# Hydrologic and Hydraulic Study for Leucadia Drainage Improvement Alternatives

## Encinitas, California

**June 14, 2004**

**Prepared for**

**Prepared by**

Rick Engineering Company

J-14413

# HYDROLOGIC AND HYDRAULIC STUDY
# FOR
# LEUCADIA DRAINAGE IMPROVEMENT ALTERNATIVES
# ENCINITAS, CALIFORNIA

**Job Number 14413**

**June 14, 2004**

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# EXECUTIVE SUMMARY

## Introduction

City of Encinitas (City) contracted with Rick Engineering Company to conduct a detailed hydrologic and hydraulic study of the Leucadia area to analyze inundation of City streets and private properties during varying return frequency storm events. Flooding has historically occurred in this area along and adjacent to Highway 101, between Encinitas Boulevard and La Costa Avenue.

The study encompassed analyses of historic drainage conditions, which led to implementation of a series of drainage improvements that now represent the existing condition. Further analyses were performed to incorporate several drainage improvement alternatives to arrive at a solution that will improve the overall drainage of Leucadia.

Rick Engineering Company prepared a final report detailing the results from the historic and existing drainage analysis for storm events up to the 5-year design frequency titled "Hydrologic and Hydraulic Study for Coast Highway 101 Interim Storm Drain Improvements, Encinitas, California" dated November 18, 2003. Focusing on the drainage patterns for larger storms, this report concentrates on the 10-year and 100-year storm frequencies.

## Historic Drainage Condition

The historic (and existing) topography in Leucadia does not allow free-flowing surface drainage. The profile of the flow path contains several peaks and valleys, subsequently creating sump areas. In the historic condition (pre-2001 storm drain installation), the sump areas in the alley west of Highway 101 did not contain underground storm drain systems. Therefore, the runoff produced by storm events ponded in the sump areas until it eventually infiltrated into the ground, evaporated, or was otherwise removed via pump or other device. During larger storm events (greater than an estimated 10-year frequency), the water ponded until it reached an elevation that allowed it to overtop into the next sump. The water followed this process until ultimately making its way north to the Batiquitos Lagoon. Since the runoff could not freely drain out of the sump areas, at times the ponded water reached elevations that inundated not only streets and alleys, but also residential and commercial properties.

**Existing Drainage Condition – Completed Projects**

The City of Encinitas has completed several projects to improve the drainage in Leucadia. These projects include the installation of a storm drain system, enhancements to the storm drain system, improvements to surface drainage, as well as implementation of emergency response protocols during storm events.

Installation of a Storm Drain System (2001)

The existing storm drain system consists of a 24" main line along Coast Highway 101 that begins near Union Street, flows in the northerly direction, and outlets into two detention basins located in series just north of La Costa Avenue. Several laterals tie into the main line, which connect the sump areas in the alley to the storm drain system. The capacity of the storm drain system when it was constructed in 2001 varied from less than 2-year storm frequency to up to 10-year storm frequency depending on the location, which provided varying degrees of drainage within the watershed.

Storm Drain System Enhancement (2003)

The City enhanced the existing storm drain system (November 2003) to reduce the extent of flooding during small, frequent storm events (up to 5-year) when compared with the historic condition. The interim improvements result in lower ponded water elevations and constant drainage at a more regulated rate. These enhancements were achieved by the installation of orifice plates in the laterals to the main storm drain line. By controlling the rate of discharge, the efficiency of the storm drain can be maintained for storm events up to 5-year frequency throughout the entire system.

Improvements to Surface Drainage (2004)

The City constructed a 1,300-foot long earthen channel with a 4-foot bottom width and 1.5:1 (horizontal:vertical) side slopes aligned parallel to Vulcan Avenue adjacent to the NCTD right-of-way from approximately Orpheus Avenue to Union Street. Prior to installation there was no defined drainage channel to convey storm runoff, resulting in inundation between Vulcan Avenue and the railroad ballast. The ditch was designed to alleviate some flooding within Vulcan Avenue and convey storm runoff to the headwall of the storm drain system in the NCTD right-of-way near Union Street.

Emergency Response Protocol (Ongoing)

Several departments within the City work collectively to alleviate the extent of flooding in Leucadia. The Fire Department implements an action plan prior to and during storm events, including placing sand bags in several areas to protect homes and businesses, closing the city streets as necessary, and pumping storm runoff from Leucadia Park westerly over the bluffs at Beacons Beach. In addition, the Public Works Department dispatches vac-con trucks to remove localized ponds from the sump areas.

**Drainage Improvement Projects in Design Phase**

The City is currently in the process of implementing additional drainage improvements in Leucadia. These options are short-term improvements that will benefit drainage in specific areas during small frequent storm events.

Phoebe Pump Station

Under existing conditions runoff is detained at a pump station located at Coast Highway 101 and Phoebe Street. The pump station discharges approximately 500 gallons per minute (gpm) into a storm drain system beneath Coast Highway 101. The existing pumps fail frequently during storms and the inlets near the pump station do not effectively collect runoff to keep the pumps functioning properly.

A redesigned pump station at Phoebe Street consisting of two new pumps with approximately 1,500-gpm capacity is currently in the design phase and installation is scheduled in the summer of 2004. In addition, two new inlets will be installed near the pump station to collect localized ponding. The new pumps and inlets will improve the local drainage in the vicinity of the pump station.

Leucadia Boulevard Drainage Swale

The City is in the design phase for an earthen channel aligned parallel to Vulcan Avenue north of Leucadia Boulevard adjacent to the NCTD right-of-way. An existing drainage pipe that collects runoff from a portion of Leucadia Boulevard currently drains into this area; however, there is no defined drainage channel to convey storm runoff. The ditch was designed to alleviate some flooding within Vulcan Avenue and convey storm runoff northerly within the NCTD right-of-way.

**Drainage Improvement Projects in Planning Phase**

Several alternatives designed to alleviate the extent of flooding for frequent storm events, as well as for the 100-year storm, are being analyzed in the planning phase. These options are grouped into two categories: short-term improvements targeted at more frequent storms, and ultimate improvements that will address the 100-year storm.

Short-term Improvements

***Alternative 1: Leucadia Park Overflow***

The City is analyzing the benefit of constructing an overflow storm drain system to collect runoff from the upper watershed (Basins 1, 2, 3, 4, and 7) at Leucadia Park. Storm runoff would be diverted from the main storm drain system at Leucadia Park to an overflow system that would extend from the park through the bluffs at Beacons Beach. Low flows would still pass through the existing 101 storm drain system and discharge to the detention basins north of La Costa Avenue.

A 4-foot diameter pipe transitioning to a 2-foot diameter pipe at the outlet discharging out the bluffs near Beacons Beach was analyzed for this option. This could potentially divert up to 90% of the 10-year runoff and relieve the downstream main storm drain system during smaller storms. The overflow system is not expected to significantly reduce 100-year floodplain elevations, or affect the size of pipes or cost of installing the ultimate 100-year storm drain system. This would eliminate the necessity for pumping during storm events smaller than 10-year return frequency.

Environmental permitting of the outlet has not been investigated but is expected to present a significant challenge in the feasibility of this project.

*Estimated Cost $1.5-2.5 million*
(Separate cost estimates prepared by Haley & Aldrich and Jacobs Associates)

***Alternative 2: Grading Options***
Three options were analyzed for re-grading areas in the northern portion of the watershed to improve surface drainage.

*Option A*
Grade a channel approximately 495-feet long with a 10-foot bottom width and 5:1 side slopes between Highway 101 and the railroad tracks within the NCTD right-of-way near Bishopsgate Road. The channel will remove an existing hump that hinders conveyance of runoff, resulting in decreased floodplain elevations up to 1-foot for the 100-year storm event.

*Estimated cost: $1 million*
(Cost estimated prepared by Rick Engineering Company)

*Option B*
Re-grade the northbound lanes of Highway 101 from approximately Grandview Street to Bishopsgate Road (1,370 linear feet) to remove an existing hump that hinders conveyance of

runoff. Floodplain elevations will decrease by up to 2-feet for both the 10-year and 100-year storm events.

*Estimated Cost: $3.5 million*
(Cost estimate prepared by Rick Engineering Company)

*Option C*
Re-grade the northbound lanes of Highway 101 from approximately Jupiter Street to Moorgate Road (3,170 linear feet), lowering the grade approximately one foot lower than Option B. Floodplain elevations will decrease by over 2-feet for both the 10-year and 100-year storm events. Option C provides the most benefit to commercial and residential properties adjacent to Highway 101 by removing approximately 5 city blocks from the 100-year floodplain.

*Estimated Cost: $4.5 million*
(Cost estimate prepared by Rick Engineering Company)

<u>Ultimate Improvements</u>

***Alternative 3: 100-year Capacity Storm Drain System***
Construct an underground storm drain system with capacity to convey the peak flow rate from 100-year frequency storm event. This would remove the floodplain for up to a 100-year storm from the study area. A 10-year storm drain system was investigated but due to only minor savings in construction costs this system is not recommended.

A large storm drain system is required to convey the undetained runoff from the Leucadia watershed. Preliminary results show that for the 100-year storm a 5-foot diameter pipe is required at the upstream end of the watershed, eventually transitioning to a 9-foot diameter pipe at the outlet into the lagoon. Environmental permitting of the outlet has not been investigated but is expected to present a significant challenge in the feasibility of this project. This option includes utilization of the existing 24" storm drain as a low flow system discharging to the detention basins north of La Costa Avenue to preserve water quality benefits.

*Estimated Cost: $22-26 million with tunneling technologies, $40 million using conventional methods*

(Separate cost estimates prepared by Haley & Aldrich and Rick Engineering Company)

**Drainage Improvements Considered but Not Analyzed**

***Ultimate Facility assuming NCTD grade separation project is constructed***

Construct an underground storm drain system with capacity to convey the peak flow rate from the 100-year frequency storm event assuming drainage changes within the NCTD right-of-way consisting of grade separation (lowering the railroad tracks) that would prevent runoff east of the tracks from getting west of the railroad tracks. This system is designed to convey runoff from the watershed area west of the railroad tracks only, approximately 30% of the watershed area of Alternative 3.

NCTD is conducting feasibility studies for the grade separation project; however, the actual construction of the project could be as many as 20 years from now. This alternative will not be pursued unless more detailed plans to construct the grade-separated tracks are available. A plan would also be in place to address the remaining 70% of the watershed that would stay east of the railroad tracks. Additionally, completion time of this project would be weighed against the other alternatives to determine the most feasible project that will address flooding issues within an acceptable amount of time.

Additional planning and investigations are required to analyze this alternative in more detail.

***Convey Storm Runoff from the Upper Basins South to Moonlight Beach***

Based on review of drainage patterns south of the Leucadia study area, it was determined that the storm drain system at Moonlight Beach is already undersized and cannot handle additional runoff. Transferring storm runoff from the Leucadia study watershed to the Moonlight Beach watershed would be of adverse impact to the receiving watershed. This option was dismissed from further review.

***Use Cisterns to Contain Storm Runoff***

Two options for the use of cisterns were evaluated: Each parcel would utilize a cistern to capture the runoff from its own property during storm events, or several large "Baker Tanks" could be used to store runoff from larger drainage areas during storm events.

Preliminary estimates of the first option, each property captures runoff in its own cistern, yielded the required volume of each cistern would fill a one-car garage. Therefore, the use of cisterns on a parcel-by-parcel basis is considered infeasible.

The second option, using large Baker Tanks to contain runoff, was also investigated. The mobilization of these large cisterns needs to be scheduled in advance; they are not intended for emergency situations such as storms. There are also challenges including volume of storage and location of tanks that further disqualify this option.

**Conclusion**

This report summarizes hydrologic and hydraulic analyses of historic drainage conditions, the implementation of drainage improvements that now represent the existing condition, as well as several proposed alternatives to improve drainage in Leucadia for both the short-term and ultimate conditions. The City of Encinitas should select one or more alternatives to further investigate based on factors including overall benefit to the community, completion time, environmental constraints, and cost.

# INTRODUCTION

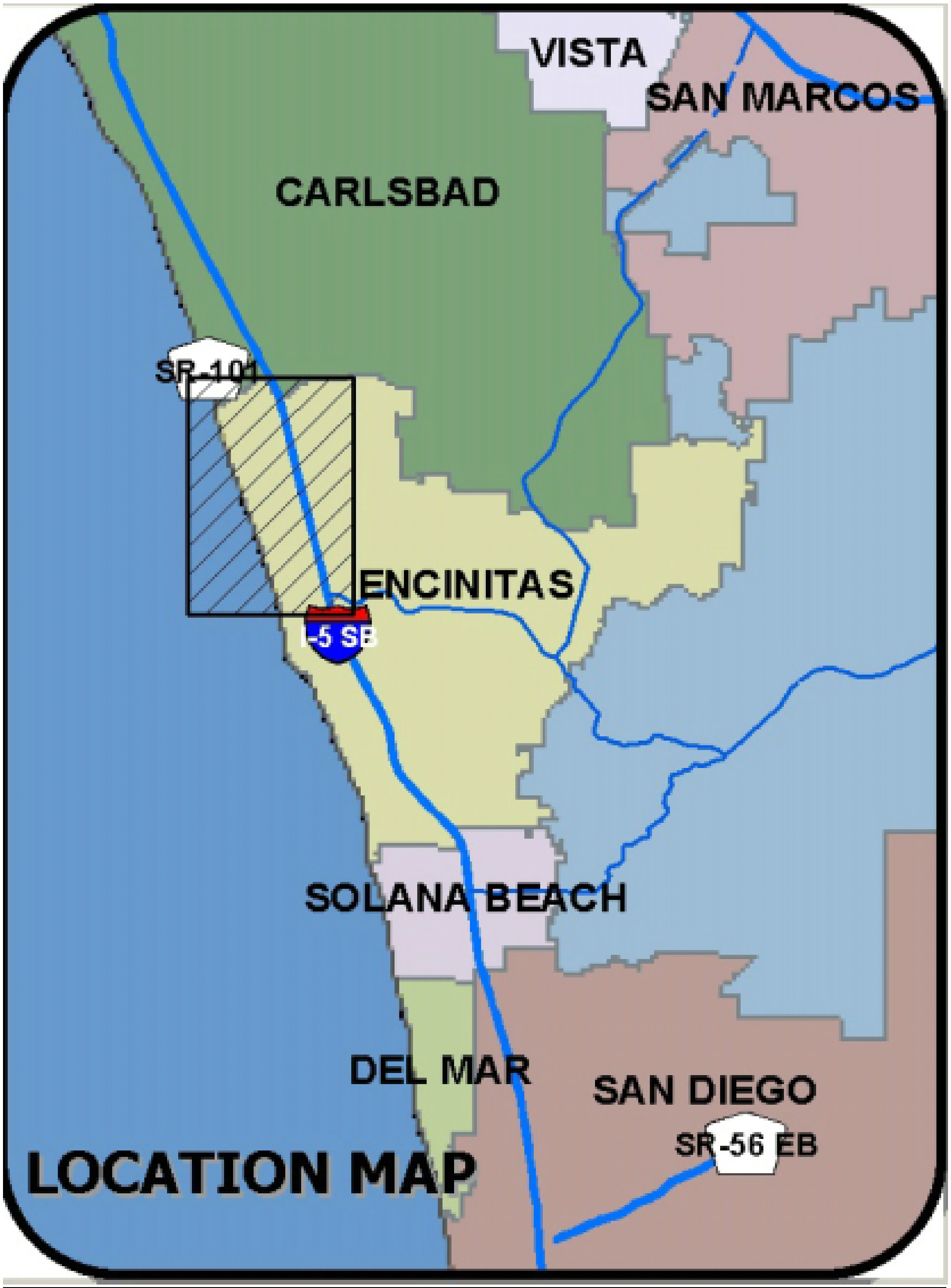
Rick Engineering Company conducted this detailed hydrologic and hydraulic study, under the direction of the City of Encinitas, to analyze inundation of City streets and private properties in Leucadia during varying return frequency storm events, as well as to analyze solutions to improve drainage within the Leucadia area. A Vicinity Map is shown on page 2.

Hydrologic and hydraulic analyses were prepared to model the existing condition, as well as several proposed drainage improvement alternatives. The results of these analyses are included in this report. The historic drainage condition and the existing drainage condition are briefly discussed, and the overall focus of this report is on the proposed drainage alternatives.

These alternatives are grouped into two categories: short-term improvements targeted at more frequent storms, and ultimate improvements that will address the 100-year storm. Short-term improvements are projects that could be constructed in a relatively short period of time (less than 5 years) for significantly less cost compared to the ultimate improvement. None of the short-term improvement projects provide ideal long-term flood protection for Leucadia although they will notably decrease floodplain elevations for portions of the study area. The ultimate improvement is the only project that removes the entire watershed from the floodplain. However, the ultimate improvement bares a significant cost, which may hinder the time period in which it would be constructed.

The City of Encinitas is tasked with selecting one or more alternatives for further analyses and design. Each alternative will be evaluated based on factors including overall benefit to the community, completion time, environmental constraints, and cost.

## VICINITY MAP



# HYDROLOGIC ANALYSIS

## Hydrologic Methodology

The U.S. Army Corps of Engineers HEC-1 computer model was used for the hydrologic analysis of the Leucadia area along Highway 101 between Encinitas Boulevard and La Costa Avenue. The HEC-1 model is designed to simulate the surface runoff response to precipitation within the drainage basin. HEC-1 also has the capability to model the effects of detention and storage of runoff within a watershed.

The HEC-1 analyses were based on the Natural Resources Conservation Service (NRCS) hydrologic method (formerly known as the Soil Conservation Service [SCS] hydrologic method) outlined in the *2003 San Diego County Hydrology Manual*. The 10-year and 100-year return frequency storms were analyzed using HEC-1 for the existing condition as well as Options A, B, and C of Alternative 2.

## HEC-1 Parameters

<u>Rainfall Distribution</u>

Hydrographs for each basin were developed using either a 10-year or 100-year frequency, 24-hour return period, nested rainfall distribution. The nested storm distribution supersedes both the Type B and Type C rainfall distributions outlined in the *1993 San Diego County Hydrology Manual*. A limitation of the Type B and Type C distributions was that each distribution was applicable to the 6-hour and 24-hour durations only, and required separate analyses to be prepared for each duration. In most cases, the 6-hour storm duration produced a higher peak flow rate, while the 24-hour storm duration generated a greater runoff volume. Use of the nested storm pattern eliminates the need for separate analyses for 6-hour and 24-hour storm durations.

The total precipitation amounts for the 10-year and 100-year storm events with 6-hour and 24-hour duration periods were obtained from the County of San Diego isopluvial maps included in Appendix A, and are presented in Table 1.

**Table 1. Coastal Encinitas Rainfall Depths**

| | **6-hour** | **24-hour** |
|---|---|---|
| **2-year** | 1.2 inches | 1.8 inches |
| **5-year** | 1.6 inches | 2.5 inches |
| **10-year** | 1.8 inches | 3.0 inches |
| **50-year** | 2.3 inches | 3.8 inches |
| **100-year** | 2.5 inches | 4.0 inches |

## Watershed Boundaries

The watershed areas were delineated from digital topography flown in July 2001, provided by the City of Encinitas. Watershed delineations were field verified to improve accuracy. The total watershed area tributary to the Leucadia area storm drain system is approximately 0.49 square miles for the 10-year storm and 0.87 square miles for the 100-year storm. Most of the 10-year watershed area is located west of the railroad tracks. With the exception of the Line A connection to the storm drain system that collects storm runoff from east of the railroad tracks, it is assumed that runoff does not make it west of the tracks. The 100-year watershed extends east of the railroad tracks, but does not include several sumps located west of Interstate 5.

Exhibits 1 and 2 on pages 5 and 6 show the 10-year and 100-year watershed maps, respectively.

## Curve Number

The composite curve number (CN) for each basin is based the soil type, land use coverage, and precipitation zone number. The CN calculations for each basin and associated support data are included in Appendix A.

### *Soil Type*

The soil type information was obtained from the San Diego Association of Governments (SANDAG) in Geographic Information System (GIS) format. The soil type is based on the United States Department of Agricultural Soil Survey for San Diego County, and consists mainly of Type A soil. Exhibit 3 on page 7 shows the Soil Survey map.

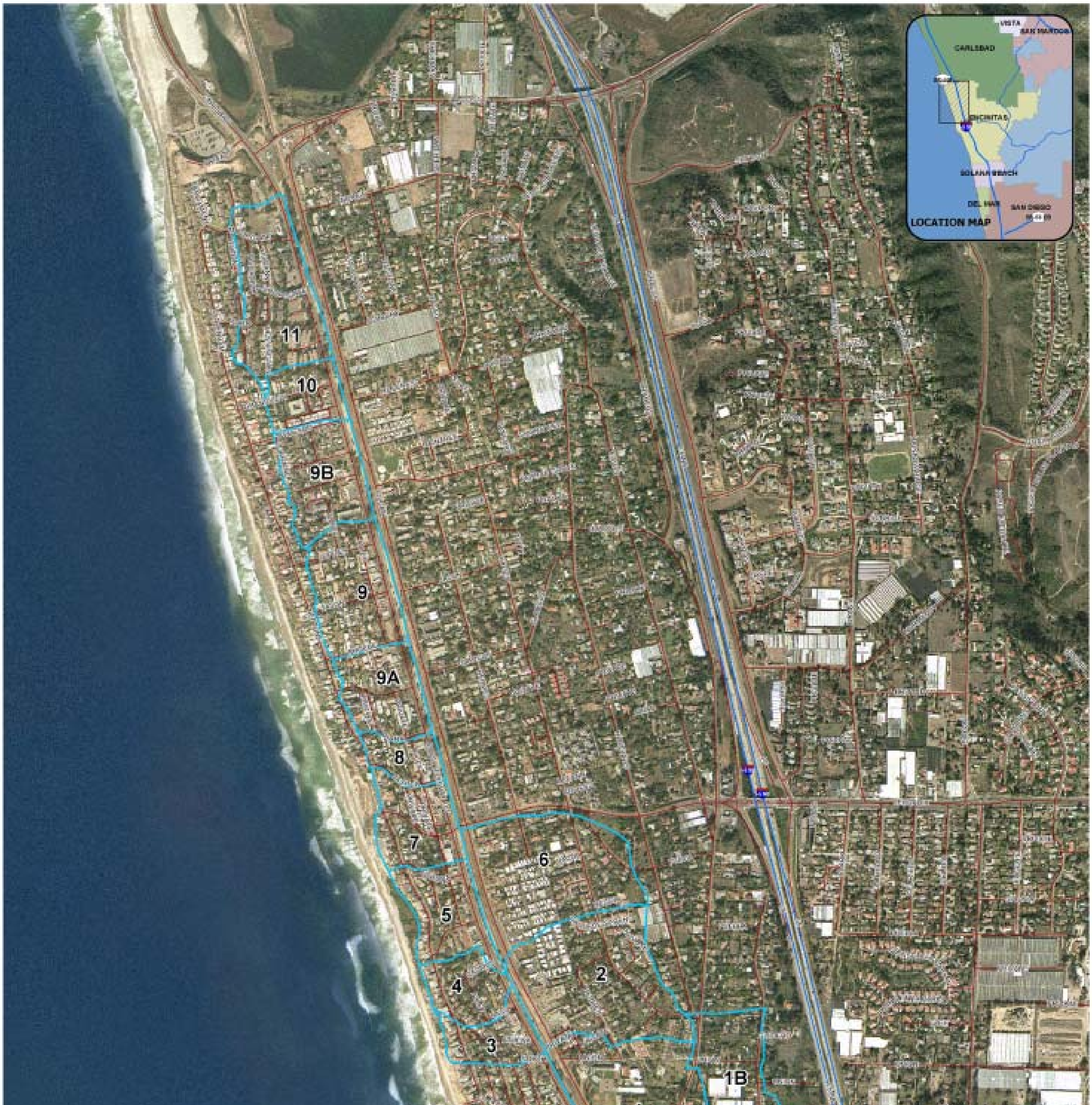



EXHIBIT DATE: JUNE 15, 2004 REC JN: 14413 U:\D_14413\leucadia_coast...\exhibit5_watersheds_10yr_unaltered.mxd

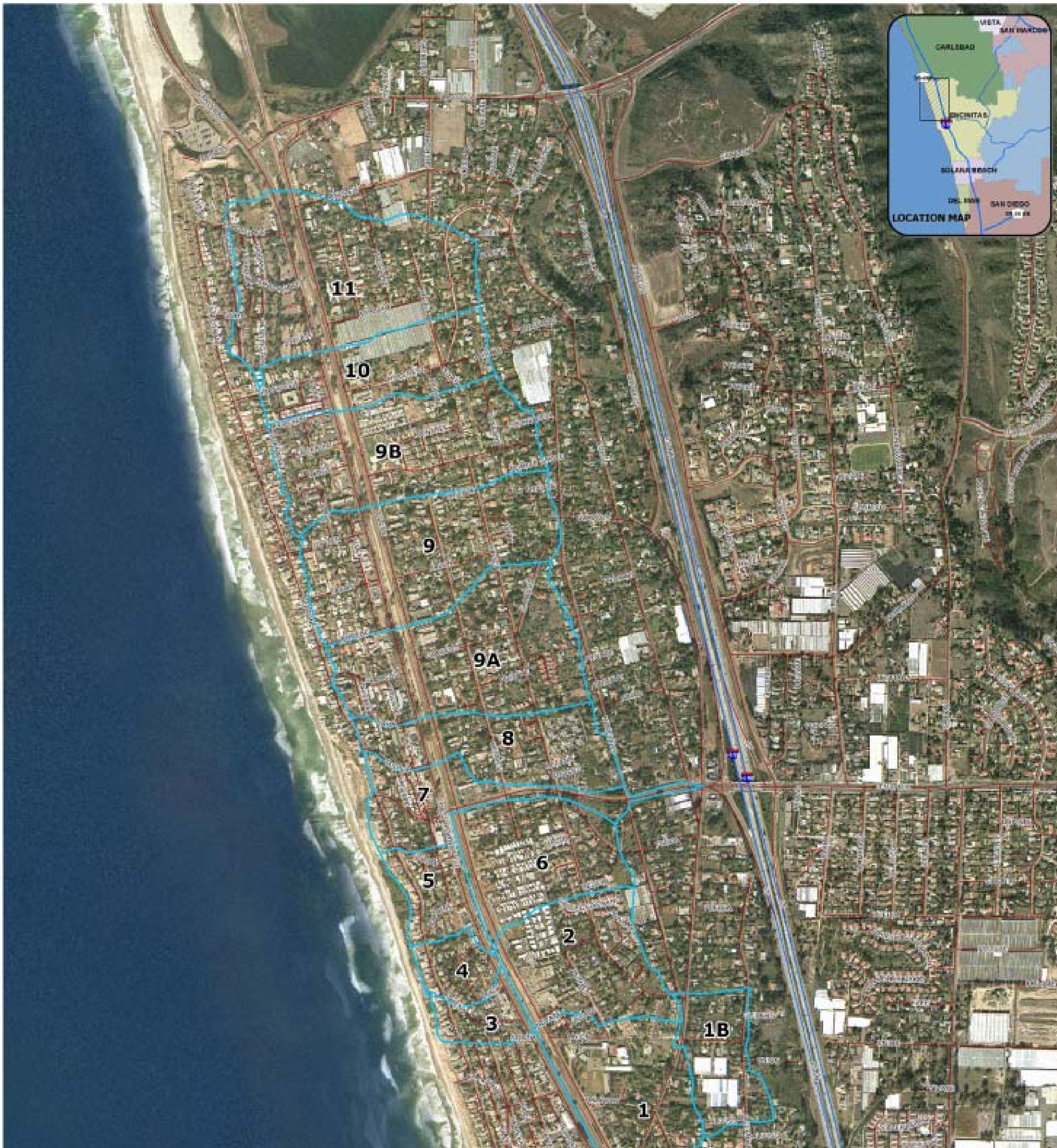
NO SCALE

## Exhibit 1: EXISTING 10-YEAR WATERSHED MAP FOR LEUCADIA

THIS PROJECT LOCATED WITHIN THE CITY OF ENCINITAS

RICK ENGINEERING COMPANY

PREPARED BY GIS SERVICES DIVISION

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NO SCALE

RICK ENGINEERING COMPANY

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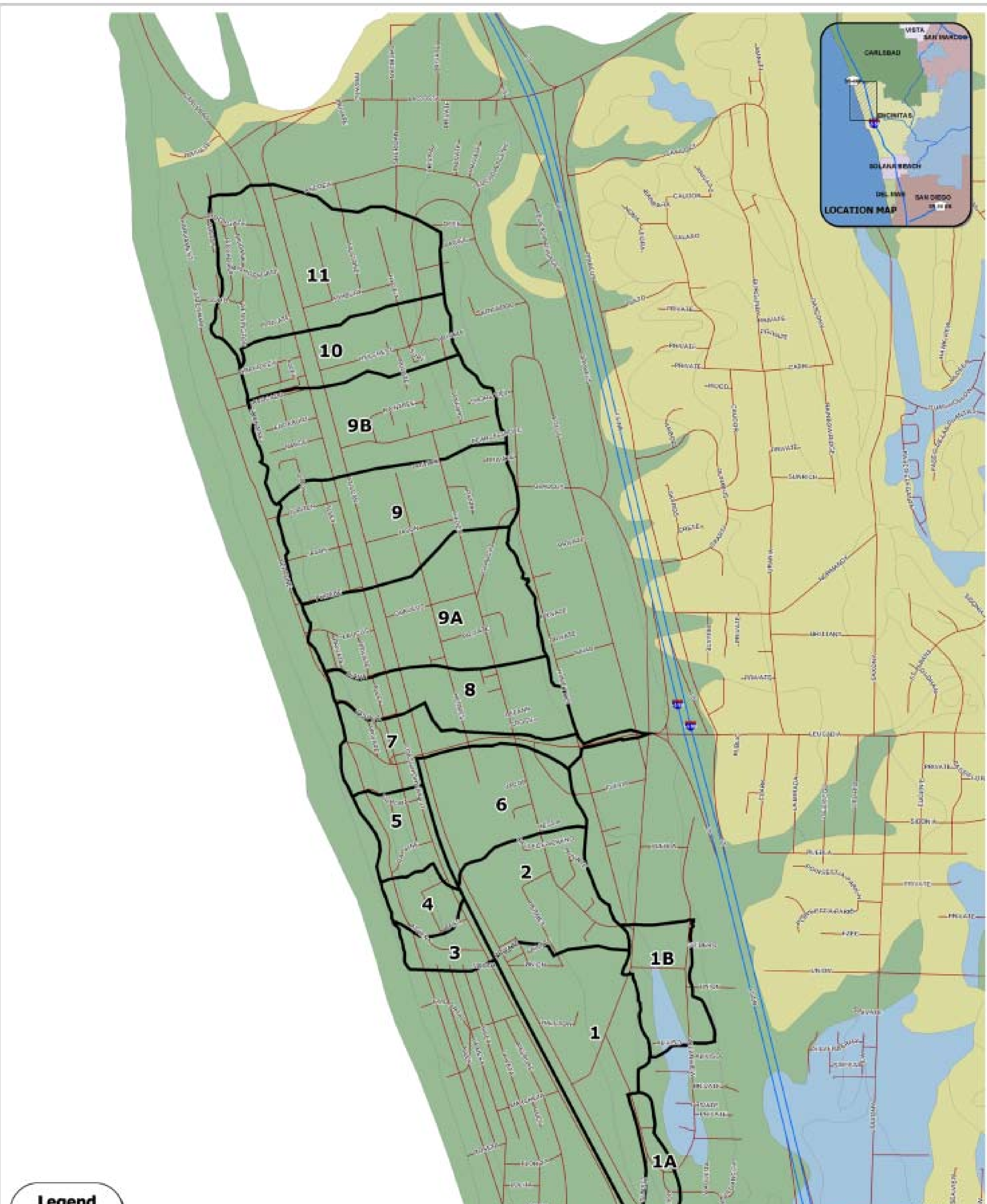
**Exhibit 2:**

**EXISTING 100-YEAR WATERSHED MAP FOR LEUCADIA**

THIS PROJECT LOCATED WITHIN THE CITY OF ENCINITAS

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## Exhibit 3: EXISTING 100-YEAR WATERSHED AND SOIL MAP FOR LEUCADIA

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NO SCALE

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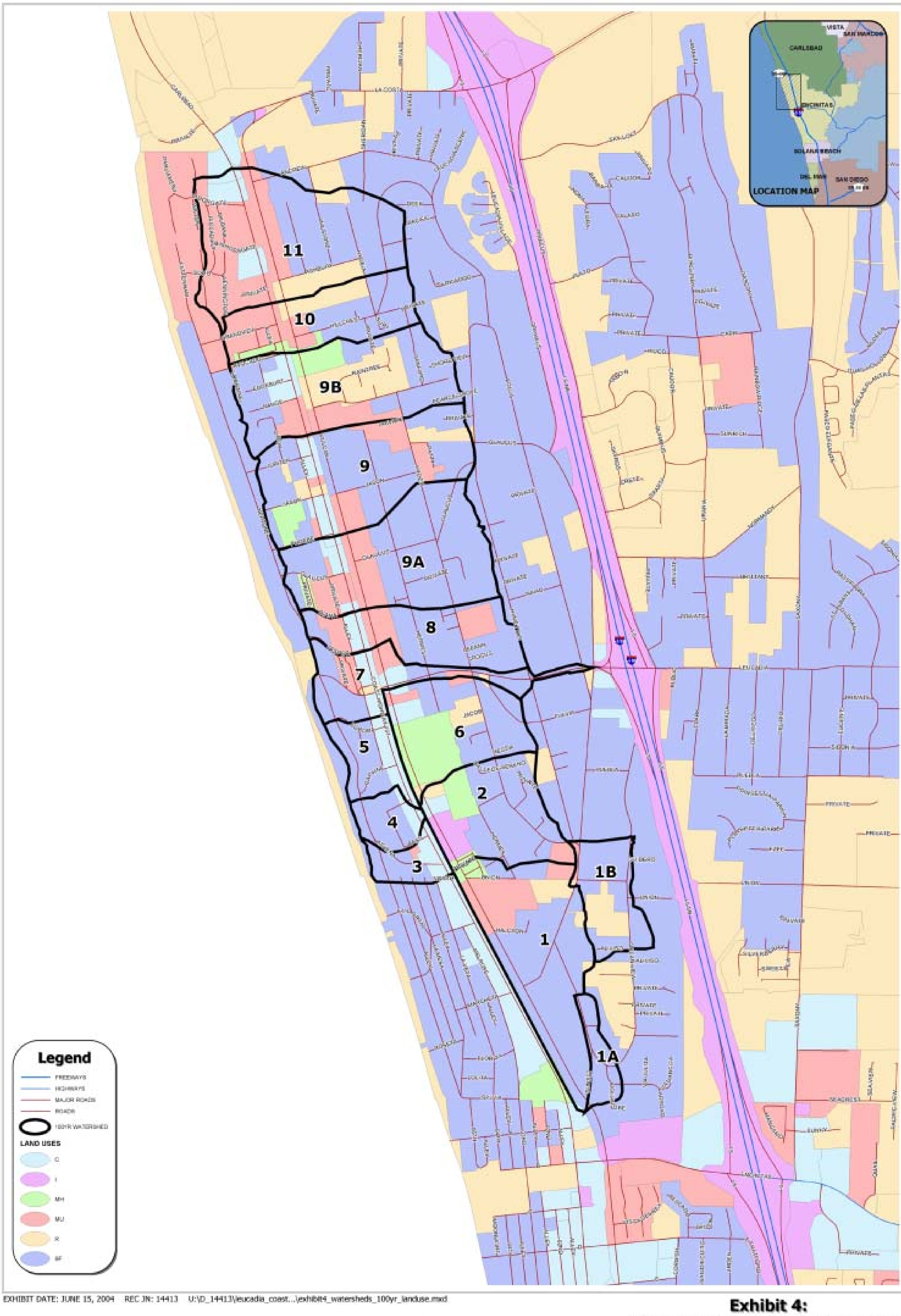


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## Exhibit 4:
## EXISTING 100-YEAR WATERSHED AND COUNTY OF SAN DIEGO LAND USE MAP FOR LEUCADIA

THIS PROJECT LOCATED WITHIN THE CITY OF ENCINITAS

NO SCALE

RICK ENGINEERING COMPANY

PREPARED BY GIS SERVICES DIVISION

*Land Use*

The land use coverage information was obtained from the SANDAG in GIS format. The land use data is 1995 existing land use based on 1995 color infrared satellite imagery, 1994/1995 black and white digital orthophoto quads, SanGIS landbase (registration) and miscellaneous sources. Exhibit 4 on page 8 shows the Land Use map.

To supplement the land use data for the watershed, review of aerial photographs showed that the ground cover of the Leucadia area is mostly developed and generally has higher imperviousness than is indicated by the land use maps. Therefore, the curve number calculation was appropriately adjusted for each basin.

*Precipitation Zone Number*

The CN was adjusted for the precipitation zone number (PZN) condition of 1.5 for the 10-year analyses and 2.0 for the 100-year analyses as outlined in the *2003 San Diego County Hydrology Manual*. The PZN condition is a function of the County of San Diego precipitation zone number map, also included in Appendix A.

## Lag Time

The lag time was first calculated based upon criteria developed by the United States Army Corps of Engineers (USACOE). The USACOE lag time is an empirical relationship of the physical characteristics of a drainage area in terms of time. The USACOE empirical relationship produced uncharacteristically short lag times for each basin. Therefore, the lag times for each watershed were determined based on the Natural Resources Conservation Service (NRCS) method using a calculated time of concentration. Lag calculations are included in Appendix A.

The time of concentration is a function of the composite runoff coefficient of the basin and the approximate velocity of the flow though the basin as outlined in the *2003 San Diego County Hydrology Manual*. The NRCS lag time, $T_{l,}$ is found by first determining $T_p$ using the following equation related to the calculated time of concentration:

$$T_p = 0.67\ T_c$$

Where:

- $T_c$ is defined as: 1) the time for runoff to travel from the furthermost point in the watershed to one point in question, and 2) the time from the end of excess rainfall to the point of inflection of the unit hydrograph.
- $T_c = T_i + T_t$
  - $T_t$ is the time of concentration of street flow
  - $T_t = D_t/V$, then divide by 60 to convert to minutes
    - $D_t$ is the length of street flow (feet)
    - V is velocity of street flow (feet per second)
  - $T_i$ is the initial time of concentration of overland flow
  - $T_i = 1.8(1.1 - C)SQRT(D)/(s^{\wedge 1/3})$

    [from Figure 3-3 in San Diego County Hydrology Manual]
    - C = Runoff Coefficient
    - D = Length of overland flow (feet)
    - s = Slope of overland flow (%)

The NRCS lag time of a watershed is then determined by the following equation:

$$\text{NRCS } T_l = T_p - D/2$$

A summary of the hydrologic information for each basin that was used for calculating the hydrograph and peak runoff in the HEC-1 analyses is provided in Appendix A.

**Existing Flow Patterns**

Existing flow patterns were modeled using detained peak flow rates. The sumps within the study area essentially act as detention basins since runoff must pond to a specific elevation to spill over to the next sump. Storage of storm water within the sumps is incorporated into the detained peak flow rate, which results in a significantly lower peak flow rate when compared to the undetained peak flow rate.

Under the existing condition runoff enters the storm drain system at a controlled rate regardless of whether the storm produces a small or large amount of runoff due to the orifice plates; therefore, the hydrologic model was adjusted to account for the flow that is diverted into the storm drain system. Diversion at the Phoebe Pump Station was accounted for as well.

**Short-Term Flow Patterns**

Short-term flow patterns for the options in Alternative 2 were modeled using a combination of the detained and undetained peak flow rates. Each of these options proposes to change the existing grade to allow the conveyance of runoff at a constant slope for a portion of the study area. The detained peak flow rate is used for the part of the study area that is not improved (Basins 1 through 8). A hydrologic model was created for each option for both the 10-year and 100-year storm events that incorporates both detained and undetained conditions in the appropriate areas for each option as described below:

- Option A: Detained peak flow rate through Basin 10, where the runoff enters the channel within the NCTD right-of-way.
- Option B: Detained peak flow rate through Basin 9B, where grading in Highway 101 commences. Undetained peak flow rate for remainder of study area.
- Option C: Detained peak flow rate through Basin 9, where grading in Highway 101 commences. Undetained peak flow rate for remainder of study area.

**Ultimate Flow Patterns**

Ultimate flow patterns were modeled using the undetained peak flow rates. The undetained peak flow rate was calculated assuming that runoff was able to drain freely, as if it did not have to travel through the sump areas. The ultimate flow patterns were used for Alternative 3, an underground storm drain system with capacity for the 100-year storm.

Table 2 shows a summary of the peak flow rates calculated by HEC-1 for the existing, short-term, and ultimate conditions.

**Table 2. Summary of Peak Flow Rates into Batiquitos Lagoon and Percent Reduction in Peak Flow due to Surface Storage**

| Drainage Condition | Storm Event | Peak Q | Percent Reduction in Peak Q due to Surface Storage |
|---|---|---|---|
| **Existing Detained (HEC-RAS)** | 10-year | 25 cfs | 81% |
| | 100-year | 188 cfs | 75% |
| **Short-term Alternative 2 Option A* (HEC-RAS)** | 10-year | 22 cfs | 84% |
| | 100-year | 187 cfs | 75% |
| **Short-term Alternative 2 Option B* (HEC-RAS)** | 10-year | 25 cfs | 81% |
| | 100-year | 222 cfs | 71% |
| **Short-term Alternative 2 Option C* (HEC-RAS)** | 10-year | 27 cfs | 80% |
| | 100-year | 274 cfs | 64% |
| **Ultimate Alternative 3 (HEC-RAS)** | 10-year | 134 cfs | 0% |
| | 100-year | 762 cfs | 0% |

*The majority of surface storage occurs in the upper watershed between Basins 1 through 8.

## HYDRAULIC ANALYSIS

### HEC-RAS

The U.S. Army Corps of Engineers HEC-River Analysis System (HEC-RAS) was used to model the hydraulic characteristics of the surface drainage in Leucadia. Hydraulic analyses for the 10-year and 100-year return frequency storm events were prepared for the Existing Condition. The following drainage improvement alternatives were also analyzed to determine the impact on the 10-year and 100-year floodplain: Alternative 2 Option A, Alternative 2 Option B, and Alternative 2 Option C. HEC-RAS has the capability to model subcritical, supercritical, and mixed flow. HEC-RAS calculates water surface profiles based on the energy equation and the momentum equation.

Geometric information, Manning's roughness coefficient, discharge, as well as any known boundary conditions are required to complete the hydraulic model. Geometric information was based on cross-sections through the study area defined by 2-foot contour topography provided by the City of Encinitas. Identifying blocked obstructions based on review of the aerial photograph further refined cross-sectional geometry. Blocked obstructions included commercial as well as residential structures located in the floodplain. Manning's roughness coefficients were estimated between 0.02 and 0.035 based on visual observation. Discharges (10-year and 100-year) were obtained from the HEC-1 analyses and input incrementally for each basin rather than using the peak flow rate at the downstream end.

Each HEC-RAS analysis contains three reaches due to the flow patterns of the area. The general flow path from approximately Athena Street to Leucadia Park follows the alley adjacent to Highway 101 (Reach 101). In addition to surface flow within and adjacent to Highway 101, runoff is conveyed east of the railroad tracks adjacent to Vulcan Avenue, and was assumed to combine with runoff from Highway 101 near Leucadia Park (Reach Vulcan). North of Leucadia Park the runoff from Reach 101 and Reach Vulcan combine and is conveyed within Highway 101 until it crosses into the NCTD right-of-way north of Grandview Street (Reach Combine).

**Manning's Equation**

Manning's Equation was used to calculate preliminary pipe sizes for the 10-year and 100-year ultimate storm drain systems. Input parameters included peak flow rate plus 20%, Manning's roughness coefficient (assumed 0.013), and longitudinal slope (assumed 0.5%). Additional analyses are required to proceed with the design of the ultimate storm drain system.

**WSPGW**

The County of Los Angeles Water Surface Pressure Gradient (WSPGW) program was used to provide a preliminary hydraulic analysis of the ultimate 100-year capacity storm drain system. The program computes and plots uniform and non-uniform steady flow water surface profiles and pressure gradients in open channels or closed conduits with irregular or regular sections. The flow in a system may alternate between supercritical, subcritical, or pressure flow in any sequence. The program uses basic mathematical and hydraulic principles to calculate data such as cross-sectional area, wetted perimeter, normal depth, critical depth, pressure, and momentum.

Input parameters included pipe sizes and reach lengths, flowline elevations, Manning's roughness coefficients, and flow rates at the upstream end of the system as well as at laterals. The pipe sizes were based on the results from the Manning's Equation calculations, and the other input parameters were approximated to determine in general whether the proposed pipe sizes would have adequate capacity to convey the peak flow rate from the 100-year return frequency storm event. Additional analyses are required to proceed with the design of the ultimate storm drain system.

**Pipe Flow**

The AES Pipe Flow Hydraulics computer program was used to provide a preliminary estimate of peak flow rate and pipe size for Alternative 1 – Leucadia Park Overflow. The program performs gradually varied flow and pressure flow profile computations. The results are provided in an incremental and summarized form, and indicate reaches of open channel and pressure flow within a given reach of pipe. The program also accounts for losses that may occur due to friction, junction structures, pipe bends, etc.

Input parameters included pipe sizes, lengths, flowline elevations, Manning's roughness coefficient, and peak flow rate. Additional analyses are required to proceed with the design of the Leucadia Park Overflow.

## DRAINAGE IMPROVEMENT PROJECTS

### Historic Drainage Condition


The historic (and existing) topography in Leucadia does not allow free-flowing surface drainage. The profile of the flow path contains several peaks and valleys, subsequently creating sump areas. In the historic condition (pre-2001 storm drain installation), the sump areas in the alley west of Highway 101 did not contain underground storm drain systems. Therefore, the runoff produced by storm events ponded in the sump areas until it eventually infiltrated into the ground, evaporated, or was otherwise removed via pump or other device. During larger storm events (greater than an estimated 10-year frequency), the water ponded until it reached an elevation that allowed it to overtop into the next sump. Since the runoff could not freely drain out of the sump areas, at times the ponded water reached elevations that inundated not only streets and alleys, but also residential and commercial properties.

The water followed this process, cascading north along the Highway 101 corridor, until making its way north into the NCTD right-of-way near Bishopsgate Road and ultimately into the Batiquitos Lagoon. Signs of erosion due to conveyance of storm flows are evident within the NCTD right-of-way near the lagoon

### Existing Drainage Condition – Completed Projects

The City of Encinitas has completed several projects to improve the drainage in Leucadia. These projects include the installation of a storm drain system, enhancements to the storm drain system, improvements to surface drainage, as well as implementation of emergency response protocols during storm events.

Installation of a Storm Drain System (2001)

The existing storm drain system consists of a 24" main line along Highway 101 that begins near Union Street, flows in the northerly direction, and outlets into two detention basins located in series just north of La Costa Avenue. Several laterals tie into the main line, which connect the sump areas in the alley to the storm drain system. The storm drain system was initially intended to convey nuisance runoff as well as runoff from small storm events. The capacity of the storm drain system when it was constructed in 2001 varied from less than 2-year storm frequency to up to 10-year storm frequency depending on the location, which provided varying levels of drainage within the watershed.

Storm Drain System Enhancement (2003)

The City of Encinitas constructed enhancements to the existing storm drain system (November 2003) to reduce the extent of flooding during small, frequent storm events (up to 5-year) when compared with the historic condition by providing a more uniform level of drainage for the entire watershed. The interim improvements result in lower ponded water elevations and constant drainage at a more regulated rate for small storm events. These enhancements were achieved by

the installation of orifice plates in the laterals to the main storm drain line (shown in photo). By controlling the rate of discharge, the efficiency of the storm drain can be maintained for storm events up to 5-year frequency throughout the entire system.

Analyses of the storm drain system with the orifice plate enhancements is detailed in the Rick Engineering Company report titled "Hydrologic and Hydraulic Study for Coast Highway 101 Interim Storm Drain Improvements, Encinitas, California" dated November 18, 2003.

Although the orifice plates enhance the performance of the existing storm drain system, runoff still ponds in the sump areas during storms, resulting in potential inundation of streets and other properties. The City addressed the extent of flooding on Vulcan Avenue near Union Street with the installation of a sluice gate/orifice plate in the storm drain system. The orifice plate serves to restrict flows from crossing under the NCTD right-of-way during the storm event, and the sluice gate can be opened to expedite drainage of the stored water after the storm when the downstream facility is no longer overtaxed.

Runoff generated by storm events greater than an estimated 10-year frequency still follows historic drainage patterns, where the water ponds until it reaches an elevation allowing it to overtop into the next sump, following this process until ultimately making its way north to the Batiquitos Lagoon. The alternatives presented in the design phase and planning phase sections of this report discuss short-term as well as ultimate solutions to further improve drainage in Leucadia.

Improvements to Surface Drainage (2004)

The City constructed a 1,300-foot long earthen channel with an 4-foot bottom width and 1.5:1 (horizontal:vertical) side slopes aligned parallel to Vulcan Avenue adjacent to the NCTD right-of-way from approximately Orpheus Avenue to Union Street (photo looking north from the Orpheus Avenue/Vulcan Avenue intersection). Prior to installation there was no defined drainage channel to convey storm runoff, resulting in inundation between Vulcan Avenue and the railroad ballast. The ditch was designed to alleviate some flooding within Vulcan Avenue and convey storm runoff to the headwall of the storm drain system in the NCTD right-of-way near Union Street.

Emergency Response Protocol (Ongoing)

Several departments within the City of Encinitas work collectively to alleviate the extent of flooding in Leucadia. The Fire Department implements an action plan prior to and during storm events, including placing sand bags in several areas to protect homes and businesses, closing the city streets as necessary, and pumping storm runoff from Leucadia Park westerly over the bluffs at Beacons Beach. In addition, the Public Works Department dispatches vac-con trucks to remove localized ponds from the sump areas.

Leucadia Park (shown in photo) is a low point in the upper watershed and therefore experiences inundation during storm events larger than about a 2-year storm. The fire department uses the park as a staging area to pump runoff to the ocean. A pump hose is extended from the park along Leucadia Boulevard to the Beacons Beach parking lot, where it connects to an existing hose that is housed within a 12-inch diameter PVC pipe. The PVC pipe rests along the slope of the bluff so the hose can be carried into the surf and can discharge flood waters to the ocean. The fire department does not pump runoff to the ocean until the existing storm drain is overtaxed, ensuring that the low flows are still conveyed in the underground storm drain system northerly to the detention basins for water quality purposes.

## Existing Drainage Condition – Hydraulic Results

Table 3 shows the existing 10-year and 100-year water surface elevations from the HEC-RAS analysis. Please refer to the HEC-RAS work map located in Map Pocket 1 for the locations of the cross-sections. Exhibits 5 and 6 on pages 22 and 23 show the 10-year and 100-year floodplain and watershed maps, respectively.

**Table 3. Existing 10-year and 100-year Floodplain Elevations**

| REFERENCE CROSS-STREETS | HEC-RAS REACH | HEC-RAS CROSS-SECTION | 10-YEAR WSEL (ft) | 100-YEAR WSEL (ft) |
|---|---|---|---|---|
| | Combine | 30 | 46.3 | 47.1 |
| | Combine | 35 | 49.7 | 50.6 |
| | Combine | 40 | 53.7 | 54.7 |
| | Combine | 45 | 54.0 | 55.4 |
| | Combine | 50 | 53.9 | 55.4 |
| **GRANDVIEW ST** | Combine | 55 | 54.1 | 55.5 |
| | Combine | 60 | 54.1 | 55.5 |
| | Combine | 65 | 54.2 | 55.5 |
| | Combine | 70 | 54.4 | 55.5 |
| | Combine | 75 | 54.6 | 55.6 |
| | Combine | 80 | 54.6 | 55.6 |
| **PHOEBE ST** | Combine | 85 | 54.6 | 55.6 |
| | Combine | 90 | 54.6 | 55.6 |
| | Combine | 95 | 54.6 | 55.6 |
| | Combine | 100 | 55.3 | 55.8 |
| | Combine | 105 | 55.3 | 56.0 |
| | Combine | 110 | 55.3 | 56.1 |
| | Combine | 115 | 55.3 | 56.1 |
| | Combine | 120 | 55.3 | 56.1 |
| | Combine | 125 | 55.3 | 56.1 |
| | Combine | 130 | 55.3 | 56.1 |
| | Combine | 135 | 55.3 | 56.1 |
| **LEUCADIA BLVD.** | Combine | 140 | 55.3 | 56.1 |
| | 101 | 145 | 55.3 | 56.1 |
| | 101 | 150 | 55.3 | 56.1 |
| | 101 | 160 | 55.3 | 56.1 |
| | 101 | 165 | 56.0 | 56.1 |
| **DAPHNE ST** | 101 | 170 | 58.6 | 58.7 |
| | 101 | 175 | 59.2 | 59.3 |
| | 101 | 180 | 59.5 | 59.6 |
| | 101 | 185 | 59.5 | 59.7 |
| | 101 | 190 | 59.5 | 59.7 |
| | 101 | 195 | 59.5 | 59.7 |
| | 101 | 205 | 59.5 | 59.7 |
| | 101 | 210 | 59.5 | 59.7 |
| | 101 | 215 | 59.5 | 59.7 |
| **BASIL ST** | 101 | 220 | 59.5 | 59.7 |
| | 101 | 225.1 | 59.5 | 59.7 |

| REFERENCE CROSS-STREETS | HEC-RAS REACH | HEC-RAS CROSS-SECTION | 10-YEAR WSEL (ft) | 100-YEAR WSEL (ft) |
|---|---|---|---|---|
| | 101 | 225.2 | 59.5 | 59.7 |
| | 101 | 225.3 | 59.5 | 59.7 |
| | 101 | 230 | 60.1 | 60.2 |
| | Vulcan | 150 | 63.4 | 64.2 |
| | Vulcan | 165 | 63.9 | 65.0 |
| | Vulcan | 175 | 66.1 | 66.5 |
| | Vulcan | 195 | 66.3 | 67.0 |
| | Vulcan | 215 | 66.8 | 67.3 |
| | Vulcan | 220 | 66.9 | 67.5 |
| | Vulcan | 225 | 66.9 | 67.5 |
| | Vulcan | 230 | 66.9 | 67.5 |
| | Vulcan | 235 | 66.9 | 67.5 |
| **UNION ST** | Vulcan | 240 | 66.9 | 67.5 |
| | Vulcan | 245 | 66.9 | 67.5 |
| | Vulcan | 2100.26 | 66.9 | 67.5 |
| | Vulcan | 2200.25 | 66.9 | 67.5 |
| | Vulcan | 2300.24 | 66.9 | 67.5 |
| | Vulcan | 2400.23 | 66.9 | 67.5 |
| **HALCYON RD** | Vulcan | 2500.22 | 66.9 | 67.5 |
| | Vulcan | 2600.21 | 66.9 | 67.5 |
| | Vulcan | 2700.2 | 68.0 | 68.9 |
| | Vulcan | 2800.19 | 69.4 | 70.4 |
| | Vulcan | 2900.18 | 69.9 | 71.1 |
| | Vulcan | 3000.17 | 70.4 | 71.6 |
| | Vulcan | 3100.16 | 70.9 | 72.1 |
| | Vulcan | 3200.15 | 71.3 | 72.6 |
| **ORPHEUS AVE** | Vulcan | 3300.14 | 72.2 | 73.1 |

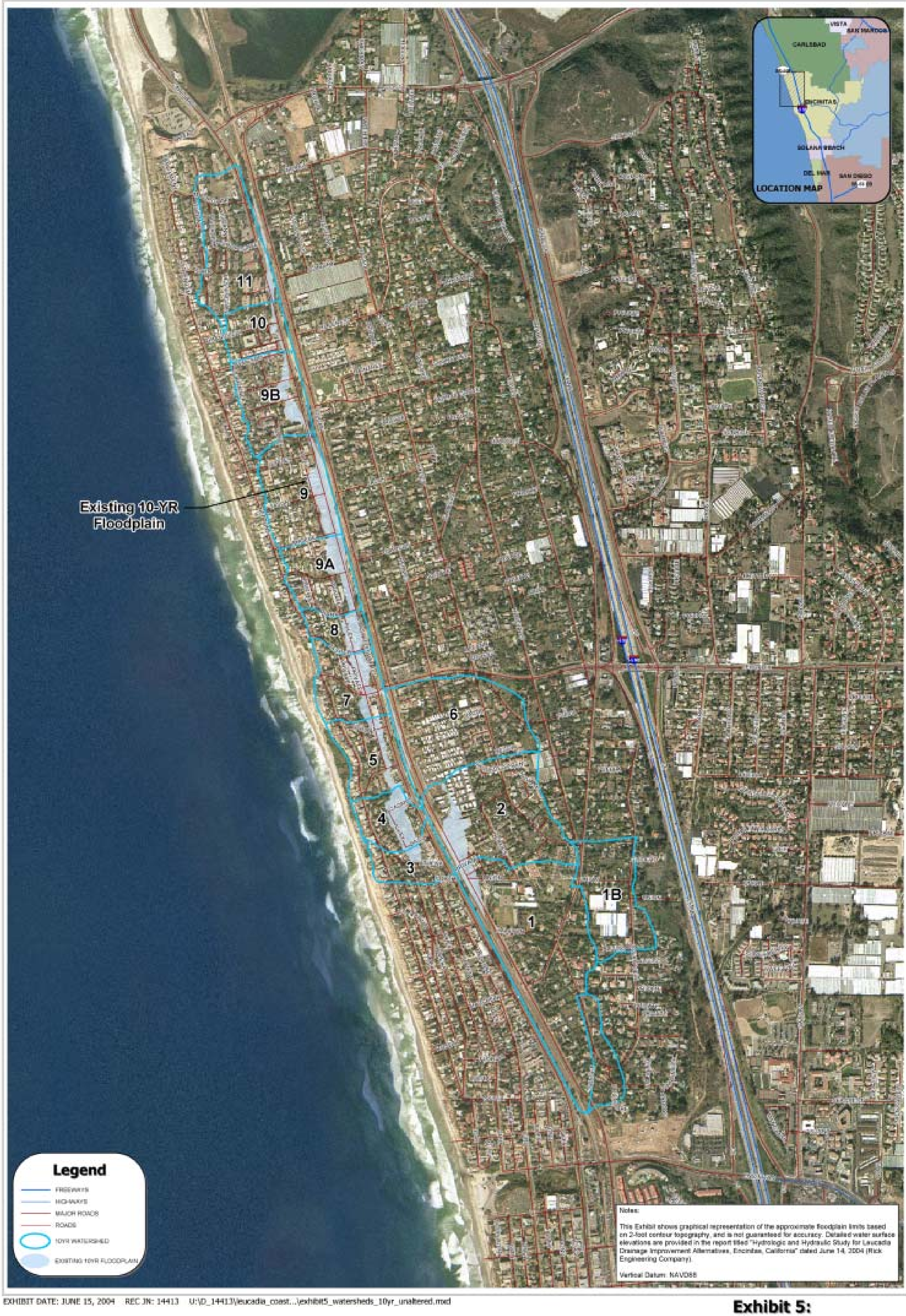



EXHIBIT DATE: JUNE 15, 2004 REC JN: 14413 U:\D_14413\leucadia_coast...\exhibit5_watersheds_10yr_unaltered.mxd

**Exhibit 5:**

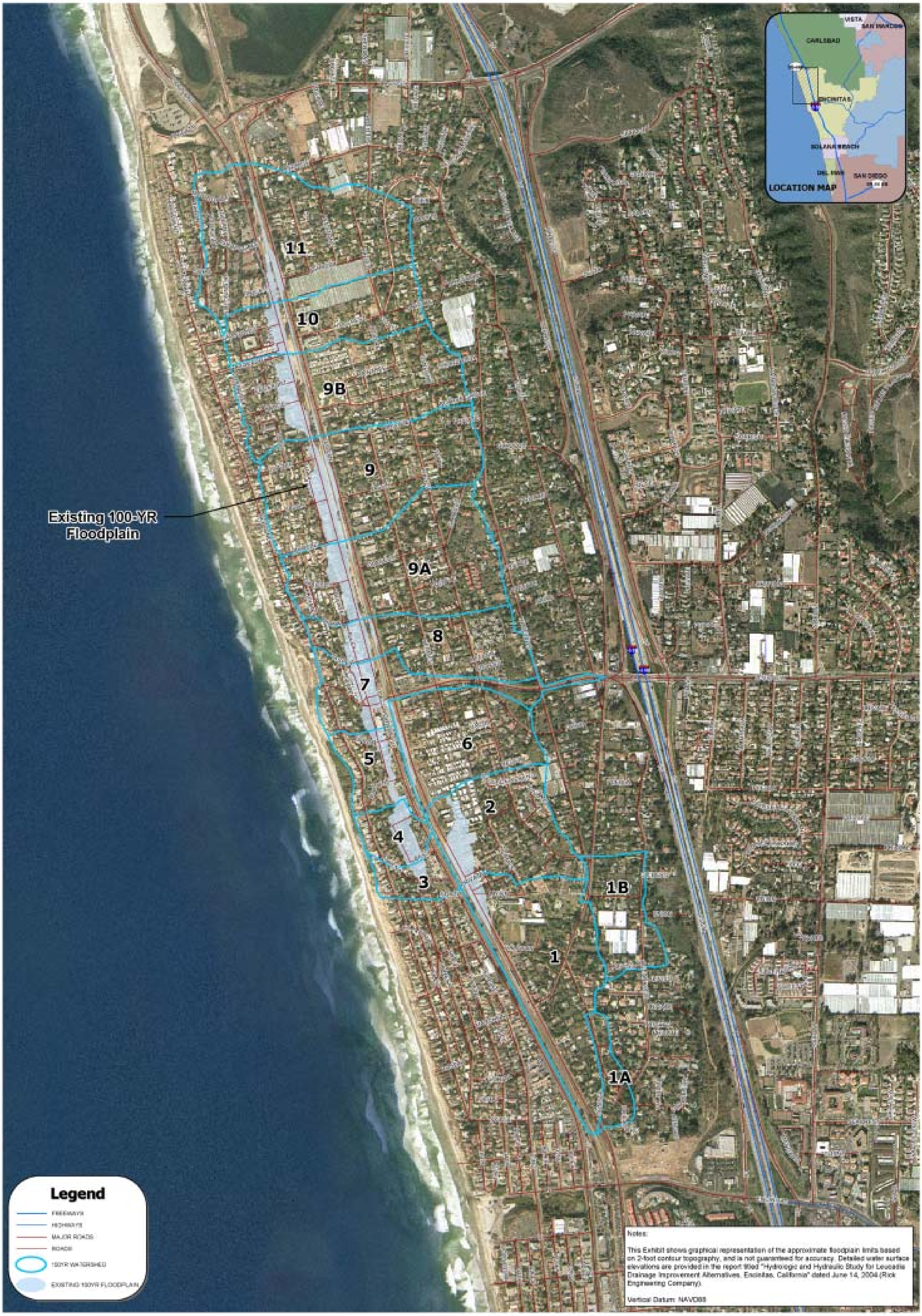
**EXISTING 10-YEAR FLOODPLAIN AND WATERSHED MAP FOR LEUCADIA**

NO SCALE

THIS PROJECT LOCATED WITHIN THE CITY OF ENCINITAS

RICK ENGINEERING COMPANY

PREPARED BY GIS SERVICES DIVISION

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NO SCALE

RICK ENGINEERING COMPANY

PREPARED BY GIS SERVICES DIVISION

**Exhibit 6:**

**EXISTING 100-YEAR FLOODPLAIN AND WATERSHED MAP FOR LEUCADIA**

THIS PROJECT LOCATED WITHIN THE CITY OF ENCINITAS

**Drainage Improvement Projects in Design Phase**

The City is currently in the process of implementing additional drainage improvements in Leucadia. These options are short-term improvements that will benefit drainage in specific areas during smaller, more frequent storm events.

Phoebe Pump Station Upgrade

Under existing conditions, runoff is detained at a pump station located at Highway 101 near Phoebe Street. The existing pump station discharges approximately 500 to 750 gallons per minute (gpm) into a storm drain system beneath Highway 101. The existing pumps fail frequently during storms due to clogging by trash and debris, and the inlets near the pump station do not effectively collect runoff from the sump areas, resulting in limited functionality of the existing pumps.

A redesigned pump station at Phoebe Street consisting of two new pumps with approximately 1,500 gpm capacity each is currently in the design phase. In addition, two new inlets will be constructed near the pump station to collect localized ponding; one between Phoebe Street and Glaucus Street (photo looking southwest between Phoebe Street and Glaucus Street) and the other between Glaucus Street and Diana Street. The new pumps and inlets will improve the local drainage in the vicinity of the pump station. Installation of the new pumps and inlets is expected to commence in the summer of 2004.

Leucadia Boulevard Drainage Swale

The City is in the design phase for an earthen channel aligned parallel to Vulcan Avenue north of Leucadia Boulevard adjacent to the NCTD right-of-way. An existing drainage pipe that collects runoff from a portion of Leucadia Boulevard currently drains into this area; however, there is no defined drainage channel to convey storm runoff resulting in inundation near the Leucadia Boulevard/Vulcan Avenue intersection (photo looking north from Leucadia Boulevard/Vulcan Avenue intersection). The ditch is being designed to alleviate localized flooding within Vulcan Avenue and more efficiently convey storm runoff northerly within the NCTD right-of-way. Exhibit 7 on page 26 shows the approximate location of the proposed drainage swale.

**Drainage Improvement Projects in Planning Phase**

Several alternatives designed to alleviate the extent of flooding for more frequent storm events, as well as for the 100-year storm, are being analyzed in the planning phase. These options are grouped into two categories: short-term improvements targeted at more frequent storms, and ultimate improvements that will address the 100-year storm. Each of the projects in the planning phase were analyzed at a preliminary level and more detailed calculations must be performed to more accurately determine parameters including pipe sizes and floodplain elevations.


EXHIBIT DATE: JUNE 15, 2004 REC JN: 14413 U:\D_14413\leucadia_coast...\exhibit7_leucadia_swale_location.mxd

**Exhibit 7:**

**LEUCADIA BOULEVARD DRAINAGE SWALE LOCATION MAP**

NO SCALE

RICK ENGINEERING COMPANY

PREPARED BY GIS SERVICES DIVISION

THIS PROJECT LOCATED WITHIN THE CITY OF ENCINITAS

Short-term Improvements

Short-term improvements analyzed in this study are projects that could be constructed in a relatively short period of time (less than 5 years) for significantly less cost compared to the ultimate improvement. Each short-term project does not benefit the entire watershed and does not significantly reduce the size or cost of the ultimate storm drain system. None of these projects provide ideal long-term flood protection for Leucadia although they will notably decrease floodplain elevations for portions of the watershed as discussed in detail in the following subsections.

***Alternative 1: Leucadia Park Overflow***

The City is analyzing the benefit of constructing an overflow storm drain system to collect runoff from the upper watershed (Basins 1, 2, 3, 4, and 7) at Leucadia Park. Storm runoff exceeding the capacity of the existing storm drain system would be diverted from the main storm drain system at Leucadia Park (shown in photo)to an overflow system that would extend from the park through the bluffs at Beacons Beach. Low flows would still pass through the existing storm drain system and discharge to the detention basins north of La Costa Avenue. Exhibit 8 on page 30 shows the approximate alignment of the Leucadia Park Overflow as well as the tributary watershed.

Runoff would be conveyed to Leucadia Park through the storm drain system and via overland flow. Since the existing storm drain system does not have capacity to convey runoff from storms greater than an estimated 5-year frequency, this alternative would only function efficiently if the storm drain system upstream of the diversion were upsized. If the storm drain system is not upsized, flooding patterns similar to the existing condition would continue because runoff would have to pond until it reached elevations high enough to allow it to pass from sump to sump until reaching the park.

A 4-foot (48-inch) diameter pipe transitioning to a 2-foot (24-inch) diameter pipe at the outlet discharging out the bluffs near Beacons Beach was analyzed for this option using Pipe Flow (see Hydraulic Methodology). Approximately 80 cfs could be diverted to the overflow, which would vary based on the design of the diversion structure. This could potentially divert up to 90% of the 10-year runoff and relieve the downstream main storm drain system during smaller storms. The overflow would eliminate the necessity for pumping from Leucadia Park by the fire department during storm events smaller than 10-year return frequency.

It is expected that if the upstream storm drain system is appropriately upsized there would be significant improvements to drainage in the upper basins for smaller storms including the 10-year frequency storm event. There would not be floodplain benefit to the lower basins (Basins 8-10). The overflow system is not expected to significantly reduce 100-year floodplain elevations, or affect the size of pipes or cost of installing the ultimate 100-year storm drain system. More detailed analyses are required to determine floodplain elevations.

Environmental permitting of the outlet has not been investigated but is expected to present a significant challenge, which should be considered in the feasibility of this project.

*Estimated Cost $1.5-2.5 million*
(Separate cost estimates prepared by Haley & Aldrich and Jacobs Associates)

Haley & Aldrich prepared a preliminary geotechnical feasibility study to evaluate trenchless techniques for storm drain pipeline installation, which included the recommendation of conventional tunneling for the Leucadia Park Overflow, and an estimated cost of $1-1.5 million, rounded to the nearest $0.5 million. Please refer to the report titled “Geotechnical Feasibility Study, Trenchless Construction Methods, Encinitas Storm Drain Project, Encinitas, California,” dated June 8, 2004, for a complete description and cost estimate of the trenchless methods.

Jacobs Associates also prepared a cost estimate of $2.5 million (rounded to the nearest $0.5 million) for the Leucadia Park Overflow, as described in the letter to Rick Engineering Company dated April 12, 2004 titled "Engineer's Opinion of Estimated Cost of Construction, Encinitas Storm Drain Improvements, Rick Contract Number 14413, Encinitas, San Diego County, California."


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NO SCALE

**Exhibit 8:**
**ALTERNATIVE 1 LEUCADIA OVERFLOW ALIGNMENT AND WATERSHED**

THIS PROJECT LOCATED WITHIN THE CITY OF ENCINITAS

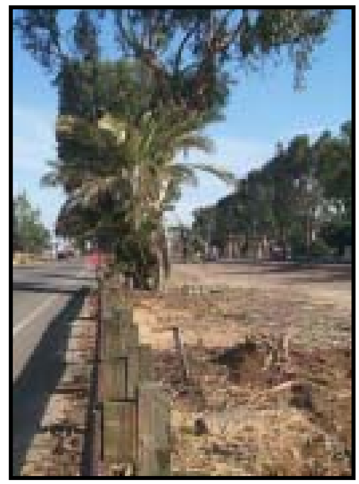
RICK ENGINEERING COMPANY

PREPARED BY GIS SERVICES DIVISION

*Alternative 2: Grading Options*

Three options were analyzed for re-grading areas in the northern portion of the Leucadia watershed to improve surface drainage. Benefits to the floodplain are seen for both the 10-year and 100-year frequency storm events, most notably in the lower (northern) part of the watershed. These grading options will not improve surface drainage in the upper basins; however, decreased floodplain elevations are seen well south of where the re-grading is proposed.

**Option A**

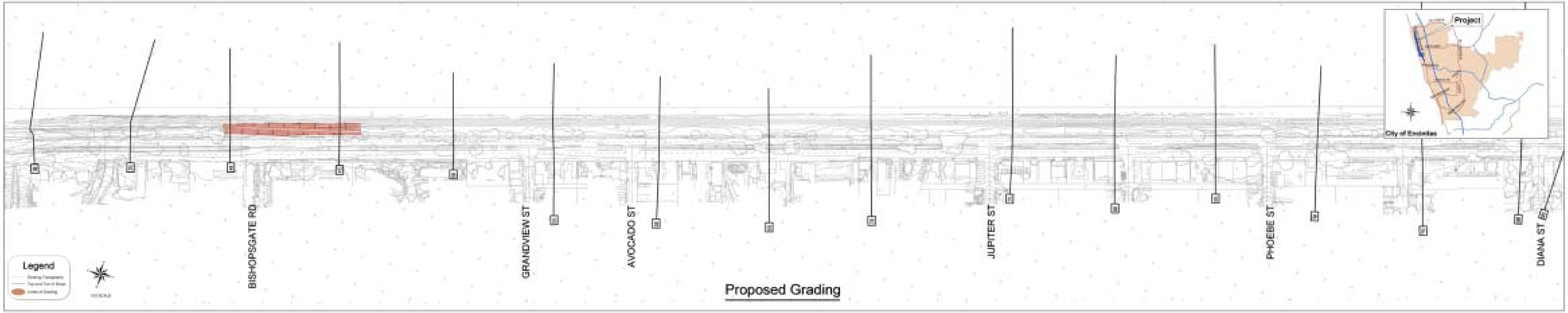


Grade a channel approximately 495-feet long with a 10-foot bottom width and 5:1 side slopes between Highway 101 and the railroad tracks within the NCTD right-of-way near Bishopsgate Road (photo looking north at NCTD right-of-way). The channel will remove an existing hump that hinders conveyance of runoff into the NCTD right-of-way, resulting in decreased floodplain elevations up to 1-foot for the 100-year storm event. Coordination and compliance by NCTD will be required for grading proposed within their right-of way.

Peak flow rates were determined using HEC-1 and flooding patterns were analyzed using HEC-RAS. Tables 4 and 5 present a summary of 10-year and 100-year floodplain elevation results for Alternative 2, respectively. See Exhibits 9 and 10 on pages 32 and 33 for a schematic of the grading, 10-year and 100-year floodplains, and typical cross-section for Option A.

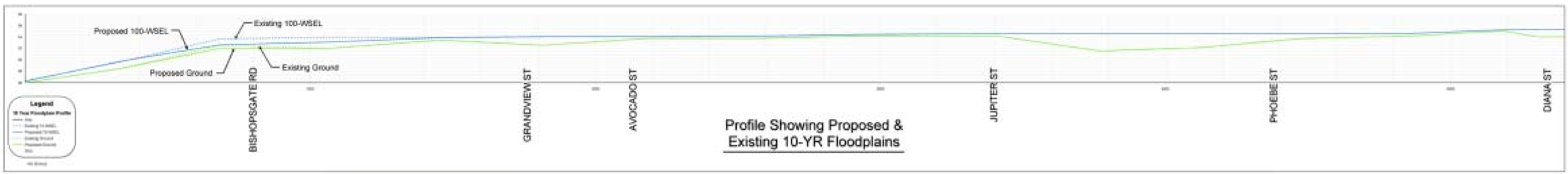
*Estimated cost: $1 million*

(Cost estimated prepared by Rick Engineering Company, included in Appendix D)



Proposed Grading

Proposed vs. Existing 10 Year Floodplains



Profile Showing Proposed & Existing 10-YR Floodplains

Notes:

This Exhibit shows graphical representation of the approximate floodplain limits based on 2-foot contour topography, and is not guaranteed for accuracy. Detailed water surface elevations are provided in the report titled "Hydrologic and Hydraulic Study for Leucadia Drainage Improvement Alternatives, Encinitas, California" dated June 14, 2004 (Rick Engineering Company).

Vertical Datum: NAVD88

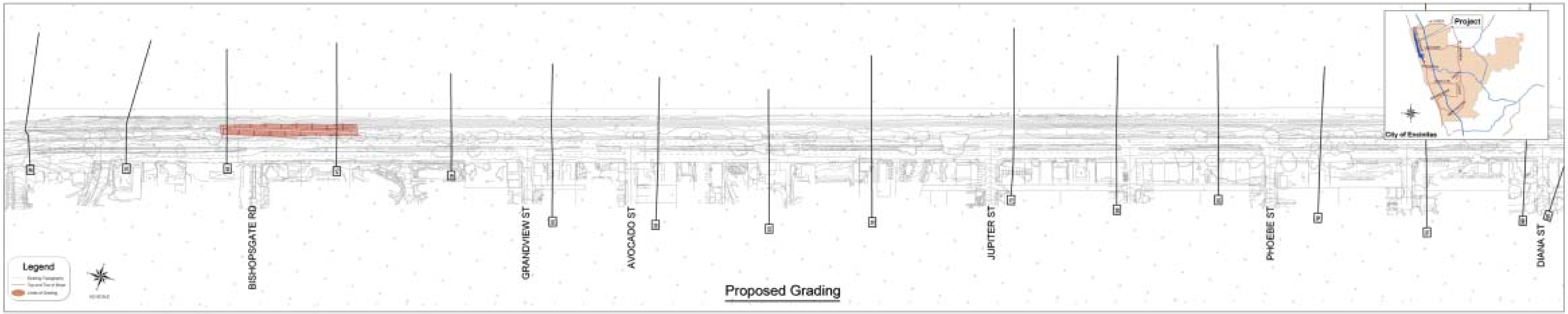
CROSS SECTION #50

# Exhibit 9: ALTERNATIVE 2 - OPTION A ALIGNMENT AND 10-YEAR FLOODPLAIN

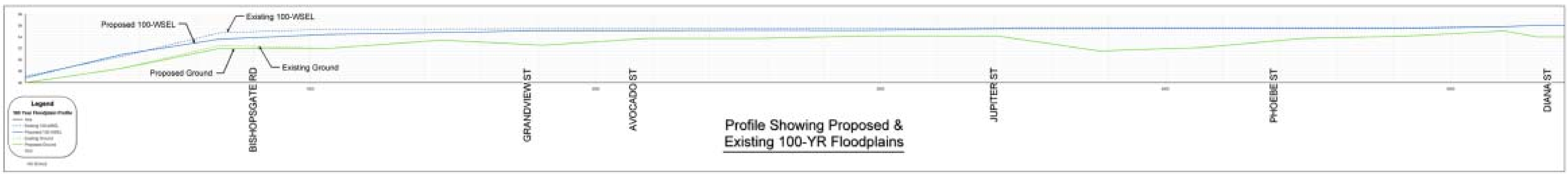
RICK ENGINEERING COMPANY

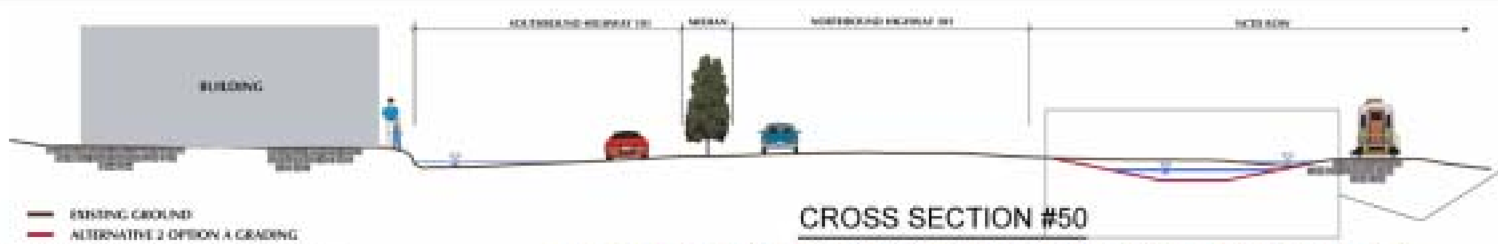
Exhibit Date: June 15, 2004 REC JN: 14413

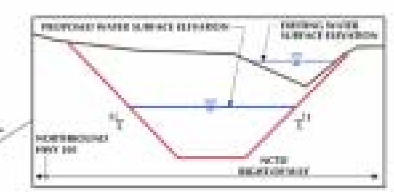
PREPARED BY GIS SERVICES DIVISION








Notes:

This Exhibit shows graphical representation of the approximate floodplain limits based on 2-foot contour topography, and is not guaranteed for accuracy. Detailed water surface elevations are provided in the report titled "Hydrologic and Hydraulic Study for Leucadia Drainage Improvement Alternatives, Encinitas, California" dated June 14, 2004 (Rick Engineering Company).

Vertical Datum: NAVD88

# Exhibit 10: ALTERNATIVE 2 - OPTION A ALIGNMENT AND 100-YEAR FLOODPLAIN

RICK ENGINEERING COMPANY

Exhibit Date: June 15, 2004 REC JN: 14413

PREPARED BY GIS SERVICES DIVISION

**Option B**

Re-grade the northbound lanes of Highway 101 from approximately Grandview Street to Bishopsgate Road (1,370 linear feet) to remove an existing hump that hinders conveyance of runoff into the NCTD right-of-way (photo looking north at Grandview Street). Floodplain elevations will decrease by up to 2-feet for both the 10-year and 100-year storm events.

The northbound lanes will be lowered, creating a constant longitudinal slope to allow conveyance of storm runoff. A typical cross-section of the proposed grading includes the following:

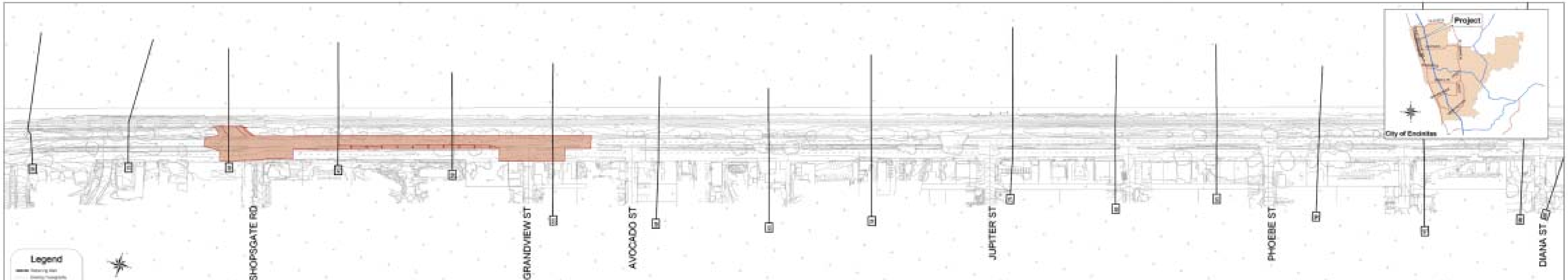
- The median will be graded at a 5:1 slope with the toe of slope at the northbound traffic lanes, allowing the initial lowering of the lanes.
- The lanes will be graded at a 2% traverse slope to allow for drainage.
- A 4-foot wide sidewalk will be constructed adjacent to the traffic lanes.
- A vertical wall varying in height between 1 to 4 feet will be constructed adjacent to the sidewalk, which will tie-in to the existing ground elevation of the NCTD right-of-way.
- A terraced wall, or a slope could be constructed in lieu of the vertical wall if desired, without significant impacts to the floodplain limits, or the cost estimates. However, coordination and compliance by NCTD will be required if grading is proposed within their right-of way.

Grading activities will occur within the median and the Highway 101 right-of-way east of the traffic lanes, which may require the removal or relocation of several established eucalyptus trees. Detailed studies are required to identify the trees that may be affected by this option.

Peak flow rates were determined using HEC-1 and flooding patterns were analyzed using HEC-RAS. Tables 4 and 5 present a summary of 10-year and 100-year floodplain elevation results for Alternative 2, respectively. See Exhibits 11 and 12 on pages 36 and 37 for a schematic of the grading, floodplain, and typical cross-section for Option B.

*Estimated Cost: $3.5 million*

(Cost estimate prepared by Rick Engineering Company, included in Appendix D)




Proposed Grading

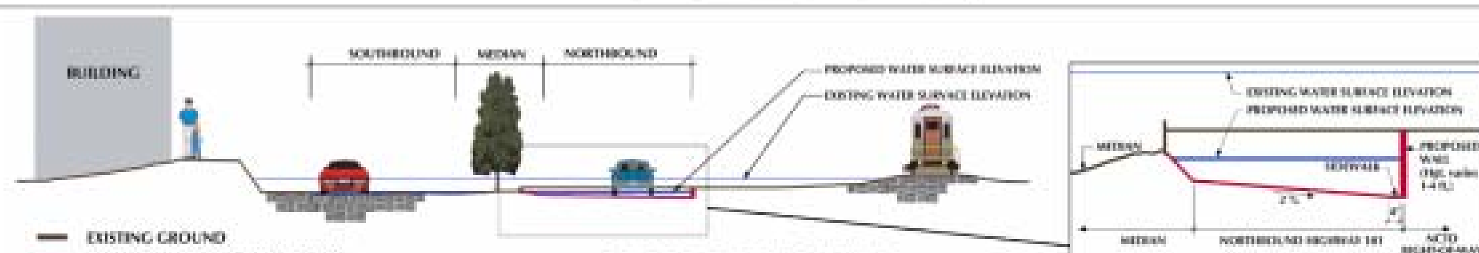

Proposed vs. Existing 10 Year Floodplains


Profile Showing Proposed & Existing 10-YR Floodplains

Notes:

This Exhibit shows graphical representation of the approximate floodplain limits based on 2-foot contour topography, and is not guaranteed for accuracy. Detailed water surface elevations are provided in the report titled "Hydrologic and Hydraulic Study for Leucadia Drainage Improvement Alternatives, Encinitas, California" dated June 14, 2004 (Rick Engineering Company).

Vertical Datum: NAVD88



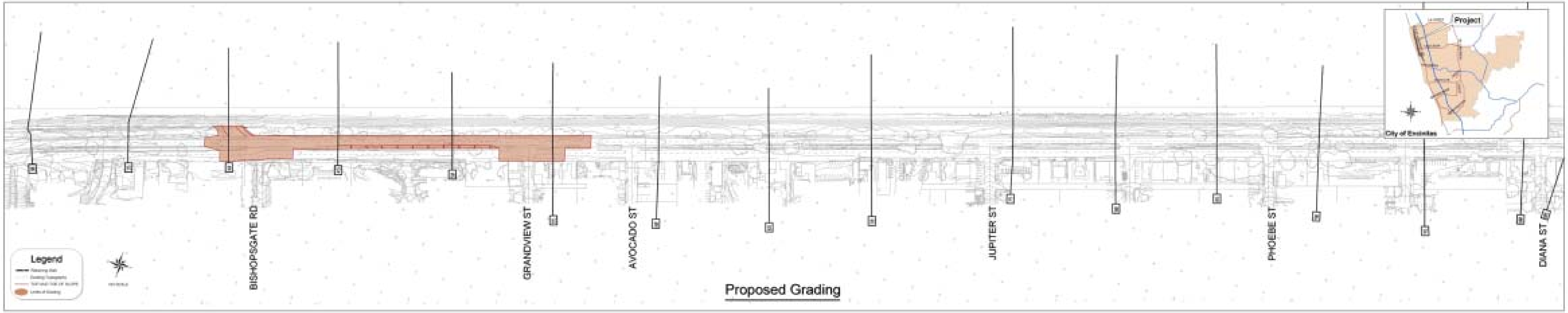

CROSS SECTION #50

# Exhibit 11: ALTERNATIVE 2 - OPTION B ALIGNMENT AND 10-YEAR FLOODPLAIN

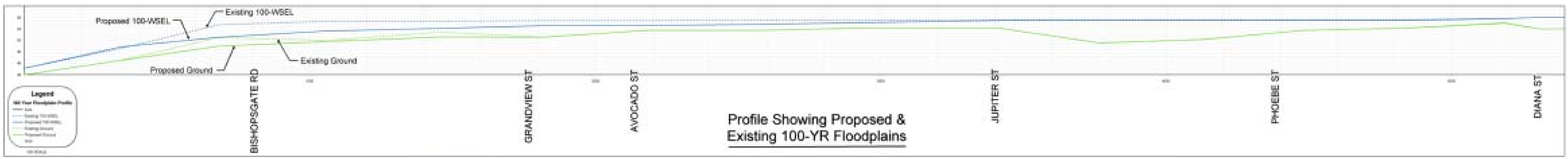
RICK ENGINEERING COMPANY

Exhibit Date: June 15, 2004 REC JN: 14413

PREPARED BY GIS SERVICES DIVISION



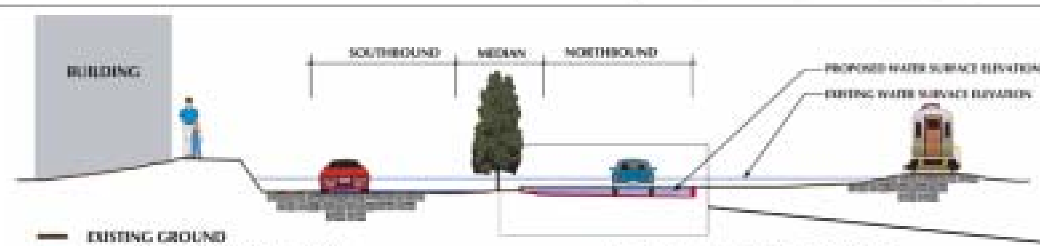


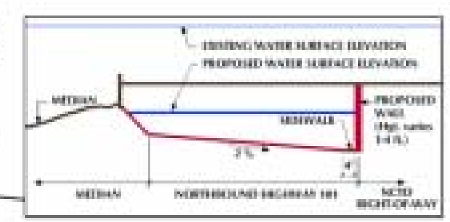



Notes:

This Exhibit shows graphical representation of the approximate floodplain limits based on 2-foot contour topography, and is not guaranteed for accuracy. Detailed water surface elevations are provided in the report titled "Hydrologic and Hydraulic Study for Leucadia Drainage Improvement Alternatives, Encinitas, California" dated June 14, 2004 (Rick Engineering Company).

Vertical Datum: NAVD88




CROSS SECTION #50

# Exhibit 12: ALTERNATIVE 2 - OPTION B ALIGNMENT AND 100-YEAR FLOODPLAIN

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**Option C**

Re-grade the northbound lanes of Highway 101 from approximately Jupiter Street to Moorgate Road (3,170 linear feet), lowering the grade approximately one foot more than Option B (photo looking north from Jupiter Street). Floodplain elevations will decrease by over 2-feet for both the 10-year and 100-year storm events. Option C provides the

most benefit to commercial and residential properties adjacent to Highway 101 by removing approximately 5 city blocks from the 100-year floodplain.

A typical cross-section of the proposed grading includes the following:

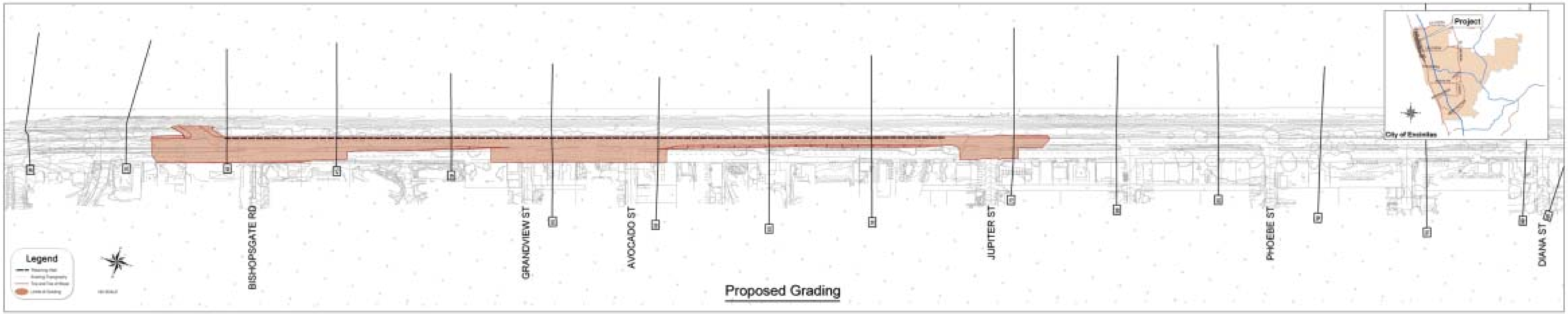
- The median will be graded at a 5:1 slope with the toe of slope at the northbound traffic lanes, allowing the initial lowering of the lanes.
- The lanes will be graded at a 2% traverse slope to allow for drainage.
- Portions of Southbound Highway 101 will be reconstructed at several intersections, resulting in a super-elevated street cross section at those locations.
- A 4-foot wide sidewalk will be constructed adjacent to the traffic lanes.
- A vertical wall varying in height between 2 to 5 feet will be constructed adjacent to the sidewalk, which will tie-in to the existing ground elevation of the NCTD right-of-way.
- A terraced wall, or a slope could be constructed in lieu of the vertical wall if desired, without significant impacts to the floodplain limits, or the cost estimates. However, coordination and compliance by NCTD will be required if grading is proposed within their right-of way.

The grading cross-section for Option C is similar to Option B, however the grading extends an additional 2,000 linear feet. More trees will likely be affected with Option C due to the additional length.

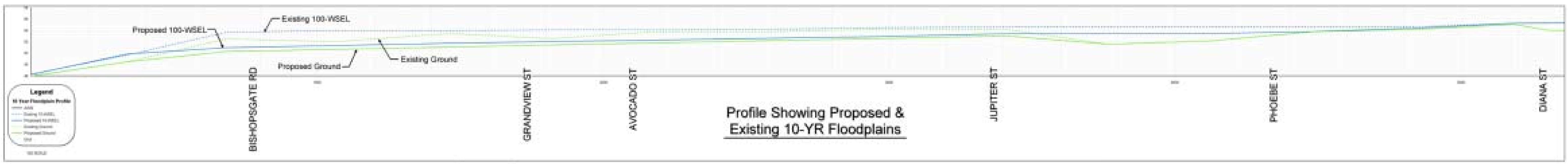
Tables 4 and 5 present a summary of 10-year and 100-year floodplain elevation results for Alternative 2, respectively. See Exhibits 13 and 14 on pages 40 and 41 for a schematic of the grading, 10-and 100-year floodplains, and a typical cross-section for Option B.

*Estimated Cost: $4.5 million*

(Cost estimate prepared by Rick Engineering Company, included in Appendix D)



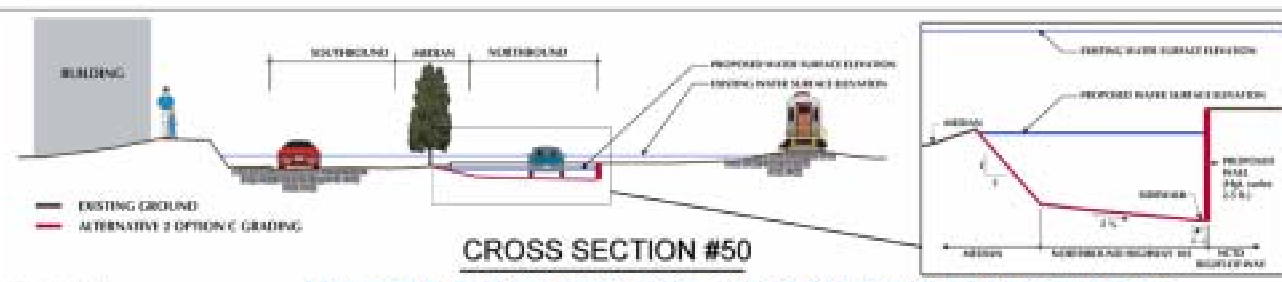





Notes:

This Exhibit shows graphical representation of the approximate floodplain limits based on 2-foot contour topography, and is not guaranteed for accuracy. Detailed water surface elevations are provided in the report titled "Hydrologic and Hydraulic Study for Leucadia Drainage Improvement Alternatives, Encinitas, California" dated June 14, 2004 (Rick Engineering Company).

Vertical Datum: NAVD88



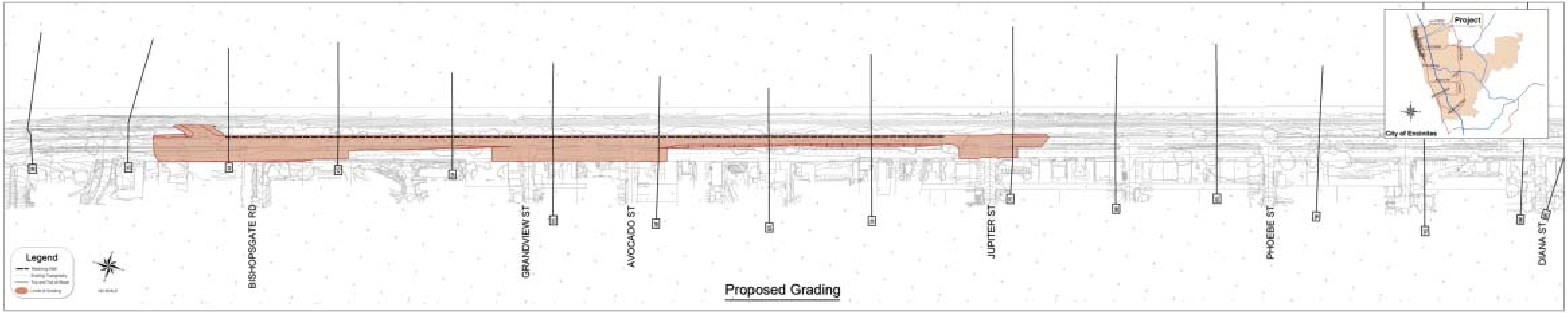

CROSS SECTION #50

# Exhibit 13:
# ALTERNATIVE 2 - OPTION C ALIGNMENT AND 10-YEAR FLOODPLAIN

RICK ENGINEERING COMPANY

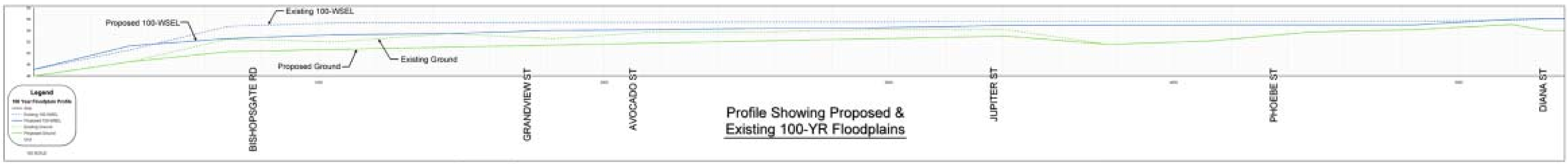
Exhibit Date: June 15, 2004 REC JN: 14415

PREPARED BY GIS SERVICES DIVISION



Proposed Grading

Proposed vs. Existing 100 Year Floodplains

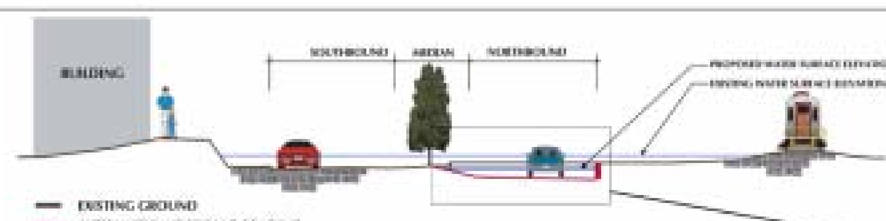


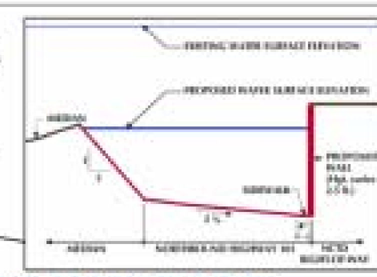
Profile Showing Proposed & Existing 100-YR Floodplains

Notes:

This Exhibit shows graphical representation of the approximate floodplain limits based on 2-foot contour topography, and is not guaranteed for accuracy. Detailed water surface elevations are provided in the report titled "Hydrologic and Hydraulic Study for Leucadia Drainage Improvement Alternatives, Encinitas, California" dated June 14, 2004 (Rick Engineering Company).

Vertical Datum: NAVD88




CROSS SECTION #50

# Exhibit 14: ALTERNATIVE 2 - OPTION C ALIGNMENT AND 100-YEAR FLOODPLAIN

RICK ENGINEERING COMPANY

Exhibit Date: June 15, 2004   REC JN: 14413

PREPARED BY GIS SERVICES DIVISION

**Table 4. 10-year Floodplain Elevations for Existing Condition and Alternative 2 Options**

| FLOW DIRECTION | DRAINAGE BASIN | HIGHWAY 101 CROSS-STREET | HEC-RAS CROSS-SECTION NO. | EXISTING HWY 101 10-YEAR WSEL (ft) | ALT. 2 OPTION A WSEL (ft) | ALT 2. OPTION B WSEL (ft) | ALT 2. OPTION C WSEL (ft) |
|---|---|---|---|---|---|---|---|
| UPSTREAM ----------------->>>>>>>> DOWNSTREAM | 11 | LA COSTA | 30 | 46.3 | 46.3 | 46.3 | 46.3 |
| | | MOORGATE | 35 | 49.7 | 49.8 | 49.9 | 49.9 |
| | | | 40 | 53.7 | 52.6 | 51.4 | 51.0 |
| | | BISHOPSGATE | 45 | 54.0 | 53.1 | 52.2 | 51.4 |
| | | | 50 | 53.9 | 53.9 | 53.0 | 51.8 |
| | 10 | GRANDVIEW | 55 | 54.1 | 54.1 | 53.4 | 52.1 |
| | 9B | AVOCADO | 60 | 54.1 | 54.1 | 54.0 | 52.3 |
| | | EDGEBURT | 65 | 54.2 | 54.2 | 54.2 | 52.6 |
| | | RANGE | 70 | 54.4 | 54.4 | 54.4 | 52.9 |
| | 9 | JUPITER | 75 | 54.6 | 54.6 | 54.6 | 53.4 |
| | | | 80 | 54.6 | 54.6 | 54.6 | 53.4 |
| | | W. JASON | 85 | 54.6 | 54.6 | 54.6 | 53.4 |
| | 9A | PHOEBE | 90 | 54.6 | 54.6 | 54.6 | 53.8 |
| | | W. GLAUCUS | 95 | 54.6 | 54.6 | 54.6 | 54.4 |
| | | | 100 | 55.3 | 55.3 | 55.3 | 55.3 |
| | 8 | DIANA | 105 | 55.3 | 55.3 | 55.3 | 55.3 |
| | | | 110 | 55.3 | 55.3 | 55.3 | 55.3 |
| | | | 115 | 55.3 | 55.3 | 55.3 | 55.3 |
| | 7 | JASPER | 120 | 55.3 | 55.3 | 55.3 | 55.3 |
| | | | 125 | 55.3 | 55.3 | 55.3 | 55.3 |
| | | | 130 | 55.3 | 55.3 | 55.3 | 55.3 |
| | | | 135 | 55.3 | 55.3 | 55.3 | 55.3 |
| | | LEUCADIA | 140 | 55.3 | 55.3 | 55.3 | 55.3 |

**Table 5. 100-year Floodplain Elevations for Existing Condition and Alternative 2 Options**

| FLOW DIRECTION | DRAINAGE BASIN | HIGHWAY 101 CROSS-STREET | HEC-RAS CROSS-SECTION NO. | EXISTING HWY 101 100-YEAR WSEL (ft) | ALT. 2 OPTION A WSEL (ft) | ALT 2. OPTION B WSEL (ft) | ALT 2. OPTION C WSEL (ft) |
|---|---|---|---|---|---|---|---|
| UPSTREAM ----------------->>>>>>> DOWNSTREAM | 11 | LA COSTA | 30 | 47.1 | 46.9 | 47.1 | 47.1 |
| | | MOORGATE | 35 | 50.6 | 50.9 | 50.9 | 51.3 |
| | | | 40 | 54.7 | 53.6 | 52.6 | 52.5 |
| | | BISHOPSGATE | 45 | 55.4 | 54.5 | 53.7 | 53.2 |
| | | | 50 | 55.4 | 54.8 | 54.1 | 53.4 |
| | 10 | GRANDVIEW | 55 | 55.5 | 55.1 | 54.6 | 53.9 |
| | 9B | AVOCADO | 60 | 55.5 | 55.1 | 54.6 | 54.1 |
| | | EDGEBURT | 65 | 55.5 | 55.2 | 54.8 | 54.3 |
| | | RANGE | 70 | 55.5 | 55.2 | 55.1 | 54.4 |
| | 9 | JUPITER | 75 | 55.6 | 55.5 | 55.5 | 54.8 |
| | | | 80 | 55.6 | 55.5 | 55.5 | 54.9 |
| | | W. JASON | 85 | 55.6 | 55.5 | 55.5 | 54.9 |
| | 9A | PHOEBE | 90 | 55.6 | 55.5 | 55.5 | 54.9 |
| | | W. GLAUCUS | 95 | 55.6 | 55.5 | 55.5 | 55.0 |
| | | | 100 | 55.8 | 55.8 | 55.8 | 56.0 |
| | 8 | DIANA | 105 | 56.0 | 56.0 | 56.0 | 56.1 |
| | | | 110 | 56.1 | 56.1 | 56.1 | 56.1 |
| | | | 115 | 56.1 | 56.1 | 56.1 | 56.1 |
| | 7 | JASPER | 120 | 56.1 | 56.1 | 56.1 | 56.1 |
| | | | 125 | 56.1 | 56.1 | 56.1 | 56.1 |
| | | | 130 | 56.1 | 56.1 | 56.1 | 56.1 |
| | | | 135 | 56.1 | 56.1 | 56.1 | 56.2 |
| | | LEUCADIA | 140 | 56.1 | 56.1 | 56.1 | 56.2 |

Ultimate Improvements

The ultimate improvement is the only project that removes the entire watershed from the floodplain. However, the ultimate improvement bares a significant cost, which may hinder the time period in which it would be constructed.

***Alternative 3: 100-year Capacity Storm Drain System***

Construct an underground storm drain system with capacity to convey the peak flow rate from 100-year frequency storm event. This option includes utilization of the existing 24” storm drain as a low flow system discharging to the detention basins north of La Costa Avenue to preserve water quality benefits. This would remove the floodplain for up to a 100-year storm from the study area. A 10-year storm drain system was investigated but due to only minor savings in construction costs this system is not recommended. Exhibit 15 on page 46 shows the proposed alignment of the 100-year capacity storm system.

A large storm drain system is required to convey the undetained runoff from the Leucadia watershed. Preliminary results show that for the 100-year storm a 5-foot diameter pipe is required at the upstream end of the watershed near Basil Street, eventually transitioning to a 9-foot diameter pipe at the outlet into the lagoon. Environmental permitting of the outlet has not been investigated but is expected to present a significant challenge in the feasibility of this project.

Hydrologic analyses for Alternative 3 included preparation of HEC-1 models to determine peak flow rates within each basin. Normal depth calculations were performed to determine preliminary required pipe sizes for both the main storm drain line and for the laterals using Manning's equation. A hydraulic model of the main storm drain line was created in WSPGW to determine whether the system met the capacity requirements. The WSPGW verified that the proposed pipe sizes would have capacity to convey the peak runoff from the 100-year storm event. However, further analyses and design is required if this Alternative is selected. Results of the Alternative 3 analyses are shown in Table 6.

**Table 6. Ultimate Storm Drain System Pipe Sizes**

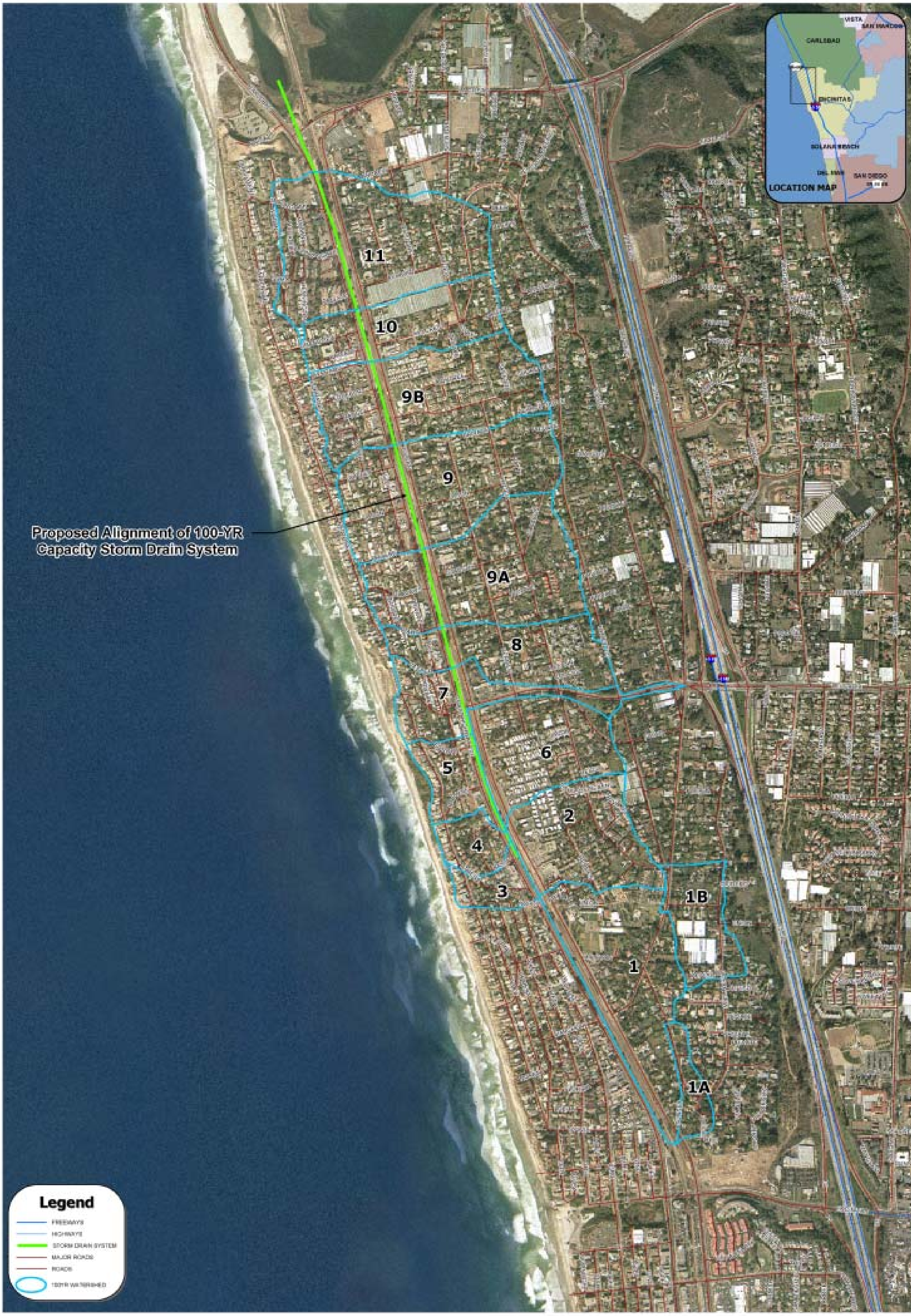
| BASIN* | PEAK Q (cfs) | DIAMETER (FT) |
|---|---|---|
| 3 | 29 | 3.0 |
| 4 | 160 | 5.0 |
| 5 | 185 | 5.5 |
| 7 | 246 | 6.0 |
| 8 | 297 | 6.5 |
| 9A | 402 | 7.5 |
| 9 | 495 | 8.0 |
| 9B | 592 | 8.5 |
| 10 | 621 | 8.5 |
| 11 | 762 | 9.0 |

*Only basins along Highway 101 were included in analysis. All basins east of the railroad tracks are considered laterals.

*Estimated Cost: $22-26 million for tunneling technologies*
*$40 million for conventional methods*

(Separate cost estimates prepared by Haley & Aldrich and Rick Engineering Company [see Appendix D for Rick Engineering Company cost estimate])

Haley & Aldrich prepared a preliminary geotechnical feasibility study to evaluate trenchless techniques for storm drain pipeline installation, which included the recommendation of a combination of a TBM machine for a portion of the tunnel followed by a transition to a tunnel excavated using digger shield methods, or one tunnel using TBM methods only. The estimated cost for this project is $22-26 million, rounded to the nearest $0.5 million. Please refer to the report titled "Geotechnical Feasibility Study, Trenchless Construction Methods, Encinitas Storm Drain Project, Encinitas, California," dated June 8, 2004, for a complete description and cost estimate of the trenchless methods.

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NO SCALE

**Exhibit 15:**
**ALTERNATIVE 3 100-YR STORM DRAIN SYSTEM ALIGNMENT**

THIS PROJECT LOCATED WITHIN THE CITY OF ENCINITAS

RICK ENGINEERING COMPANY

PREPARED BY GIS SERVICES DIVISION

Other Alternatives Considered but Not Analyzed

***Ultimate Facility Assuming NCTD Grade Separation Project is Constructed***

Construct an underground storm drain system with capacity to convey the peak flow rate from the 100-year frequency storm event assuming drainage changes within the NCTD right-of-way consisting of grade separation (lowering the railroad tracks) that would prevent runoff east of the tracks from getting west of the railroad tracks. This system is designed to convey runoff from the watershed area west of the railroad tracks only, approximately 30% of the watershed area of Alternative 3.

NCTD is conducting feasibility studies for the grade separation project; however, the actual construction of the project could be as many as 20 years from now. This alternative will not be pursued unless more detailed plans to construct the grade-separated tracks are available. A plan would also be in place to address the remaining 70% of the watershed that would stay east of the railroad tracks. Additionally, completion time of this project would be weighed against the other alternatives to determine the most feasible project that will address flooding issues within an acceptable amount of time.

Additional planning and investigations are required to analyze this alternative in more detail.

***Convey Storm Runoff from the Upper Basins South to Moonlight Beach***

Based on review of drainage patterns south of the Leucadia study area, it was determined that the storm drain system at Moonlight Beach is already undersized and cannot handle additional runoff. Transferring storm runoff from the Leucadia study watershed to the Moonlight Beach watershed would be of adverse impact to the receiving watershed. This option was dismissed from further review.

***Use Cisterns to Contain Storm Runoff***

Two options for the use of cisterns were evaluated: Each parcel would utilize a cistern to capture the runoff from its own property during storm events, or several large “Baker Tanks” could be used to store runoff from larger drainage areas during storm events.

Preliminary estimates of the first option, each property captures runoff in its own cistern, yielded the required volume of each cistern would fill a one-car garage. Therefore, the use of cisterns on a parcel-by-parcel basis is considered infeasible.

The second option, using large Baker Tanks to contain runoff, was also investigated. The mobilization of these large cisterns needs to be scheduled in advance; they are not intended for emergency situations such as storms. There are also challenges including volume of storage and location of tanks that further disqualify this option.

## CONCLUSION

This report presents results from hydrologic and hydraulic analyses for the existing drainage condition in Leucadia, as well as several proposed drainage improvement alternatives. Results include the existing 10-year and 100-year floodplain elevations, as well as preliminary results for floodplain elevations (Alternative 2) and proposed storm drain pipe sizes (Alternatives 1 and 3).

The alternatives analyzed in this study are grouped into two categories: short-term improvements targeted at more frequent storms, and ultimate improvements that will address the 100-year storm. Short-term improvements are projects that could be constructed in a relatively short period of time (less than 5 years) for significantly less cost compared to the ultimate improvement. None of these projects provide ideal long-term flood protection for Leucadia although they will notably decrease floodplain elevations. The ultimate improvement is the only project that removes the entire watershed from the floodplain. However, the ultimate improvement bares a significant cost, which may hinder the time period in which it would be constructed. A summary of the estimated costs of the projects in planning phase is provided in Table 7.

**Table 7. Cost Estimate Summary**

| | |
|---|---|
| ***Short-term Improvements*** | |
| Alternative 1: Leucadia Park Overflow | $1.5-$2.5 million |
| Alternative 2 Option A: Re-grade approx. 495 linear feet in NCTD right-of-way | $1 million |
| Alternative 2 Option B: Re-grade approx. 1,370 linear feet of NB Hwy 101 | $3.5 million |
| Alternative 2 Option C: Re-grade approx. 3,170 linear feet of NB Hwy 101 | $4.5 million |
| ***Ultimate Improvements*** | |
| Alternative 3: 100-year Capacity Storm Drain | |
| Constructed using tunneling technologies | $22-$26 million |
| Constructed using conventional methods | $40 million |

The City of Encinitas is tasked with selecting one or more alternatives for further analyses and design. Each alternative will be evaluated based on factors including overall benefit to the community, completion time, environmental constraints, and cost.