

**HYDROLOGY STUDY
FOR
Lake Jennings Campground Improvements**

Prepared For:

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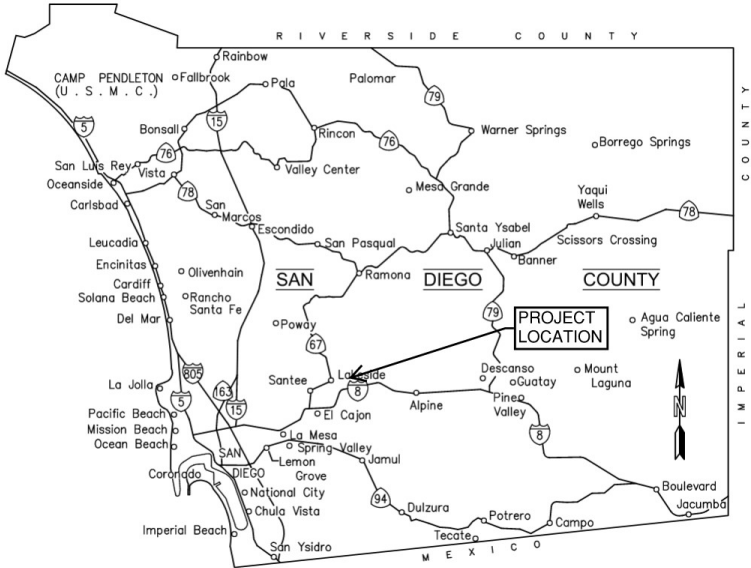
- Hydrologic Soil Groups Map (Web Soils)
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1.0 INTRODUCTION

The purpose of this hydrology study is to evaluate the existing and proposed hydrology impacting the Lake Jennings Campground and associated County Park area. This hydrology study has been prepared in accordance with the methods and standards of County of San Diego’s Hydrology Manual, County’s Hydraulic Design Manual and Public Road Standards. As such, this report identifies information such as the project location, project description, the existing watershed, and various methods used for calculations.

1.1 PROJECT LOCATION

The site project divided into two areas, Lake Jennings Campground and the County Park addition. Lake Jennings campground is located on the northwest side of Lake Jennings along Bass Drive about 1.3 miles northwest of highway 8. The County Park is located approximately 0.6 miles south of the campground along Bass Drive at the southwest corner of Lake Jennings. Both project areas are located in the City of Lakeside in the County of San Diego.





1.2 PROJECT DESCRIPTION

The Lake Jennings Campground Improvement project consists of a whole site redevelopment. Improvements include: Repaving of Bass Road through the entire site while keeping the existing alignment, Accessibility improvements through the addition of stabilized DG and concrete walkways, concrete and asphalt accessible parking stalls, DG campground sites with permeable paver plaza spaces, multiple playgrounds throughout the site with an added splash pad, 4 ECO Tents equipped with water and sewer connections, and drainage improvements including the addition of a curb inlet, storm drain line, and concrete energy dissipater. Regrading of the existing hillside will be necessary to accommodate added camp sites.

The county park to the south will be adding a new concrete driveway and accessible parking stalls, DG parking lot and pathways, a wood fiber playground with perforated underdrain, and a dog park with concrete walkway access. A biofiltration basin will be placed to collect runoff from the dog park and a new water line and backflow preventer will be installed to service two drinking fountains.

The layout of the project this hydrology study is addressing includes all added bid alternatives.

2.0 WATERSHED PROPERTIES

2.1 EXISTING TOPOGRAPHY

The project is located in within the vicinity of Lakeside in the County of San Diego with surrounding areas consisting of hillside and small rural density residential communities. The campground project area currently sits on top of a hill with lake Jennings on the east side. The slope within the existing roadway varies between 1% - 15% and steep hillside surrounding the project site can reach up to 60% slope. Graded camp sites surround the existing roadway with areas of vegetation in between sites. The County Park area borders Bass Drive and consists of an asphalt paved area with a small hillside to the east that borders Lake Jennings. Bass road has a high point towards the middle of the project site area which splits flows north, south, and west. A vegetated area bordering the asphalt paving to the south slopes towards the lake varying between 1% - 6%.

The existing topography maps found in **Appendix A** were acquired using the County of San Diego field survey and surrounding SANGIS database with 2-foot contours.

2.2 EXISTING DRAINAGE

Existing drainage for the Campground project site consists of two Basins split apart by a ridge. This ridge runs throughout the middle of the entire site and splits the flow from draining towards the Lake and draining inland.

Basin E1.0: Basin E1.0 sits on the northern side of the ridge that separates the two basins and includes a portion of the existing roadway, multiple campground sites, small buildings, and a gazebo structure. Stormwater sheet flows south to north before collecting into small cross gutters that span the roadway, eventually out letting onto the hillside. Stormwater then flows to naturally formed drainage channels as it flows offsite inland.

Basin E2.0: Basin E2.0 sits on the southern side of the ridge and consists of a portion of the existing roadway, playground area, multiple campground sites, small buildings, and concrete drainage channels. Stormwater sheet flows north to south with the eastern portion of the Basins stormwater collecting into a series of concrete drainage channels that outlet off site towards Lake Jennings. The western portion sheet flows and collects into naturally formed drainage channels that lead towards Lake Jennings.

The county park project site area has a ridge line running across the middle of the existing asphalt paving splitting flows to Bass Drive and Lake Jennings. The existing high point on Bass Drive directs flow north and south dividing the County Park area into three basins. All basin stormwater outlet into Lake Jennings.

Basin E3.0: Basin E3.0 is the southern part of Bass Drive and consists only of asphalt. An AC dike prevents stormwater from flowing into the vegetated area of County Park and directs flow south along Bass Drive. The stormwater collects into a flume down drain that directly outlets into Lake Jennings.

Basin E4.0: Basin E4.0 consists of the western portion of the asphalt paving and the northern portion of Bass Drive. Stormwater sheet flows from the asphalt paving and collects onto Bass Drive. An AC dike directs flow north before out letting of the side of the road directly into Lake Jennings.

Basin E5.0: Basin E5.0 consists of the east side of the asphalt paving as well as the vegetated area bordering it on the south. Stormwater in this basin sheet flows directly east into Lake Jennings.

2.3 PROPOSED DRAINAGE

The drainage over the proposed site has been designed to redirect stormwater that would be flowing away from the lake into systems that will outlet towards Lake Jennings. Existing drainage patterns have been maintained to the full extent possible. Roadway grades have been adjusted to most efficiently accommodate drainage over the campground area. A drainage system has been proposed to accommodate all non self mitigating drainage areas to convey runoff to outlet into Lake Jennings. The site has been divided into 14 different Basins which cover the proposed limits of work. Basins P1.0 – P9.0 are located within the Lake Jennings Campground project site area while Basins P10.0-P14.0 are located within the County Park project site area.

Basin P1.0: Basin P1.0 consists of campground sites with DG walkways, a portion of Bass Drive, a concrete accessible parking space, and a concrete walkway. Stormwater sheet flows across the basin from north to south where it eventually outlets into Lake Jennings.

Basin P2.0: Basin P2.0 consists of campground sites with permeable paver plaza areas, DG walkways, a portion of Bass Drive, and the proposed ECO tents. This area primarily sheet flows directly into lake Jennings with a portion of the area being guided by AC dikes before draining into Lake Jennings as well.

P3.0: P3.0 consists of a portion of Bass Drive, a concrete drainage channel, concrete walkways, a playground area with shade structure, and campground sites. Stormwater from the northwest of this basin is directed across the road into a concrete drainage channel. This concrete drainage channel outlets on to Bass Road and is directed by the AC dike towards an break in the dike for water to flow into pervious area and into Lake Jennings.

P4.0: P4.0 consists of a portion of Bass Drive, concrete drainage channels, and campground sites. Stormwater from the north of this basin is directed into a across the road into a concrete drainage channel. This concrete drainage channel outlets onto Bass Drive and head south along an AC dike. The flow then enters another concrete drainage channel that outlets offsite and enters into Lake Jennings.

P5.0: P5.0 consists of portions off Bass Road, an asphalt ADA parking space, playground, and campground sites. Stormwater flows north to south from a high point at the northern end of the basin. Runoff sheet flows until it collects at an AC dike that runs along Bass Drive. The AC dike directs the stormwater south towards an outlet at the south side of the roundabout. From there, water will discharge into Lake Jennings.

P6.0: P6.0 consists of a portion of Bass Drive, concrete walkways, a small building, asphalt ADA parking spaces, and campground sites. Stormwater flows southwest to northeast along an AC dike on the east side of Bass Drive being directed towards an outlet located towards the middle of the parking spaces. From the outlet, runoff will directly discharge into Lake Jennings.

P7.0: P7.0 is a self mitigating basin with a concrete walkway, DG pathway, and DG campground sites. Stormwater in this basin sheet flows off site away from Lake Jennings.

P8.0: P8.0 consists of portions of Bass Road, small buildings, DG campground sites, permeable paver plaza areas, a concrete plaza with gazebo, concrete walkways, and curb inlet. Stormwater flows south to north along a proposed AC dike that is on the north side of Bass Road. This AC dike directs flow into a proposed curb inlet located at the north end of the basin. From the curb inlet, runoff is directed through a 24" PVC pipe that outlets into a concrete energy dissipater and eventually into Lake Jennings.

P9.0: P9.0 is a smaller basin consisting of a building, concrete flatwork, and a splash pad. Stormwater sheet flows through the basin to a low point located at the middle and west end of the splash pad. An inlet will collect runoff and connect into the proposed 24" PVC storm drain that outlets into a concrete energy dissipater and eventually Lake Jennings.

P10.0: P10.0 consists of a DG walkway and vegetation. This walkway is sloped towards a hillside that borders Lake Jennings, so stormwater sheet flows from the walkway and directly into the lake.

P11.0: P11.0 consists of a DG walkway, and a playground area with an underdrain. Stormwater flows from the DG walkway onto the playground and enters the underdrain below the wood fiber. This underdrain outlets to the hillside that leads towards Lake Jennings.

P12.0: P12.0 consists of DG and concrete walkways, a dog park, and a biofiltration Basin. Stormwater sheet flows across the walkways into the vegetated mound located at the east side of the dog park. This mound directs water into the biofiltration basin at the south end of the basin and enters a perforated underdrain. This perforated underdrain flows into a catch basin located in the biofiltration basin and outlets into a PVC pipe. This PVC pipe outlets into an existing downdrain flume that leads toward Lake Jennings.

P13.0: P13.0 consists of the existing asphalt of Bass drive which has an AC dike located on the east side. This AC dike directs stormwater from north to south, discharging into an existing downdrain flume that leads to Lake Jennings.

P14.0: P14.0 consists of a portion of Bass Drive, concrete ADA parking spaces, a DG parking lot, DG pathways, and a concrete driveway. Stormwater sheet flows across the DG parking lot from southeast to northwest until it collects onto Bass Drive which has an AC dike on its east side. This AC dike directs flows north until it outlets off the side of the road into Laake Jennings.

3.0 DESIGN CRITERIA AND METHODOLOGY

3.1 HYDROLOGY

Runoff produced on the project site was calculated for the 100-year storm event using the methodology outlined in the San Diego County Hydrology Manual.

3.1.1 Rational Method

The rational method formula estimates the peak rate or runoff at any location within a watershed. The rational method assumes that the peak runoff rate is generated from a constant rainfall intensity over an area for a specific duration of time. This duration of time is equal to the time of concentration which is defined as the time required for a rain drop to fall at the most upstream point in the tributary drainage basin to the point in question. The rational method equation is as follows:

$$Q = CIA$$

Q = Peak Discharge Rate (cfs)

C = Runoff Coefficient

I = Rainfall Intensity (in/hr)

A = Tributary Area (acres)

3.1.2 Runoff Coefficient

The runoff coefficient is the percentage of excess rainfall that will flow overland at the point of interest. The runoff coefficient is based on the surface type and the soil type. The runoff coefficient can be represented by the equation below:

$$C = 0.9 (\%imp) + C_p (\%pervious)$$

C = Runoff Coefficient

% imp = Percent of impervious surface with 90% runoff

% per = Percent of pervious surfaces (%per = 1 - %imp)

C_p = Pervious Runoff Coefficient based on soil type

The soil classification for the catchment area is mostly type D, according to the Hydrologic Soils Group Map in the County of San Diego Hydrology Manual. The USDA NRCS Soil Survey was utilized to better identify the boundaries and quantities of the hydrologic soil group.

3.1.3 Rainfall Intensity

The rainfall intensity (I) is the constant rate of rainfall over the tributary area for a duration of time that is equal to the time of concentration for a selected design storm frequency. To estimate the rainfall intensity an Intensity-Duration design chart (Figure 3-1 of the Hydrology Manual) was used. The Intensity-Duration design chart is modeled after the following equation:

$$I = 7.44 P_6 D^{-.645}$$

I = Rainfall intensity specific to Design storm (in/hr)

P_6 = Adjusted 6-hour storm rainfall amount (in)

D = Storm Duration which equals the Time of Concentration, T_c

The 6-hour rainfall amount is determined for the storm event in question from isopluvial maps located in Appendix B of the Hydrology Manual. For Madrid Way, the 100-year design storm was analyzed for the road way drainage. The 6-hour storm rainfall amount is as follows:

100 Year Storm Event $P_6 = 2.9$ in

3.1.4 Time of Concentration

The time of concentrations (T_c) is the time required for the runoff to flow from the most remote part of the drainage area to the point of interest. The time of concentration is calculated as the sum of the initial time of concentration (T_i) and the travel time (T_t).

$$T_c = T_i + T_t$$

Initial Time of Concentration

The initial time of concentration is based on sheet flow conditions at the upstream portion of the drainage basin. Sheet flow conditions are analyzed using the Overland Time of Flow developed by the Federal Aviation Agency (FAA). This method is based on the following equation:

$$T_i = \frac{1.8*(1.1-C)\sqrt{D}}{\sqrt[3]{S}}$$

T_i = Initial time of concentration (min)

C = Weighted runoff coefficient

D = Distance or length of sheet flow (ft)

S = Slope of sheet flow (%)

Travel Time

The travel time is the time required for the runoff to flow in a concentrated flow condition from the upper portion of the watershed to the point of interest.

For Concentrated Flow - Kirpich (Appendix I-C):

$$T_t = \left(\frac{11.9L^3}{\Delta E} \right)^{0.385}$$

T_t = Travel Time (min)

L = Watercourse Distance (miles)

ΔE = Change in elevation along effective slope (feet)

3.2 HYDRAULIC DESIGN CRITERIA

Drainage improvements for Lake Jennings Campground must collect and convey all onsite excess storm water while safely collecting and routing off-site runoff towards Lake Jennings. Each drainage Curb Inlet and Grate Inlet has been analyzed to convey the peak flow through the drainage management area using the following criteria and methodology.

3.2.1 Roadway Drainage

The capacity of surface drainage system must be consistent with the downstream storm water conveyance system. Roadway drainage features are required to convey runoff to inlets within a specified width, depth, and velocity of flow. Design requirements for roadway drainage are as follows:

- The maximum permissible velocity for unreinforced vegetation is 5 feet per second. Flows below this velocity will not require scour analysis.
- All road cross sections must have the capacity to convey the peak discharge from a 100 year storm event.
- The maximum depth of flow in the roadway shall have 0.1 foot of freeboard below the top of curb during the 50-year storm event.
- The maximum product of velocity and depth shall be less than 6 ft²/second.

Analysis of the flow conditions within the roadside swale assumes a uniform flow condition. This assumption allows the use of the Manning Equation:

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

Where

Q = discharge (cfs)

n = Manning Coefficient

A = Flow Area (ft²)

R = Hydraulic Radius (ft)

S = Swale slope (ft/ft)

3.2.2 Inlet Capacity Design

- The curb inlet on Bass drive has been designed in a sump condition. Sizing calculations have been provided for the curb inlet in **Appendix C**.
- The inlet capacity for the curb inlet on Bass Drive was analyzed under both weir and orifice conditions.
- The inlet capacity governed by the weir condition is calculated as:
- $Q = C_w L_w d^{3/2}$ For Curb Inlets

Where:

- Q = inlet capacity governed by weir flow (cfs)
 - C_w = Weir Coefficient ($C_w = 3.00$)
 - P_e = Effective Perimeter for sides accepting flow (ft)
 - L_w = Effective Weir Length (Curb Opening) (ft)
 - d = depth of flow at the grate (ft)
-
- The inlet capacity governed by the orifice flow condition is calculated as:
 - $Q = C_o h L (2gd)^{1/2}$ For Curb Inlets

Where:

- Q = inlet capacity governed by orifice flow (cfs)
- L = Curb Opening Length
- C_o = Orifice Coefficient ($C_o = 0.67$)
- g = gravitational acceleration (32.17 ft/s^2)
- A_e = Effective Area (ft^2)
- d = depth of flow at the grate (ft)
- h = Curb Opening Height

See **Appendix D** for inlet hydraulic calculations.

3.2.3 Storm Drain Pipes

The proposed underground storm drain system collects surface runoff from Basins P8.0 and P9.0. Each storm drain system has been positioned to accept a delineated drainage area and placed at low points or flow by locations intercepting the necessary intake of runoff. Cleanout spacing complies with the chapter 3 of the Hydraulic Design Manual based on the size of the storm drain line.

Per the Hydraulic Design Manual, underground storm drain pipes that flow under a public road must have the capacity to capture and convey the 100-year design storm.

3.3 GREEN STREET INFRASTRUCTURE

Storm water treatment BMPs are a significant part of the storm water management systems. The County of San Diego BMP manual's Appendix K "Green Streets Guidelines" has been implemented to meet stormwater requirements within the County's public right-of-way. A Green Street is a street that uses natural process to manage storm water runoff at its source. Green street features include biofiltration planters, permeable paving, street trees, vegetated curb extensions, sidewalk planters, and landscaped medians.

Green street improvements for the Lake Jennings Campground Improvements includes a biofiltration planters at the south end of the proposed dog park. The biofiltration basin has been appropriately designed to convey and treat the proposed runoff.

3.4 SOFTWARE USED

Computer aided software will be used to assist in hydraulic modeling of the storm water conveyance system. The program used for hydraulic analysis is Autodesk Hydraflow Storm Sewers 2014.

Autodesk Hydraflow Storm Sewers 2020

Hydraflow will be used to analyze specific cross sections that qualify for the Manning equation. Hydraflow Storm Sewer uses the energy-based standard step method to compute the hydraulic profile. This method is an iterative procedure that applies Bernoulli's Energy Equation between the downstream and upstream ends of each line in the system. It uses Manning's equation to determine head losses due to pipe friction. Using this method, a solution can always be found regardless of the flow regime. This method makes no assumptions as to depth of flow and is only accepted when the energy equation is balanced.

4.0 SUMMARY

Below is a summary of the Hydrologic Analysis Proposed and Existing calculation results.

4.1 EXISTING HYDROLOGY CALCULATION SUMMARY

EXISTING BASIN SUMMARY

100 YEAR - 6 HOUR Storm

Basin	C Value	Tc (mins)	Intensity (in/hr)	Area (acres)	Runoff (Q, cfs)
E1.0	0.44	9.26	5.13	10.41	23.49
E2.0	0.44	10.90	4.62	11.61	23.63
E3.0	0.90	5.00	7.64	0.13	0.91
E4.0	0.82	5.00	7.64	0.37	2.34
E5.0	0.61	8.67	5.36	0.80	2.63
TOTAL RUNOFF TO CANYON=					23.49
TOTAL RUNOFF TO LAKE =					23.63
TOTAL RUNOFF (COUNTY PARK) =					5.88

4.2 PROPOSED HYDROLOGY CALCULATION SUMMARY

PROPOSED BASIN SUMMARY

P6 = 2.9

P24 = 6.4

100 YEAR - 6 HOUR Storm

P6/P24 = 45%

Basin	C Value	Tc (mins)	Intensity (in/hr)	Area (acres)	Runoff (Q, cfs)
P1.0	0.40	11.13	3.93	2.86	4.45
P2.0	0.42	11.16	3.93	4.15	7.94
P3.0	0.54	9.40	4.38	0.94	2.59
P4.0	0.48	10.15	4.17	1.38	3.19
P5.0	0.49	11.15	3.93	1.79	4.01
P6.0	0.73	5.00	6.59	1.12	6.24
P7.0	0.35	6.72	5.44	4.80	10.67
P8.0	0.50	12.02	3.74	4.76	10.28
P9.0	0.74	5.00	6.59	0.21	1.20
P10.0	0.35	5.36	6.29	0.28	0.71
P11.0	0.39	6.60	5.51	0.05	0.12
P12.0	0.38	10.12	4.18	0.23	0.43
P13.0	0.90	5.00	6.59	0.13	0.91
P14.0	0.52	8.79	4.58	0.61	1.69
TOTAL RUNOFF =					50.57
TOTAL RUNOFF (COUNTY PARK) =					3.87

5.0 CONCLUSION

The analysis indicates a proposed combined 100-year peak flow for the Lake Jennings Campground project site of approximately 39.90 cfs that enters Lake Jennings, 10.67 cfs that runs off site away from the lake, and 3.87 cfs from the County Park project site. This is compared to a pre-project flow of 23.63 cfs that enters Lake Jennings, 23.49 cfs that runs off site away from the lake, and 5.88 cfs from the County Park project site. The project improvements present an overall increase of 69.9% in runoff towards Lake Jennings, and overall decrease of 54.8% in runoff away from Lake Jennings, and an overall decrease of 34.2% in runoff from the County Park. These increases and decreases are due to a larger area within the Lake Jennings Campground site being routed to Lake Jennings, as well as the decrease in impervious area in the County Park project site.

The Improvements to Lake Jennings Campground and County Park propose a new drainage system for Basin 8.0 which routes more stormwater towards Lake Jennings. This drainage system includes a curb inlet, storm drain line, and concrete energy dissipater all of which are properly sized through Hydraulic analysis. Due to runoff entering Lake Jennings, treatment of stormwater is not necessary. A biofiltration basin at the south end of the proposed dog park has been properly sized to treat any stormwater and debris.