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Technical Memorandum Task 3.2A: Hydrogeology and Aquifer Characteristics, North Santa Monica Bay Watersheds Regional Watershed Implementation Plan and Malibu Creek Bacterial TMDL

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1.0 Introduction

1.1 Background and Statement of Problem

The North Santa Monica Bay Watersheds (NSMBW) are unique among the greater Los Angeles area watersheds because a majority of the watersheds contain a large amount of open space and several natural creeks. This region is primarily characterized by its rural environment, natural beauty, wildlife, and recreational opportunities. However, the NSMBW also support urban, residential, and business communities primarily in a strip along the Malibu Coastline and the upper reaches of Malibu Creek Watershed (MCW) in both Los Angeles and Ventura Counties. Roads, highways, water utilities, sanitary sewer systems, on-site wastewater treatment systems, and coordinated trash disposal serve these diverse communities. Stormwater discharges from these communities can convey pollutants that impact the natural waterways and northern beaches of Santa Monica Bay. This presents a challenge to the stormwater dischargers to comply with three regulations of concern - the National Pollutant Discharge Elimination System (NPDES) permits; total maximum daily load (TMDL) allocations; and Assembly Bill 885 (AB 885), which will regulate on-site wastewater systems. To address these regulations, municipalities and agencies within the NSMBW are developing a Regional Watershed Implementation Plan (RWIP) to address watershed management principles through strategic implementation of best management practices (BMPs) to obtain optimal regional benefits and to meet the regulatory requirements in a cost efficient manner.

The Malibu Creek Watershed (MCW) is the largest watershed within the North Santa Monica Bay Watersheds and at 109 square miles, it is the second largest watershed, after Ballona Creek (128 square miles), that drains into Santa Monica Bay. MCW includes portions of unincorporated Los Angeles and Ventura Counties, as well as seven Cities in the two Counties. Much of the watershed is open space under the jurisdiction of the State and the Santa Monica Mountains Conservancy. The water in Malibu Creek, its five tributaries (Stokes

Creek, Las Virgenes Creek, Palo Comado Creek, Medea Creek, and Lindero Creek) and Malibu Lagoon, which receives runoff from Malibu Creek exceeds the water quality objectives (WQOs) for indicator bacteria, including fecal coliform, total coliform, E. coli, and Enterococcus. This continuing exceedence has resulted in the requirement under the Federal Clean Water Act and the California Porter-Cologne Act to prepare a TMDL for bacteria for the watershed. The TMDL has been approved by the State Water Resources Control Board (SWRCB) and is waiting United States Environmental Protection Agency (U.S. EPA) Region 9 approval which is expected in January 2006. Jointly responsible for meeting TMDL requirements are the two Counties; the Cities of Calabasas, Malibu, Westlake Village, Agoura Hills, Hidden Hills, Simi Valley and Thousand Oaks; the California Department of Parks and Recreation; the National Park Service, the Santa Monica Mountains Conservancy; and Caltrans. In order for MCW to comply with the Bacteria TMDL allocation the responsible agencies are developing a TMDL Implementation Plan (TMDLIP) that will present an integrated plan of BMPs to be implemented throughout the watershed to meet water quality objectives.

1.2 Purpose of this Technical Memorandum

An important aspect of an integrated approach to Best Management Practices (BMPs) that considers watershed principals and optimizes regional benefits is consideration of beneficial reuse of stormwater as part of a strategy for meeting water quality objectives. The purpose of this technical memorandum is to identify and review documents containing information on the hydrogeology and groundwater aquifer(s) characteristics of the NSMB watersheds, and evaluate the feasibility of groundwater infiltration or injection to support the reuse of stormwater for surface water quality improvement. This memo will present a series of maps and tables illustrating and summarizing these features.

The geologic features of the area are described in Section 3, as a basis for the hydrogeologic characteristics of the area, followed by a discussion and summary of the hydrogeology and aquifer characteristics in Section 4. A discussion of possible regional recharge projects is presented in Section 5, followed by conclusions in Section 6.

2.0 Methodology

The geology of the Santa Monica Mountains, encompassing the NSMB watersheds, has been described by Dibblee (1992a, 1992b, 1993a, 1993b, 1993c), Campbell et al. (1996), Yerkes and Campbell (1980, 1993, 1994, 1997), and Yerkes and Showalter (1993). These geologic maps and explanatory notes were reviewed for an understanding of the regional distribution and relationships of likely aquifer units in the NSMB watersheds. The California Department of Water Resources published, and updates, a list of groundwater basins within the state, listing general aquifer characteristics, and this report (Bulletin 118) was reviewed and incorporated where relevant. A number of municipal general plans and environmental impact reports for various projects within the watersheds were reviewed for an understanding of local aquifer characteristics. In addition, a number of special studies by municipalities or agencies were reviewed with regard to water supply, reuse, and groundwater, in particular Las Virgenes Municipal Water District (LVMWD) reports.

3.0 Topography, Drainage and Geology

General drainage patterns in the study area are from the Santa Monica Mountains on the north towards the Pacific Ocean on the south (Figure 1). The Santa Monica Mountains are an east-west trending range that widen with the curve of Santa Monica Bay, and reach their highest peaks on the ocean side of the range (National Park Service, 2004). The rugged, deeply dissected Santa Monica Mountains rise abruptly from a narrow coastal strip of rocky or sandy beaches. The elevation range in the study area is from sea level to 3,111 feet at Sandstone Peak in the northern portion of Arroyo Sequit sub-watershed. (United States Geological Survey Topographic-Bathymetric Map Los Angeles, CA 1975).

The coastal watersheds are short steep drainages leading to the ocean (Figure 1). Malibu Creek, however, stands out as the largest watershed of the NSMB watersheds that drains to Santa Monica Bay, with a short steep, rugged lower canyon, and a large relatively moderate relief upper watershed. There are two theories regarding the formation of MCW: 1) an ancestral, or antecedent drainage eroded through tectonically rising Santa Monica Mountains (Dibblee, 1992); or 2) a more recent analysis suggests stream capture by a coastal stream eroding inland capturing the inland portion of the MCW. Support for the second theory includes the change in topographic relief from the coastal watersheds to the inland portion of MCW, and the steep, bedrock-eroding nature of Malibu Canyon in the lower portion of Malibu Creek (Meigs, et al., 1999).

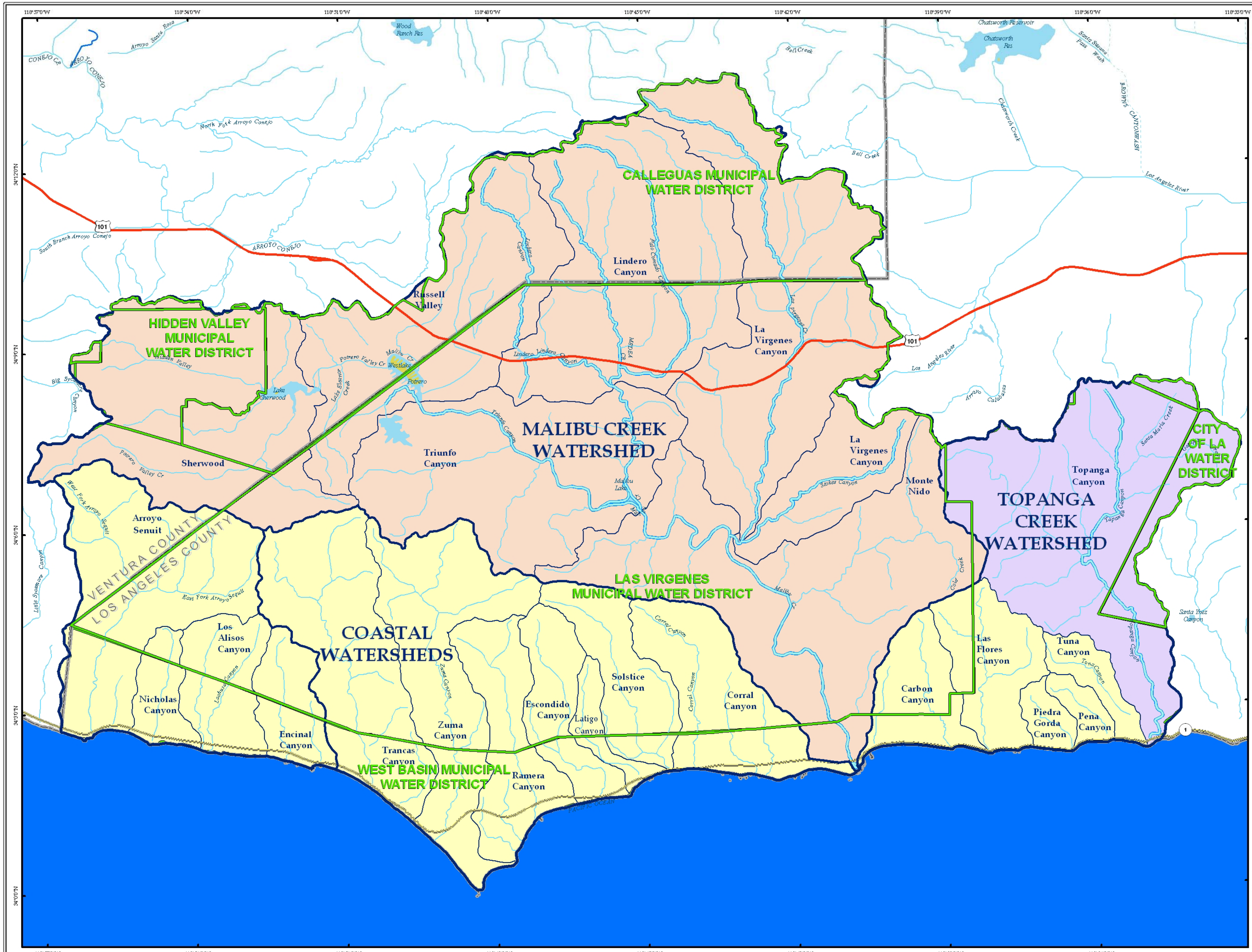

Figure I

WATERSHED FEATURES

North Santa Monica Bay Regional Watershed Implementation Plan

LEGEND

Interstates and Highways

- Interstate
- Highway

Hydrologic Features

- Streams
- 303d Listed Streams
- Lake, reservoir, or pond
- NSMB Watershed Boundary
- Hydrologic Area Boundary
- Hydrologic Sub-Area Boundary
- Water District Boundary

0 1 2

Miles

Map prepared by:

Integrated Water Resources, Inc.

January 2006

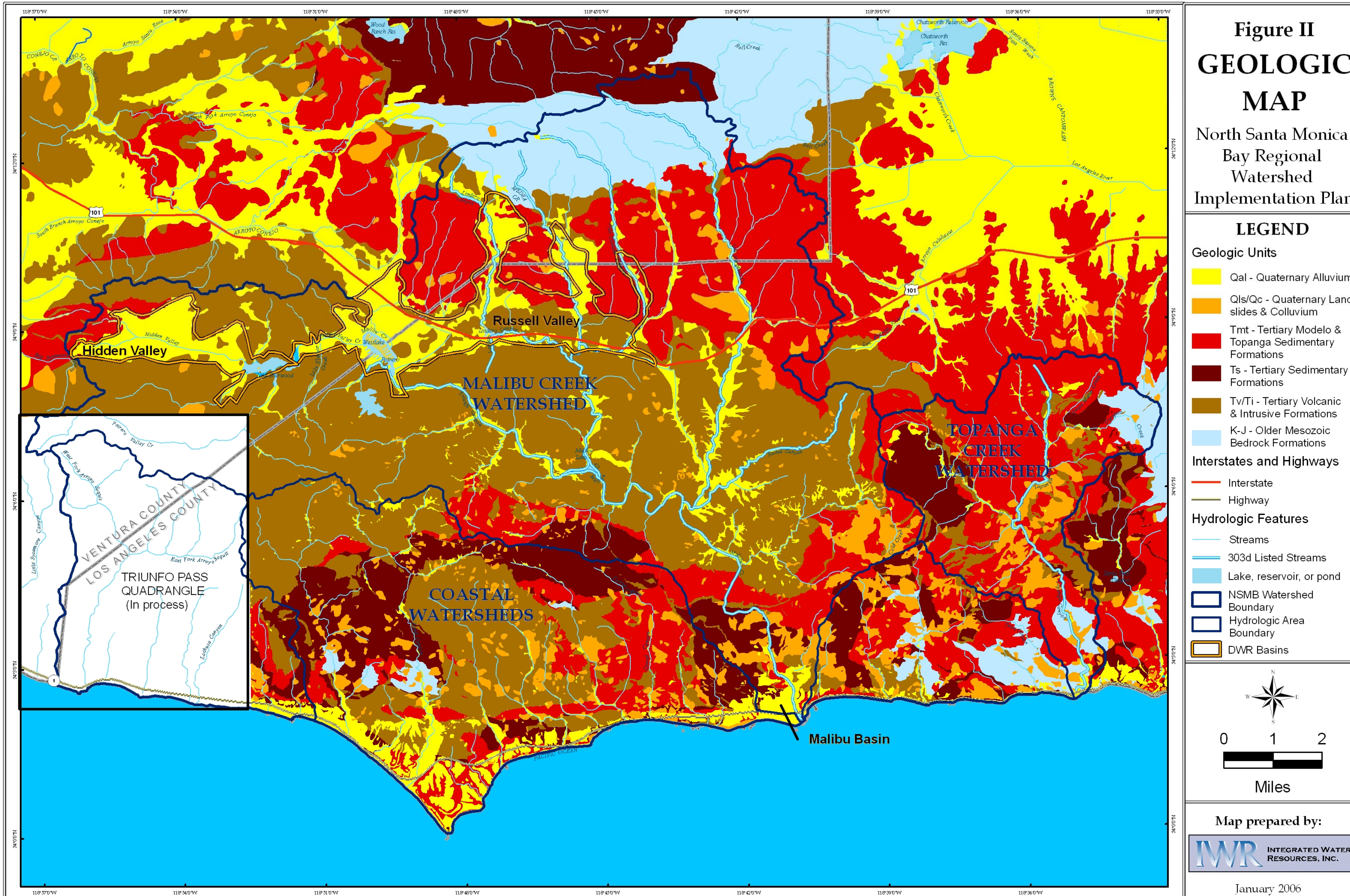

Figure II
GEOLOGIC MAP
North Santa Monica Bay Regional Watershed Implementation Plan
LEGEND
Geologic Units
Qal - Quaternary Alluvium
Qls/Qc - Quaternary Land slides & Colluvium
Tmt - Tertiary Modelo & Topanga Sedimentary Formations
Ts - Tertiary Sedimentary Formations
Tv/Ti - Tertiary Volcanic & Intrusive Formations
K-J - Older Mesozoic Bedrock Formations
Interstates and Highways
Interstate
Highway
Hydrologic Features
Streams
303d Listed Streams
Lake, reservoir, or pond
NSMB Watershed Boundary
Hydrologic Area Boundary
DWR Basins
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Miles
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January 2006
MALIBU CREEK WATERSHED
TOPANGA CREEK WATERSHED
COASTAL WATERSHEDS
Russell Valley
Hidden Valley
Malibu Basin
VENTURA COUNTY
LOS ANGELES COUNTY
TRIUNFO PASS QUADRANGLE (In process)

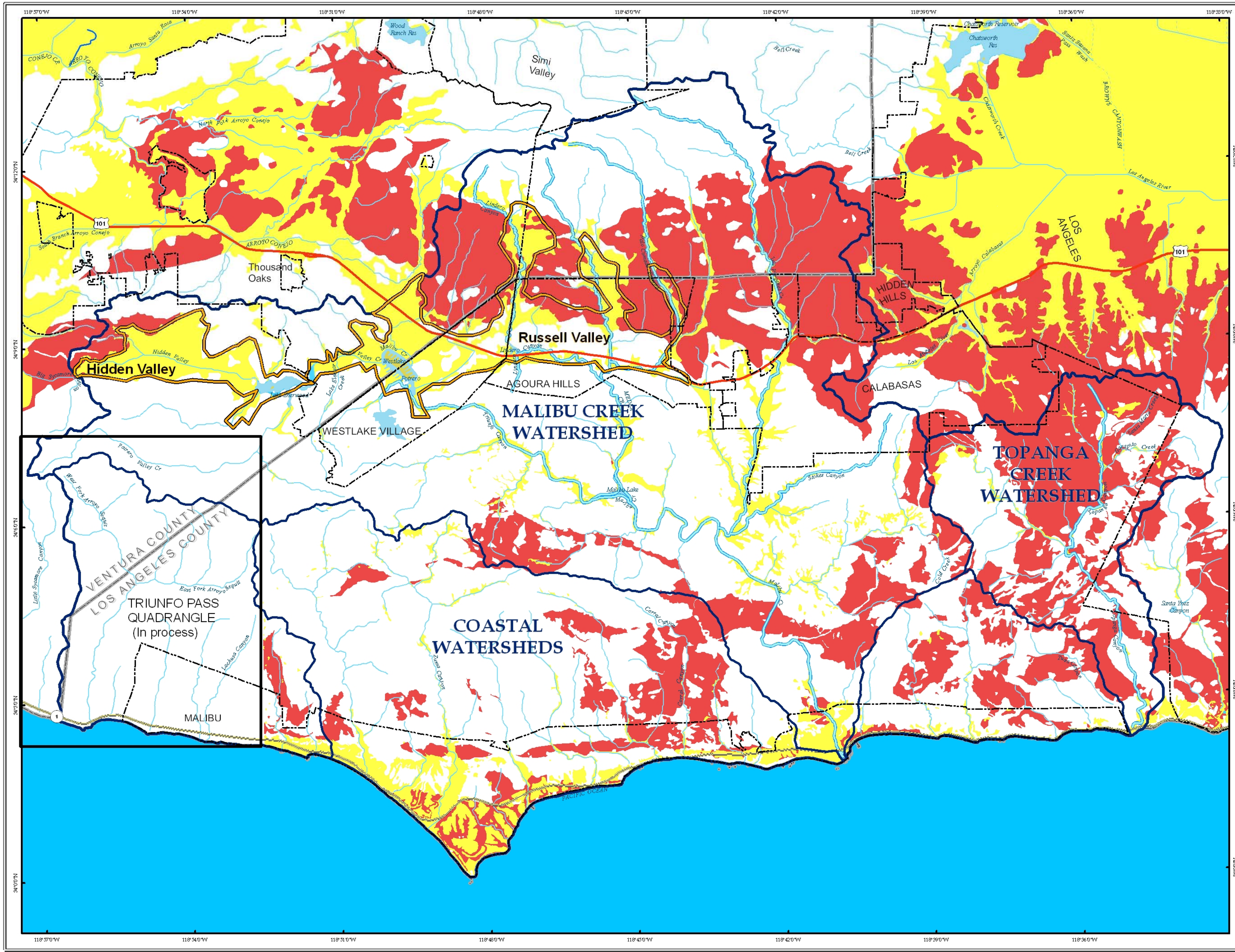

Figure III

Alluvial and Sedimentary Bedrock Aquifers

of North Santa Monica Bay Watersheds

LEGEND

Geologic Units

- Qal - Quaternary Alluvium
- Tmt - Tertiary Modelo & Topanga Sedimentary Formations

Interstates and Highways

- Interstate
- Highway

Hydrologic Features

- Streams
- 303d Listed Streams
- Lake, reservoir, or pond
- NSMB Watershed Boundary
- Hydrologic Area Boundary
- DWR Basins
- City Boundaries

0 1 2

Miles

Map prepared by:

INTEGRATED WATER RESOURCES, INC.

January 2006

The geology of the Santa Monica Mountains is dominated by a sequence of Tertiary sedimentary and volcanic formations. For the purposes of this analysis, these formations have been grouped into three units: Tmt: - Tertiary Modelo and Upper Topanga Formations; Ts - Tertiary Sedimentary formations, other than Modelo and Upper Topanga Formations; and Tv/Ti - Tertiary volcanic and intrusive rocks of the Conego Formation (Figure 2). The oldest units within the Santa Monica Mountains are a series of Jurassic and Cretaceous Sedimentary Formations (K-J) that are beneath the Tertiary Formations of interest.

The Conejo Volcanic Formation (Tv/Ti) forms the core of the Santa Monica Mountains, and underlies much of Malibu Creek Watershed. The younger Tertiary sedimentary formations of the Modelo and Upper Topanga Formations flank the Conejo to the north and south. The south flank of the Santa Monica Mountains is structurally dominated by the Malibu Coast Fault that runs along the foot of the mountains at the coast. This fault, and associated structures, creates a considerably more complex geologic setting on the south flank of the Santa Monica Mountains compared to the north flank, where the Tertiary formations are gently folded. The active nature of the Malibu Coast fault and associated structures accounts for the steep and rugged coastal topography of the NSMB watersheds.

Eroded from, and overlying, these bedrock formations are a series of recent alluvial units. For the purposes of this analysis, these alluvial units have been combined into two map units (Figures 2 and 3): Quaternary alluvium (Qal) - comprising alluvium, including stream deposits, alluvial fan and floodplain deposits, beach deposits, dissected and older alluvial deposits; and Quaternary land slides and colluvium (Qls/Qc) - comprising land slide deposits and colluvium deposits. The colluvium represents relatively thick continuous deposits of soil and rock fragments which are common on the steep slopes of the coastal canyons, and generally feed the many landslides, soil slips and debris flows.

4.0 Hydrogeology and Aquifer Characteristics

Hydrogeologic aquifers in the NSMB watersheds can be divided between bedrock aquifers and alluvial aquifers. The bedrock aquifers consist of younger Tertiary sedimentary and volcanic formations (Tmt and Tv/Ti; Figures 2 and 3). The alluvial aquifers consist of alluvial stream deposits and alluvial fan and floodplain deposits (Qal; Figures 2 and 3). By definition the landslide deposits and colluvium deposits are on slopes that are too steep or unstable to be considered for further hydrogeologic analysis.

Part of what gives the NSMB watersheds their individual and picturesque character is the steep topography. Caused by a complex interplay of tectonic uplift and erosion (Meigs, et al., 1999), this active landscape has not produced large alluvial basins, such as the San Fernando basin, which are ideal alluvial aquifers. The NSMB watersheds in fact have only three very small alluvial groundwater basins identified by California Department of Water Resources (DWR): Hidden Valley and Russell Valley basins in Ventura County and Malibu Valley basin in Los Angeles County (Table 1). Russell Valley basin is presently used intermittently by LVMWD to augment recycled water during summer peak usage. The Malibu Valley groundwater basin is no longer pumped, and is considered, at least locally, contaminated with septic effluent and fuels from leaking underground storage tanks (MBC, 2002).

Russell Valley and Hidden Valley basins are similar in size (3,100 and 2,200 acres respectively), geologic setting and aquifer characteristics. Both are relatively shallow alluvial aquifers lying on top of fractured Conejo Formation volcanic rocks. Water levels for both rise and fall rapidly, even with minimal pumping, indicating relatively small storage capacity that is easily depleted and rapidly replenished by winter rains. Groundwater levels, reported in DWR Bulletin 118 or by Ventura County, indicate depth to water is approximately 20 to 30 feet (Table 1).

Russell Valley basin is adjacent to the Thousand Oaks alluvial basin. The difference between the two is that Russell Valley surface water drains to the Pacific Ocean through Malibu Creek Watershed, whereas surface water from Thousand Oaks basin drains to the Pacific Ocean through Conejo Creek in the Calleguas Creek Watershed. These two basins are likely connected at depth. Existing public information does not allow a determination of the subsurface structure or groundwater flow of either of these basins.

Water quality, where known, for these alluvial aquifers is poor, with high total dissolved solids (1,000 mg/l or higher), in particular sulfate, which is likely caused by fluid flow between bedrock volcanic units and the alluvial aquifer (Table 2).

Within the coastal watersheds groundwater depths are relatively shallow, ranging in depth from 5 feet below ground surface in beach areas to a depth of 10 feet in the coastal plains and coastal stream canyons. Bedrock groundwater depths are unknown. Because most of the residences within the coastal watersheds utilize onsite wastewater treatment systems (septic systems), seepage and impacts to groundwater are of importance, particularly since the level of risk of exposure is closely tied to the vertical separation between the infiltrating surface of the dispersal system and the water table.

The bedrock aquifers in the NSMB watersheds are found throughout the Malibu Creek Watershed. Bedrock of Tertiary volcanic and sedimentary units underlies most of the MCW. The Tertiary Modelo and Upper Topanga Formations are a set of interlayered shale, siltstone, sandstone, and gravel units. The sandstone and gravel layers are the primary aquifer units. The Conejo Volcanic Formation is considered suitable as an aquifer only where fracturing has produced significant permeability. There is very little public information regarding groundwater wells in the bedrock formations. Several wells drilled into Conejo Volcanic Formation and Modelo Formation in the northern edge of the MCW indicate pumping rates of 10 to 100 gpm, with total dissolved solids between 700 and 1,000 mg/l (Fugro, 1994). These wells are considered suitable for landscape irrigation in most cases, but high sodium and sulfate preclude their use for crop irrigation. The other source of information is from wells that were drilled into alluvial aquifers and which subsequently penetrated bedrock formations.

5.0 Regional Groundwater Recharge

The potential for regional groundwater injection and infiltration is very limited for the coastal (J1/4) watersheds, given the local hydrogeology and groundwater conditions, and the need to avoid excessively raising groundwater levels in areas with onsite wastewater systems. Localized, or on-site, infiltration practices are considered more feasible. Because there is very little groundwater extraction it must be recognized that even local recharge will likely raise the water table, thereby potentially impacting septic systems. As such, local recharge must be carefully evaluated for its potential to affect septic systems.

For Malibu Creek Watershed the regional groundwater recharge opportunities are only marginally better than those for the coastal watersheds. LVMWD has investigated several locations, inside and outside the watershed, for groundwater recharge of recycled water through infiltration or injection. From this list of potential projects, LVMWD has not identified any viable projects, largely because of the same difficulties that face reuse of stormwater: lack of suitable alluvial aquifer, seasonality and need for storage, treatment needs, and poor aquifer water quality.

The one possible location that recharge of stormwater may be possible is Russell Valley. Even though the alluvial aquifer is shallow, it is connected in the subsurface to the Thousand Oaks alluvial aquifer. Infiltration of stormwater in Russell Valley might, if the subsurface aquifer geometry is conducive, allow for recharge of considerably more water than the small amount of storage considered available just within Russell Valley proper, by causing groundwater to flow to the north and west into Thousand Oaks Valley. An investigation of Russell and Thousand Oaks basins would be required to fully understand the consequence of recharge. Russell Valley is at the upper reaches of Triunfo Creek and Lindero Creek, and to the extent that urban runoff from MS4s could be re-routed to infiltration systems (e.g. above ground basins, below ground storage and infiltration systems) rather than to these two creeks, it could ultimately benefit downstream water quality. However, because of the location at the upper reaches of the watershed, the quantity of water available for infiltration will not represent a significant portion of the MCW storm flows.

LVMWD has investigated a number of possibilities for increasing use of recycled water in Malibu Creek Watershed. Many of these possibilities include transfer of water out of the basin, or increased treatment and transfer to local reservoirs. The bedrock aquifers, through injection, have been considered for aquifer storage and recovery projects (LVMWD, 2005), but because of poor water quality as well as issues of storage and treatment needed for stormwater, are not considered suitable. None of the LVMWD studied projects would be suitable for stormwater, due to stormwater timing, quantities and flow rates involved, storage and treatment difficulties.

Table 1. Aquifer Properties

Basin Name	Basin Area (acres)	Basin Boundaries	Hydrology	Hydrogeologic Formation	Recharge	Groundwater Levels	Groundwater Storage
Hidden Valley	2,210	Underlies Hidden Valley in southwest Ventura County.	Bounded by the semi-permeable rocks of the Santa Monica Mountains. The valley drains into Sherwood Lake.	Unconfined in the Conejo Formation volcanic deposits and overlying alluvium.	Recharges rapidly with seasonal rains, implying that recharge comes chiefly from percolation of precipitation to the valley and ephemeral streamflow.	Average - 75 feet. Water levels declined by as much as about 50 feet by 1988. During 1988 through 1992, the rate of decline of water levels increased, with water levels in 1992 reaching as much as 180 feet below high water levels of the previous decade. Water levels recovered again in 1993 and experienced seasonal fluctuations of as much as 60 feet through 2000. Groundwater moves southeastward through the basin toward Lake Sherwood.	4,000 AF estimated. Recoverable storage estimated between 250-400 AF.
Malibu Valley	610	Small alluvial basin located along the Los Angeles County coastline; bounded by the Pacific Ocean on the south and by non water-bearing Tertiary age rocks on all remaining sides.	The valley is drained by Malibu Creek to the Pacific Ocean.	Primarily in unconfined Quaternary alluvium which consists of clays, silts, sands, and gravels. Thickness of the alluvium ranges from 90 feet at the upper end to more than 140 feet at the lower end. The Malibu Coast fault crosses the valley but is not considered groundwater barrier.	Recharge of the basin is from percolation of precipitation, runoff, and effluent from domestic septic systems.	Groundwater levels generally shallow - 10-50 feet. Groundwater moves south towards the Pacific Ocean.	Unknown
Russell Valley	3,100	Relatively small alluvial basin bounded by semi-permeable rocks of the Santa Monica Mountains. The basin is bordered on the west by the Thousand Oaks Groundwater Basin.	Triunfo Creek drains the valley into Malibu Creek.	The unconfined groundwater primarily pumped from Quaternary alluvium, although some groundwater is extracted from underlying Tertiary volcanic and sedimentary rocks. Alluvium consists of unconsolidated, poorly bedded, poorly sorted to sorted sand, gravel, silt, and clay with some cobbles and boulders that averages about 35 to 55 feet thick.	Recharge is dominantly from percolation of rainfall.	Depth to groundwater - 35 feet	The total storage capacity is estimated at 10,570 acre-feet (af). Recharge from underflow is estimated to be 300 to 500 af/yr and about 50 to 150 af/yr more from irrigation return. Extraction is estimated to be about 600 af/yr.

Sources: CA DWR Bulletin 118 (2/27/04); Ventura County Public Works Agency

Table 2. Water Quality

Basin Name	Basin Area (acres)	Total Dissolved Solids	Groundwater Quality	Well Characteristics		
				Yields	Depths	Basin Management
Hidden Valley	2,210	Below 800 mg/L	Varies from calcium bicarbonate to calcium-magnesium bicarbonate.	Average: 30 gal/min.	Unknown	
Malibu Valley	610	Single analysis resulted in total dissolved solids (TDS) content of 1,310 mg/L.	Seawater intrusion occurred in 1950, and again in 1960. Chloride concentrations exceeding 100 mg/L were found in groundwater in the coastal part of the basin. Basin known to have leaking underground storage tanks of fuel, and is suspected to be locally impacted by septic system effluent.	1,000 gal/min.	Range: 100-550 ft	Los Angeles County Department of Public Works; Malibu Water Company
Russell Valley	3,100	Ranges from 800 to 2,800 mg/L.	Generally sodium bicarbonate or calcium bicarbonate water, but also may be sodium bicarbonate or calcium-magnesium sulfate. Sulfate averages 300 mg/L in most wells due to the volcanic basalt that constitutes the basement rock. TDS and sulfate both exceed their maximum allowable contaminant levels (MCL) for some wells in the basin.	Average: 25 gal/min.	Unknown	Calleguas Municipal Water District, Ventura County Public Works Agency

Sources: CA DWR Bulletin 118 (2/27/04); Ventura County Public Works Agency

Local, or on-site, infiltration projects could be more successful. Tasks 6, 7 and 8 all relate to the development and siting of structural BMPs. Incorporation of spatial distribution of alluvial aquifers together with the BMP siting tasks will provide an added assessment tool for determining priority. Specific areas where local infiltration projects would be useful, based on the presence of alluvial deposits, include the creeks of the upper portion of Malibu Creek Watershed, in particular Upper Lindero and Upper Medea creeks. These areas are within the service areas of wastewater treatment districts, and therefore infiltration would not impact onsite wastewater treatment systems. Consideration of local infiltration sites outside of wastewater district service areas will need to consider impacts on nearby onsite wastewater treatment systems prior to implementation.

6.0 Conclusions

To the extent that LVMWD identifies and implements expansions to their recycled water system, regional watershed stormwater management efforts benefit from these successes. As LVMWD finds customers or beneficial uses for all of its recycled water, stormwater may ultimately be able to fill any gap that develops between recycled water production and demand. For this reason, watershed management practices that further the goals of recycled water providers, will ultimately improve the likelihood of increased beneficial uses of stormwater.

The spatial distribution of alluvial deposits limits the potential areas of regional recharge. This highlights the importance of identifying local, on-site, infiltration sites associated with structural BMPs. The upper reaches of Malibu Creek Watershed, in particular Upper Lindero and Upper Medea creeks, where these alluvial deposits exist in areas of concentrated urban development, represent the initial focus area for siting local infiltration projects.

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