Attachment 1

Technical Support Document

Los Peñasquitos Lagoon Sediment/Siltation TMDL

Also known as Attachment 1, Technical Support Document to the Staff Report for the Sediment TMDL for Los Peñasquitos Lagoon

Prepared for:

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and

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Abbreviations:

BAT:	Best Available Technology
BMP:	Best Management Practice
CWA:	Clean Water Act
CFR:	Code of Federal Regulations
EFDC:	Environmental Fluids Dynamic Code
EMC:	Event Mean Concentration
USEPA:	United States Environmental Protection Agency
LA:	Load Allocation
LSPC:	Loading Simulation Program in C++
MLS:	Mass Loading Station
MOS:	Margin of Safety
MS4:	Municipal Separate Storm Sewer System
NPS:	Nonpoint Source Pollution
NPDES:	National Pollutant Discharge Elimination System
SANDAG:	San Diego Association of Governments
TBELs:	Technology Based Effluent Limitations
TMDL:	Total Maximum Daily Load
TSS:	Total Suspended Solids
TWAS:	Temporary Watershed Assessment Stations
USGS:	Unites States Geological Survey
WQOs:	Water Quality Objectives
WLA:	Wasteload Allocation
WDRs:	Waste Discharge Requirements
WQBELs:	Water Quality Based Effluent Limitations (WQBELs)

Executive Summary

The purpose of this technical report is to present the development of a Total Maximum Daily Load (TMDL) for sedimentation/siltation in Los Peñasquitos Lagoon (Lagoon). Sedimentation within the Lagoon has restricted the tidal prism, or exchange between the ocean and the Lagoon, and degraded salt marsh habitats through various processes. As required by Section 303(d) of the Clean Water Act (CWA), a TMDL was developed to address sedimentation within the Lagoon, which was originally identified as impaired for sediment on the 1996 CWA Section 303(d) List of Water Quality Limited Segments.

The purpose of a TMDL is to attain water quality objectives (WQOs) that support beneficial uses in the waterbody. A TMDL is defined as the sum of the waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background [40 CFR 130.2] such that the capacity of the waterbody to assimilate pollutant loading (i.e., the loading capacity) is not exceeded. Therefore, a TMDL represents the maximum amount of the pollutant of concern that the waterbody can receive and still attain water quality standards. Additionally, a TMDL represents a strategy for meeting WQOs by allocating quantitative limits for point and nonpoint pollution sources. Once this maximum pollutant amount has been calculated, it is then divided up and allocated among all of the contributing sources in the watershed.

Based on historical and current accounts of sediment-associated impacts to the Lagoon, the San Diego Regional Water Quality Control Board (Regional Board) placed the Lagoon on the CWA Section 303(d) List of Water Quality Limited Segments as being impaired (i.e., does not meet applicable water quality standards). Sediment water quality standards are narrative in nature and ensure that sediment accumulation or alteration does not cause a nuisance or adversely affect beneficial uses. Excessive sedimentation within the Lagoon threatens critical habitat areas and beneficial uses such as, Estuarine (EST), Marine Life Habitat (MAR), and Preservation of Biological Habitats of Special Significance (BIOL). Additional information on beneficial uses impacted by the impairment is discussed in Section 3.3.

In order to calculate a TMDL for sediment, a numeric target must be identified. A numeric target was selected based on historical conditions that met WQOs and supported the designated beneficial uses of the Lagoon. A historical analysis of available literature that describes the pattern of urbanization within the watershed and impacts to the Lagoon over time was used to identify the time period when the Lagoon met WQOs. Existing and historical land use conditions were then modeled to determine

the acceptable net annual sediment load that the Lagoon could assimilate and still meet WQOs.

Available data were used to configure, calibrate, and validate a customized modeling framework developed to support sediment TMDL development. The modeling framework consists of a watershed model (based on the Loading Simulation Program in C++, LSPC) and a receiving water model (based on the Environmental Fluids Dynamic Code, EFDC). The watershed model was used to calculate existing and historical sediment loading to the Lagoon from the Los Peñasquitos watershed, while the Lagoon receiving water model was used to simulate hydrodynamics and sediment transport characteristics for this tidally-influenced waterbody.

A source analysis was performed to identify and quantify the sources of sediment to the Lagoon. The most significant source identified was urban development and urban runoff delivered by the storm drain system to the Lagoon from the surrounding watershed. In particular, from open space areas located below storm water outfalls and from stream bank erosion/bed scouring. Additional sources include wave action, tidal exchange, and loads contributed by transportation infrastructure.

The TMDL also includes a margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and predicted water quality of the receiving water. An implicit MOS was included through the application of a number of conservative assumptions, including establishing the TMDL based on the 1993 critical wet period, and consideration of the overall predictive capability of the modeling framework that was developed for this study.

The TMDL is divided among the waste load allocation (WLA) for point sources, load allocation (LA) for nonpoint sources, and the MOS. Load reduction requirements are assigned to point sources and nonpoint sources. Identified point sources include the municipalities that are included in the San Diego County Phase I municipal separate storm sewer system (MS4s) permit, MS4 Phase II permittees, and the California Department of Transportation (Caltrans) storm water permit. Sediment loading to the Lagoon was estimated based on modeling of watershed runoff, streambank erosion, and sediment transport. A total WLA was assigned to the respective municipalities regulated under the Phase I MS4 permit (San Diego County, the City of San Diego, the City of Del Mar and the City of Poway), Phase II MS4 permittees, and Caltrans.

There is legal authority and a regulatory framework that empowers the Regional Board to require dischargers to implement and monitor compliance with the requirements set forth in this TMDL. As previously noted, sediment is transported to the impaired Lagoon through runoff generated from urbanization, scouring of canyons below storm outfalls, stream bank erosion/bed scouring, land use practices, and other processes. A significant amount of the sediment load results from controllable water quality factors which are defined as those actions, conditions, or circumstances resulting from anthropogenic activities that may influence the quality of the waters of the State and that may be reasonably controlled. This TMDL establishes a WLA for point sources and a LA for nonpoint sources of sediment to the Lagoon.

The regulatory framework for point sources differs from the regulatory framework for nonpoint sources. CWA section 402 establishes the National Pollutant Discharge Elimination System (NPDES) program to regulate the ‘‘discharge of a pollutant,’’ other than dredged or fill materials, from a ‘‘point source’’ into ‘‘waters of the U.S.” Under section 402, discharges of pollutants to waters of the U.S. are authorized by obtaining and complying with NPDES permits. These permits commonly contain effluent limitations consisting of either Technology Based Effluent Limitations (TBELs) or Water Quality Based Effluent Limitations (WQBELs).

In California, State Waste Discharge Requirements (WDRs) for discharges of pollutants from point sources to navigable waters of the United States that implement federal NPDES requirements and CWA requirements (NPDES requirements) serve in lieu of federal NPDES permits. These are referred to as NPDES requirements. Such requirements are issued by the State pursuant to the authority that is described in California’s Porter Cologne Water Quality Control Act. Point source discharges of sediment to the Lagoon include municipal MS4 Phase I and II dischargers, Caltrans, and NPDES construction and industrial permits within the watershed.

For each TMDL where nonpoint sources are determined to be significant, a LA is calculated, which is the maximum amount of a pollutant that may be contributed to a waterbody by “nonpoint source” discharges in order to attain WQOs. The Porter-Cologne Water Quality Control Act applies to both point and nonpoint sources of pollution and serves as the principle legal authority in California for the application and enforcement of TMDL LAs for nonpoint sources. The State plan and policy for control and regulation of nonpoint source pollution is contained in the Plan for California’s Nonpoint Source Pollution Control Program (NPS Program Plan) and the Policy for the Implementation and Enforcement of the Nonpoint Source Pollution Control Program (NPS Implementation and Enforcement Policy). Nonpoint sources that warrant regulation include, for example, runoff from farms and urban development. This policy applies to discharges from agricultural irrigation return flow, nursery irrigation return flow, orchard irrigation return flow, animal feeding operations, manure composting, soil amendment operations, and septic systems. Individual landowners and other persons engaged in these land use activities can be held accountable for attaining sediment load reductions in affected watersheds through enforcement of WDRs and the Waiver Policy.

Nonpoint source discharges from natural sources are considered largely uncontrollable, and therefore should not be regulated. Sediment discharged via tidal exchange is an example of an uncontrollable nonpoint sediment source that is not governed by a MS4 permit. Hydromodification and accelerated erosion via storm water runoff are controllable sources of sedimentation.

In order to meet the TMDL, a Sediment Load Reduction Plan (SLRP) will be developed that will describe the regulatory and/or enforcement actions that the Regional Board and dischargers may take to reduce pollutant loading and monitor effluent and/or receiving waters. The SLRP will describe the pollutant reduction actions that are recommended by the various dischargers to meet the allocation. The SLRP will include provisions to perform studies by the dischargers to fill data gaps, refine the TMDL and required load reductions, and/or modify compliance requirements. The dischargers will conduct monitoring to assess the effectiveness of the implementation measures at meeting the wasteload reduction.

The TMDL results are summarized in the tables below. The overall WLA is represented by the watershed contribution in Tables ES-1 and ES-2. The ocean boundary (LA) includes sediment loads from storm surge, wave action, and tidal exchange. The historical load represents the estimated load contribution from the mid-1970s time period (reference condition).

Table ES-1. TMDL summary

Source	Critical Wet Period Load (tons)	Daily Load (tons)
TMDL	12,360	59
Watershed contribution (WLA)	2,580	12
Ocean boundary (LA)	9,780	46
MOS	Implicit	Implicit

Table ES-2. Current vs. historical loads and percent reduction

Source	Current Load (tons)	Historical Load (tons)	Load Reduction (tons)	Percent Reduction Required
TMDL	13,663	12,360	1,303	10%
Watershed contribution (WLA)	7,719	2,580	5,139	**67%**
Ocean boundary (LA)	5,944	9,780	+3,836 (increase)	+39% (increase)

1 Introduction

The purpose of this technical report is to present the Total Maximum Daily Load (TMDL) that was developed for sediment/siltation for Los Peñasquitos Lagoon (Lagoon). The Lagoon is listed as impaired for sediment/siltation on the Clean Water Act (CWA) Section 303(d) List of Water Quality Limited Segments. Sedimentation within the Lagoon restricts the tidal prism, or exchange between the ocean and the Lagoon, and degrades critical salt marsh habitats through various processes. A TMDL is needed to help restore the beneficial uses of the Lagoon and achieve water quality standards.

Section 303(d) of the CWA requires that each state identify waterbodies within its boundaries for which the effluent limitations are not stringent enough to meet applicable water quality standards, which consist of beneficial uses, water quality objectives (WQOs), and an antidegradation policy. The CWA also requires states to establish a priority ranking for these impaired waters, known as the CWA Section 303(d) List of Water Quality Limited Segments, and to establish TMDLs for the identified waterbodies.

The purpose of a TMDL is to attain WQOs that support beneficial uses in the waterbody. A TMDL is defined as the sum of the individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background, such that the capacity of the waterbody to assimilate pollutant loading (i.e., the loading capacity) is not exceeded[1]. A TMDL, therefore, represents the maximum amount of the pollutant of concern that the waterbody can receive and still attain water quality standards. Additionally, a TMDL represents a strategy for meeting WQOs by allocating quantitative limits for point and nonpoint pollution sources. Once the total maximum pollutant load has been calculated, it is divided up and allocated among all of the contributing sources in the watershed.

The TMDL process begins with the development of a technical analysis which includes the following seven components:

1) **Problem Statement** – generally describes impairment (Section 2)
2) **Numeric Targets** – identifies the historic numeric target which will result in attainment of the WQOs and protection of beneficial uses (Section 4)
3) **Source Assessment** – identifies all of the known point sources and nonpoint sources of the impairing pollutant in the watershed (Section 6)
4) **Linkage Analysis** – establishes the relationship between pollutant sources and receiving water conditions and calculates the Loading Capacity of the waterbody,

[1] 40 CFR 130.2

which is the maximum load of the pollutant that may be discharged to the waterbody without causing exceedances of WQOs and impairment of beneficial uses (Section 7)

5) **Margin of Safety (MOS)** – accounts for uncertainties in the analysis (Section 8)
6) **Seasonal Variation and Critical Conditions** – describes how these factors are accounted for in the TMDL determination (Section 8)
7) **Allocation of the TMDL** – division of the TMDL among each of the contributing sources in the watershed; wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint and background sources (Section 9)

The write-up for the above components is generally referred to as the technical TMDL analysis. This technical report also includes background information on the Lagoon, including a description of the Lagoon and its watershed, discussion of the applicable WQOs and beneficial uses (Section 3), and a discussion summary of the data that were used to characterize the impairment and associated pollution sources (Section 5). The TMDL Implementation Section will be included later, as this information is currently being developed. This section focuses on the Regional Board's regulatory authority. This information will be updated in the future through development of a detailed Sediment Load Reduction Plan (SLRP) that will be submitted for approval after adoption of the TMDL.

This TMDL was developed through close collaboration between the municipalities within the Los Peñasquitos watershed (City of San Diego, San Diego County, City of Del Mar, and City of Poway), the California Department of Transportation (Caltrans), San Diego Coastkeeper, California State Parks, the Los Peñasquitos Lagoon Foundation, and representatives from the Regional Board. This third party TMDL effort was led by the City of San Diego and included detailed modeling of the Lagoon and its contributing watershed.

2 Problem Statement

Under Section 303(d) of the Clean Water Act (CWA), states are required to identify waters whose beneficial uses have been impaired due to specific constituents. Los Peñasquitos Lagoon was placed on Section 303 (d) list of Water Quality Limited Segments in 1996 for sedimentation and siltation with an estimated area affected of 469 acres. The Lagoon is subject to the development of a total maximum daily load (TMDL) (USEPA, 2009).

The Lagoon is an estuarine system that is part of the Torrey Pines State Natural Reserve. In addition to its marine influence, the Lagoon receives freshwater inputs from an approximately 60,000-acre watershed comprised of three major canyons (Carroll Canyon, Los Peñasquitos Canyon, and Carmel Canyon). Given the status of "Natural Preserve" by the California State Parks, the Lagoon is one of the few remaining native salt marsh lagoons in southern California, providing a home to several endangered species (California State Parks, 2009). The Lagoon is ecologically diverse, supporting a variety of plant species, and providing habitat for numerous bird, fish, and small mammal populations. The Lagoon also serves as a stopover for the Pacific Flyway, offering migratory birds a safe place to rest and feed, as well as providing refuge for coastal marine species that use the Lagoon to feed and hide from predators.

The San Diego Basin Plan states, "The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses". Beneficial uses listed in the basin plan for the lagoon include contact water recreation, non-contact water recreation (although access is not permitted in some areas per California State Parks), preservation of biological habitats of special significance, estuarine habitat, wildlife habitat, rare, threatened or endangered species, marine habitat, migration of aquatic organisms, and spawning, reproduction and/or early development. The beneficial use that is most sensitive to increased sedimentation is estuarine habitat. Estuarine uses may include preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (such as marine mammals or shorebirds).

Impacts associated with increased and rapid sedimentation include: reduced tidal mixing within Lagoon channels, degradation and (in some cases) net loss of riparian and salt marsh vegetation, increased vulnerability to flooding for surrounding urban and industrial developments, turbidity associated with siltation in Lagoon channels, and constriction of a main wildlife corridor. The Los Peñasquitos Lagoon Enhancement Plan and Program (1985), San Diego Basin Plan (1994), and Clean Water Act Section 303(d) highlight sedimentation as a significant impact associated with urban development and a leading cause in the rapid loss of salt marsh habitt in the Lagoon, making sediment reduction a management priority.

According to California State Parks, the Lagoon consists of approximately 510 acres of wetland habitats including coastal salt marsh (this includes salt panne, tidal channels, and mudflats), brackish marsh, riparian woodland and scrub, and freshwater marsh. The Lagoon's 510 acres includes approximately 210 acres of tidal salt marsh and 120 acres of freshwater wetlands are considered unimpaired (data from California State Parks 2010; see Figure 7). The remaining 180 acres of salt marsh and brackish marsh vegetation has been impaired by sedimentation, converting coastal salt marsh to freshwater or upland habitats. The environmental processes that support wetland habitats in the Lagoon have been altered by urban development in three ways:

1) Increase in the volume and frequency of freshwater input
2) Increase in sediment deposition
3) Decrease in the tidal prism

These factors have led to decreases in saltwater and brackish marsh habitats and increases in freshwater habitats as well as increases in the abundance of non-native species.

Developing a sediment TMDL for the Lagoon is necessary for the restoration of the beneficial uses of the Lagoon, including the estuarine beneficial use most impacted by sediment accumulation.

3 Background Information

This section describes the Los Peñasquitos watershed and Lagoon, applicable water quality standards (including beneficial uses and WQOs), and provides background information on the impairment.

3.1 Los Peñasquitos Watershed Description

The Los Peñasquitos watershed is located in central San Diego County (Figure 1). Both the watershed and Lagoon are included in the Los Peñasquitos Hydrologic Unit (906), which also includes Mission Bay and several coastal tributaries. This 93 mi^2 (approximately 60,000 acres) coastal watershed includes portions of the cities of San Diego, Poway, and Del Mar (Figure 2). In addition, a small portion of San Diego County is located in the eastern headwaters area. There are also several major road corridors that are maintained by Caltrans within the watershed.

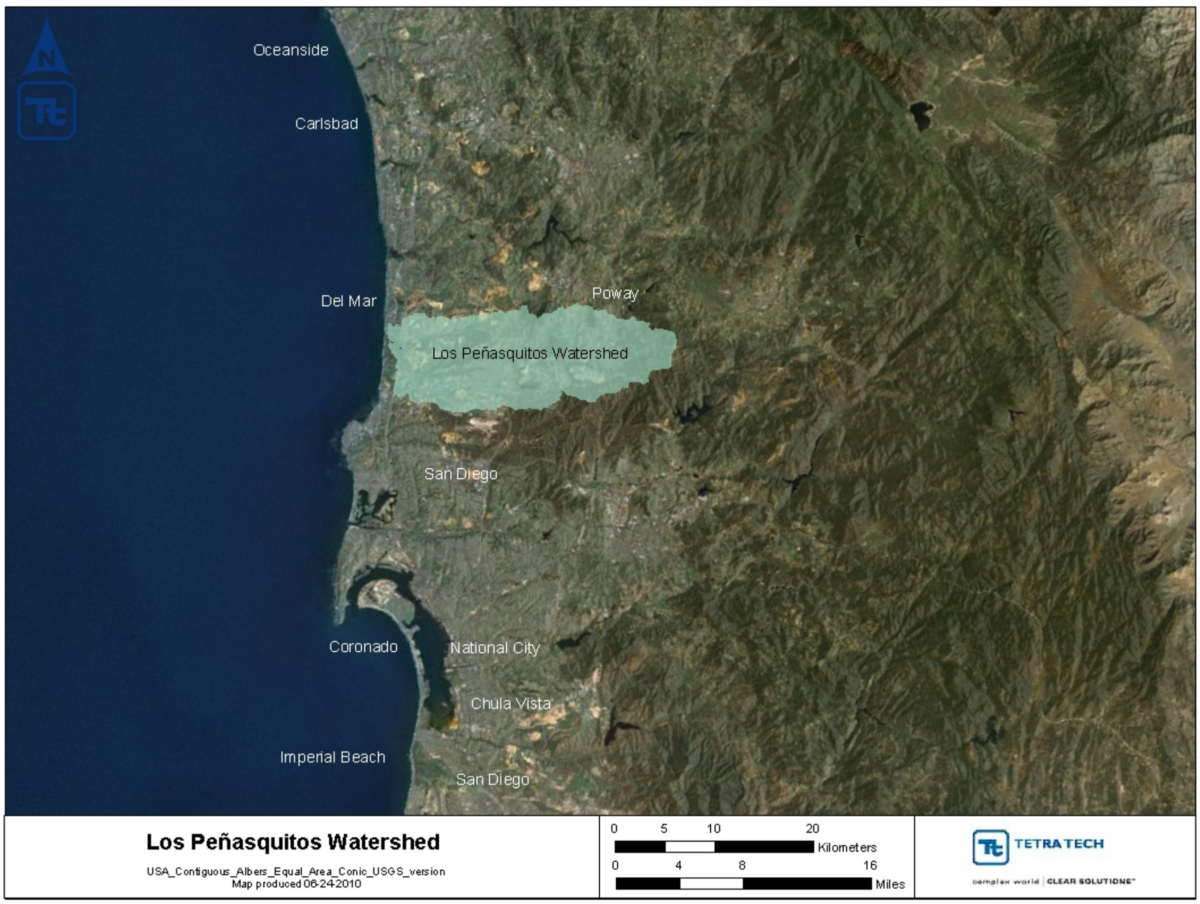

Figure 1. Location of the Los Peñasquitos watershed

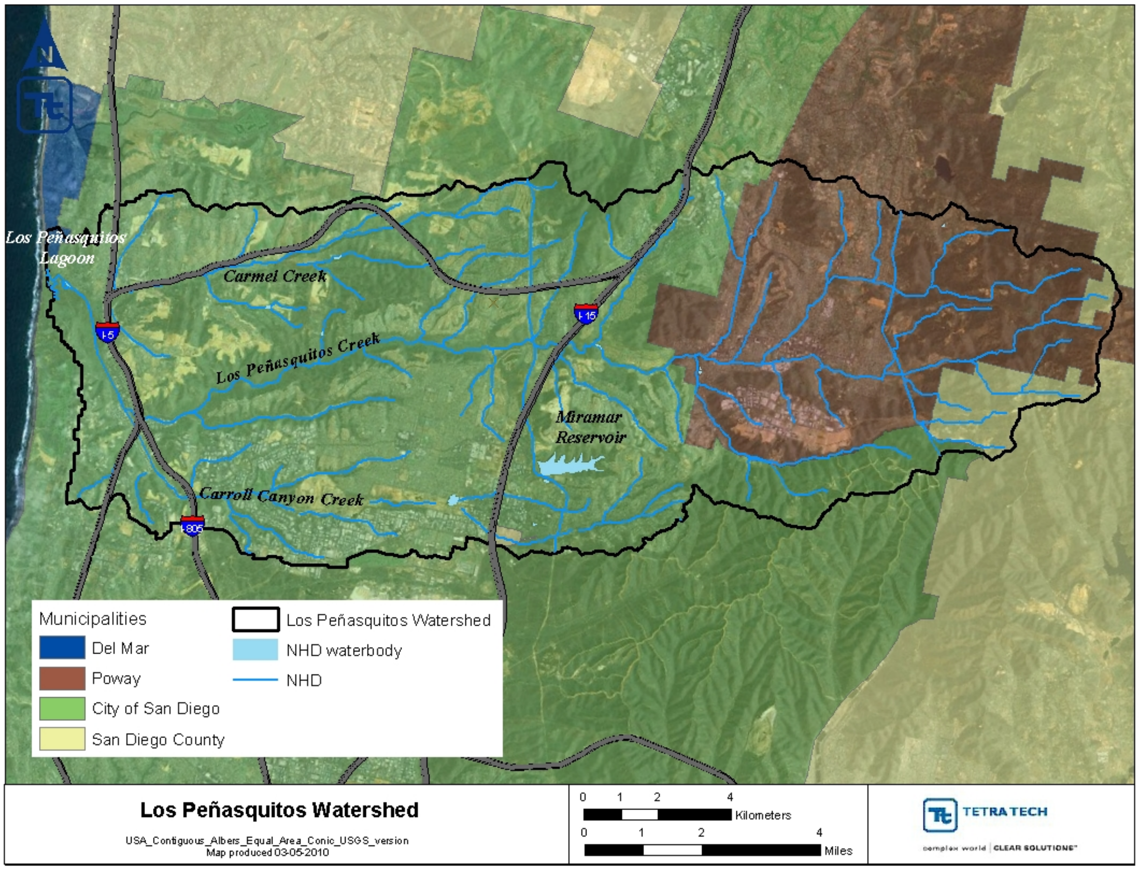

Figure 2. Municipalities within the Los Peñasquitos watershed

The climate in the Region is generally mild with annual temperatures averaging around 65°F near the coastal areas. Average annual rainfall ranges from nine to 11 inches along the coast. There are three distinct types of weather in the Region. The summer dry weather occurs from May 1 to September 30. The winter season occurs from October 1 to April 30 and has two types of weather; 1) winter dry weather when rain has not fallen for the preceding 72 hours, and 2) wet weather consisting of storms of 0.1 inches of rainfall (or greater) and the 72 hour period after the storm. 85 to 90 percent of the annual rainfall occurs during the winter season.

Three major streams drain the watershed and flow into the tidal Lagoon (Figure 2). Los Peñasquitos Creek is the largest catchment in the watershed draining 59 mi^2 (approximately 37,760 acres) through its central portion. Carroll Canyon Creek is the second largest catchment (approximately 18 mi^2 or 11,520 acres) and drains the southern portion of the watershed. Carmel Creek is located along the northern, coastal area and drains the remaining 16 mi^2 (approximately 10,240 acres). Los Peñasquitos Creek and Carroll Canyon Creek confluence together prior to entering the Lagoon.

There is one major dam in the Carroll Canyon Creek watershed, which drains approximately 1 mi^2 (approximately 640 acres) and forms Miramar Reservoir (retains imported drinking water; does not discharge downstream). Watershed elevation rises from sea level to 2,600 ft in the headwaters (Figure 3).

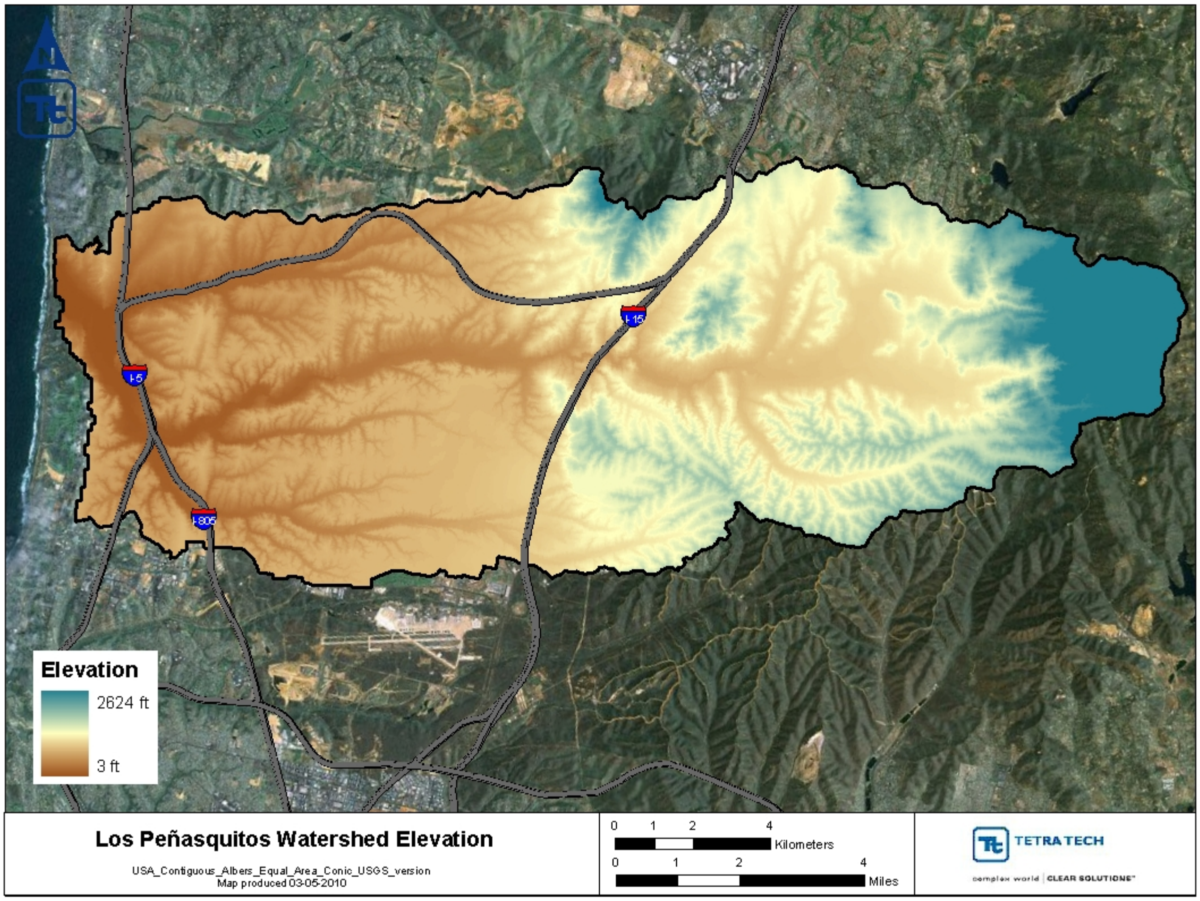

Figure 3. Los Peñasquitos watershed elevation

The 27-acre El Cuervo Norte wetlands restoration project is located in the Peñasquitos Canyon Preserve and will provide over 24 acres of southern willow scrub, oak-sycamore woodland and freshwater marsh habitat. The project consists of approximately 9 acres of wetland creation, 14.3 acres of wetlands enhancement, 2 acres of upland native buffer, and 1.3 acres of park access road and a San Diego Gas & Electric power pole maintenance area.

Data detailing land use in the Los Peñasquitos watershed is available through the San Diego Association of Governments 2000 land use coverage[2] and presented in (Figure 4). Approximately 54 percent of the watershed has been developed, with 46 percent of

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[2] http://www.sandag.org/resources/maps_and_gis/gis_downloads/downloads/zip/Land/CurrentLand/lu.zip

that area classified as impervious. The largest single land use type in the Los Peñasquitos watershed is open space (approximately 25,500 acres), followed by low density residential development (approximately 14,250 acres), and industrial/transportation (approximately 11,660 acres). The percent distribution of all land uses in the watershed is presented in Figure 5. Additional key watershed characteristics that are important for model configuration are described in later sections and within the modeling report (Appendix A).

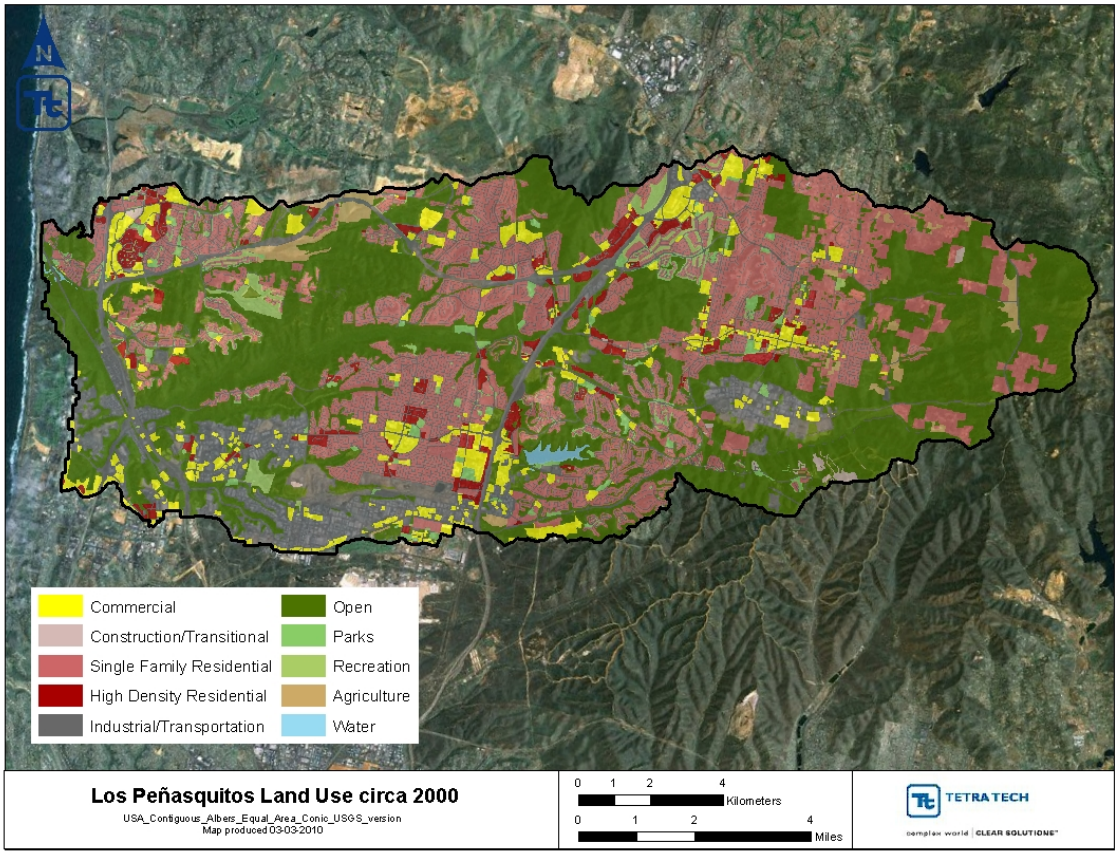

Figure 4. Land uses in the Los Peñasquitos watershed

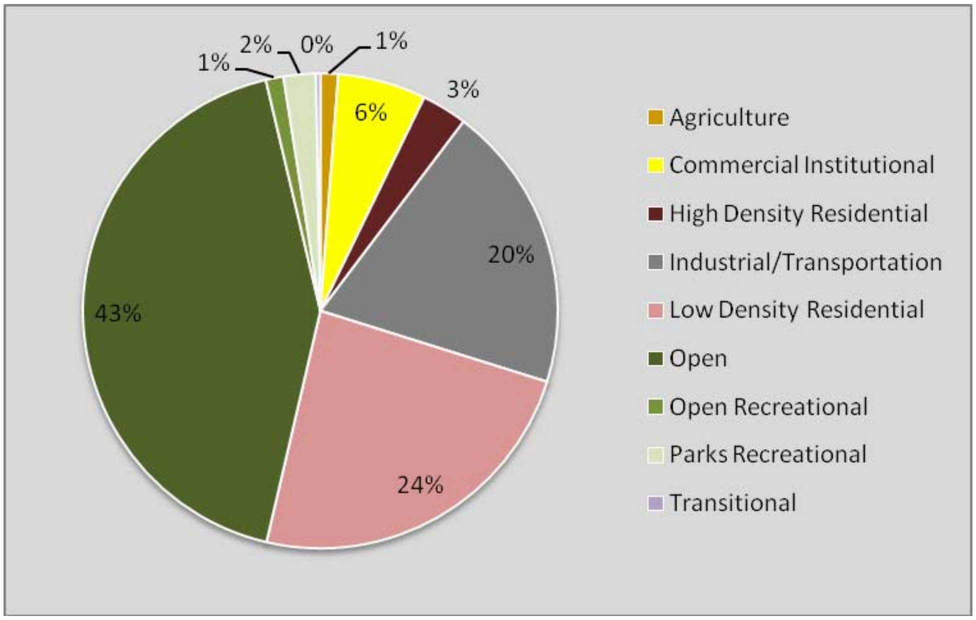

Figure 5. Land use distribution in the Los Peñasquitos watershed

3.2 Los Peñasquitos Lagoon Description

The Los Peñasquitos Lagoon is a relatively small estuarine system (approximately 0.6 mi^2 or 384 acres) that is part of the Torrey Pines State Natural Reserve (Figure 6). Given the status of "Natural Preserve" by the California State Parks, the Lagoon is one of the few remaining native salt marsh lagoons in southern California. The Lagoon is ecologically diverse, supporting a variety of plant species, and providing habitat for numerous bird, fish, and small mammal populations. The Lagoon also serves as a stopover for migratory birds and provides habitat for coastal marine and salt marsh species.

Figure 6. Photograph of Los Peñasquitos Lagoon

Tidal flows enter the Lagoon during periods when the Lagoon mouth is open to the ocean. Currently, the Lagoon mouth is open throughout most of the year. Mouth closures are typically caused by coastal processes (deposition of sand and cobble storms surges and wave action) and structures, such as the U.S. Highway 101 abutments. Mechanical dredging is used when needed to eliminate blockages and allow for tidal flow into the Lagoon in order to improve water quality conditions and support salt marsh species.

Most of the freshwater input flows through Los Peñasquitos Canyon into the Lagoon. Carroll Canyon Creek to the south and Carmel Creek to the north also contribute freshwater to the Lagoon. Historically, Los Peñasquitos Creek was the only tributary that flowed year-round, while Carroll Canyon and Carmel Creeks only flowed during significant rainfall events. Beginning in the 1990s, these drainages also began flowing year-round due to increasing urban development within the watershed. Carroll Canyon Creek confluences with Los Peñasquitos Creek upstream and the combined stream channel extends into the Lagoon along the western side of the railroad track berm. This berm acts as a barrier between the eastern and western portions of the Lagoon for much of its length. The railroad trestle along the northern side provides the main connection between eastern and western portions of the lagoon. The Lagoon channel that receives flow from Carmel Creek crosses through this area. In addition, there are two smaller bridges located in the southern portion of the Lagoon which allow flow from Carroll Canyon Creek to pass through to the eastern side of the Lagoon during high flow events.

3.3 Applicable Water Quality Standards

Water quality standards consist of WQOs, beneficial uses, and an anti-degradation policy. WQOs are defined under Water Code section 13050(h) as "limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water." Under section 304(a)(1) of the CWA, the USEPA is required to publish water quality criteria that incorporate ecological and human health assessments based on current scientific information. WQOs must be based on scientifically sound water quality criteria, and be at least as stringent as those criteria.

The sediment WQO, as set forth in the Water Quality Control Plan for the San Diego Basin (Basin Plan), is narrative in nature and states "*The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses*" (Regional Board, 1994). To interpret the narrative nature of the sediment WQO, a numeric target was developed to establish the allowable sediment loading to the Lagoon. Section 4 presents the detailed information that was used to develop a numeric target for sediment.

The Basin Plan identifies the beneficial uses that are designated for Los Peñasquitos Lagoon (Regional Board, 1994) (Table 1). The narrative standard for sediment is applied to all beneficial uses. Compliance with WQOs must be assessed and maintained throughout the waterbody to protect all beneficial uses.

Table 1. Beneficial uses designated for Los Peñasquitos Lagoon

Beneficial Use	Beneficial Use Description
REC 1	Includes uses of water for recreation activities involving body contact with water, where ingestion of water is reasonable possible. These uses include, but are not limited to, swimming, wadding, water skiing, ski and SCUBA diving, surfing, white water activities, fishing, or use of natural hot springs. *Note that access to some areas is not permitted per California State Parks
REC 2	Includes the use of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonable possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beach combing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities. *Note that access to some areas is not permitted per California State Parks
BIOL	Includes uses of water that support designated area or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS),

Beneficial Use	Beneficial Use Description
	where the preservation or enhancement of natural resources requires special protection.
EST	Includes uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds)
WILD	Includes uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
RARE	Includes uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.
MAR	Includes uses of water that support marine ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
MIGR	Includes uses of water that support habitats necessary for migration, acclimatization, between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.
SPWN	Includes uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish. This use is applicable only for the protection of anadromous fish.
SHELL	Includes uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters and mussels) for human consumption, commercial, or sport purposes.

3.4 Impairment Description

The Lagoon is listed as impaired on the CWA Section 303(d) list due to sediment/siltation impacts that originate from watershed sediment contributions. This impairment impacts several beneficial uses; however, the estuarine habitat use is the most sensitive to increased sedimentation. The Lagoon's wetland habitats consist of estuarine and riparian habitats, including coastal salt marsh habitat and wetland/upland buffer areas. The 303(d) listing indicates that an estimated area of 469 acres is impaired. Recent surveys by California State Parks indicate that greater than 180 acres of the 510 acres of coastal salt marsh has been impaired by sedimentation, converting coastal salt marsh to riparian habitat (California State Parks, 2009; California State Parks, 2010). .

As discussed in the problem statement, impacts associated with sedimentation include: reduced tidal mixing within Lagoon channels, degradation and (in some cases) net loss of wetland vegetation, conversion from saline to freshwater habitats, and turbidity associated with siltation in Lagoon channels. There are many potential sources that have influenced the accumulation of sediment within the Lagoon. Sources include erosion of canyon banks, bluffs, scouring stream banks, and tidal influx. Some of these processes are exacerbated by anthropogenic disturbances, such as urban development within the watershed. Urban development transforms the natural landscape and results in increased runoff due to hydromodifcation resulting in scouring of sediment, primarily below storm water outfalls that discharge into canyon areas. Sediment loads are transported downstream to the Lagoon during storm events causing deposits on the salt flats, and in Lagoon channels. These sediment deposits have gradually built-up over the years due to increased sediment loading and inadequate flushing, which directly and indirectly affects lagoon functions and salt marsh characteristics.

To address the impairment, and interpret the narrative WQOs, a historical watershed-based approach was used to calculate the acceptable sediment load to the Lagoon. The historical analysis focused on identifying an earlier time period that corresponds with natural sediment loading from the watershed which did not exceed the Lagoon's assimilative capacity, as described in the following section (Section 4).

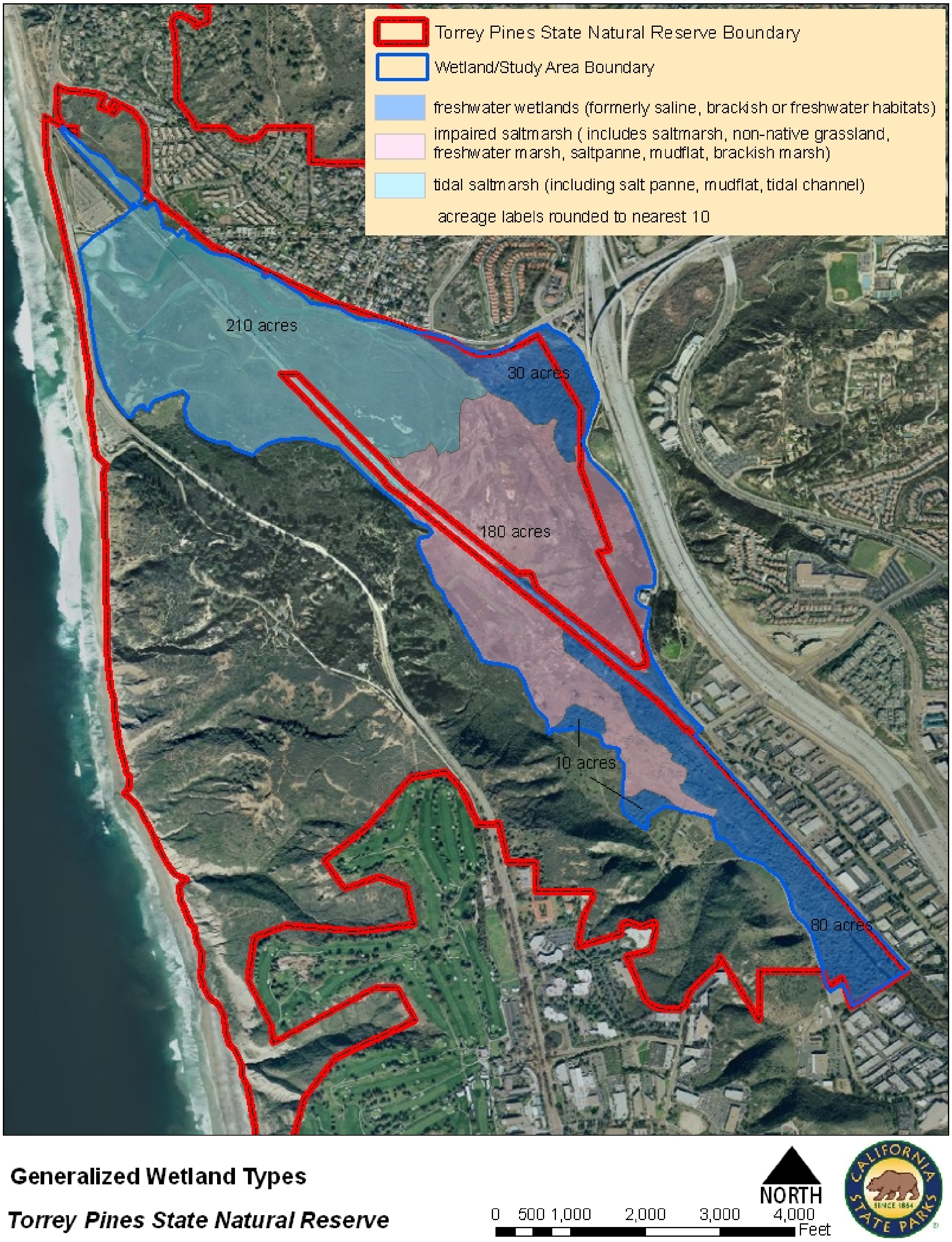

Figure 7. Wetland habitats within Los Peñasquitos Lagoon (California State Parks, 2010)

4 Numeric Targets

When calculating TMDLs, numeric targets are selected to meet the WQOs for a waterbody and subsequently establish measureable targets for the restoration and/or protection of beneficial uses. The sediment WQO, as set forth in the Basin Plan, is narrative and states:

> *The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses* (Regional Board, 1994).

Due to the narrative nature of the sediment/siltation WQO, this WQO must be interpreted through the development of a numeric target for TMDL and implementation planning purposes. A numeric target is needed to define the conditions that will result in the attainment of water quality conditions. For the sediment/siltation impairment of the Lagoon, a numeric target was derived using a ‘reference watershed approach’. The ‘reference watershed approach’ typically refers to the process of comparing the impaired waterbody to a similar-unimpaired waterbody to establish an acceptable loading capacity which would result in the attainment of water quality standards. Due to the unique characteristics of the Lagoon, it was determined that a historical analysis of the Lagoon and its watershed would provide the best information available for determining the conditions that support water quality standards. Available literature and past accounts of sedimentation impacts within the Lagoon were reviewed to understand the relationship between urbanization in the watershed and associated changes in Lagoon water quality conditions. A timeline of significant events and literature references was developed to document important changes in lagoon condition over time in relation to changes in land use (urbanization in particular) and other impacts (Figures 8 and 9). The linkage between these factors was evaluated using a weight of evidence approach (Sections 4.1 through 4.3) in order to identify an appropriate reference time period that could be used calculate the numeric target for sediment TMDL development (Section 4.4). Note that much of the background information presented below is also referenced in the historical timeline.

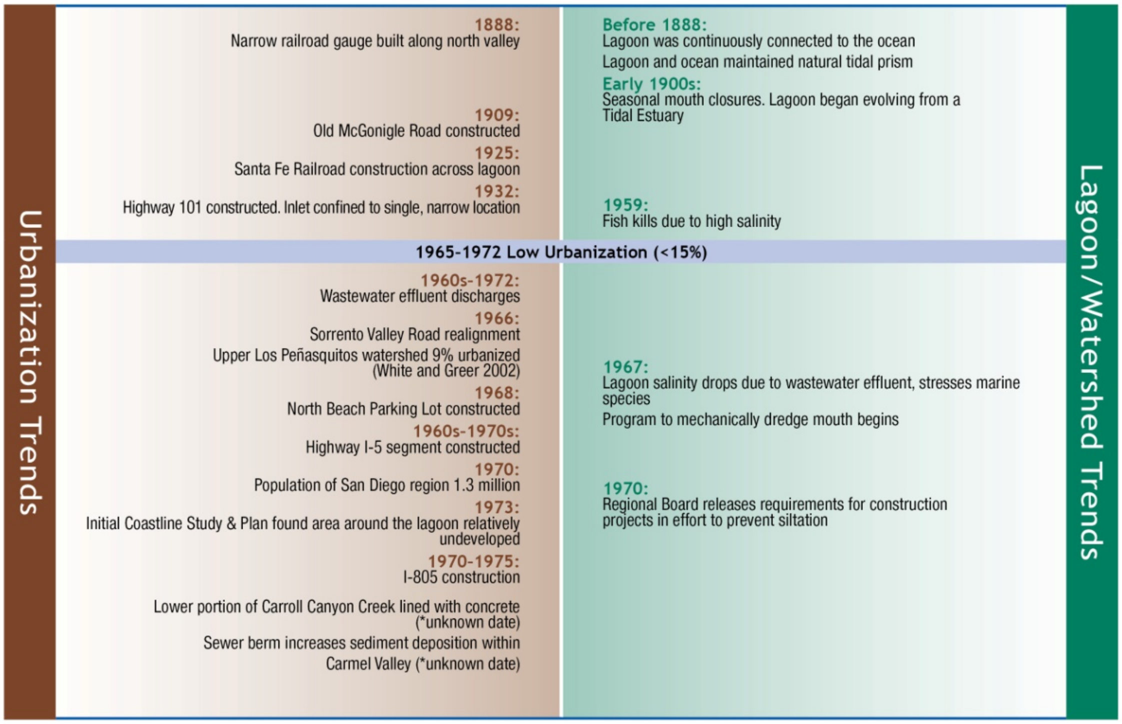

Figure 8. Timeline of urbanization and lagoon trends (1800s through early 1970s)

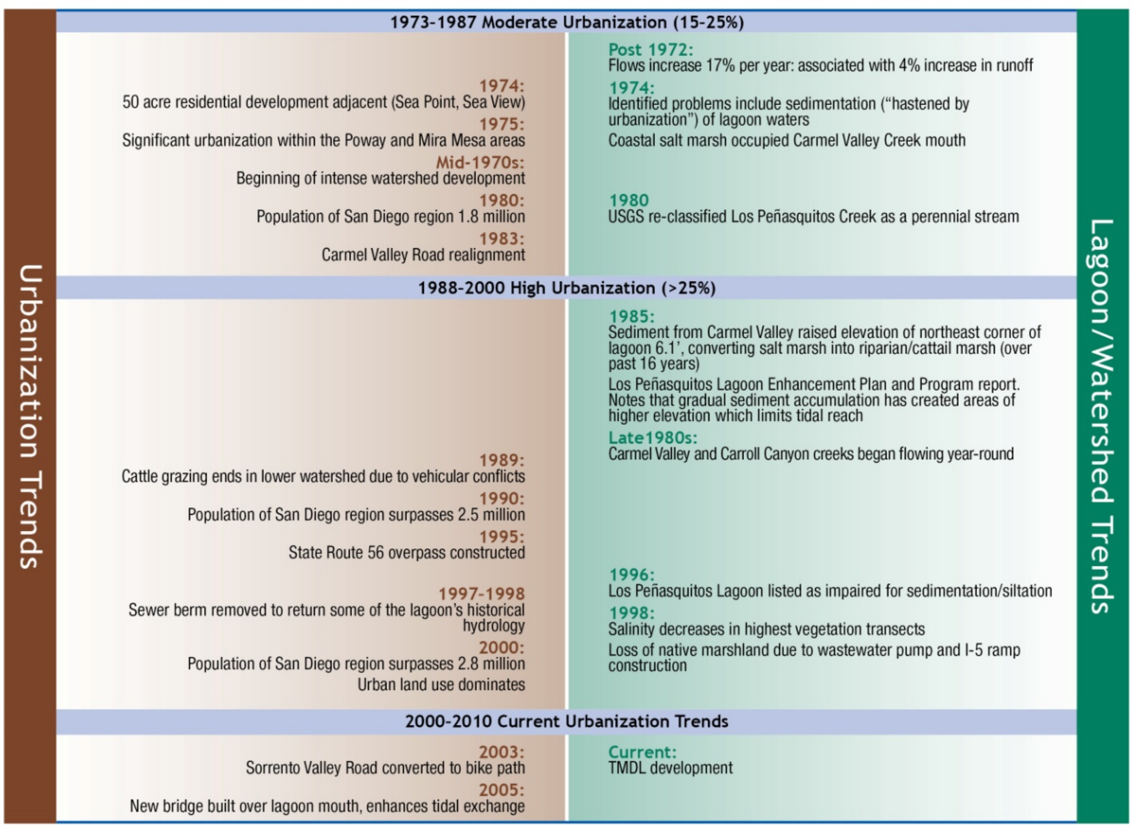

Figure 9. Timeline of urbanization and lagoon trends (mid 1970s through current)

4.1 Land Use Changes in the Los Peñasquitos Watershed

As the first Mexican land grant in California, land in the Los Peñasquitos watershed was historically maintained as a family homestead and livestock ranch throughout the 1800s and early 1900s. By the early 1900s, the City of San Diego and San Diego County began acquiring parcels of land surrounding the Lagoon. As the region began to develop, urban infrastructure, including construction of the railroad (1880s-1925), altered the natural drainage and restricted the mouth of the Lagoon. Later, the construction of U.S. Highway 101 in 1932 permanently confined the inlet to a single, narrow location and restricted the tidal prism and exchange between the ocean and Lagoon (Mudie et al., 1974). The North Beach Parking Lot was constructed in 1968 by California State Parks in historically tidal areas which further influenced hydrologic exchanges (LPL Foundation and the State Coastal Conservancy, 1985). Although there were significant alterations to the Lagoon's hydrology, the Initial Coastline Study and Plan released in 1973 found that the area surrounding the Lagoon remained relatively undeveloped (Duncan and Jones, 1973), but was at the threshold of rapid growth (Jet Propulsion, 1971).

In 1966 the Upper Los Peñasquitos subwatershed was 9% urbanized (White and Greer, 2002); however, by 1975, the watershed experienced significant urbanization with agricultural areas being converted to urban uses, specifically in the Poway and Mira Mesa areas (City of San Diego, 2005). In 1974, a California Fish and Game report expressed concerns associated with the anticipated completion of a 50 acre development along the shores of the Lagoon. The report also stated that within the following five years (1974 to 1979), the population surrounding the immediate lagoon environs was expected to increase by a factor of four to six over the 1972 level of approximately 1,000 people (Mudie et al., 1974). Urban runoff associated with the increased development had already been identified as the primary threat to water quality in the Lagoon (Jet Propulsion Lab, 1971); however, other factors existed including agriculture and grazing. In 1989, cattle grazing in the Los Peñasquitos Creek watershed ceased (White and Greer, 2002) primarily due to vehicular conflicts.

While development occurred sporadically before the 1970s, the mid-1970s appears to be the beginning of intense watershed development. Land use associated with this time period is illustrated in Figure 10. Land use/land cover data for the Los Peñasquitos watershed were not available for this period, therefore, a historical coverage was developed based on the location and type of structures that are shown in USGS topographic maps from the 1970s (primarily the La Jolla quadrangle – dated 1975). The most recent land use coverage (from SANDAG 2000 – refer to Section 3.1) was modified based on this information in order to create a uniform historical land use map for the watershed for comparison. Land use differences between the current and historical time periods are shown in Table 2.

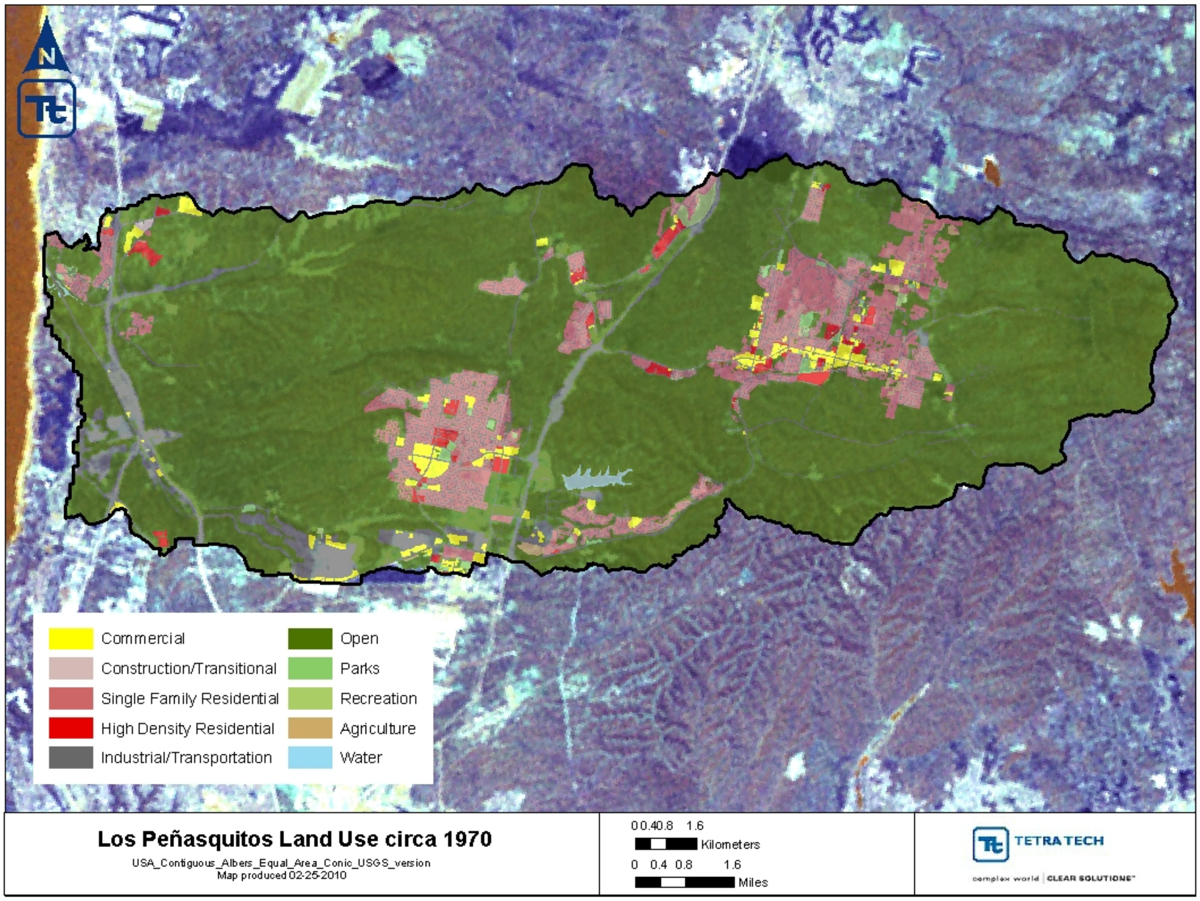

Figure 10. Historic land use in the Los Peñasquitos watershed (1970's)

Table 2. Current (SANDAG 2000) vs. historical land use comparison

Land Use	Current area (ac)	Current area (%)	Historic area (ac)	Historic area (%)	Relative Change (%)
Agriculture	741	1.24%	100	0.17%	1.07%
Commercial	3,591	6.00%	1,088	1.82%	4.18%
Construction/Transitional	169	0.28%	23	0.04%	0.24%
High Density Residential	1,840	3.07%	648	1.08%	1.99%
Industrial/Transportation	11,654	19.46%	4,830	8.07%	11.40%
Open	25,463	42.52%	47,445	79.23%	-36.71%
Parks	1,326	2.22%	2,884	0.48%	1.73%
Recreation	670	1.12%	139	0.23%	0.89%
Single Family Residential	14,258	23.81%	5,155	8.61%	15.20%
Water	161	0.27%	160	0.27%	0.00%
Total	59,879	100.00%	59,879	100.00%	

From 1966 to 1999, the acreage of urbanized land within the upper Los Peñasquitos Creek watershed increased by 290 percent (White and Greer, 2002) and by 2000, the Los Peñasquitos watershed was dominated by urban uses (City of San Diego, 2005). Additional highway infrastructure was built in and around the Los Peñasquitos watershed to accommodate increasing population growth. Realignment of Sorrento Valley Road (~1966) and Carmel Valley Road (1983) both impacted the surrounding watershed (Greer and Stow, 2003) as well as segments of the I-5 freeway (1994) and the State Route 56 overpass (1995). To decrease impacts from road infrastructure, Sorrento Valley Road was converted to a bike path in 2003 and a new U.S. Highway 101 bridge was constructed over the Lagoon mouth in August 2005, enhancing tidal exchange. Figure 11 shows the major roads within the watershed. Runoff from surrounding roads and highways ultimately reaches the Lagoon.

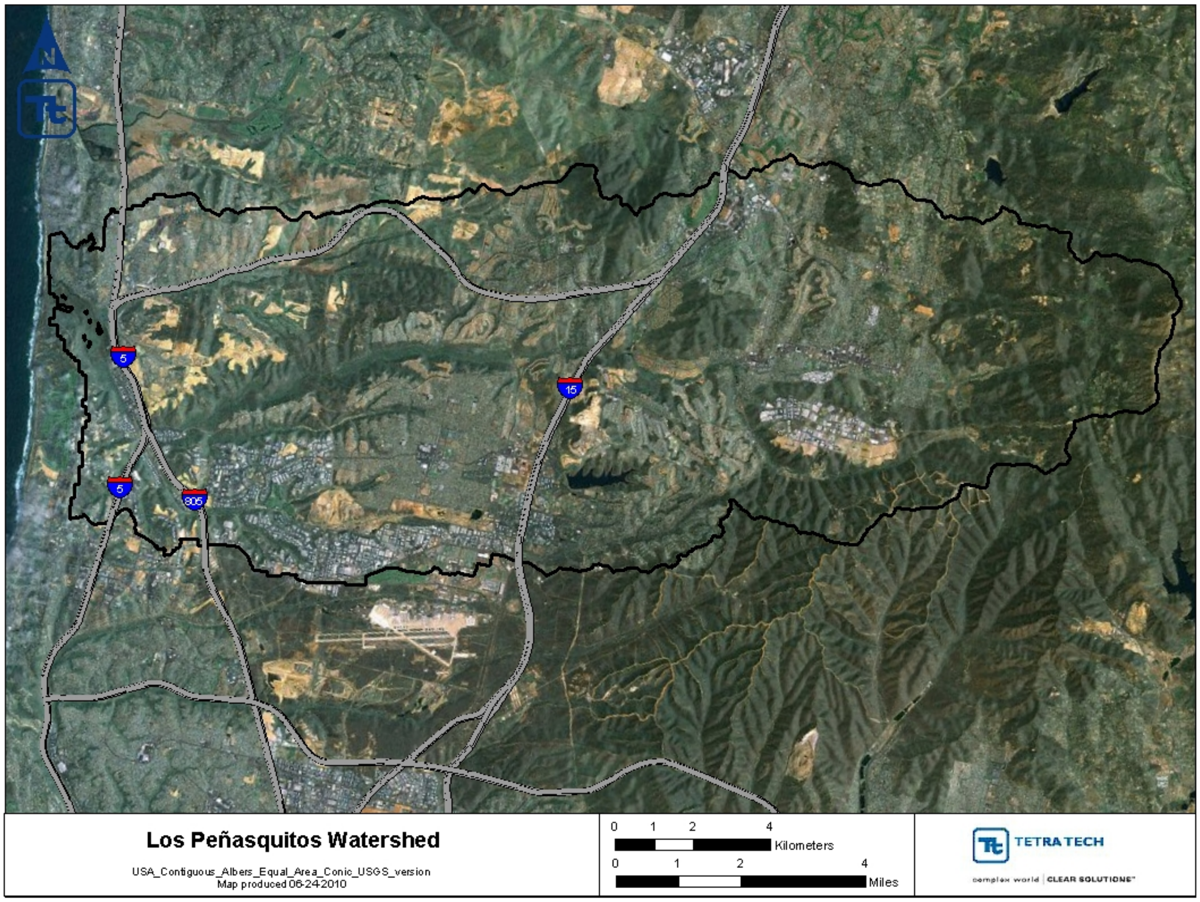

Figure 11. Major roads within the Los Peñasquitos watershed

To further characterize the land use changes, population trends in the San Diego region were evaluated. Population steadily increased from 1970 to 2010 in the San Diego region[3] as shown in Figure 12. This regional population analysis was used to evaluate general trends and includes surrounding areas. General trends show expansive population growth, resulting in intense development throughout the region.

[3] www.sandag.org

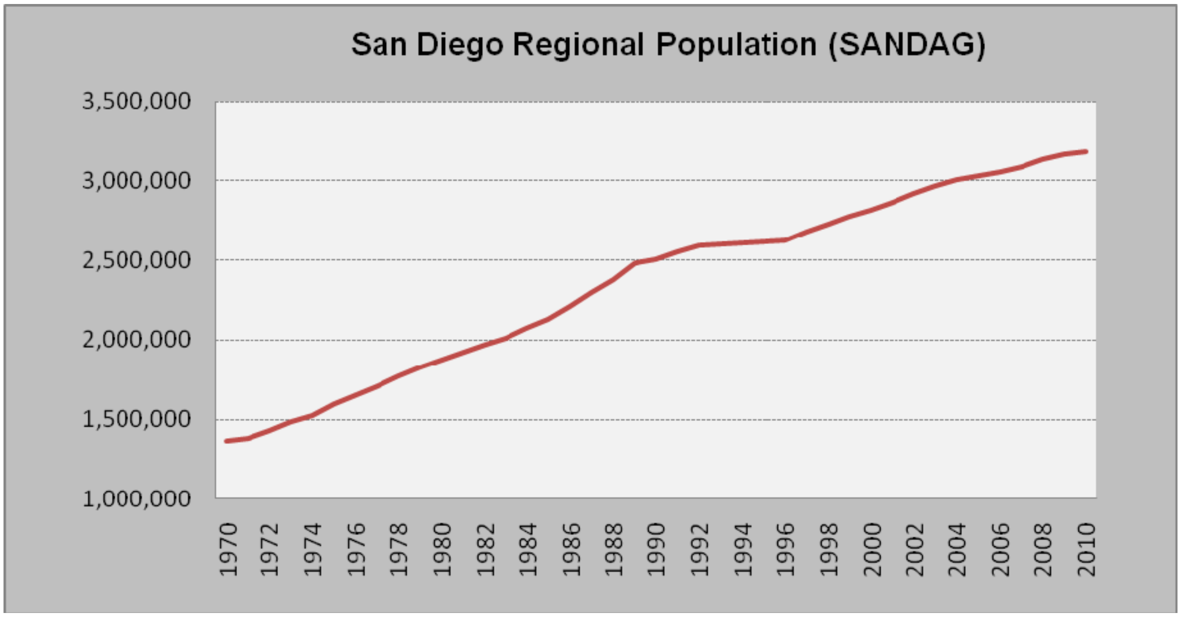

Figure 12. San Diego regional population trends (SANDAG, 2010)

4.1.1 Los Peñasquitos Lagoon Historical Water Quality Conditions

In the past 60 years, the Lagoon has evolved from a tidal estuary with an active connection to the ocean, to one that is closed to tidal action for long periods of time and requires mechanical excavation to reopen. The major factors that were responsible for degradation of the lagoon before the 1990s are: (1) the railroad embankment that cuts off lagoon channels; (2) construction of North Torrey Pines Road (part of U.S. Highway 101) along the barrier beach that restricted the location of the lagoon mouth; (3) construction of the North Beach Parking Lot in historic tidal areas; (4) increased sediment from changing land uses upstream; and, (5) decreased water quality from urban runoff and sewage effluent (LPL Foundation and State Coastal Conservancy, 1985). Hydromodification linked to urban development within the watershed and lagoon in the 1980s and 1990s played (and still plays) a major role in the degradation of the Lagoon. Water quality impacts to the Lagoon are primarily associated with a restricted tidal prism, historical discharge of wastewater effluent from 1962-1972; and more recently, hydromodification that has resulted in increased sedimentation and year-round freshwater inputs. Information that relates to each of these impacts is discussed below.

4.1.2 Tidal Prism Restriction

Maintaining a tidal prism, and proper exchange between the ocean and the Lagoon, is critical for maintaining adequate salt marsh salinity levels, and other water quality parameters. The Los Peñasquitos Enhancement Plan identifies mouth closures as one of the most important problems occurring in the Lagoon (Elwany, 2008). Tidal inflows and outflows of impounded water from large storm events help to keep the mouth open, whereas, wave-induced currents are responsible for the depositional processes which tend to close the lagoon entrance (LPL Foundation and State Coastal Conservancy, 1985). Sedimentation of lagoon environments is a natural process; research of the Lagoon determined that the volume of sand trapped in the inlet is a function of wave and flooding dynamics (Elwany, 2008). Although increased sediment loading from the watershed may increase the build-up rate of sand bar formation, this study also determined that the grain size distribution of accumulated sand at the inlet was comparable to the distribution of grain size on the beach, thus identifying significant marine sources (Elwany, 2008) rather than watershed sources affecting the western portion of the Lagoon.

Despite the natural process, historical evidence indicates that the lagoon was continuously connected to the ocean until at least 1888 and after this time period, the natural process within the Los Peñasquitos watershed was accelerated by disturbances (Mudie et al., 1974). For example, construction of the railroad and U.S. Highway 101 across the lagoon reduced the volume of water flowing in and out of the lagoon; this allows sand to build up at the entrance and can prevent tidal flow altogether (Duncan and Jones, 1973). In 1966, a program was initiated to restore the tidal prism by mechanically dredging and removing the accumulated sediment at the mouth of the Lagoon (LPL Foundation and State Coastal Conservancy, 1985). This effort was later refined in the mid 1980s and early 1990s to improve tidal mixing and reduce the frequency of mouth closures. Because of continued, sporadic mouth closures, a dredging program continues to date (Elwany, 2008). The program seeks to enhance tidal flushing, water quality, and marine habitats.

4.1.3 Wastewater Effluent Discharge

To accommodate increasing urban development within the watershed, two wastewater treatment plants operated from 1962-1972 and discharged effluent to the Lagoon or tributaries that ultimately reach the Lagoon. Although these facilities elevated minimum and median annual discharge values and assisted with maintaining the tidal prism, the effluent caused insect and odor problems (Mudie et. al., 1974), as well as elevated nutrients (Bradshaw and Mudie, 1972), and depressed salinity[4] concentrations. These problems continued until 1972 when surrounding areas were all connected to the San Diego Metropolitan sewer system.

4.1.4 Watershed Sedimentation

Several studies have documented the influx of sediment originating in the watershed to the Lagoon. Mudie and Byrne (1980) estimate that sedimentation rates have increased to 50 cm/100 years since European settlement of the area. Between 1968 and 1985,

[4] (http://www.torreypine.org/parks/Peñasquitos-lagoon.html).

sediment from Carmel Valley has raised the elevation of the northeast corner of the lagoon by 6.1 feet, converting salt marsh vegetation into riparian and cattail marsh which helps retain sediment (LPL Foundation and State Coastal Conservancy, 1985). The main depositional areas in the lagoon are just downstream of the I-5 Carmel Valley Creek culverts and at the southern end of the Lagoon near Sorrento Valley. Deposition at the I-5 culvert, which is the outlet of Carmel Valley, was caused by a sewer berm located about 1000' west of I-5 (removed in the late 1980s). Storm flows from Carmel Valley pond behind the berm and allow coarse sediment to be deposited (LPL Foundation and State Coastal Conservancy, 1985). Gradual sediment accumulation in the lagoon has created areas of higher elevation which tidal water no longer reaches. The mouth of Carmel Valley Creek is the primary example of this process. In 1974, coastal salt marsh occupied the Carmel Valley Creek mouth; however, the ground elevation at the lower end of the Carmel Valley culverts rose 6.1 feet in the past 16 years, due to sedimentation from upstream (LPL Foundation and State Coastal Conservancy, 1985).

In an attempt to control the increasing sedimentation rate from development in the watershed, the Regional Board first approved a resolution (70-R26). This resolution established requirements for control of siltation from construction projects in areas that drain to the Lagoon in 1970 (Mudie et al., 1974). Despite these actions, a 1974 report by the California Department of Fish and Game expressed concerns associated with a significant increase in flow of urban runoff draining into the eastern channel. It was determined that the runoff was the result of intensive residential development of the mesas northeast of the lagoon. During the fall of 1973, this runoff volume amounted to approximately 1,500 gal/day (Mudie et al.,1974). Prestegaard (1978) concluded that unmitigated urbanization could double the annual sediment load within 30 years. More recently, the City of San Diego identified increasing urban development, resulting in alterations in hydrology and modified geomorphic conditions within the three main tributaries of the Lagoon's watershed, as a source of sedimentation (City of San Diego, 2005).

The regional climate is characterized by higher precipitation during winter months and lower precipitation, and corresponding high lagoon salinity, during the dry summer months (Williams, 1997). Storm events transport sediment into the lagoon which deposits on the salt flats and within lagoon channels. These sediment deposits have gradually built-up over the years due to increased sediment loading and inadequate flushing, which directly and indirectly affects lagoon functions and salt marsh characteristics.

4.1.5 Habitat alterations

Continued sedimentation and freshwater inputs, both resulting from urbanization, have resulted in significant alterations to habitat (White and Greer, 2002; Greer and Stowe, 2003; CE, 2003; Mudie et al, 1974; LPL Foundation and State Coastal Conservancy, 1985). In 1985, the Los Peñasquitos Lagoon Enhancement Plan estimated that sedimentation had removed 25 acres from the coastal salt marsh inventory. The encroachment of freshwater wetlands and reduction of saltwater marsh is evident in the National Wetland Inventory (NWI) maps from 1985 and 2009 (Figures 13 and 14). The location of different wetland types is also shown in maps that were included in the Los Peñasquitos Lagoon Enhancement Plan (1985) and in the Mudie et al. 1974 report (Figures 15 and 16). Although there are differences in the depiction of wetland areas from each study and time period, these maps show an encroachment of riparian, freshwater, and upland vegetation types in the eastern portion of the lagoon that is likely related to sediment accumulation and impediments to tidal flow. As discussed in Section 3.4, California State Parks estimated that 180 acres of the 390 to 570 acres of coastal salt marsh has been impaired by sedimentation, converting coastal salt marsh to more riparian habitat.

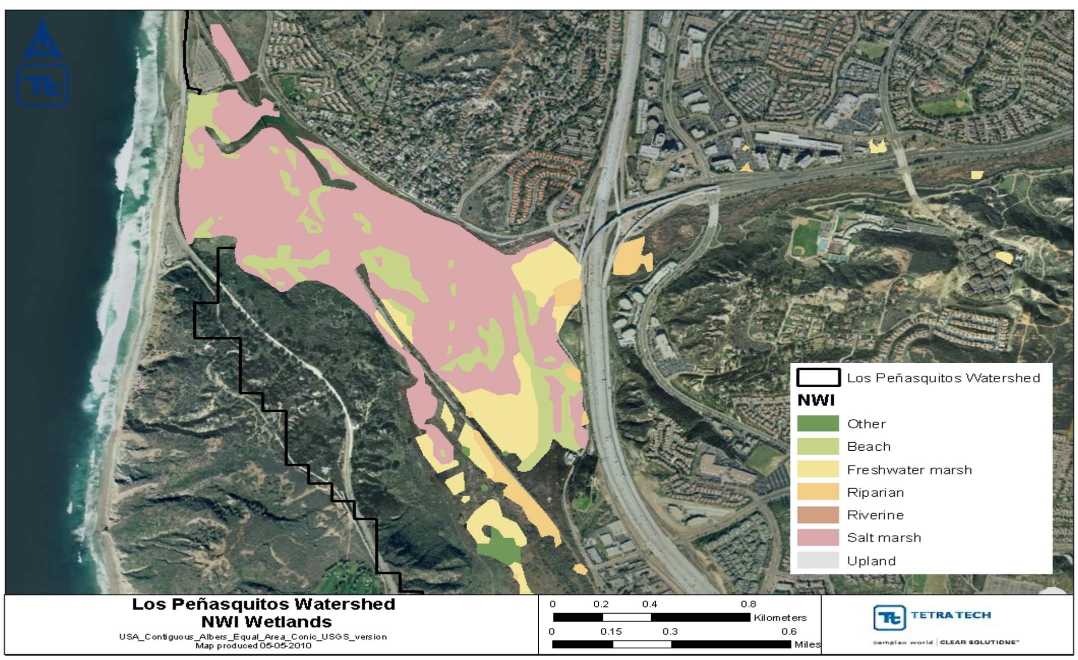

Figure 13. National Wetland Inventory (NWI) - 1985

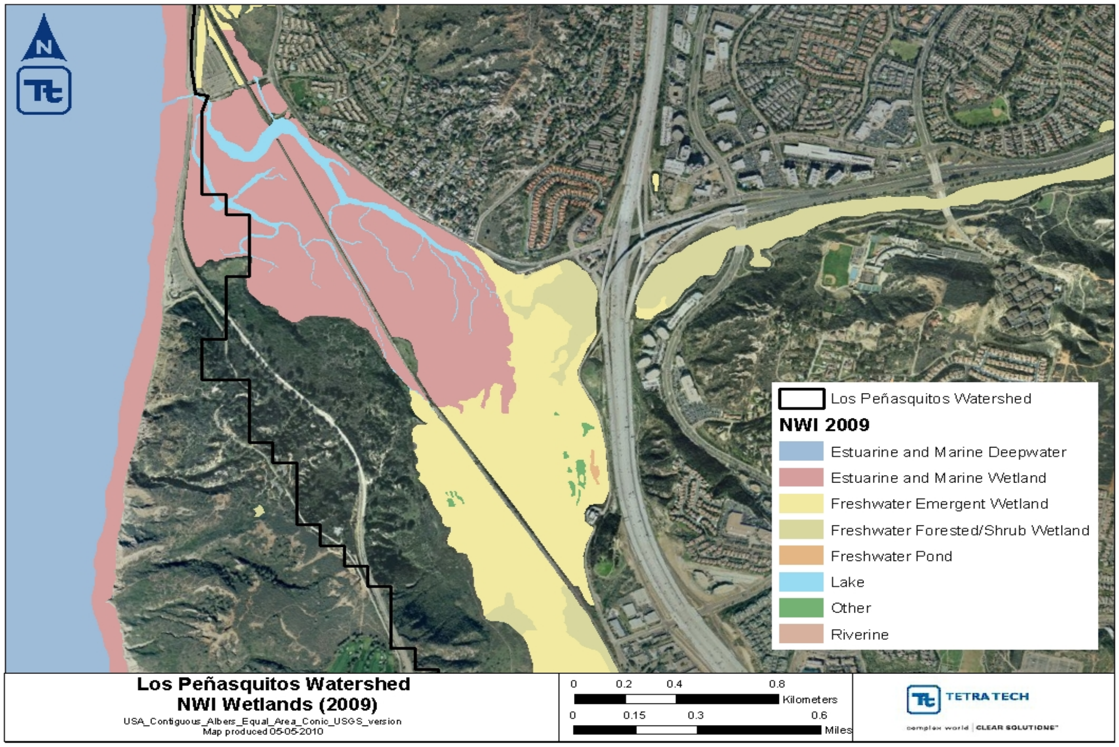

Figure 14. National Wetland Inventory (NWI) - 2009

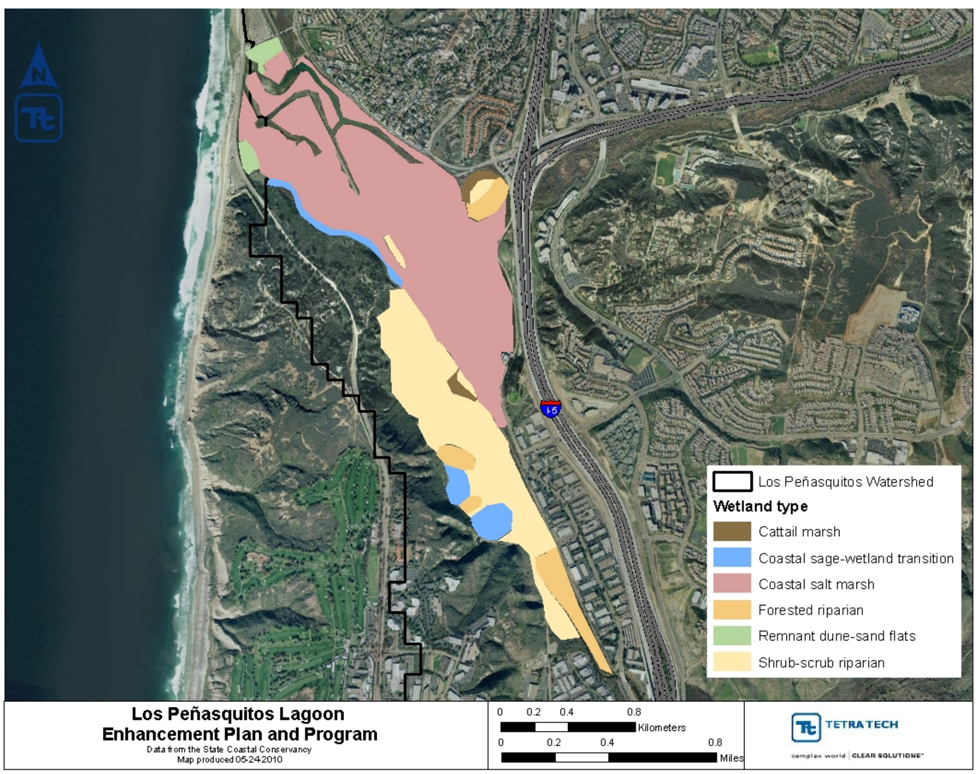

Figure 15. LPL Enhancement Plan – 1985 wetland types

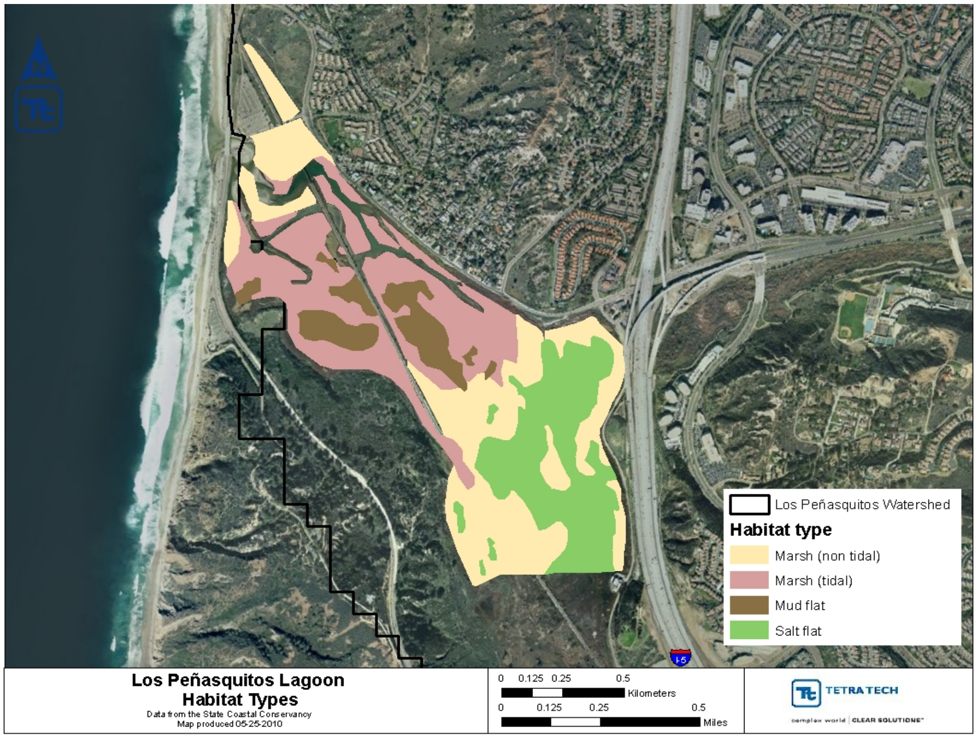

Figure 16. Historical lagoon wetland types (Mudie et al. 1974)

4.2 Impacts of Urbanization on Water Quality

Rapid urbanization of the watershed directly affects the natural drainage, pollutant loads and hydrologic characteristics such as peak flow rates, flow volumes, flow durations, and flow velocities (City of San Diego, 2005). Increased development has resulted in year-round flow in the main tributaries to the Lagoon (White and Greer, 2002; Greer and Stow, 2003). In addition to pollutant loading associated with specific land use practices, urbanization changes the landscape from pervious to impervious. Recent research has shown that impervious surfaces represent the imprint of land development on the landscape and is directly related to runoff (Burton and Pitt, 2002; Scheuler, 1994). Furthermore, impervious cover has been identified as the ‘unifying theme’ in stream degradation (USEPA, 1999); with stream degradation occurring with as little as ten percent imperviousness of the watershed (Scheuler, 1994).

The concerns associated with urban development are multifaceted. Land development typically results in increased erosion and runoff rates; accounting for up to 50 percent of sediment loads in urban areas (Burton and Pitt, 2002). In addition, urbanization increases imperviousness, resulting in alteration of the volume, velocity, duration, and timing of runoff events. Lowered infiltration rates speed surface runoff which leads to increased surface erosion and gullying. Ultimately, increased erosion destabilizes streambanks and washes sediment into surface waters. Freshwater runoff from adjacent and upstream urban development also reduces salinity, and brackish and freshwater plant species have encroached upon the area, reducing the salt marsh acreage (CE, 2003).

Previous studies which focused on the Lagoon and the surrounding watershed provide additional information on historical conditions and hydrologic changes associated with urbanization. For example, White and Greer (2002) classified three distinct periods of urbanization within the upper Los Peñasquitos Creek watershed: 1965-1973 was classified as low urbanization (<15 percent), 1973-1987 as moderate urbanization (15-25 percent), and 1988-2000 as high urbanization (>25%). Across the entire time period, the 1-2 year flood interval increased from 229 cubic feet per second (cfs), to 745 cfs, to 1,272 cubic feet per second in each respective period. Flow duration curves indicate increased baseflow, such that discharges above 1.7 cfs occurred more often during the period between 1973 to1987 than the earlier period (White and Greer, 2002). This study also estimated a four percent increase in runoff, per year, since 1972, with an increase in minimum flows throughout the study equivalent to 17 percent per year (2002). These findings are supported by a recent review of flow data in Los Peñasquitos Creek (Figure 17), which demonstrates a steady increase in monthly mean flows since the 1970s. These analyses illustrate the general urbanization trends throughout the watershed that impact the Lagoon and assist with identifying a period in time when development, and increased sediment delivery from the watershed, was not the primary concern.

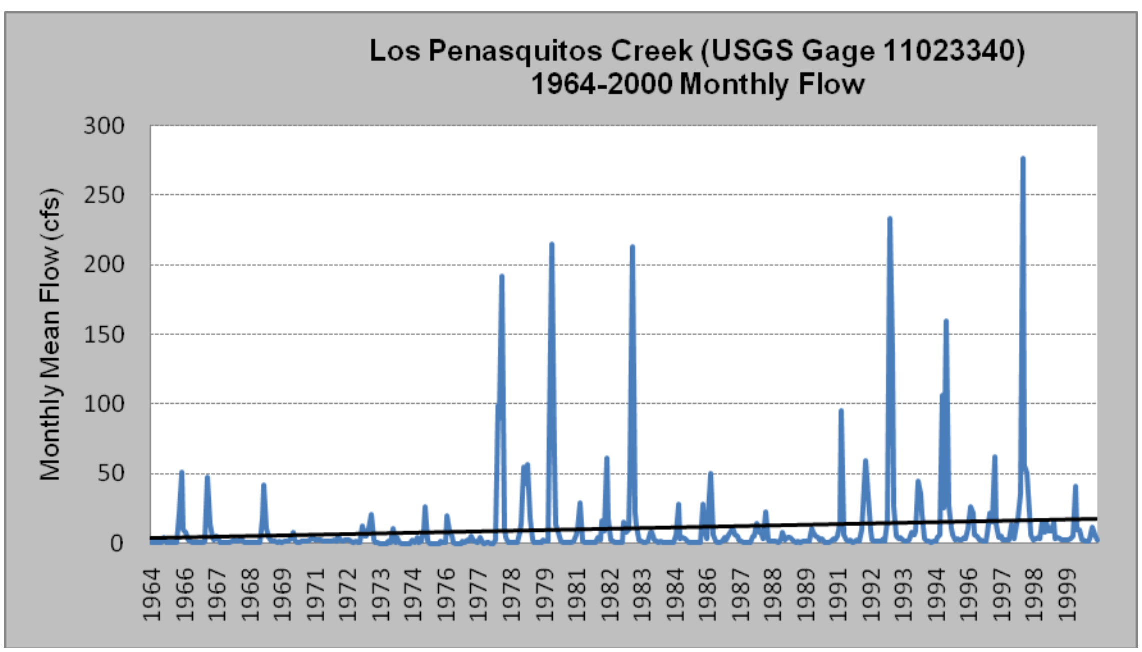

Figure 17. Hydrograph for Los Peñasquitos Creek

4.3 Selection of TMDL Numeric Target

A numeric sediment TMDL target was established through the historical analysis of land use and lagoon conditions using a ‘weight of evidence’ approach. The numeric target provides the link to the narrative WQO for sediment and defines the conditions that will result in the attainment of WQS for the Lagoon. Available data and literature studies of the Lagoon and watershed were evaluated to help identify the general time period when sedimentation impacts were likely minimal. This time period defines the reference condition upon which the numeric sediment target load was calculated. This approach was needed because numeric criteria are not specified in California’s water quality standards and available data for the Lagoon does not specifically define a sediment loading rate or other measure of natural background sediment loading that can be used for TMDL development.

Several lines of evidence were considered when evaluating the watershed and Lagoon conditions in order to determine an appropriate reference time period for TMDL development. These lines of evidence include:

- **Urbanization trends**: A review of historical literature that describes urbanization in the watershed (Section 4.1) indicates that intensive development began in the in the mid-1970s. Land use data shows a nearly 37% decrease in open space in the watershed beginning in the mid 1970s.
- **Population data**: Trend analysis of population data (Section 4.1) indicates that the population of the San Diego region has been steadily increasing since 1970.
- **Flow data**: Review of historical streamflow data from the USGS gage on Los Peñasquitos Creek and the conclusions drawn by White and Greer (2002) indicate that flow has increased substantially since the 1970s. White and Greer (2002) associated these flow increases with urbanization trends in the watershed.
- **Evaluation of Lagoon conditions** (Section 4.1.1). As described above, Lagoon conditions have been influenced by several factors, which can be separated into watershed impacts and problems associated with the lagoon mouth. Salt marsh habitat loss is primarily associated with long-term sedimentation impacts, reduced tidal flushing, and year-round freshwater input. Watershed impacts to the Lagoon include sediment delivery associated with urban development, which increased substantially in the mid-1970s. The wastewater treatment plants impacted water quality in the Lagoon until 1972 when the area was connected to the city sewer system, making it difficult to differentiate between the wastewater impacts and development-associated impacts during this time period (pre-1972). Available literature indicates that sediment deposition from the watershed is not adequately flushed out of the system due to problems at the lagoon mouth caused by the railroad berm (and other physical alterations) and sediment build-

up at the ocean inlet. Note that the Highway 101 bridge abutments were recently replaced and have resulted in improved tidal exchange through the area. As discussed above, reductions in the tidal prism have resulted in increased sediment build-up at the ocean inlet. Sediment impacts at the ocean inlet are primarily a function of littoral forces (Elwany, 2008) and other factors that are largely separate from the sedimentation problems that originate from the watershed. These factors are important to understand in order to effectively manage and improve conditions within the Lagoon, but are outside the scope of the sediment TMDL analysis.

Consideration of these various lines of evidence indicates that the Lagoon was likely achieving WQS for sediment before the mid-1970s; therefore the numeric target was calculated based on the historic mid-1970s land use distribution for the watershed (Figure 10). Existing and historic land use areas and the calculated percent change by land use category are shown in Table 2. This table indicates that open space decreased by nearly 37% between the mid-1970s and existing conditions (based on SANDAG 2000 land use data). The percent impervious associated with the historic land use cover was also determined. Overall, in the mid-1970s the Los Peñasquitos Lagoon watershed was approximately 9.4% percent impervious, which is just below the threshold of stream degradation that occurs at 10 to 15 percent of watershed imperviousness (Scheuler, 1994), thereby further justifying use of this historic time period.

The historic land use coverage was used to calculate the sediment load to the Lagoon using the LSPC watershed model (see Appendix A). This historic sediment load represents the sediment TMDL numeric target.

5 Data Inventory and Analysis

Multiple data sources were used to characterize the watershed and Lagoon, in particular stream flow and water quality conditions. Much of this information was recently collected by watershed stakeholders to assist with TMDL model development. Data describing the watershed's topography, land use, soil characteristics, meteorological data, and irrigation needs along with available bathymetric survey information and data sondes analyzing pressure and salinity were used to calibrate the watershed and Lagoon models. This section summarizes stream flow and total suspended sediment data; refer to the Modeling Report (Appendix A) for additional details.

5.1 Streamflow Data Summary

Available streamflow data collected within the watershed were compiled for model calibration and validation. The United States Geological Survey (USGS) maintains a long term flow gage (11023340) in the upper Los Peñasquitos watershed (Figure 18). Daily data from 1990 through 2008 were downloaded for calibration of model hydrologic parameters. Total suspended solids (TSS) data were also collected at this location and a downstream USGS sediment monitoring station (325423117124501) (see Section 5.2). Additional streamflow data were collected at the base of Los Peñasquitos, Carroll Canyon, and Carmel Creeks as part of the Los Peñasquitos TMDL monitoring study (City of San Diego, 2009) as described in the Modeling Report (Appendix A) (Figure 18).

Los Peñasquitos Creek drains the largest area within the watershed and, accordingly, recorded the highest measured flows and runoff volume (Figure 19). Review of recent data (2007-2008) shows that median flows in Los Peñasquitos Creek were roughly twice those in Carmel Creek and two orders of magnitude greater than in Carroll Canyon Creek. A continual increase in cumulative volume for Los Peñasquitos Creek and Carmel Creek indicated consistent baseflows. By contrast, streamflow data collected on Carroll Canyon Creek included periods with little change in cumulative volume, flashy response time, and low baseflow. Low flows at this station were within the tenth percentile. Additional stream flow data, including a discussion of data from the mass loading station (MLS) and location-specific challenges to flow monitoring are presented in Appendix A.

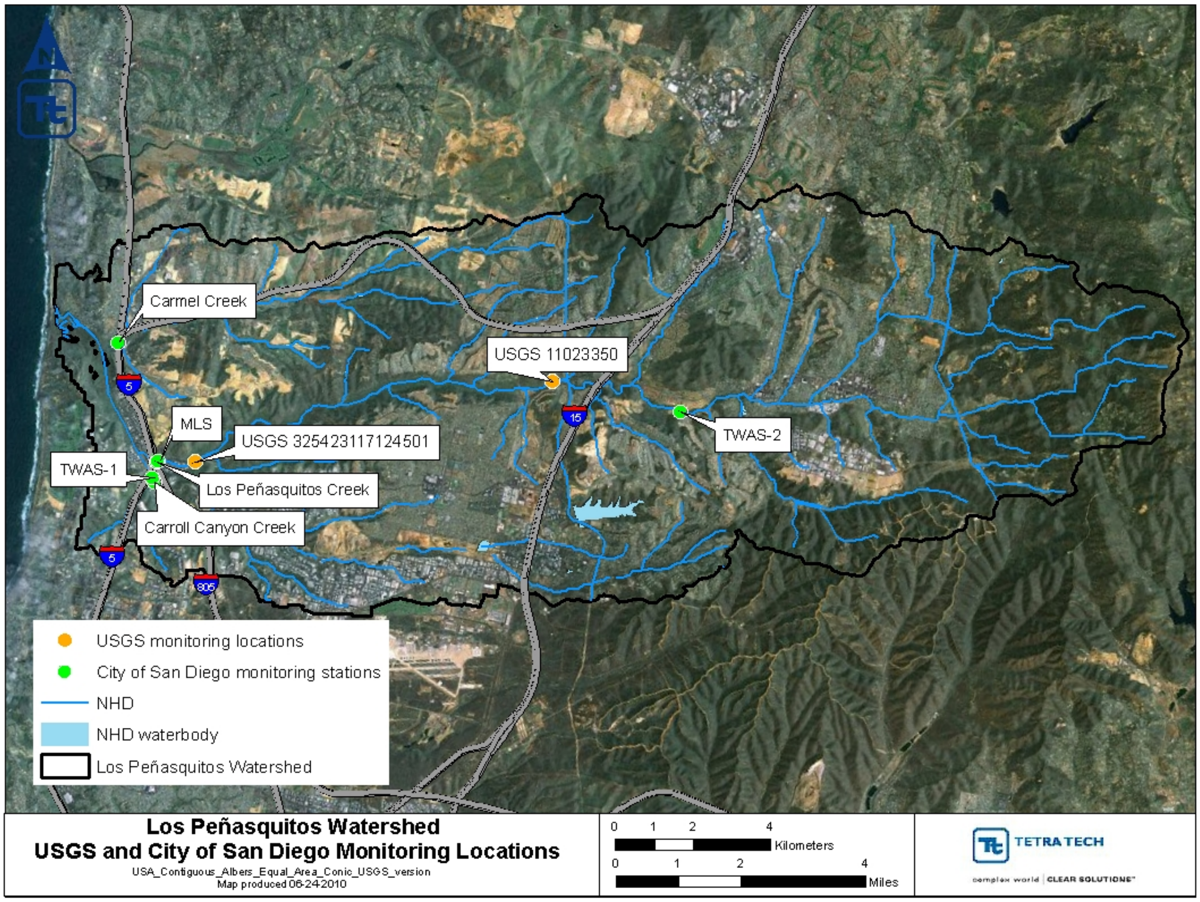

Figure 18. Monitoring locations in the Los Peñasquitos watershed

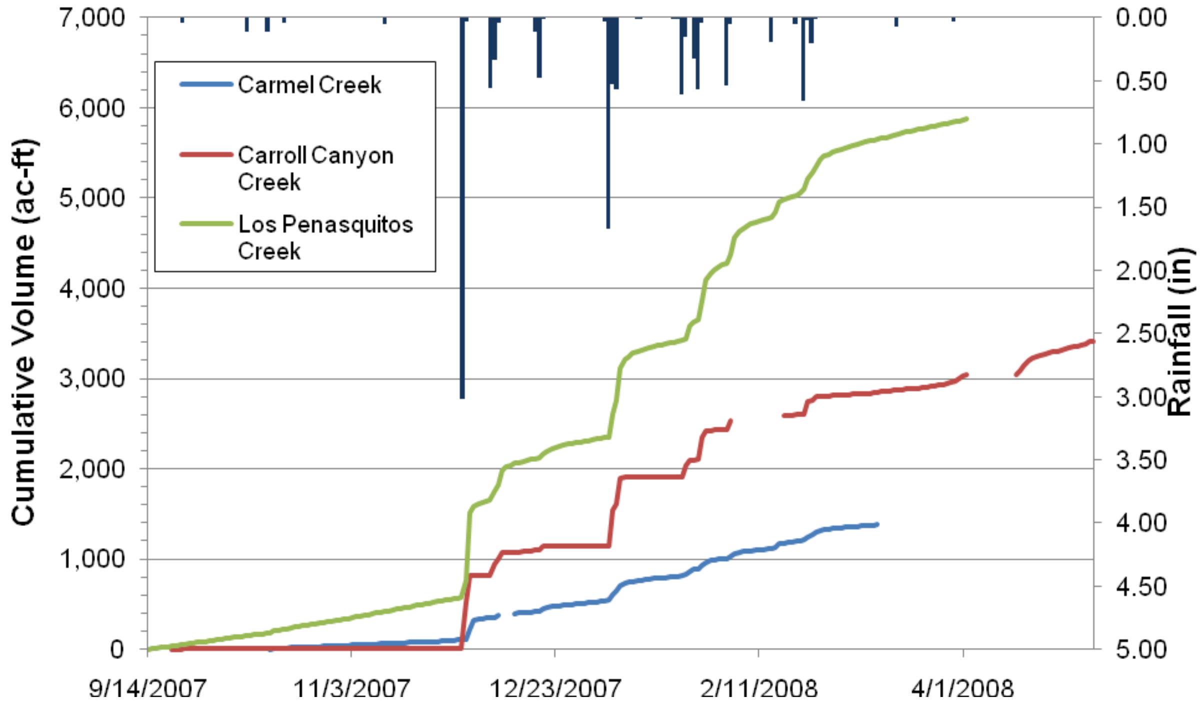

Figure 19. Cumulative flow volumes at TMDL monitoring locations

5.2 Suspended Sediment Data Summary

Total suspended solids and particle size data were collected by the City of San Diego (in accordance with Regional Board requirements) at several locations within the Los Peñasquitos watershed and used to develop and calibrate the watershed model (Figure 18). The USGS collected samples at gage 11023340 as well as at gage 325423117124501 (USGS, 2009). Event mean concentrations (EMCs) from storm water and dry weather runoff were collected at the MLS on Los Peñasquitos Creek immediately upstream of the confluence with Carroll Canyon Creek. Storm water and dry weather runoff events were also monitored at this station since 2001, in accordance with NPDES permit requirements. In addition, two Temporary Watershed Assessment Stations (TWAS) are located within the watershed on Los Peñasquitos Creek upstream (TWAS-2) and on Carroll Canyon Creek (TWAS-1). Collectively, these data were used to better understand the relationship between flow and sediment loading for model development purposes.

Pollutograph samples characterizing suspended sediment concentration changes throughout a storm were collected during three storms in the 2007-2008 storm season as part of the TMDL monitoring study. Samples were collected from the three major streams flowing into the lagoon: Los Peñasquitos, Carroll Canyon, and Carmel Creeks.

Longer-term datasets were also available for comparison (MLS and USGS stations). TSS concentrations recorded at the MLS on Los Peñasquitos Creek since 2001 were more than five times lower than the data collected by the USGS at both stations, possibly due to the presence of cattails upstream of the Los Peñasquitos MLS and the presence of the El Cuervo Norte wetland diverting flows from Los Peñasquitos Creek (Figure 20). When comparing just the pollutographs for the three major streams, TSS EMCs at Carroll Canyon Creek were consistently higher than those at Los Peñasquitos and Carmel Creeks (Figure 20). Additional details on sediment data, including particle size distribution, further comparison of the pollutographs and EMCs, and correlations with rainfall are presented in Appendix A.

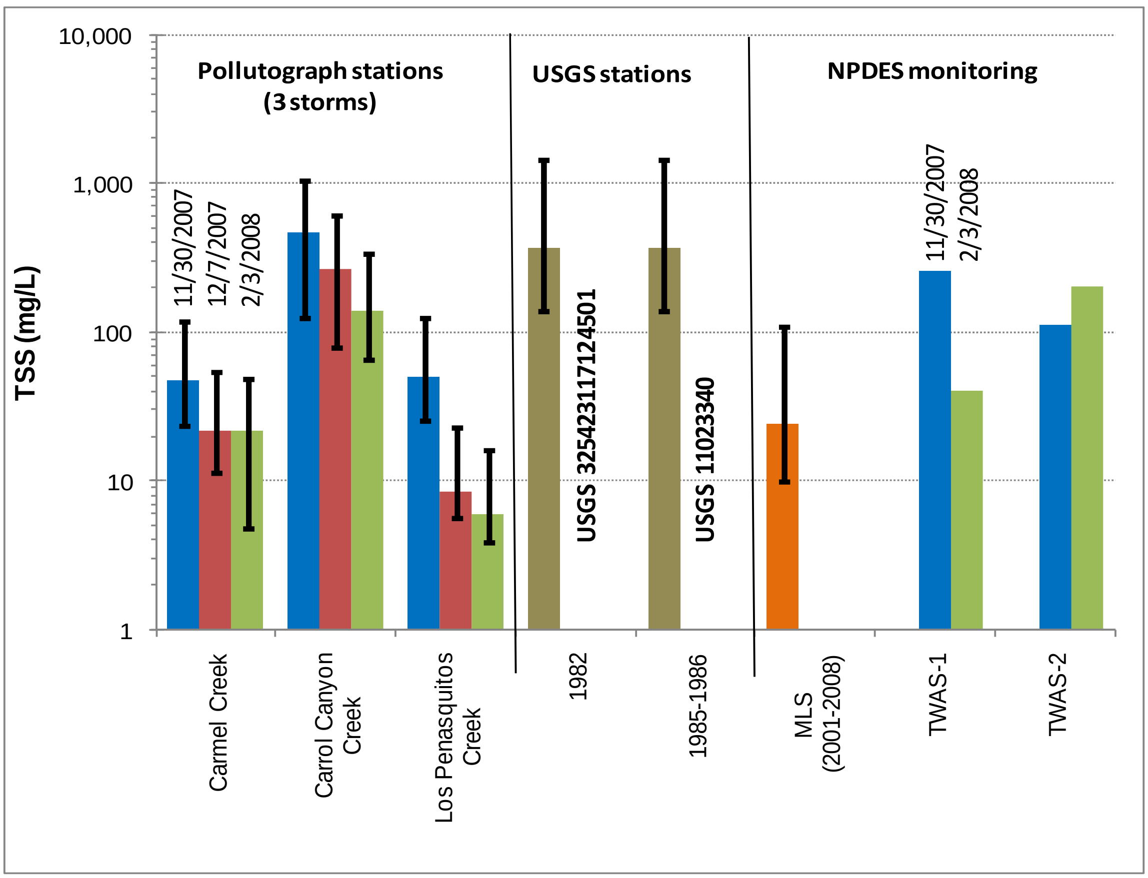

Figure 20. EMC/Median TSS and 95th percentile confidence intervals for all sampling events

6 Source Assessment

The purpose of the source assessment is to identify and quantify the sources of sediment to the Los Peñasquitos Lagoon. Sediment can enter surface waters from both point and nonpoint sources. Point sources typically discharge at a specific location from pipes, outfalls, and conveyance channels from, for example, municipal wastewater treatment plants or municipal separate storm sewer systems (MS4s). These discharges are regulated through waste discharge requirements (WDRs) that implement federal NPDES regulations issued by the State Water Board or the Regional Board through various orders. Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters. Some nonpoint sources, such as agricultural and livestock operations are regulated under the Basin Plan's waste discharge requirement waiver policy (Waiver Policy). The source assessment quantification is measured as an annual or daily load, which is then used to separate the load allocations or wasteload allocations for the TMDL. The following sections discuss the sediment sources that contribute to Los Peñasquitos Lagoon.

6.1 Land Use / Sediment Source Correlation

Sources of sediment are generally the same under both wet weather and dry weather conditions; however, storm events can cause significant erosion and transport of sediment downstream (especially from canyon areas below storm water outfalls). Dry weather loading is dominated by nuisance flows from urban land use activities such as car washing, sidewalk washing, and lawn over-irrigation, which pick up and transport sediment into receiving waters. Wet weather loading is dominated by episodic storm flows that wash off sediment that has built up on land surfaces during dry periods and from canyon areas below storm water outfalls. Due to the higher runoff potential associated with wet weather conditions, emphasis was placed on characterizing wet weather watershed loading.

Sediment sources were quantified by land use group since sediment loading can be highly correlated with land use practices. For example, land disturbance may occur from construction or agricultural practices, disturbing native vegetative cover and leaving the soil susceptible to erosion. With the native cover disturbed, a rainfall event can cause soil detachment and further erosion of the land due to overland flow. For impervious areas, a different process occurs where sediment builds up over time to a maximum amount for each impervious land use type. For both pervious and impervious land uses, the amount of sediment that can be transported is a function of runoff. Scouring of stream banks can also occur in un-protected areas.

Since several land use types share hydrologic or pollutant loading characteristics, many were grouped into similar classifications, resulting in a subset of nine categories for modeling. Selection of these land use categories was based on the availability of monitoring data and literature values that could be used to characterize individual land use contributions and critical sediment-contributing practices associated with different land uses. For example, multiple urban categories were represented independently (e.g., high density residential, low density residential, and commercial/institutional), whereas other natural categories were grouped. The three major land use sources in the watershed are open space, low density residential, and industrial/transportation.

The sediment load contributed by each land use type was calculated using the LSPC model. Modeling parameters varied by land use to provide the correlation between sediment loading and land use type. The amount of runoff and associated sediment concentrations are highly dependent on land use.

6.2 Point Sources

Storm water runoff is regulated through the following NPDES permits: the San Diego County Phase I municipal separate storm sewer system (MS4) permit, the Phase II MS4 permit for small municipal dischargers, and the statewide storm water permit issued to Caltrans. The permitting process defines these discharges as point sources because storm water is discharged from the end of a storm water conveyance system, as described below. NPDES permits are also issued for construction and industrial sites that are enrolled in the statewide General Storm Water permit program. These sites are located within areas controlled by the San Diego County Phase I MS4 permit and are, therefore, not specifically included in the TMDL analysis.

6.2.1 Phase I Municipal Separate Storm Sewer System (MS4)

In 1990, the USEPA developed rules establishing Phase I of the NPDES storm water program, designed to prevent harmful pollutants from being washed by urban runoff into MS4s or from being discharged directly into MS4s, and then local receiving waters. Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or more) to implement an urban runoff management program as a means to control polluted discharges from MS4s.

Approved urban runoff management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipally owned operations and hazardous waste treatment. More specifically, large and medium operators are required to develop and implement Urban Runoff Management Plans that address, at a minimum, the following elements:

- Structural control maintenance;
- Areas of significant development or redevelopment;
- Roadway runoff management;
- Flood control related to water quality issues;
- Municipally owned operations such as landfills, wastewater treatment plants, etc.;
- Hazardous waste treatment, storage, or disposal sites, etc.;
- Application of pesticides, herbicides and fertilizers;
- Illicit discharge detection and elimination;
- Regulation of sites classified as associated with industrial activity;
- Construction site and post-construction site runoff control; and
- Public education and outreach.

Twenty one entities are identified in Regional Board Order R9-2007-0001 (NPDES No. CAS0108758) and are responsible for addressing water quality concerns for the MS4 (Regional Board, 2007). Responsible Municipal Dischargers within the Los Peñasquitos watershed are San Diego County, the City of San Diego, the City of Del Mar, and the City of Poway.

During wet weather events, significant erosion can occur along canyon walls below storm water outfalls. Sediment also builds up on the land surface from various sources and associated management practices and is then washed off the surface during rainfall events. The amount of runoff and associated concentrations are, therefore, highly dependent on the nearby land management practices. Note that the redistribution of sediment to other areas of the Lagoon can be caused by both anthropogenic and natural processes; however, most of the sediment is contributed by point sources in the watershed so this resuspension is associated with and quantified in the MS4 load calculations.

All land uses were classified as generating point source loads because, although the sediment sources on these land use types may be diffuse in origin, the pollutant loading is transported and discharged to receiving waters through the MS4. Sediment loads that are attributed to point sources are discharged via the MS4 from all land uses. Note that several construction and industrial sites regulated under the General Statewide Storm Water Permit program are located within the Phase 1 MS4 permitted area. Additional information would be needed to estimate the sediment load contribution from these sites.

6.2.2 Phase II Municipal Separate Storm Sewer System (MS4)

In 1999, the USEPA developed rules establishing Phase II of the NPDES storm water program, extending the regulations to storm water discharges from small MS4s located in “urbanized areas” and construction activities that disturb 1 to 5 acres of land. Small MS4 systems are not permitted under the municipal Phase I regulations, and are owned or operated by the United States, a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity.

The General Permit for the Discharge of Storm Water from Small MS4s, Water Quality Order No. 2003-0005-DWQ (Small MS4 General Permit) regulates discharges of storm water from “regulated Small MS4s.” A “regulated Small MS4” is defined as a Small MS4 that discharges to a water of the United States or to another MS4 regulated by an NPDES permit. The General Permit requires that Small MS4 Dischargers develop and implement a Storm Water Management Program (SWMP) that reduces the discharge of pollutants through their MS4s to the Maximum Extent Practicable (MEP). The SWMP must describe the best management practices (BMPs), measurable goals, include time schedules of implementation, and assign responsibility of each task.

Non-traditional Small MS4s may also require coverage by the permit. The non-traditional Small MS4s include those located within or discharge to a permitted MS4, and that pose significant water quality threats. In general, these are storm water systems serving public campuses (including universities, community colleges, primary schools, and other publicly owned learning institutions with campuses), military bases, and prison and hospital complexes within or adjacent to other regulated MS4s, or which pose significant water quality threats. The State Water Board considered designating non-traditional small MS4s when adopting this General Permit.

Entities that enroll in Order No. 2003-0005-DWQ are responsible for addressing water quality concerns from their small MS4s. In the San Diego Region, the non-traditional small MS4s that are subject to the Order include the San Diego Unified School District (SDUSD) and others, as applicable, in the watershed.

As with Phase I MS4s, pollutants build up on land surfaces and then are washed off during rainfall events. The amount of runoff and associated concentrations are highly dependent on the nearby land uses and management practices.

6.2.3 Caltrans MS4s

Caltrans is regulated by a statewide storm water discharge permit that covers all municipal storm water activities and construction activities (State Board Order No. 99-06-DWQ; CAS000003). The Caltrans storm water permit authorizes storm water discharges from Caltrans properties such as the state highway system, park and ride facilities, and maintenance yards. The storm water discharges from most of these Caltrans properties and facilities eventually ends up in either a city or county storm drain system.

6.3 Nonpoint Sources

A nonpoint source is a source that discharges via sheet flow or natural discharges. Additionally, storm surges and ocean tides can be a source of sediment to the mouth of the Lagoon; however, a recent study found that accumulated sediment at the Lagoon's ocean inlet was similar to beach sediment and tidal sources (Elwany, 2008). For this reason, watershed loading was assumed to have a less significant contribution to sediment build-up at the inlet. Beach erosion processes cannot be modeled with the existing model configuration which lacks wave, wave-breaking, and wave-current interaction components; therefore, sediment modeling used a reduced grid which sets the open ocean boundary immediately outside of the ocean inlet (see Appendix A for a more detailed discussion).

7 Linkage Analysis

The technical analysis of the relationship between pollutant loading from identified sources and the response of the waterbody to this loading is referred to as the linkage analysis. The purpose of the linkage analysis is to quantify the maximum allowable sediment loading that can be received by an impaired waterbody and still attain the WQOs of the applicable beneficial uses. This numeric value is represented by the TMDL.

The linkage analysis for this TMDL is based on computer models that were developed to represent the physical processes within the impaired receiving waterbody and the associated watershed. The models provide estimation of sediment loadings from the watersheds based on rainfall events, and simulation of the response of the receiving water to these loadings. The following sections provide more detailed discussion regarding model selection and linkage analyses.

7.1 Model Selection Criteria

In selecting an appropriate approach for TMDL calculation, technical and regulatory criteria were considered. Technical criteria include the physical system, including watershed or receiving water characteristics and processes and the constituents of interest. Regulatory criteria include water quality objectives or procedural protocol. The following discussion details the considerations in each of these categories. Based on these considerations, appropriate models were chosen to simulate watershed and receiving water conditions.

7.2 Technical Criteria

Technical criteria were divided into four main topics. Consideration of each topic was critical in selecting the most appropriate modeling system to address the types of sources and the numeric target associated with the impaired waterbody.

Physical Domain

Representation of the physical domain is perhaps the most important consideration in model selection. The physical domain is the focus of the modeling effort—typically, either the receiving water itself or a combination of the contributing watershed and the receiving water. Selection of the appropriate modeling domain depends on the constituents and the conditions under which the waterbody exhibits impairment. For a waterbody dominated by point source inputs that exhibits impairments under only low-flow conditions, a steady-state approach is typically used. If the system includes tidal influences, quasi-steady-state simulation is typically performed that assumes steady-state inputs, but includes diurnal variability in hydrodynamics associated with tidal effects. The steady-state and quasi-steady-state modeling approaches primarily focus on receiving water processes during a user-specified condition.

For waterbodies affected additionally or solely by nonpoint sources or primarily rainfall-driven flow and pollutant contributions, a dynamic approach is recommended. Dynamic models consider time-variable nonpoint source contributions from a watershed surface or subsurface, as well as a hydrodynamic response of the receiving water. Some models consider monthly or seasonal variability, while others enable assessment of conditions immediately before, during, and after individual rainfall events. Dynamic models require a substantial amount of information regarding input parameters and data for calibration purposes.

Source Contributions

Primary pollutant sources must be considered in the model selection process. Accurately representing contributions from nonpoint sources and point sources is critical in properly representing the system and ultimately evaluating potential load reduction scenarios.

Water quality monitoring data were not sufficient to fully characterize all sources of sediment to the Lagoon, however, available data indicate that the main controllable sources are watershed runoff and streambank erosion. As a result, the models selected to develop a sediment TMDL for the Los Peñasquitos Lagoon need to address the major source categories during conditions considered controllable for TMDL implementation purposes.

Critical Conditions

The goal of the TMDL analysis is to determine the assimilative capacity of the waterbody and to identify potential allocation scenarios that will enable that waterbody to achieve WQOs. The critical condition is the set of environmental conditions for which controls designed to protect water quality will ensure attainment of objectives for all other conditions. This is typically the period of time in which the waterbody exhibits the most vulnerability. For the Lagoon and its watershed there is a high degree of variability in when sediments are deposited at the mouths of each creek. This variability is due to the nature of wet weather events that represent the critical condition for sediment deposition.

Constituents

Another important consideration in model selection and application is the constituent(s) to be assessed. Choice of state variables is a critical part of model implementation. The more state variables included, the more difficult the model will be to apply and calibrate.

However, if key state variables are omitted from the simulation, the model might not simulate all necessary aspects of the system and might produce unrealistic results. A delicate balance must be met between minimal constituent simulation and maximum applicability.

7.3 Regulatory Criteria

A properly designed and applied model provides the source-response linkage component of the TMDL and enables accurate assessment of assimilative capacity and allocation distribution. The receiving water's assimilative capacity is determined by assuming adherence to WQOs. For all waters in the San Diego Region, the Basin Plan establishes the beneficial uses for each waterbody to be protected and the WQOs that protect those uses. In the case of narrative objectives, interpretation is required to develop a numeric target for TMDL development (refer to Section 4). The modeling framework must enable direct comparison of model results to the selected numeric target and allow for the analysis of the duration of those conditions. For the watershed loading analysis and implementation of required reductions, it is also important that the modeling framework allow for the examination of gross land use loading.

7.4 Model Selection and Overview

Establishing the relationship between the receiving water quality target and source loading is a critical component of TMDL development. This allows for the evaluation of management options that will help achieve the desired source load reductions. This can be established through a number of techniques, ranging from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. The objective of this section is to present the approach taken to develop the linkage between sources and receiving water responses for TMDL development in the Lagoon.

In addition, to assist in TMDL development and to provide decision support for watershed management, the models can be used to simulate various scenarios and may require future modifications to address specific management and environmental factors. Such scenarios may result from the augmentation of input data to be collected in ensuing monitoring efforts, future implementation of various management strategies or best management practices (BMPs), or adaptation and linkage to additional models developed in subsequent projects. Therefore, model flexibility is a key attribute for model selection.

The modeling system was divided into two components representative of the processes essential for accurately modeling hydrology, hydrodynamics, and water quality. The first component of the modeling system is a watershed model that predicts runoff and external pollutant loading as a result of rainfall events. The second component is a hydrodynamic and water quality model that simulates the complex water circulation and pollutant transport patterns in the Lagoon.

The models selected for the Lagoon sediment TMDL are components of USEPA's TMDL Modeling Toolbox (Toolbox), which was developed through a joint effort between USEPA and Tetra Tech, Inc. (USEPA, 2003). The Toolbox is a collection of models, modeling tools, and databases that have been utilized over the past decade to assist with TMDL development and other environmental studies. The Loading Simulation Program in C++ (LSPC) is the primary watershed hydrology and pollutant loading model and the Environmental Fluids Dynamic Code (EFDC) is the receiving water hydrodynamic and water quality model in the Toolbox modeling package. Both the LSPC and EFDC models are summarized below and described in detail in the Modeling Report (Appendix A).

7.4.1 Watershed Model: Loading Simulation Program in C++ (LSPC)

LSPC was selected for simulation of land-use based sources of sediment and the hydrologic and hydraulic processes that affect delivery (Shen et al., 2004; Tetra Tech and USEPA, 2002; USEPA, 2003). LSPC was specifically used to simulate watershed hydrology and transport of sediments in the streams and storm drains flowing to the impaired Lagoon. LSPC is a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) (Bicknell et al., 1997) algorithms for simulating hydrology, sediment, and general water quality on land, as well as a simplified stream fate and transport model. Since its original public release, the LSPC model has been expanded to include additional GQUAL components for sorption/desorption of selected water quality constituents with sediment, enhanced temperature simulation, and the HSPF RQUAL module for simulating dissolved oxygen, nutrients, and algae.

The hydrologic (water budget) process is complex and interconnected within LSPC. Rain falls and lands on various constructed landscapes, vegetation, and bare soil areas within a watershed. Varying soil types allow the water to infiltrate at different rates while evaporation and plant matter exert a demand on this rainfall. Water flows overland and through the soil matrix. There may also be point source discharge and water withdrawals/intakes. The land representation in the LSPC model environment considers three flowpaths; surface, interflow, and groundwater outflow. The sediment routine in LSPC represents the general detachment of sediment due to rainfall, overland and instream transport, attachment when there is no rainfall, and scour.

The model can simulate sediment loadings from specific source areas (i.e., subwatershed or land use areas). This is important in terms of TMDL development and allocation analysis. For this TMDL, the LSPC model was used to calculate both historic and existing conditions within the watershed to establish the TMDL numeric target and required load reductions from existing conditions. The LSPC model output was incorporated as an input to the receiving water model for the Lagoon, as described below.

7.4.2 Lagoon Model: Environmental Fluid Dynamics Code (EFDC)

The Los Peñasquitos Lagoon was simulated using the EFDC model. The LSPC watershed model was linked to EFDC and provided all freshwater flows and loadings as model input. EFDC is a public domain, general purpose modeling package for simulating one-dimensional (1-D), two-dimensional (2-D), and three-dimensional (3-D) flow, sediment transport, and biogeochemical processes in surface water systems including rivers, lakes, estuaries, reservoirs, wetlands, and coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications (Hamrick, 1992). This model is now being supported by the USEPA and has been used extensively to support TMDL development throughout the country. In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and noncohesive sediment transport, near-field and far-field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. The EFDC model has been extensively tested, documented, and applied to environmental studies worldwide by universities, governmental agencies, and other entities.

The EFDC model includes four primary modules: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model. The hydrodynamic model predicts water depth, velocities, and water temperature. The water quality portion of the model uses the results from the hydrodynamic model to compute the transport of the water quality variables. The water quality model then computes the fate of up to 22 water quality parameters including dissolved oxygen, phytoplankton (three groups), benthic algae, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria (Cerco and Cole 1994). The sediment transport and toxics modules use the hydrodynamic model results to calculate the settling of suspended sediment and toxics, resuspension of bottom sediments and toxics, and bed load movement of noncohesive sediments and associated toxics. For this project, the hydrodynamics and sediment transport models were used. The hydrodynamics model simulated the circulation, water temperature, and salinity in the lagoon driven by ocean tides and watershed inflows. The sediment transport model simulated the transport of sand, silt as non-cohesive sediments, and clay as cohesive sediment. Details of the EFDC model's hydrodynamic and eutrophication components are provided in Hamrick (1992) and Tetra Tech (2002, 2006a, 2006b, 2006c, 2006d).

The EFDC model was configured to simulate hydrodynamics and sediment transport in the Los Peñasquitos Lagoon for both existing and historic conditions. Specifically, water temperature and salinity were both modeled for hydrodynamics. Sediment fractions considered in the model include sand, silt, and clay. Sand and silt were modeled using the non-cohesive sediment module and clay was modeled using the cohesive sediment module in EFDC.

7.5 Model Application

A complete discussion, including model configuration, hydrologic and hydrodynamic calibration and validation, and water quality calibration and validation, of the LSPC and EFDC models is provided in the Modeling Report (Appendix A). These models provide the technical analysis framework that will be used to make regulatory and management decisions for the Lagoon and its watershed.

The models were initially calibrated to observed hydrologic and water quality data to characterize existing conditions in the watershed and Lagoon (required load reductions are based on these existing loads). In addition, the models were used to establish a TMDL numeric target for sediment. As described in Section 4, a historical review of available literature regarding urbanization trends and Lagoon impacts was used to identify an appropriate time period (mid 1970s) for calculating the numeric target that represents the sediment WQO. Conditions present at this time were associated with loads that met WQOs and did not adversely impact the Lagoon. To characterize this historical period, a historic land use coverage for the watershed was developed and model simulations were performed. The resulting historical net annual sediment load was identified as the TMDL numeric target and represents the loading (assimilative) capacity for the lagoon (i.e. the TMDL). Percent reductions were calculated based on the difference between the TMDL load and the sediment load that corresponds with existing conditions.

8 Identification of Load Allocations and Reductions

The calibrated models were used to simulate historical and existing sediment loads to the Los Peñasquitos Lagoon from which numeric targets and load reductions were established. Point sources were then assigned a wasteload allocation (WLA) while nonpoint sources were assigned a load allocation (LA). This section discusses the methodology used for TMDL development and the results in terms of loading capacities and required load reductions for the Los Peñasquitos Lagoon. Other TMDL components are also discussed including the margin of safety (MOS), seasonality and critical conditions, and a daily load expression.

8.1 Loading Analysis

The calibrated LSPC model was used to estimate existing sediment loads to the Lagoon, with the receiving water simulated based on the EFDC model (see Appendix A). Using the EFDC model, the assimilative capacity of the Lagoon was assessed and compared to the historical numeric target for evaluation of sediment quality.

8.2 Application of Numeric Targets

As discussed in Section 4, the narrative WQO for sediment was interpreted using a weight of evidence approach to determine a reference condition to define the TMDL numeric target (i.e., a historical period when the Lagoon was not impaired for sedimentation). Several lines of evidence used to establish a numeric sediment target include: urbanization trends, population data, flow data, and evaluation of Lagoon conditions over time.

8.3 Load Estimation

Estimation of current watershed loading to the impaired Lagoon required use of the LSPC model to predict flows and pollutant concentrations. The dynamic model-simulated watershed processes, based on observed rainfall data as model input, provided temporally variable load estimates for the critical period. These load estimates were simulated using calibrated, land use-specific processes associated with hydrology and sediment transport (see Appendix A).

8.4 Identification of Critical Conditions

Due to the higher transport potential of sediment during wet weather, the 1993 El Nino time period was selected as the critical period for assessment. The wet season that includes the 1993 El Nino storm events (10/1/92 – 4/30/93) is one of the wettest periods on record over the past several decades. Statistically, 1993 corresponds with the 93rd

percentile of annual rainfall for the past 15 years measured at the San Diego Airport (Lindbergh Field). Selection of this year was also consistent with studies performed by the Southern California Coastal Water Research Project (SCCWRP). An analysis of rainfall data for the Los Angeles Airport from 1947 to 2000 shows that 1993 was the 90th percentile year; meaning 90 percent of the years between 1947 and 2000 had less annual rainfall than 1993 (Los Angeles Water Board, 2002).

8.5 Critical Locations for TMDL Calculation

For TMDL calculation, a critical location within the impaired waterbody is selected for comparison to the numeric target in order to determine the required pollutant load reductions needed to meet the WQOs. The selection of a critical location (or locations) represents a conservative assessment of water quality conditions, as these areas typically display the worst water quality conditions and are the most vulnerable to pollution impacts. Although, a critical location is used for water quality assessment in the TMDL analysis, compliance with WQOs must be assessed and maintained throughout a waterbody in order to protect beneficial uses.

Due to the variability and dynamic nature of conditions within the Lagoon (e.g., mouth closures, tidal fluctuations, sediment fate and transport, etc.), the entire modeled Lagoon area was assessed as the critical location. Load reductions for sediment were based on achieving the numeric TMDL target across the Lagoon.

8.6 Calculation of TMDLs and Allocation of Loads

Load calculations for sediment were developed using land use-based generation rates and meteorological conditions from the critical wet period (10/1/92 – 4/30/93). The TMDL was divided among point sources as a WLA and nonpoint sources as a LA. The point sources identified in the Los Peñasquitos watershed are Phase I MS4 co-permittees (San Diego County and the cities of San Diego, Poway, and Del Mar), Phase II MS4s, and Caltrans. The USEPA’s permitting regulations require municipalities to obtain NPDES requirements for all storm water discharges from MS4s. The existing loads estimated were solely the result of watershed runoff (land-use based) and streambank erosion and not other types of point sources.

8.7 Margin of Safety

A margin of safety (MOS) is incorporated into a TMDL to account for uncertainty in developing the relationship between pollutant discharges and water quality impacts (USEPA, 1991). The MOS can be incorporated in the TMDL either explicitly or implicitly. Reserving a portion of the loading capacity provides an explicit MOS, whereas, the use of conservative assumptions in the modeling and TMDL analysis provides an implicit

MOS. In either case, the purpose of the MOS is to ensure that the beneficial uses that are currently impaired will be restored, given the uncertainties in the TMDL analysis.

For this TMDL, an implicit MOS was included through the application of conservative assumptions throughout TMDL development. The following list describes several key assumptions that were used.

- **Critical condition** - The wet season that includes the 1993 El Nino storm events (10/1/92 – 4/30/93) was selected as the critical condition time period for TMDL development. This is one of the wettest periods on record over the past several decades. Because of the large amount of rainfall, sediment loads were significant higher during this period than in other years with less rainfall.

- **Soil composition** - Soils that are more easily transported typically have higher proportions of smaller particles sizes (silt and clay fractions), as compared to local parent soils, because of differences in settling rates and other sediment transport characteristics. To account for these differences in the model, soils transported by surface runoff were assumed to be composed of 5 percent sand, twice as much clay as the percentage of clay within each hydrologic soil group, and the remainder assigned to the silt fraction.

- **Numeric target** - The historical analysis involved an extensive literature search and technical analysis in order to identify an appropriate time period for development of the numeric sediment target. This comprehensive 'weight of evidence' analysis considered all available information regarding urbanization and lagoon impacts over time in order to identify a conservative reference condition.

- **Critical location** - TMDL load reductions are based on meeting the numeric target across the entire Lagoon (lagoon channels and marsh areas). This approach ensures protection of beneficial uses throughout the lagoon. .

It was determined that an explicit MOS was not needed because of use of conservative assumptions and the overall predictive capability of the modeling framework that was developed for this study.

8.8 Seasonality

The federal regulations at 40 CFR 130.7 require that TMDLs include seasonal variations. Sources of sediment are similar for both dry and wet weather seasons (the two general seasons in the San Diego region). Despite the similarity of wet/dry sources, transport mechanisms can vary between the two seasons. Throughout the TMDL monitoring period, the greatest transport of sediment occurred during rainfall events. It is recognized that dry weather will contribute a deminimus discharge of sediment;

however, model calibration and TMDL development focused on wet weather conditions as sediment transport is dramatically higher during wet weather. Model simulation was completed for the 10/1/92 – 4/30/93 wet period to account for the much greater sediment loading and associated impacts to the Lagoon during this time period.

8.9 Daily Load Expression

The load allocations for the Lagoon are presented in Section 9. Load allocations are expressed in terms of net sediment load for the critical period (tons) because sediment delivery to streams is highly variable on a daily and annual basis. Loads were also divided by the number of days in the critical period (211) to derive daily loading rates (tons/mi^2/day). EPA expects the load allocations to be evaluated using a long-term rolling average period (e.g. 15-year), because of the natural variability in sediment delivery rates. In addition, EPA does not expect each square mile within a particular source category throughout the watershed to necessarily meet the load allocation; rather, EPA expects the watershed average for the entire source category to meet the load allocation for that category.

9 Total Maximum Daily Loads and Allocations

The TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody while still achieving the numeric target. Allowable loadings from pollutant sources that cumulatively amount to no more than the TMDL must be established; this provides the basis to establish water quality-based controls. TMDLs can be expressed on a mass loading basis (e.g., net sediment amount per year) or as a concentration in accordance with 40 CFR 130.2(l).

A TMDL for a given pollutant and waterbody is comprised of the WLA for point sources and LA for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and water quality in the receiving waterbody. Conceptually, this definition is represented by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

A TMDL was established for the Lagoon using the methodology described above (Section 6). The WLA portion of this equation is the total loading assigned to point sources. The LA portion is the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and computational methodology, as described in Section 8. An implicit MOS was incorporated for this TMDL.

9.1 Wasteload Allocations

Federal regulations (40 CFR 130.7) require TMDLs to include a WLA for point source discharges regulated under a discharge permit. The Los Peñasquitos watershed includes several MS4 municipalities and other permitted dischargers. The total sediment contribution from all dischargers in the watershed is presented as the WLA.

Twenty entities are identified in Regional Board Order R9-2007-0001 (NPDES No. CAS0108758) and are responsible for addressing water quality concerns for the MS4 (Regional Board, 2007). The Phase I MS4 municipal dischargers within the Los Peñasquitos watershed are the County of San Diego, the City of San Diego, the City of Del Mar, and the City of Poway. Sediment loads generated from land use activities within MS4 boundaries were included in the WLA. The total WLA includes the contribution from Phase II MS4 facilities within the watershed and highway areas regulated under the Caltrans MS4 permit. Permittees enrolled under the General

Statewide Construction and Industrial Storm Water Permit program are located within the permitted area of the Phase 1 MS4 municipalities and are, therefore, included in the total WLA. Additional information may be needed in the future to help determine the contribution from construction areas and industrial facilities in the watershed to assist with implementation planning. No other individual NPDES permits for point sources are located in the watershed.

9.2 Load Allocations

According to federal regulations (40 CFR 130.2(g)), load allocations are best estimates of the nonpoint source or background loading. For the Los Peñasquitos watershed, land use contributions to MS4 systems are included in the WLAs described above. A LA was assigned to sediment contributions from storm surges and wave action along the ocean boundary (ocean sediment contributions).

9.3 Summary of TMDL Results

The overall TMDL and its component loads are presented in Table 3. Daily loads are established by dividing the modeled loads by the number of days within the critical wet period (211 days). Current loads, historical loads, and required reductions are presented in Table 4. Existing loads were estimated based on modeling of current land use conditions (from the SANDAG 2000 land use coverage) and meteorological conditions from the critical wet period (10/1/92 – 4/30/93). As described in Section 4, the numeric target was calculated based on modeling of historical (mid-1970s) land use conditions and the same meteorological data in order to accurately compare the watershed and Lagoon response to the same weather conditions. Historic loads define the allowable load; therefore, required load reductions represent the difference between current sediment loads and historic (allowable) loads. Note that sediment dynamics within the Lagoon are dependent on a number of factors, including runoff volumes and the amount of sediment that is transported to the lagoon from the watershed. These factors are important components in determining the timing and magnitude of erosion and depositional processes within the Lagoon. The Lagoon model shows that a reduction in watershed sediment loading affects the amount of sediment that can deposit throughout the lagoon from oceanic inputs (considering a constant input of sediment from the ocean boundary under current and historical conditions). The model analysis for historical conditions indicates that a greater proportion of sediment that deposits in the Lagoon originates from tidal inputs during lower watershed loading periods, therefore, the TMDL results show that a net decrease in oceanic loads occurs during the critical wet period under historical landuse conditions. To meet the TMDL, the total load reduction required from the watershed is approximately 67%. Tidal input from the ocean boundary represents natural background loads, therefore, no reduction is required for this source category.

Table 3. TMDL summary

Source	Critical Wet Period Load (tons)	Daily Load (tons)
TMDL	12,360	59
Watershed contribution (WLA)	2,580	12
Ocean boundary (LA)	9,780	46
MOS	Implicit	Implicit

Table 4. Current vs. historical loads and percent reduction

Source	Current Load (tons)	Historical Load (tons)	Load Reduction (tons)	Percent Reduction Required
TMDL	13,663	12,360	1,303	10%
Watershed contribution (WLA)	7,719	2,580	5,139	**67%**
Ocean boundary (LA)	5,944	9,780	+3,836 (increase)	+39% (increase)

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