road network within the watershed is another viable possibility for reducing the loading and rapid transit of nutrients and sediments. As a source control method, regular street sweeping is a recommended MMs/MPs currently being implemented in other communities in the Monterey Bay area.

Management target/outcome: Reduction of surface flow of nutrients, sediments and sediment-bound nutrients leaving adjacent properties.

Other Benefits: Removal of metal particles and other hazardous waste products left by passing vehicles that can be extremely harmful to fish and other wildlife. Reduction of localized flooding from clogged storm drains.

Costs: Costs include funding a pilot scale sweeping project to demonstrate efficacy and if found to be beneficial, ongoing cost of street cleaning.

Agricultural Non-Structural Practices

Irrigation and Nutrient Management

Irrigation and nutrient management improvements could reduce agricultural runoff containing sediments and nutrients to Pinto Lake. Further efforts to target growers in the Pinto Lake Watershed to take advantage of the Irrigation and Nutrient Management Program, the MANA Program and NRCS Farm Bill Programs are recommended. These programs provide technical assistance and cost-share funding to growers. The RCD, Natural Resources Conservation Service (NRCS) and regional agriculture system specialists could spearhead efforts to involve the agricultural sources/stakeholders as participants in creating plans for managing irrigation and fertility on properties in the Pinto Lake watershed. This first requires engagement with the stakeholders for collective decision-making for goals of reducing regional sediment and nutrient inputs. Potential solutions could include making agriculture research, recommendations and workshops more available for agriculture operators in the watershed and the dissemination of information and guides for nutrient and sediment management.

Management target/outcome: Reduction of surface and subsurface nutrients.

Other Benefits: Reduced erosion from irrigation runoff and cost saving incentives to growers.

Costs: Principle costs include equipment and time for new management plan with some monitoring over time. Also cost of consulting services and evaluations.

Domestic Structural Practices

Potential domestic pollutants contributing to CHAB production include sediments, fertilizer nutrients from landscape maintenance, septic and grey water discharge containing both phosphorus and nitrogen. MPs for controlling runoff from domestic/urban sources can employ similar technology as implemented for controlling urban stormwater. Structural MM/MPs or Low Impact Development may be of higher effectiveness when designed and used in conjunction with one another. The following BMPs have been implemented throughout communities within the Monterey Bay and include physical treatment systems.

Sediment Detention Ponds

Sediment detention ponds (design basins) can reduce particulate loads of up to 90%, though they are ineffective at reducing dissolved nutrients to a significant degree. Detention ponds can also lower peak discharge rates, protecting stream banks and drainages from erosion. Ponds must be well-designed to retain fine silt particles which are the largest source of particulate nutrients. Silt will only settle out in the ponds when the particles have enough time to settle out.

Design basin area is recommended to be at a ratio of greater than or equal to 1% of watershed area, or at a ratio of pond volume to mean storm runoff volume (VB/VR) of 2.5. Ponds must not be so deep that they thermally stratify, or phosphorus cycling may occur. Basins must be monitored and maintained to ensure that they do not aggrade (fill in) to a degree which impairs their function.

Management target/outcome: Reduction of sediments from surface flow up to 90%.

Other Benefits: Also potential for lowering peak tributary discharge rates and protect stream banks and drainage perimeters from erosion.

Costs: Principle costs include construction with some monitoring and maintenance to ensure continued function over time.

Constructed Wetlands

Constructed wetlands are actively managed systems which are used to detain water, store particulate materials, and reduce dissolved nutrients . Constructed wetlands are very effective for phosphorus removal, also being highly effective at nitrate removal. Constructed wetlands generally are not as complex in design as natural wetlands, but are intended to perform similar ecological function. Most successful constructed wetlands are in series with detention ponds which can reduce scouring energy and particulate matter in incoming water. Constructed wetlands require year-round water to operate properly (to a depth of 0.5-1.0m), and may be constructed with different zones, including a deep pool, high and low marsh zones. Wetland vegetation such as cattails (*Typha spp.*) and bulrush (*Scirpus spp.* and *Schoenoplectus spp.*) is important for supplying organic carbon required by microorganisms to uptake and form reservoirs of nutrients. Wetlands perform long-term storage of nutrients by sedimentation and accumulation of resistant and partially degraded organic matter (peat).

Management target/outcome: Reduction of sediments and dissolved phosphate and nitrate.

Other Benefits: Also potential for lowering peak tributary discharge rates and protect stream banks and drainage perimeters from erosion. Inclusion of riparian and wetland plants will also help reduce the water temperature reaching the lake.

Costs: Principle costs include construction with monitoring and maintenance to ensure continued function over time. Cost vary significantly depending on size, location, permitting, and existing land use.

Denitrifying Bioreactors (Biofiltration)

These are constructed wetlands which are defined by subsurface flow through a bioreactor. Bioreactors may be constructed of different materials, including woodchips, strawbales , and other carbonaceous materials with the goal of decreasing dissolved nutrient concentrations. Carbon is metabolized by microorganisms which also use and decrease availability of nutrients dissolved in the inlet water as it travels through the bioreactor. These microorganisms require an anaerobic (oxygen-free) environment which is furnished by year-round saturation of the soils. Bioreactors are most effective at reducing nitrates, but can also be highly effective at reducing dissolved phosphorus as well.

Management target/outcome: Reduction of soluble nitrate and potentially phosphate

Other Benefits: Potentially smaller scale installation in comparison with other constructed wetlands.

Costs: Principle costs include construction with monitoring and maintenance to ensure continued function over time.

Natural Wetlands and/or Riparian Corridor Restoration

Restoring natural wetland function, through replanting of native species from local native genetic materials (i.e. seeds, cuttings, rootstock) should prove effective in decreasing particulate and dissolved nutrients. Wetlands have been found to be most effective at reducing nitrogen compounds, but also may be important sinks for phosphorus as well. This process occurs through natural microbial reactions, settling of particulate matter, uptake into plant matter, and soil adsorption.

Degraded wetlands, those containing a significant portion of non-native species, being hydrologically altered (e.g. through channel alteration) may have improved function when restored to a more natural hydrological regime and vegetation types. Restoring natural wetlands and riparian corridors has a dual benefit of remediating degraded habitat and increasing habitat connectivity while also increasing ecological function of that wetland to process dissolved and particulate nutrient inputs from the watershed.

Initial implementation of structural reduction measures in areas of Pinto Lake County Park where there are pre-existing riparian areas in the major tributaries for the lake is recommended. These riparian areas could be improved to reduce flow velocity, increase sedimentation and reduce nutrient loads. To track the efficacy of the nutrient and sediment removal, sampling should take place above and below the installments.

Management target/outcome: Reduction of nitrate and phosphate, sediments and sediment-bound nutrients.

Other Benefits: Potential installation within existing lake tributary riparian areas and some existing onsite wetlands can serve as a guide or model for the other tributaries. These can be implemented downstream from multiple properties to provide reductions for multiple sources.

Costs: Principle costs include replanting with native plants, monitoring and maintenance to ensure plant survival and some construction to accommodate plantings.

Agricultural Structural Practices

Potential agriculture pollutants contributing to CHAB production include sediments, fertilizer nutrients and nutrients from plant and animal waste. A variety of proven agricultural structural approaches for reducing nutrient and sediment discharges have been implemented throughout the region and are recommended for the Pinto Lake area.

Water and Sediment Control Basins

These basins serve to slow runoff flow, settle sediments and other solids from the water column and potentially reduce nutrients loads. They can be implemented both on the scale of individual properties as well as regional or watershed basis to collect runoff from several properties. The efficacy of basins will depend on many specifics of the sediment type, slope, discharge rates and particular land use among other factors and have to be scaled appropriately. Because Pinto Lake is an environmentally sensitive waterbody, basins should be designed with an efficiency of 80 percent or greater.

Management target/outcome: Reduction of sediments from surface flow up to 90%.

Other Benefits: Also potential for lowering peak tributary discharge rates and protect stream banks and drainage perimeters from erosion.

Costs: Principle costs include construction with some monitoring and maintenance to ensure continued function over time. Costs incurred by private landowners could be subsidized by Farm Bill or other cost-share grant funded programs.

Vegetated Waterways

These practices allow for the primary productivity of emergent vegetation, algae and biofilms to convert nutrients and carbon in the effluent into biomass. Nutrient removal efficacy depends on transit time, type of plants, loading and flow rates among other factors.

Management target/outcome: Reduction of dissolved nutrients in runoff.

Other Benefits: Potential increase in riparian habitat. Sufficient vegetation can also provide shading for surface flow, and help decrease the water temperature of surface flow thereby increasing dissolved oxygen.

Costs: Principle costs include planting and some monitoring and maintenance to ensure continued function over time. Costs incurred by private landowners could be subsidized by Farm Bill or other cost-share grant funded programs.

Vegetative Treatment Systems (VTS)

This practice includes bands of planted or indigenous vegetation situated downslope of cropland or animal production areas to provide localized erosion protection and contaminant reduction. Planted or indigenous vegetation includes pasture, grassed waterways, or cropland that is used to treat runoff through settling, filtration, adsorption, and infiltration. The VTS are combinations of specifically designed vegetated areas, retention basins and terraces to redirect and slow surface flow, increase infiltration and sediment settling and reduce nutrient loads.

There are several main guidelines for implementing VTS which should be noted (Murphy and Harner 2001):

Grass-based filters have specific slope and length requirements to ensure the transit time is sufficient for flow speed reduction and sediment settling. The total area has to be scaled with the particular estimated nutrient loads in mind.

Infiltration basins are a containment type of system with a berm place around the vegetated area. The basin must be sized to ensure infiltration of runoff within 30 to 72 hours.

Terraces are similar to infiltration basins for slowing runoff on sloped areas. Overflow terraces move runoff from one terrace to an adjacent terrace at a lower elevation by cascading of runoff over the terrace top or by plastic tile drains. Serpentine terraces move runoff back and forth across the face of a slope.

Management target/outcome: Reduction of some nutrients in runoff and sediment.

Other Benefits: Improved infiltration from vegetation will decrease runoff. Establishment of vegetation will improve habitat. Protection from slope erosion and there are several versions of VTS to meet the needs of varying topography and sediment/nutrient reduction targets.

Costs: Principle costs include planting and some monitoring and maintenance to ensure continued function over time. Costs incurred by private landowners could be subsidized by Farm Bill or other cost-share grant funded programs.

Critical Area Planting, Filter Strips, Hedgerows and Vegetative Buffer Strips

These are akin to the above described vegetated systems to help capture sediment and nutrients moving from adjoining cropland before they reach the stream or lake. The nutrients are taken up by vegetation (including grass, trees, or shrubs).

Management target/outcome: Reduction of sediments and some nutrients in runoff.

Other Benefits: Protection from slope erosion

Costs: Principle costs include planting and some monitoring and maintenance to ensure continued function over time. Costs are born by private land owners alone or in cooperation with others in the subwatershed.

Pre-Dam Treatment Wetland

Similar to the VTS with a retention basin in conjunction with a vegetated filter or waterway, the pre-dam treatment wetland is a combined approach with both a vegetated area followed by an accumulation area. This model aims to reduce nutrient content of the runoff in the wetland followed by sediment settling from the water column and increased infiltration of runoff in the pre-dam basin. A further modification of the dam can include a surface level dam or a subsurface dam. A sub-surface dam retains denser, cold-water flow from winter storm runoff as it flows into the basin and sinks below the surface water. The surface-level dam would collect the most runoff, but has the detriment of collecting large amounts of sediments rapidly. The subsurface dam, while not collecting as much water, is beneficial in collecting less sediment and retaining the cold winter runoff preferentially. Furthermore, the pre-dam treatment wetland model is constructed to receive all flows for a watershed or sub-watershed and thus is a collective approach to addressing CHABs.

Management target/outcome: Reduction of sediments, nutrients and sediment-bound nutrients from runoff.

Other Benefits: Can be installed to accommodate several properties within a subwatershed.

Costs: Principle costs include construction, monitoring and maintenance and removal of built-up sediments in the basin to ensure continued function.

Table 7: Prioritized Management Measures/Practices

Action Timing	Category	Measure/Practice	Purpose
Immediate	Lake Treatment	Carp Removal.	Reduction of Phosphorus released into Lake which drives the production of CHABs.
Immediate	Stakeholder Engagement	Formation of landowner group "Friends of Pinto Lake."	Reduction in watershed based pollutants that contribute to CHABs from private and public lands within the Pinto Lake Watershed. Outreach and education on a neighborhood basis.
Immediate	Watershed Treatments	Irrigation and Nutrient Management (Drip irrigation) on 1.5 acres of Ag land that drains to Pinto Creek.	Reduces water use and nutrient runoff to Pinto Lake. Can also reduce cost of operations. This practice had been recommended to the landowner.
Immediate	Watershed Treatments	Irrigation and Nutrient Management (Water Management) on less than one acre of Ag land that drains to Pinto Creek.	Reduces water use and nutrient runoff to Pinto Lake. Can also reduce cost of operations. This practice had been recommended to the landowner.
Immediate	Watershed Treatments	Hedgerows (300 feet).	Reduction of sediments and some nutrients in runoff. Dust control. Can also attract beneficial insects and be used to reduce chemical controls. This practice had been recommended to the landowner.
Immediate	Watershed Treatments	Hedgerows (300 feet).	Reduction of sediments and some nutrients in runoff. Dust control. Can also attract beneficial insects and be used to reduce chemical controls. This practice had been recommended to the landowner.
Short-term	In-Lake Treatment	Alum Treatment and Floating Island (Pilot Study).	Estimated 50–80% potential reduction of internally-loaded phosphorus from the sediments for a 3–10 year period. Alum treatment has shown additional benefit of reducing/slowing migration of cyanobacteria from the sediments to the water column
Short-term	Watershed Treatments	Develop incentive programs with the initial goal of installing 2-6 sediment and nutrient reduction projects in the watershed. One program would target agriculture and the other domestic uses.	Reduction on watershed based contributions of CHAB forming pollutants. This should be done in conjunction with the in-lake alum treatment study. Reduction of watershed based pollutants to the lake will be critical to the success of the alum treatment.
Short-term	Watershed Studies	Design and implement a fate and transport study that will identify specific landuses or areas in the watershed that are contributing the greatest amount of nutrients to the lake.	Greater reduction in CHAB pollutants from watershed based sources by identifying the largest contributors. This will help drive the specific watershed treatments practices and outreach.
Short-term	Watershed Studies	Inventory and study the condition of existing Pinto Lake watershed wetland and riparian resources and measures needed to restore them.	To identify the role existing wetlands and riparian areas are playing in nutrient contributions to Pinto Lake and determine if restoration efforts are necessary.
Short-term	Watershed Studies	Study of functioning of septic systems in the Pinto Lake watershed during winter months with recommendations for appropriate action to address failing/undersized systems.	To reduce nitrate and phosphorus input to Pinto Lake from leaking septic systems by identifying the scale in which this source contributes to the total lake loading.
Short-term	Stakeholder Engagement	Install interpretive signs at both City and County Pinto Lake Parks.	Reduction in watershed based pollutants that contribute to CHABs from private and public lands within the Pinto Lake Watershed. Outreach and education on a neighborhood basis.
Long-term	In-Lake Treatment	Alum or Floating Island or both depending on results of the pilot study.	Estimated 50–80% potential reduction of internally-loaded phosphorus from the sediments for a 3–10 year period. Alum treatment has shown additional benefit of reducing/slowing migration of cyanobacteria from the sediments to the water column.
Long-term	Watershed Treatments	Agriculture Performance Incentive Programs.	Reduction in watershed based pollutants that contribute to CHABs from agricultural lands within the Pinto Lake Watershed. To create a long-term self-sustaining incentive for water quality improvements.
Long-term	Watershed Treatments	Sewer Line Extensions.	Reduction of nutrients from ground water or surface flow. If septic tank study and fate and transport study determines septics to have a significant nutrient contribution to Pinto Lake, investigate sewer lines extensions.
Long-term	Watershed Treatments	Street Sweeping.	Runoff from streets can contain significant levels of sediments and nutrients. Street sweeping is a proven method of reducing such loadings.

Public outreach event discussing the Pinto Lake Study

Implementation Strategy

The results of the project showed that lake sediments, referred to as internal loading, are the dominant sources of nutrients for cyanobacterial growth, and therefore should be a high priority for management measures. Watershed inputs however, cannot be ignored and must also be addressed due to the fact that management of the lake sediments alone will not be enough for recovery of the lake.

This implementation strategy includes the four key components of the recommended management measures; stakeholder involvement, additional studies and pilot projects, lake treatments, and watershed treatments. It is important to note that the successful implementation of this strategy is dependent on many factors including available funding, landowner willingness to participate, efficacy of management practices and others.

Please refer to Tables 7-8 for more details on the implementation sequence and potential barriers.

Stakeholder Engagement

Coordinating with stakeholders will be key to the long-term success of this strategy and in developing an effective and implementable TMDL for the Pinto Lake Watershed. Working with stakeholders is a high priority component of this strategy to reduce cynobacteria growth in the lake and will be incorporated into all phases of the various recommendations.

In the first year, the RCD will work with the local landowners in Pinto Lake to start the "Friends of Pinto Lake" landowners group. This group will be made of landowners within the watershed including agricultural, residential, and commercial landowners. This group will disseminate information about and collaborate on the various management measures and practices recommend. There will be two subgroups. One representing domestic uses and the other agricultural interests.

The intent of the domestic strategy is source reduction through incentivized septic maintenance, gray water and stormwater management, landscape maintenance and street sweeping programs. While this segment of the watershed population is lower priority due to the estimated lesser impacts to the lake, it is low cost to implement and provides overall community involvement and allows all residents to partake in rehabilitating the Lake.

Surveys conducted at the final Pinto Lake public workshop identified cost and lack of available information as the top two barriers for implementing management practices at residential properties.

The agricultural strategy includes collaboration with growers in the watershed to discuss the Pinto Lake study findings, work to get additional recommendations on management practices and encourage potential implementers.

As new study data becomes available, the various stakeholders will come together to update the plan and management measures accordingly and collectively seek funding for the implementation of practices where applicable.

Additionally in the first year, the RCD and "Friends of Pinto Lake" will work with Santa Cruz County Parks to install a kiosk or interpretive signage at Pinto Lake Park discussing what landowners can do to protect the lake.

Watershed Studies

In the first year, a scope of work should be drafted that outlines the specific studies to be conducted that will be used to account for the various inputs into Pinto Lake. This will allow targeted, instead of general, watershed treatments. In doing so, efforts can be spent working directly with specific landowners to address concerns that might be identified on or near their properties. Recommended studies include 1) Fate and Transport of Nutrients, 2) Riparian and Wetland Inventory, and 3) Septic Tank Study.

Lake Treatments

Lake treatments represent the main source of loading and are therefore the highest priority of the direct treatments to reduce cyanobacterial growth.

Carp Removal

The removal of benthivorous/bioturbating carp is set to being in April 2013 and this MM/MP does not require sequential implementation with other in-lake treatments, but will necessary for the alum treatment to be effective. Ongoing monitoring of total mass of removed fish and associated lake water quality is recommended.

Alum Treatment

Pilot study of alum treatment of lake sediments to immobilize soluble reactive phosphorus and help flocculate carbon and phytoplankton out the water column. Prior to a full lake-scale application we recommend beginning with a series of pilot-scale experiments to determine feasibility of this MM. Experiments with this treatment have successfully been implemented in other systems and have proven to be effective for determining the potential success of lake-wide alum treatment without the cost associated with lake-wide initial implementation. Smaller scale pilot implementation allows for eventual lake-wide implementation (should the pilot study be efficacious) to be timed to occur along side watershed-based reductions of nutrients and sediments.

Floating Island Technology

Pilot study of the floating island technology to evaluate efficacy of treatment in reducing nutrients and suspended sediments from the system.

Watershed Treatments

The first priority is to develop incentives for the voluntary implementation of watershed based management measures and practices.

Specific watershed on the ground treatments are broken down into recommendations for both domestic and agricultural properties. There are low and medium priority domestic MM/MPs and medium to high priority MM/MPs for agriculture (see table 7). This difference is reflective of both type of land use and overall land cover.

First year recommendations include identifying potential projects and referring landowners to existing available resources through Farm Bill, RCD and other local programs.

Domestic Non-Structural Practices

These recommendations include septic tank maintenance, vehicle washing, grey water and stormwater management and landscape maintenance. The first year volunteers through Friends of Pinto Lake will help disseminate information on these practices and their importance to Pinto Lake. Referrals will be made to existing programs through the RCD and Ecology Action, a local non-profit. If deemed a higher priority through study results, potential funding sources to expand outreach, education and potential rebates should be explored.

Agricultural Non-Structural Practices

These practices include irrigation and nutrient management. In the first year, growers should be referred to the various existing programs that provide services and evaluations at no charge. Potential funding should be pursued if study results show a high benefit for this practice at specific locations.

Domestic Structural Practices

These practices include sediment detention ponds, constructed wetlands, denitrifying bioreactors (Biofiltration), natural wetlands and riparian corridor restoration. These practices are considered a medium priority because they potentially treat greater volumes of pollutants than the non-structural practices. Recommendations for the first year are to locate potential pilot project areas and work with the landowners to implement one to two projects that can used to further understand their benefits to Pinto Lake. The results will drive further efforts.

Agricultural Structural Practices

These practices include water and sediment control basins, vegetated waterways, vegetative treatment systems (VTS), critical area planting filter strips and vegetative buffer strips, and pre-dam treatment wetlands. As with the non-structural agricultural practices growers should be referred to a various programs that provide services and evaluations at no charge. Farm Bill programs provide cost-share incentives to growers and practices and some of these practices have already been installed with assistance through those programs. Additional funding should be pursued if study results show a high benefit for these practices at specific locations.

Table 8: Implementation Strategy and Sequence

MM/MPs	Pollutant Targeted	Benefit	Barriers to Implementation
Stakeholder Engagement			
Friends of Pinto Lake for domestic and agricultural land users.	All	Community ownership of solving Pinto Lake problems can lead to more voluntary participation in implementing MM/MPs.	Recruiting volunteers and cost for assistance with initial organization of meetings and materials for the group. Fear of working with government organizations, time, and cost for attending meetings, planning, facilitating, etc.
Interpretive signs and literature kiosk at park	All	Community ownership of solving Pinto Lake problems can lead to more voluntary participation in implementing MM/MPs.	Cost, vandalism, and maintenance.
Watershed Studies			
Fate and Transport Study, Wetland and Riparian Inventory and Septic study.	All	The ability to reduce CHAB forming pollutants through identifying specific land use contributions and customizing management practices for those locations.	Cost and willing landowners for monitoring locations.
Lake Treatments			
Alum Treatment of Lake Sediments	Internally loaded phosphorus.	Estimated 50–80% potential reduction of internally loaded phosphorus from the sediments for a 3–10 year period.	High cost. Recommend pilot study to ensure efficacy.
Carp Removal	Internally loaded phosphorus.	Reduction in the release of internally loaded phosphorus.	In Progress
Floating Treatment Wetland Technology	Internally loaded phosphorus and nitrogen.	Reduction of sediments and nutrients through bioaccumulation. Can also increase dissolved oxygen, decrease water temperature around the installations and provide habitat for aquatic species.	High cost, recommend pilot study to ensure efficacy
Watershed Treatments			
Incentive Programs	Nutrients and Sediments	Reduction in external nutrients and sediments to the lake.	Cost, willing land owners, established measurement tools.
Septic Tank Maintenance	Nitrate, phosphate and ammonium from subsurface flow.	Reduction in external nutrients to the lake.	Cost, funding for County staff time, Need for further eduction of landowners.
Vehicle Washing and Grey Water Management	Phosphate from subsurface and surface flow.	Reduction in external sources of nutrients to the lake.	Need for further eduction of landowners, cost of permitted grey water systems, and cost of car washing and/ laundromat vouchers.
Landscape Maintenance and Stormwater Management	Nutrients from subsurface and surface flow.	Reduction in external sources of nutrients to the lake.	Need for further eduction of landowners, cost and time.
Street Sweeping	Sediments and sediment bound nutrients.	Reduction in external sources of nutrients to the lake.	Cost, approval of new locations.

Priority	Year 1	Year 2	Year 3	Year 4	Year 5+
High	This group was initiated in May 2013.The RCD will work Friends of Pinto Lake Neighborhood group, and assist with “door hangers” or other outreach materials.	Annual update on group actions to the partners.	Annual update on group actions to the partners.	Annual update on group actions to the partners.	Annual update on group actions to the partners.
Medium	Discuss interpretive signs and literature kiosk with County Parks, install if applicable and create literature.	Annual maintenance and bi-monthly literature check by volunteers.	Annual maintenance and bi-monthly literature check by volunteers.	Annual maintenance and bi-monthly literature check by volunteers.	Annual maintenance and bi-monthly literature check by volunteers.
High	Identify scope of work and seek funding.	Conduct research and monitoring.	Conduct research and monitoring.	Utilize results to inform and update strategy and identify specific high priority management measures.	
High	Identify scope of work and seek funding.	Implement pilot projects.	Monitor projects.	Monitor projects.	Seek funding for full treatment if results show this to be an effective strategy.
High	Implementation scheduled for April 2013.	Monitor.	Monitor.	Monitor.	Monitor.
High	Identify scope of work and seek funding.	Implement pilot projects.	Monitor projects.	Monitor projects.	Seek funding for full treatment if results show this to be an effective strategy
Med/High	Seek funding to develop program and incentives.	Identify landowners to participate/implement	Identify landowners to participate/implement	Identify landowners to participate/implement	Identify landowners to participate/implement
Low	Seek funding for landowner outreach and workshops and onsite inspections.	Conduct landowner outreach and workshops. Conduct landowner survey or onsite inspections upon request.	Conduct landowner outreach and workshops. Conduct landowner survey or onsite inspections upon request.	Conduct landowner outreach and workshops. Conduct landowner survey or onsite inspections upon request.	Conduct landowner outreach and workshops. Conduct landowner survey or onsite inspections upon request.
Low	Seek funding for vouchers and literature. Distribute literature.	Conduct surveys to determine efficacy of outreach.	Conduct surveys to determine efficacy of outreach.		
Low	Seek funding for landowner outreach and workshops and onsite evaluations.	Conduct landowner outreach and workshop, conduct landowner survey or onsite technical assistance.	Conduct landowner outreach and workshop, conduct landowner survey or onsite technical assistance.	Conduct landowner outreach and workshop, conduct landowner survey or onsite technical assistance.	Conduct landowner outreach and workshop, conduct landowner survey or onsite technical assistance.
Low		Seek funding and implement street sweeping			

MM/MPs	Pollutant Targeted	Benefit	Barriers to Implementation
Watershed Treatments Cont...			
Irrigation and Nutrient Management	Nutrients, sediments, and sediment bound nutrients.	Reduction in external sources of nutrients and sediments to the lake.	Low water cost do not provide incentives for water conservation, cost of irrigation upgrades, and access to and uncertainty of new technologies.
Sediment Detention Ponds	Sediments.	Reduction in external sediment to the lake. Can also reduce peak discharge rates which may reduce erosion in stream channels.	Cost, permits, and willing landowners.
Constructed Wetlands	Sediments and dissolved phosphate and nitrate.	Reduction in external sediment and dissolved phosphate and nitrate to the lake. Can also reduce peak discharge rates which may reduce erosion in stream channels. Riparian and wetland plants may also reduce water temperature reaching lake during warm periods.	Cost, willing landowners, and location.
Denitrifying Bioreactors (Biofiltration)	Soluble nitrate and potentially phosphate.	Reduction of soluble nitrate and potentially phosphate. Potentially smaller scale installation in comparison with other constructed wetlands.	
Natural Wetlands and Riparian Restoration	Nutrients.	Reduction of dissolved nutrients in runoff	Food safety, permits, loss of land, cost, maintenance
Water and Sediment Control Basins	Sediments from surface flow.	Reduction of sediments from surface flow up to 90%. Potential for lowering peak tributary discharge rates and protecting stream banks from erosion.	Permits, loss of land, cost, maintenance
Vegetated Waterways	Dissolved nutrients in runoff.	Reduction of dissolved nutrients. Potential increase in riparian habitat. Sufficient vegetation can also provide shading for surface flow, and help decrease the water temperature of surface flow thereby increasing dissolved oxygen.	Food safety, loss of land, cost, maintenance, and willing landowners.
Vegetative Treatment Systems (VTS)	Nutrients in runoff and sediment.	Improved infiltration from vegetation will decrease runoff. Establishment of vegetation will improve habitat. Protection from slope erosion and there are several versions of VTS to meet the needs of varying topography and sediment/nutrient reduction targets.	Food safety, loss of land, cost, maintenance, and willing landowners.
Critical Area Planting, Filter Strips, Hedgerows and Vegetative Buffer Strips	Sediments and some nutrients in runoff.	Reduction of sediments and some nutrients in runoff.	Food safety, loss of land, cost, maintenance, and willing landowners.
Pre-dam Treatment Wetland	Sediments, nutrients and sediment-bound nutrients from runoff.	Reduction of sediments, nutrients and sediment-bound nutrients from runoff. Can be installed to accommodate several properties within a subwatershed.	Food safety, loss of land, cost, maintenance, and willing landowners.

Priority	Year 1	Year 2	Year 3	Year 4	Year 5+
Med/High	Continue to provide information on existing Farm Bill, RCD, and other local grower assistance programs.	Additional implementation contingent upon incentive program funding and fate and transport study results.	Implement projects through incentive programs targeting Pinto Lake	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects
Med/High	Identify potential locations for pilot projects and seek funding for high priority locations.	Additional implementation contingent upon incentive program funding and fate and transport study results.	Implement projects through incentive programs targeting Pinto Lake	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects
Low/Medium	Implementation contingent upon study results		Identify potential locations for pilot projects and seek funding for high priority locations.	Designs, permit and install.	Monitor.
Low/Medium	Implementation contingent upon study results		Identify potential locations for pilot projects and seek funding for high priority locations.	Designs, permit and install.	Monitor.
Low/Medium	Implementation contingent upon study results		Identify potential locations for pilot projects and seek funding for high priority locations.	Designs, permit and install.	Monitor
Medium	Identify potential locations for pilot projects and refer landowners to existing assistance programs.	Additional implementation contingent upon incentive program funding and fate and transport study results.	Implement projects through incentive programs targeting Pinto Lake	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects
Medium	Identify potential locations for pilot projects and refer landowners to existing assistance programs.	Additional implementation contingent upon incentive program funding and fate and transport study results.	Implement projects through incentive programs targeting Pinto Lake	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects
Medium	Identify potential locations for pilot projects and refer landowners to existing assistance programs.	Additional implementation contingent upon incentive program funding and fate and transport study results.	Implement projects through incentive programs targeting Pinto Lake	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects
Medium	Identify potential locations for pilot projects and refer landowners to existing assistance programs.	Additional implementation contingent upon incentive program funding and fate and transport study results.	Implement projects through incentive programs targeting Pinto Lake	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects	Implement projects through incentive programs targeting Pinto Lake and monitor previous projects
Medium	Identify potential locations for pilot projects and refer landowners to existing assistance programs.	Additional implementation contingent upon incentive program funding and fate and transport study results.	Seek funding for project implementation if study results reveal this to be an effective strategy at specific locations.		

Glossary

Aerosolization: the process of converting a physical substance into the form of particles small and light enough to be carried on the air.

Ammonium: a positively charged form of nitrogen with the formula NH^{4+}. A by-product of animal and microbial metabolism, ammonium can enter a water system through surface runoff or be released from lake sediments.

Cyanobacteria: aquatic bacteria that obtain energy through sunlight via photosynthesis. Some cyanobacteria form dense accumulations on the surface of water bodies.

Cyanotoxin: naturally-occurring chemicals produced by cyanobacteria that have health or ecosystem impacts.

Epilimnion: the top-most and warmer layer of water in a temperature-stratified lake. Due to the physics of water, warmer water is less dense than cooler water. As a result of the surface layer being warmer and less dense than deeper, cooler water, the epilimnion floats above deeper layer and is resistant to mixing with deeper layer.

Eutrophic: a water body with high biological productivity as demonstrated via high dissolved nutrients and dense water column accumulations of algae and cyanobacteria.

Hepatotoxin: a toxic substance that damages the liver.

Hypereutrophic: a water body with high nutrient levels (greater than 0.1 ppm phosphorus) and a corresponding density of phytoplankton (less than 3 foot visibility).

Hypolimnion: the dense, bottom layer of water in a thermally-stratified lake.

Limnological: relating to the study and biological, chemical, physiological and geological properties of lakes.

Microcystis: a genus of freshwater cyanobacteria.

Microcystin: a hepatotoxic cyanotoxin produced by several cyanobacteria.

Nitrate: a negatively charged form of nitrogen with the formula NO^{3-}. Highly soluble and biologically active form of nitrogen, nitrate is widely applied in fertilizers.

Total phosphorus: a measure of the combined dissolved phosphate plus insoluble phosphorous in the form of precipitates or within microbes

Watershed: an area of land where surface water from rain flow converges to a single outlet, usually at the junction with another water body such as a lake, reservoir, estuary, wetland or ocean.