ROSE CREEK WATERSHED

HYDROLOGIC, HYDRAULIC, SEDIMENT TRANSPORT, AND GEOMORPHIC ANALYSES

TASK 5 – EXISTING CONDITIONS SUMMARY

BACKGROUND

The Hydrologic, Hydraulic, Sediment Transport, and Geomorphic Analyses for the Rose Creek Watershed (RCW Analysis) are being conducted to build upon the previously completed RCW Opportunities Assessment (Assessment) and associated technical memorandums. The Assessment included the following documents:

- Rose Creek Watershed Opportunities Assessment (KTU+A 2005a) – Identifies opportunities in the RCW for restoration projects, enhancement and protection of cultural resources, and public access improvements and provides recommendations for implementation of these opportunities.

- Existing Conditions Report (KTU+A 2005b) – Baseline documentation of the current health of the RCW. Existing conditions included physical watershed characteristics, land uses, and biological, water, cultural, and recreational resources.

- Hydrologic Modifications Technical Memorandum (KTU+A 2005c) – Discusses the relationship of land development and changed hydrologic conditions by assessing aerial photographs at different points in time.

The purpose of Task 5 was to augment the existing hydrologic, hydraulic, sediment transport, and geomorphic conditions of the Assessment based on data, information, and observational insight gained from completion of Tasks 1, 2, and 4. This existing conditions summary includes additional data related to precipitation, interception, infiltration, runoff, evapotranspiration, stream flows, stream velocities, stream elevations, sediment yield, sediment delivery, fluvial geomorphology, and land uses. The additional data will be used in developing analytical tools and establishing baseline conditions under Tasks 6 and 7.

PHYSICAL CHARACTERISTICS

The physical characteristics of the RCW determine the hydrology, vegetation, and development patterns for the entire watershed. These characteristics are discussed in the sections that follow to increase the understanding of the natural processes that affect the RCW.

The Rose Creek Watershed (RCW) consists of three planning basins, Rose Canyon, San Clemente Canyon, and Lower Rose Creek, as shown in Figure 1. Rose Canyon and San

Clemente Canyon extend 13 miles east to west from the eastern extent in MCAS Miramar to the confluence of Rose and San Clemente Creeks just south of the Interstate 5 and State Route 52 intersection before turning south for an additional 3 miles before entering the northeast corner of Mission Bay.

The 36-square mile RCW is located within the City of San Diego and MCAS Miramar. The City of San Diego has jurisdiction over the western half of RCW and includes the communities of Clairemont Mesa, La Jolla, Mira Mesa, Mission Bay Park, Pacific Beach, Scripps Miramar Ranch, and University City. MCAS Miramar covers 52% of the RCW and this portion of the RCW has been owned by the federal government since World War I when it was known as Camp Kearny. The RCW is part of the Penasquitos Hydrologic Unit, which is roughly 162 square miles and includes portions of the City of San Diego, Del Mar and Poway. The Penasquitos Hydrologic Unit is centrally located within San Diego County and includes Los Penasquitos Creek, Los Penasquitos Lagoon, Rose Creek, Tecolote Creek, Mission Bay, and Miramar Reservoir. The San Diego Regional Water Quality Control Board (SDRWQCB) has sub-divided the Penasquitos Hydrologic Unit into two Watershed Management Areas: 1) Penasquitos Watershed Management Area, which is comprised of the Miramar Reservoir (906.1) and Poway (906.2) Hydrologic Areas and 2) Mission Bay Watershed Management Area, which is comprised of the Scripps (906.3), Miramar (906.4), and Tecolote (906.5) Hydrologic Areas. Rose and San Clemente Creeks are located within the Miramar Hydrologic Area, which at roughly 27,667 acres (37 square miles), makes it the second largest hydrologic area in the Penasquitos Hydrologic Unit.

For the Assessment, a topographic delineation was performed to assess runoff and stream flow that discharges from the mouth of Rose Creek into Mission Bay. The RCW delineation refined the boundary of the Miramar Hydrologic Area to 23,427 acres (36 square miles). The area within the hydrologic area that is not considered part of the study area occurs toward the mouth of Rose Creek where it flows into Mission Bay, and includes those land areas that drain directly into Mission Bay. The Assessment defined the three planning basins created by this delineation, Upper Rose Creek, San Clemente Creek, and Lower Rose Creek. San Clemente Canyon is the largest planning basin occupying 49% of the RCW while Lower Rose Canyon, which includes Stevenson Canyon, occupies 11% of the RCW.

Elevations and Slopes

Elevation influences several important natural conditions including precipitation, creek flow, slope stability, and vegetation. The RCW is characterized by relatively steep foothills in the headwaters, transitioning to broad mesas throughout the mid-section, which drain into steeply incised canyons towards Mission Bay. The topographic profile of the RCW ranges from sea level at the mouth of Rose Creek at Mission Bay to over 1,100 ft east in the headwaters on MCAS Miramar (Figure 2). The mid-elevations of the mesa tops (250-

500 ft) dominate the RCW, representing over 80% of the watershed. Mt. Soledad is the highest point along the western boundary in La Jolla that rises 822 ft above sea level.

Slope stability is a concern in areas of rough terrain, as they are more likely to have erosion problems caused by periods of intense rainfall or increased velocities. The slope percentages within the RCW are shown in Figure 3. Gently sloped (0-3%) mesa tops and creek channels dominant the watershed occupying roughly 39% of the RCW primarily within MCAS Miramar. A majority of the moderately steep slopes (25-50%) can be found in the San Clemente Creek headwaters east of Interstate 15 and west of Interstate 805 in the communities of Clairemont Mesa and University. Steep slopes (>50%) are predominantly found along the bluffs of Rose Canyon and San Clemente Canyon on the western edge of the RCW.

Land Use

A breakdown of existing land uses (SANDAG 2002) is shown in Table 1 and illustrated in Figure 4. Undeveloped land is the dominant land use within the RCW covering 8,393 acres (36% of the RCW) of which 7,477 acres are found within MCAS Miramar. The second largest land use category is family housing, which encompass 3,480 acres (16%) of the RCW. The majority of family housing and commercial services can be found west of Interstate 805 in the communities of La Jolla, Pacific Beach, Clairemont Mesa, and University City. Lands dedicated to transportation uses cover the third largest area of about 3,175 acres. Much of this area is contained within the rights-of-way for Interstates 5, 805, and 15, as well as State Route 52 and 163 that crisscross the RCW. Parks and preserves account for 9% of the RCW (2,048 acres).

Table 1 – Existing Land Uses within RCW

Existing Land Use	Clairemont Mesa	Kearny Mesa	La Jolla	MCAS Miramar	Mira Mesa	Mission Bay Park	Pacific Beach	Scripps Miramar Ranch	University	Totals
Agriculture				80						80
Aviation				809						809
Commercial	39	113		31	5		23		170	381
Extractive Industry				108						108
Family Housing	1,384	33	293	50	1	8	248	102	1,722	3,840
Group Quarters				54			35		56	145
Hotel / Motel		13		2	5		1		28	49
Industrial	82	258		116	31		6		29	523
Junkyard/Dump/Landfill				859						859
Medical	3			5					60	68
Military				1,184						1,184
Military Undevloped				7,477						7,477
Office	19	29	3				3		187	241
Parks / Preserves	487	44	260	45		11	4	633	564	2,048
Public Services	16	13	14	57			4		36	139
Recreation	8	3	27	502		18	4	3	29	592
Schools	126						24	28	499	676
Transportation	707	188	162	816	39	8	125	35	1,095	3,175
Under Construction	0	25							46	71
Private Undeveloped	153	150	65		6		28	20	493	916
Water Bodies	16			7		9	17			49
Totals	3,040	869	823	12,201	86	53	522	821	5,014	23,428

Reproduced from KTU+A 2005b
*Units in acres

Land uses also dictate the hydrologic parameter for interception, which is the amount of rainfall retained by vegetation or buildings and is evaporated before reaching the ground. Vegetated land uses have interception values ranging from 0.03 to 0.2 inches for heavy forest cover. Interception for impervious or urban land uses, such as parking lots, generally range between 0.03 and 0.1 inches (EPA 2000).

Soils

The RCW is comprised of approximately 20 different soil series (Table 2 and Figure 5) with five of these series representing nearly 86 percent of the RCW. The five dominant soil series are: Redding gravelly loam (30.1%); Redding cobbly loam (17.3%); Urban Land Complexes (13.6%); Loamy alluvial land (10.4%); and Chesterson fine sandy loam (8.3%). The two largest soils types, gravelly loam and cobbly loam compose 49% of the watershed east of Interstate 805 in the communities of Mira Mesa, Kearny Mesa, Scripps Miramar Ranch, and MCAS Miramar. Gravelly loam is found predominantly between Interstates 15 and 805, while cobbly loam is found east of Interstate 15. The Chesterson and Urban land complexes dominate the developed portions west of Interstate 805.

Loamy sand can be found adjacent to Rose Canyon and San Clemente Canyon from Interstate 805 to Mission Bay.

Table 2 – Soil Types

Soils	Clairemont Mesa	Kearny Mesa	La Jolla	MCAS Miramar	Mira Mesa	Mission Bay Park	Pacific Beach	Scripps Miramar Ranch	University City	Totals
Clay Loam	90								134	224
Clays	96		2	25					755	878
Coarse sandy loam									4	4
Cobbly loam	26	136	31	3,180	6		18	648	380	4,425
Fine sandy loam	489	358	5	720					1,129	2,701
Gravel pit				89						89
Gravelly loam		319		5,910	73			164	481	6,947
Gravelly loamy sand			69	402				10	42	522
Loamy alluvial land				4						4
Loamy sand	162		45			3	55		683	949
Made land	163		49			35	35		47	329
Riverwash	53	15		661					48	776
Terrace escarpments	403	1	493	1,198	7		52		251	2,405
Tidal flats						4				4
Unclassified				4		9	8			20
Urban land complex	1,557	40	129			1	355		1,060	3,143
Water				8						8
Totals	3,040	869	823	12,201	85	53	522	821	5,014	23,427

Reproduced from KTU+A 2005b
*Units in acres

The loam soil types are made up of undulating to gently rolling soils that formed on gravelly marine terraces. These soils have little value for farming or ranching, which has allowed native vegetation such as Diegan Coastal Sage Scrub and various types of chaparral to develop and persist. These vegetation types provide relatively little interception.

The soil types influence the runoff generated by rainfall based on the infiltration characteristics of the soils. Soils with high infiltration rates will result in low surface runoff while low infiltration rates result in high surface runoff. A summary of the infiltration rates by soil type is shown in Table 3. Nearly all of the soil series are included in SCS Hydrologic Soil Group D, which is characterized by very slow infiltration rates when wet, high shrink-swell potential, shallow clay hardpans, or are shallow over near impervious subsurface material. The vast majority of the soil series also has serve erosion potential and naturally generates higher rates of surface runoff due to the low infiltration rates and water holding capacity.

Table 3 – Infiltration Rates by Soil Type

SOIL TYPE	SCS HYDROLOGIC SOIL GROUP	INFILTRATION POTENTIAL	INFILTRATION RATE* (IN/HR)
Sand, loamy sand, or sandy loam	A	High infiltration, low runoff	0.4 – 1.0
Silt loam or loam	B	Moderate infiltration, moderate runoff	0.1 – 0.4
Sandy clay loam	C	Low infiltration, moderate to high runoff	0.05 – 0.1
Clay loam, silty clay loam, sandy clay, silty clay, or clay	D	Very low infiltration, high runoff	0.01 – 0.05

Source: SCS 1986
*EPA 2000

Precipitation

Precipitation patterns show a west to east gradient, with the eastern headwater receiving the highest amounts, as shown Figure 6. This pattern reflects an orographic effect that is common throughout the coastally influenced portions of Southern California where precipitation generally increases with increasing elevation. The higher elevations receive an average of 15-18 inches of rain per year on the eastern most limits of the watershed, while the lower elevations average less than 12 inches per year. Understanding the precipitation pattern is important because it affects creek flow characteristics (e.g., timing and amounts), which in turn influences the types and extents of wetland restoration, creation, or enhancement opportunities. Precipitation and evapotranspiration are not currently monitored within the RCW.

Surface Water

The major surface water resources within the RCW are Rose Creek and San Clemente Creeks (Figure 7), which are similar to other rivers in Southern California with natural flows occurring during the wet season. Both creek systems are very cobbled in nature with numerous sections of standing water in their lower reaches. Both creeks would naturally only have precipitation driven seasonal flows with riparian and aquatic communities adapted to periods of dry conditions. With the contribution of dry weather flows from the nearby urbanized landscaping, the lower sections of both Rose Creek and San Clemente Creek are now nearly perennial in nature.

The portions of Rose and San Clemente Creeks east of Interstate 805 are intermittent streams with cobblestone streambeds and various trees growing intermittently within them. As the creeks progress southwest beyond Interstate 805, their character changes as dry weather flows are added from adjacent urban development from over-irrigation of landscapes. These dry weather flows have allowed the formation of dense riparian scrub habitat with numerous small in-stream ponds as wide as six feet. Various types of riparian trees have taken root within the drier channel segments, or within the over-bank floodplain, including sycamores, bay laurel, coast live oak, and various willows. Along the lower portions of the creeks, the riparian scrub habitat is dense with a healthy understory and narrow channels varying from two feet to six feet wide. The San Clemente Creek channel is typically a bit wider than Rose Creek due to the difference in drainage areas.

There are no major surface water impoundments within the Rose Creek Watershed. The closest major surface water impoundment is the Miramar Reservoir just north of the northeastern watershed boundary in Scripps Miramar Ranch. The largest surface water impoundment within the RCW is the Fish Pond within MCAS Miramar on Rose Creek. The Fish Pond is used for recreational purposes by MCAS Miramar personnel and has been stocked with non-native game fish species. Other small in-stream impoundments can be found along both Rose Creek and San Clemente Creek. The larger of these are found along San Clemente Creek at the site of past aggregate extraction activities near the current Sim J. Harris operation in the middle of MCAS Miramar.

Hydromodifications

A hydromodification is the alteration of the natural circulation or distribution of water by the placement of structures or other activities. Hydromodifications are typically anthropogenic modifications to surface water hydrology such as dams, channelization, culverts, or storm drains. Hydromodifications within the RCW include storm drains, concrete channels, culverts, bridges, and other concrete structures

Storm drains re-direct runoff from urbanized areas of the watershed. The storm drain system within the RCW is shown in Figure 8. The majority of the storm drain systems discharge into tributary canyons. Occasional storm drain outlets directly discharge into the creeks, especially within the lower portions of the RCW. Historically, Stevenson Canyon drained directly to Mission Bay near De Anza Cove, but has since been connected to Lower Rose Creek via storm drains along Balboa Ave. In addition, the City of San Diego has implemented storm drain low-flow diversion programs within the lower portion of Rose Creek to improve water quality in Mission Bay.

There are four concrete channels along Rose Creek. Two concrete bank trapezoidal channels are located above the Rose and San Clemente Creek confluence beneath the Interstate 5 and State Route 52 interchange. A concrete trapezoidal channel is located along Santa Fe Avenue above the Santa Fe Avenue Bridge. A concrete rectangular channel is located between the Interstate 5 and Mission Bay Drive bridges. Riprap banks are found between the Garnet and Grand Avenue bridges. In addition, there are four man-made cobble embankments along San Clemente Creek.

Rose and San Clemente Creeks are diverted through culverts throughout MCAS Miramar. Seven culverts are located along Rose Creek between Interstate 15 and Pless Road.

Three culverts are located along San Clemente Creek between Interstate 15 and Convoy Street.

Four bridges are located along San Clemente Creek at Kearny Villa Road, Austin Avenue, Genesee Avenue, and Regents Road. There are eight bridges along Rose Creek that include one pedestrian bridge, two railroad bridges, and five road bridges.

There are two other concrete structures along Rose Creek. A concrete weir is located just upstream of the railroad and Santa Fe Avenue bridges. Concrete flow training vanes are located at the upstream side of the Mission Bay Drive Bridge.

EXISTING HYDROLOGIC CONDITIONS

Accurate hydrologic information is essential for planning, designing and implementing watershed restoration and enhancement projects. Hydrologic information helps to define the amount and intensity of rainfall, rate of flow in streams, and balance in the stream between soil and water.

The review of the existing hydrologic data and studies within the RCW found that most hydrologic studies rely on the U.S. Army Corps of Engineers (USACE) hydrologic studies conducted in 1970 and 1972. However, the watershed has experienced significant development since then and there can be potentially significant increases in flood flows caused by the additional hydrologic modifications that have occurred since the 1970's.

The 1970 USACE study was conducted for the County of San Diego Department of Sanitation and Flood Control. The study area included about 6 miles of Rose Canyon from the Miramar Naval Air Station to the confluence with San Clemente Creek and 6.6 miles of San Clemente Canyon upstream of the confluence. The hydrology analysis was conducted to generate flood maps of the intermediate regional flood (approximately the 100-year flood) and standard project flood. Watershed topography was based on a 1963 aerial photograph. The developed frequencies were based on a comparative analysis of recorded annual peak discharges in hydrologically similar basins since there were no gages within the RCW. The intermediate regional flood was developed from gage data of the San Diego River (1964).

The other USACE hydrologic study was conducted for the entire RCW and is reported in the Flood Insurance Study (FIS) for San Diego County developed by the Federal Emergency Management Agency (FEMA) and last updated in 2002. In the FIS, flood hazard areas are determined using statistical analyses of records of river flow, storm tides, and rainfall. The hydrologic analysis was used to determined the 100-year storm event (1% annual chance flood event) to define base flood elevations and designate floodways and risk zones (e.g., Zones A, AE, A1-30, AH, AO, VE, and V1-30). This information was obtained through consultation with the community, use of floodplain topographic surveys, and hydrologic and hydraulic analyses. For Rose and San

Clemente Creeks, the flood flows were taken from prior USACE studies. A summary of the flood flow return periods is provided in Table 4.

Table 4 – Return Period Flood Flows

LOCATION	DRAINAGE AREA (MI^2)	10-YR*	100-YR*	500-YR*
Rose Creek downstream of Interstate 805	6.9	900	4,100	9,400
Rose Creek downstream of Genesee Avenue	9.7	1,100	5,000	11,200
Rose Creek upstream of confluence	13.7	1,300	6,200	13,900
Rose Creek downstream of confluence	32.1	2,500	11,000	26,500
San Clemente Creek upstream of Interstate 805	12.5	1,000	4,900	11,000
San Clemente Creek upstream of Genesee Avenue	15.3	1,200	5,600	12,000
San Clemente Creek upstream of confluence	18.4	1,400	6,900	16,000
Rose Creek at mouth	37.0	2,700	12,000	28,000

Source: FEMA 2002
*Cubic feet per second

Floodplain mapping and management within the RCW is divided along the jurisdictional lines of the City of San Diego and MCAS Miramar. Both jurisdictions have relied on the USACE to analyze and map the floodplains within their jurisdictions, but have done so at different points in time and have not collaborated to develop a comprehensive map of the floodplains within the RCW using consistent methodologies and data inputs. In 2001, the USACE Engineering Research and Development Center (ERDC) conducted a hydrologic and hydraulic analysis to determine the 100-year floodplain map for major streams on MCAS Miramar (ERDC 2001). The hydrologic analysis to determine the 100-year flood was based on the National Flood Frequency (NFF) program, a compilation of regression equations based on geographic area by USGA, FHWA, and FEMA. The watershed characteristics were determined from undated, USGS topographic maps. The 100-year flood flows were not reported.

In 1986, another hydrologic analysis was conducted for the watershed erosion/sedimentation study (Woodward-Clyde 1986). An analytical analysis was used to determine the 2-year return period flows at seven locations throughout the RCW.

EXISTING HYDRAULIC CONDITIONS

Hydraulic information helps to further define how water moves through a stream and the potential impacts of that movement such as erosion. This information is essential both when designing improvements to a stream system or resolving pre-existing problems as alterations to a stream can have implications downstream and upstream.

There have been several hydraulic analyses conducted on various segments of Rose and San Clemente Creeks. These hydraulic analyses were based on hydrologic analyses conducted in the early 1970's. The only hydraulic analysis for the entire RCW was the FEMA study (updated in 2002). The FEMA FIS also includes a hydraulic analysis to determine the flood elevations along Rose and San Clemente Creeks. Channel bed profiles (stream elevations) and water surface elevation profiles for the 10-, 50-, 100-, and 500-year return periods are provided. The hydraulic analysis was based on numerical model (HEC-2) simulations with cross-section data taken from topographic maps generally made from data collected in the 1970's.

Hydraulic analyses have been conducted for portions of the RCW. The 2001 hydraulic analysis of MCAS Miramar consisted of using a numerical model (HEC-RAS) to compute the 100-year water elevation, which was then transcribed to the flood map using the Watershed Model System (WMS). HEC-RAS is basically an updated version of the HEC-2 numerical hydraulic model.

Two other hydraulic studies have been conducted for the lower portion of Rose Creek. The most recent hydraulic study completed in 2005, used HEC-2 to determine the 50- and 100-year water surface elevations and velocities downstream of Grand Avenue. The 50-yr water surface elevations ranged from 3.0 to 8.0 ft, NGVD with velocities ranging from 4.22 to 12.53 ft/sec. The 100-year water surface elevations ranged from 4.3 to 10.0 ft, NGVD with velocities ranging from 5.01 to 14.16 ft/sec.

The other study was a HEC-RAS hydraulic analysis conducted as part of the Rose Creek Canyon Enhancement Plan to determine flood elevations for the lower portion of Rose Creek from the concrete channel below the Interstate 5 Bridge to the Grand Avenue Bridge. Flood elevations, which are summarized in Table 5, were determined for the 10-, 50-, and 100-year flood events. All flood elevations were within the channel banks. The flood flows were based on the FEMA FIS for Rose Creek.

Table 5 – Flood Elevations* for Rose Creek

LOCATION	STATION	10-YEAR	50-YEAR	100-YEAR
Begin Concrete Channel	5950	20.5	23.2	24.8
Flow Training Vanes	5500	11.8	15.5	18.0
Upstream side of Mission Bay Drive Bridge	5310	11.7	15.4	17.9
End of Concrete Channel	4950	10.5	14.1	16.7
	4900	10.4	14.3	16.9
	4160	9.3	13.5	16.4
Upstream side of Garnet Avenue Bridge	3960	8.9	12.8	15.7
	3750	8.2	11.9	13.9
	2900	6.1	9.7	11.5
	2700	5.8	9.3	11.1
Downstream side of	2400	4.4	7.3	8.9

Grand Avenue Bridge				

Source: KTU+A 2000
* in feet NGVD

EXISTING SEDIMENT TRANSPORT CONDITIONS

The most comprehensive study on sediment transport conditions for the RCW was the 1986 Watershed Erosion/Sedimentation Study – Rose and San Clemente Canyons (Woodward-Clyde 1986). This study evaluated the annual loading of sediment being transported into Mission Bay via Rose Creek. The annual sediment yield from sheet and rill erosion was estimated utilizing an empirical relationship that accounts for watershed characteristics of climate, topography, hydrology, and soil. The annual sediment yield contribution from gully and channel erosion was estimated using the USACE field procedure combined with comparative aerial photographic and topographic evaluations. The total sediment yield calculations were verified through comparison with dredging records of Mission Bay at the mouth of Rose Creek. The results of these calculations are presented in Table 6, along with the average annual dredging volume in Mission Bay. The study also included a recommendation for the average annual sediment yield to use for years with normal rainfall and that value is also presented in Table 6.

Table 6 – Average Annual Sediment Yield for Rose Creek Watershed (1961 - 1980)*

DESCRIPTION	SEDIMENT YIELD (CY/YR)
Sheet and Rill Erosion	12,468
Gully and Channel Erosion	1,863
Total Calculated Contribution	*14,331*
Average Annual Mission Bay Dredging	*14,232*
Recommended Average Annual Sediment Yield for Normal Rainfall Years	**14,300**

*Woodward-Clyde 1986

EXISTING GEOMORPHIC CONDITIONS

Geomorphologic analyses of Rose and San Clemente Creeks have been limited to general historical descriptions on the movement of the lower portion of Rose Creek and identification of erosion areas. The Assessment Hydrologic Modifications Technical Memorandum (KTU+A 2005c) contains brief descriptions of aerial photos of the RCW west of MCAS Miramar from 1928, 1945, 1953, 1966, 1977, 1989, and 2000.

In the 1800's Rose and San Clemente Creeks originally emptied into the mudflats and salt march of the historical False Bay, which was renamed Mission Bay for the 1915 World's Fair. The San Diego River also flowed into False Bay until floods in1825 caused the river to shift into San Diego Bay. The San Diego River was then diverted back into False Bay in 1876.

Floods in 1916 redirected Rose Creek to the present day alignment. The flood velocity took a direct path to the bay, cutting a channel through the current area that is now the rock and concrete channel seen today. The mouth of Rose Creek migrated over a broad fluvial plain that is apparent in the 1928 aerial photo.

Gradual improvements to the new channel were accelerated in the 1930's to accommodate WWII military needs and postwar land development in the 1940's. The 1940-41 wet season was the 2nd wettest season and prompted the channelization of portions of lower Rose Creek. By 1949 heavy machinery began to erase the last vestiges of Rose Creek's natural course ushering the post war building boom. The straightening and fixing of the creek channel allowed development in the historical flood delta at the mouth where it enters Mission Bay. In the 1950's, Stevenson Canyon was redirected via storm drains at a time when development in the upper portion of Rose Creek and San Clemente was still at a minimal. By the mid 1960's, the upper portions were developed with greater than 80% of the urbanization between Interstate 5 and 805 having occurred. By this point in time, the community of Pacific Beach had expanded to occupy much of its present day developed area, including the southern slopes of Mount Soledad. The community of Clairemont had been substantially developed on the mesa tops to the south of San Clemente Canyon and along both sides of Stevenson Canyon. A substantial portion of the residential development with the community of University City along Governor Drive between present day Interstate 805 and Interstate 5 had also been developed. By 1966, the expansion of development within these areas essentially established the hydrologic and land development conditions present today within the San Clemente Canyon area. The historical flood delta at the mouth of Rose Creek had been almost completely developed and the creek channel re-configured to its present day form.

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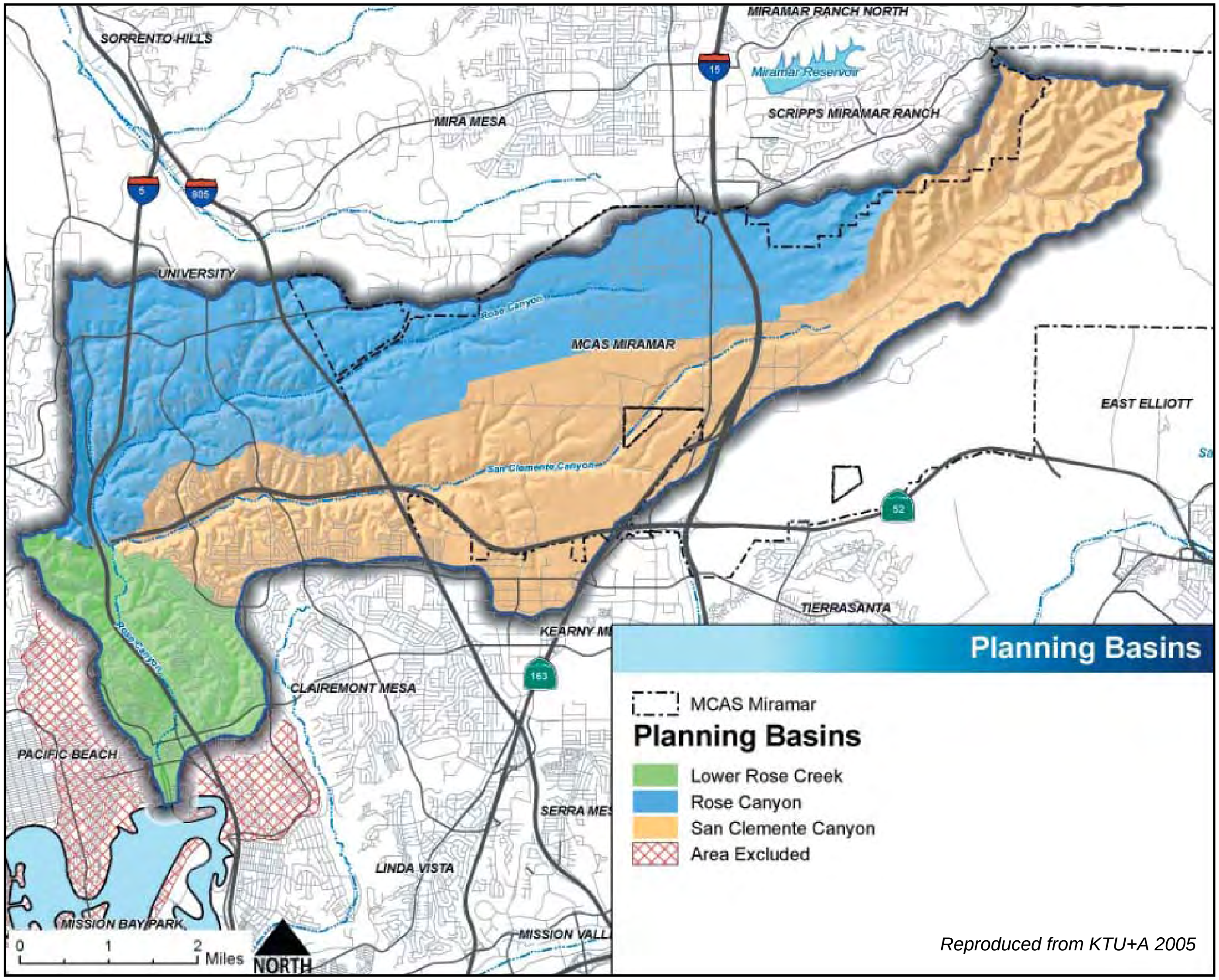

Figure 1 – Rose Creek Watershed

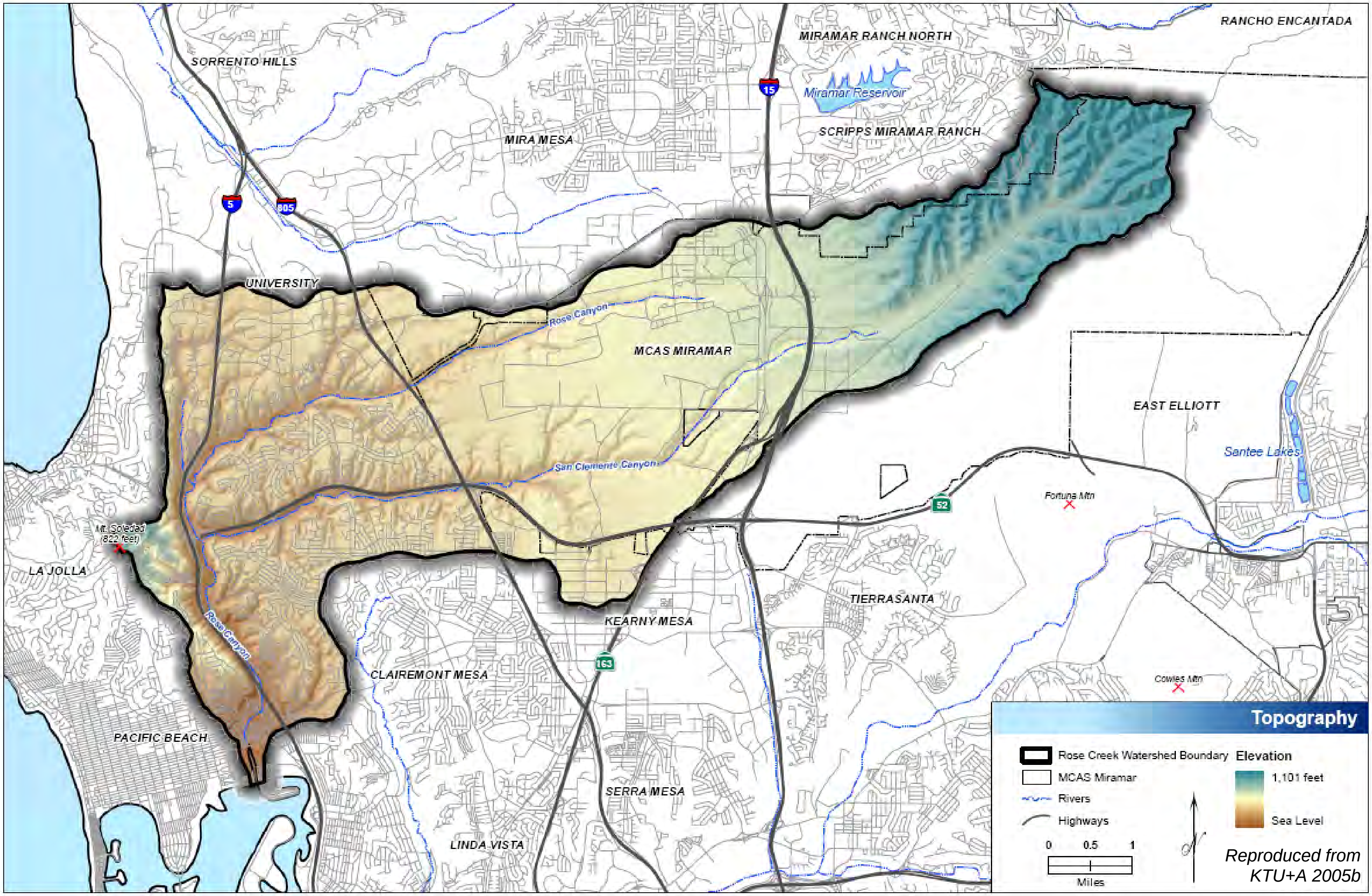

Figure 2 – Rose Creek Watershed Topography

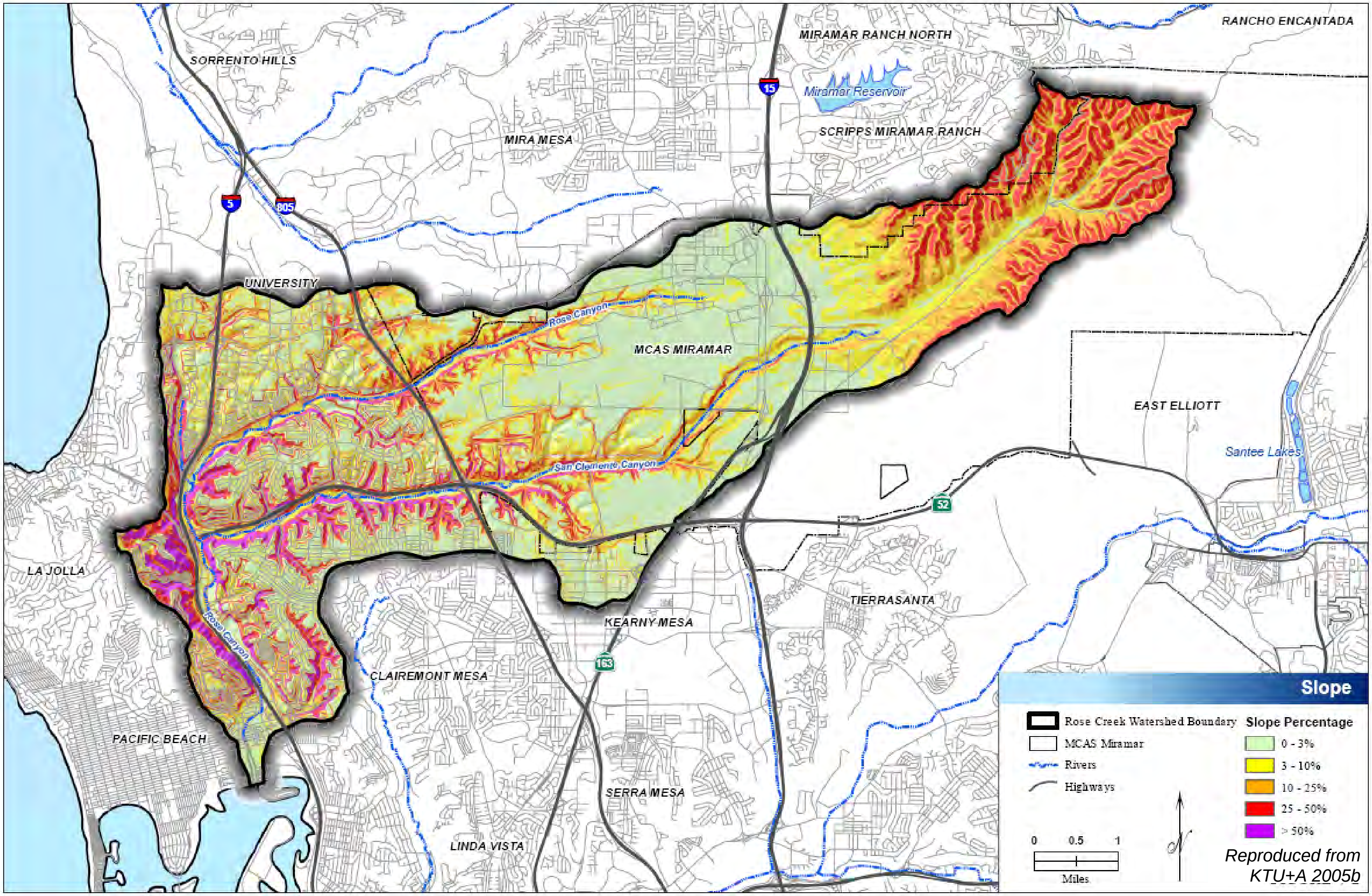

Figure 3 – Rose Creek Watershed Slope

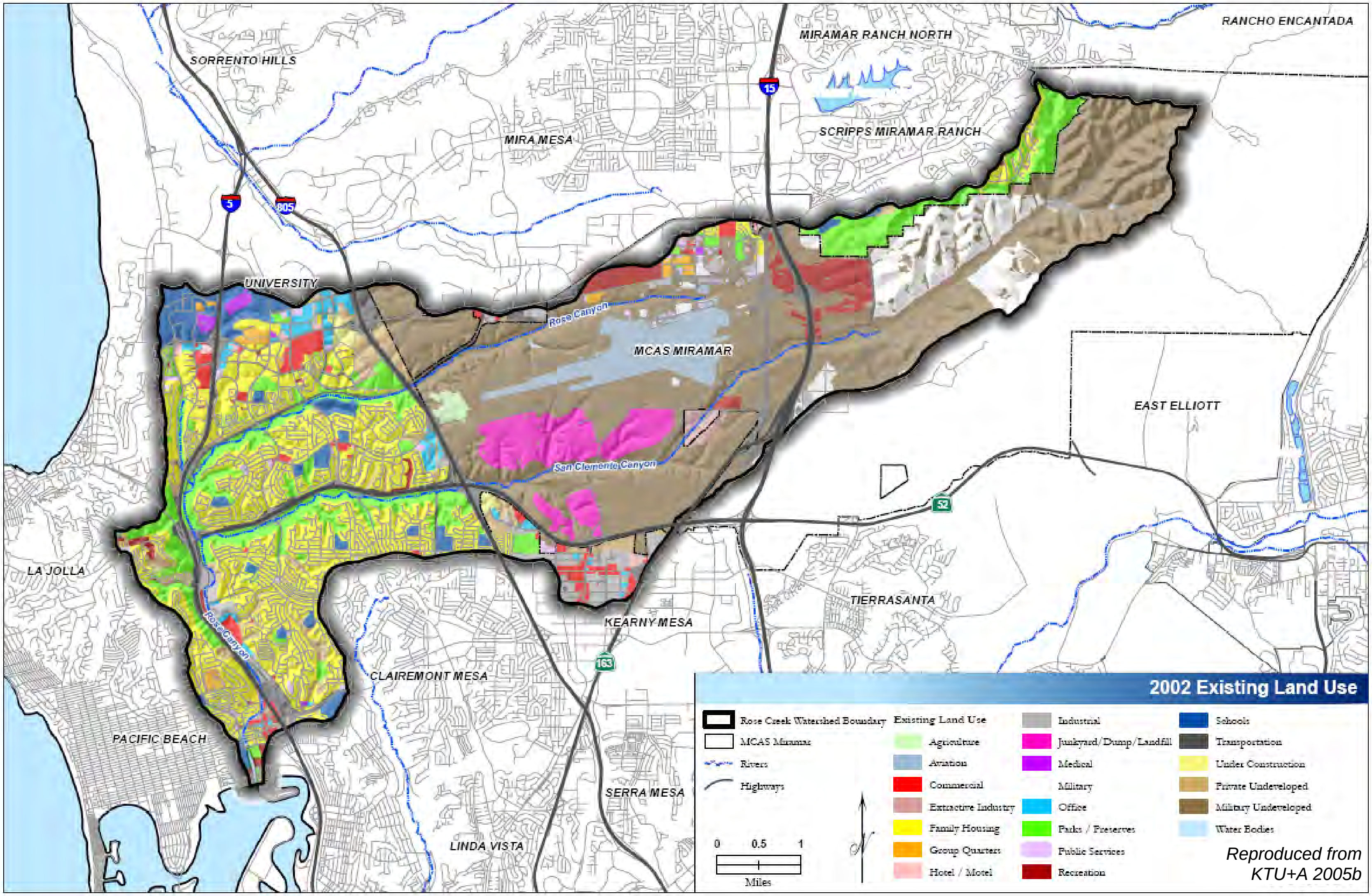

Figure 4 – Rose Creek Watershed Land Uses

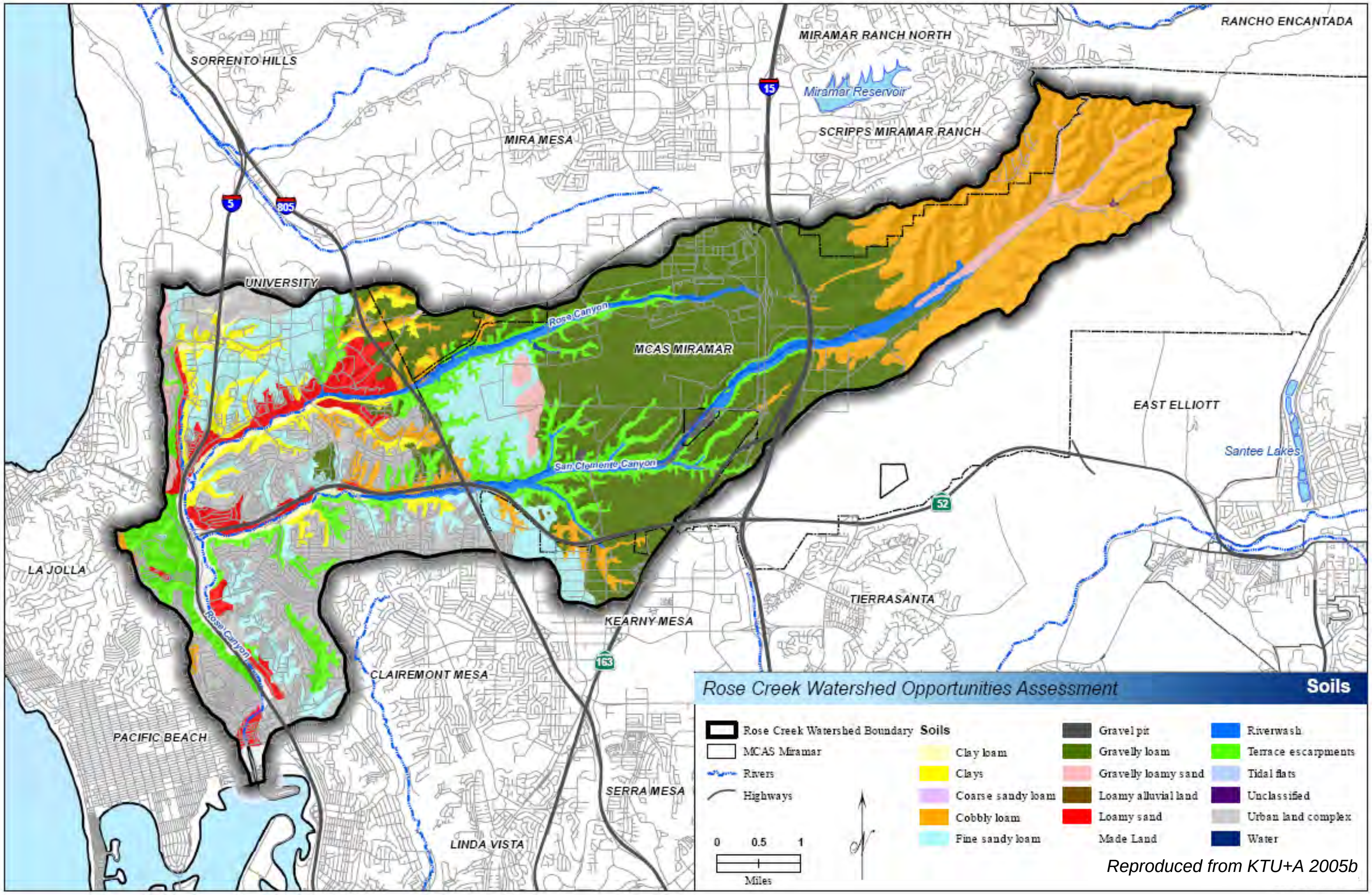

Figure 5 – Rose Creek Watershed Soil Types

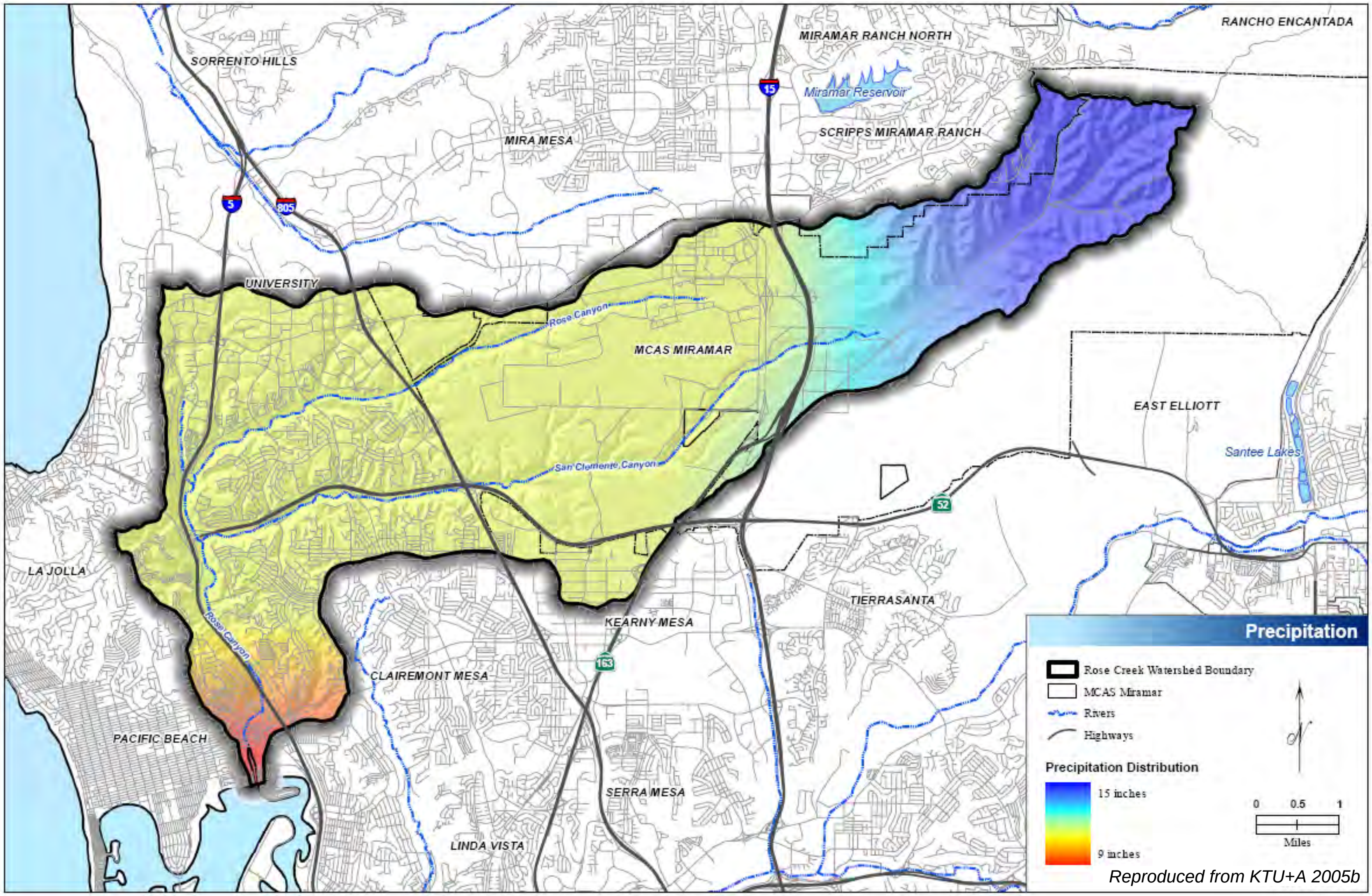

Figure 6 – Rose Creek Watershed Precipitation Pattern

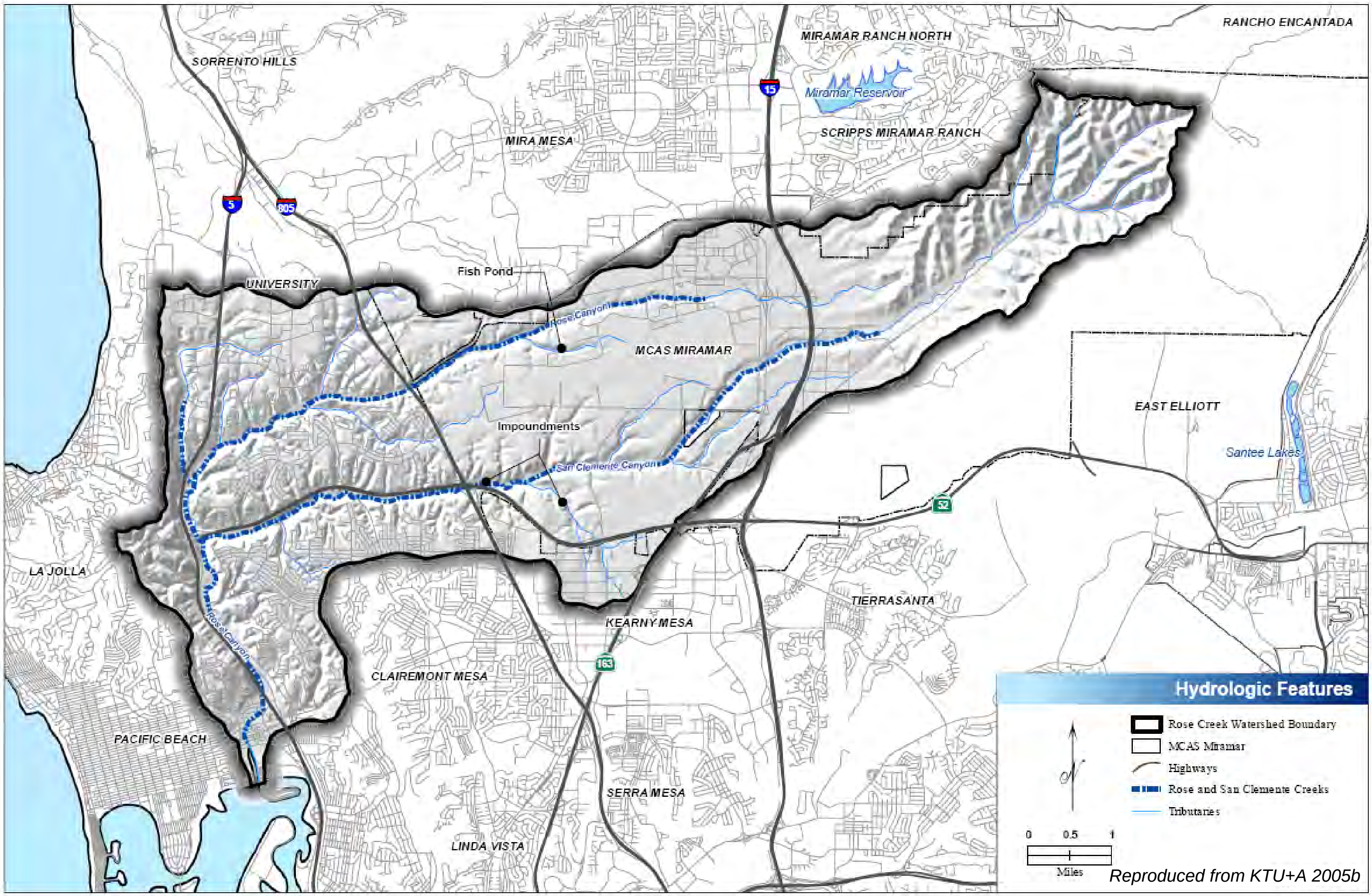

Figure 7 – Surface Waters

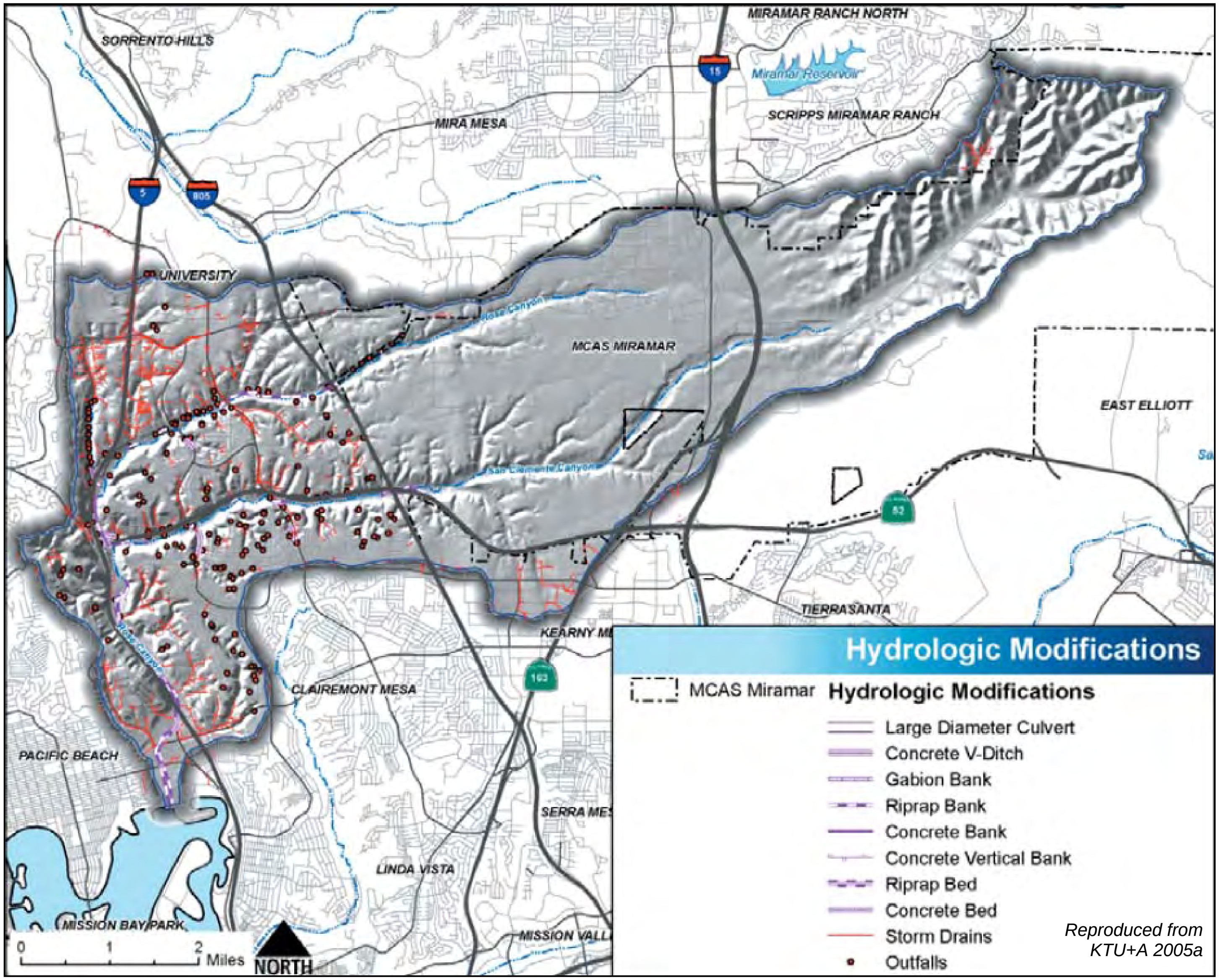

Figure 8 – Storm Drains and Other Hydromodifications