PRELIMINARY HYDROLOGY/BRIDGE CROSSING REPORT

Santa Monica Mountains, CA

October 27, 2009

CLIENT: Santa Monica Mountains Conservancy

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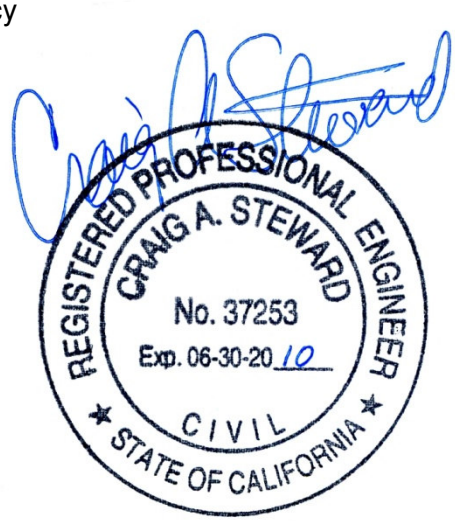

Table of Contents

List of Figures

List of Tables

Appendices

Ramirez Canyon (Typical for Each Canyon)

- Hydrology
  - Watershed Map
  - Summary Printout for 2, 5, 10, 25, 50 and 100 year events (clear water)
  - Summary Printout for 2, 5, 10, 25, 50, and 100 year events (burned)
  - Summary Printout for 2, 5, 10, 25, 50, and 100 year events (burned and bulked)
  - Sites of Interest Map
  - Summary Table for Just Sites of Interest
- Hydraulics
  - Summary HEC-RAS printout

Escondido Canyon
Latigo Canyon
Solstice/Dry Canyon
Corral Canyon
Malibu Bluffs
Parking Lot and Site Drainage Impacts
Creek Crossing Inundation Maps

PURPOSE OF REPORT

The Santa Monica Mountains Conservancy is proposing construction of a series of trails and other facilities to provide public access to the Santa Monica Mountains. The trails will cross creeks of various sizes and configurations. In order to provide for a safe and durable creek crossing design, it is necessary to understand the potential limits of flood water inundation and flow velocities that may impact these trails under various conditions. This report quantifies a range of peak flow rates for various watersheds, defines the inundation limits at proposed creek crossings and improvement areas, estimates flow velocities and makes preliminary recommendations for appropriate creek crossing improvements.

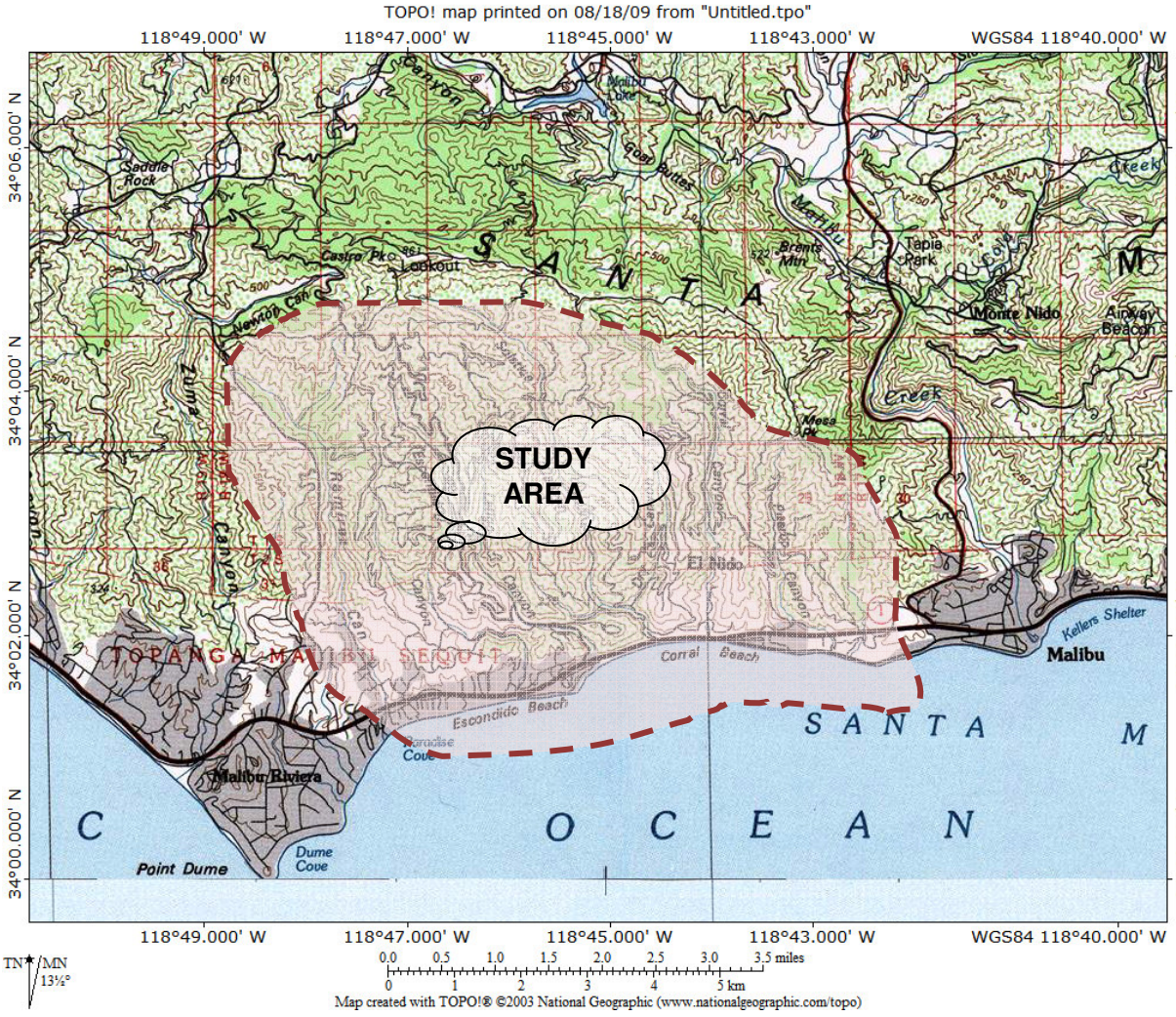

Figure A – Vicinity Map

LOCATION

The project is located on the south facing slopes of the Santa Monica Mountains between Point Dume and Malibu Creek. It covers Ramirez Canyon, Escondido Canyon, Latigo Canyon, Solstice and Dry Canyons, Corral Canyon and the areas tributary to the Malibu Bluffs. See Figure A.

BACKGROUND

The Santa Monica Mountains Conservancy has been in the process of identifying trail routes and potential camp sites suitable for public access within the public lands of the Santa Monica Mountains. The public lands in this area are steep and rugged, varying in height from 2,824 feet in elevation at Castro Peak to sea level and the point of discharge. Table 1 summarizes the various watershed characteristics.

Table 1 - Watershed Characteristics

	Ramirez Canyon	Escondido Canyon	Latigo Canyon	Solstice/Dry Canyon	Corral Canyon	Malibu Bluffs*
Tributary Area, ac	2,170	2,080	690	2,830	2,270	520
Basin Slope, ft/ft	0.1418	0.1320	0.1501	0.1436	0.1468	0.1319
Sinuosity Factor	1.09	1.23	1.14	1.15	1.23	1.00
Average Elevation, feet	328	348	299	414	350	198

** Marie Canyon only*

The upper hillsides are generally vegetated with native chaparral and largely undeveloped. Much of the lower reaches of the canyons have been developed in large lot residential units. Because the hillsides are steep and covered with the dense, flammable vegetation, the watersheds are subject to both wild fire and consequent debris laden runoff. No significant debris control devices are currently located within these watersheds.

METHOD OF ANALYSIS

The watershed hydrology was calculated using standard methods outlined in the Los Angeles County Department of Public Works Hydrology Manual (January 2006). The Modified Rational (MODRAT) methodology was used as implemented by the computer program WMS v8.2. The following steps were taken:

- Delineate watershed boundary using USGS digital elevation models
- Divide up the watershed into sub-watersheds of about 40 acres each.
- Number each sub-watershed and connecting stream lengths as required by the MODRAT program.
- Determine development intensity for each sub-watershed.
- Determine the weighted soil type for each sub-watershed.
- Determine the weighted rainfall for each watershed for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year event.
- Determine the time of concentration for each sub-watershed.

- Calculate the clear water flow rates for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events for each of the sub-watersheds.
- Calculate the burned watershed flow rates for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events for each of the sub-watersheds.
- Calculate the burned and bulked watershed flow rates for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events for each of the sub-watersheds.

The burned and bulked peak flow rates were then applied to a hydraulic analysis model (HEC-RAS) to determine the depth, inundation limits and velocity of flow are various locations identified as likely to be impacted by creek flow. Topographic mapping was provided via LIDAR mapping. Manning's roughness values were determined from typical values and review of aerial photography. Starting water surface elevations were assumed to be critical depth and all flow was presumed to be in the subcritical flow regime.

Parking lot and campsite hydrology was calculated using the County of Los Angeles TC calculator program which is designed for smaller tributary areas. Peak flows were calculated for the water quality condition (0.75 inches of rainfall), and for the 10-year event. Pre-project and post-project conditions were evaluated.

Detailed input and output data for both the hydrologic and hydraulic analyses are presented in the appendices and organized by watershed.

Creek crossing design was determined by assessing:

- Likelihood of use during rainfall events
- Calculated depth and width of flow
- Calculated velocity
- Ease of crossing restoration after damage versus potential disturbance and cost of more permanent facilities

Crossing design exhibits are found in the appendices and organized by watershed and include plotted inundation limits of the 2-year and 50-year clear water flow rates and 2-year and 50-year[1] burned and bulks flow rates.

[1] In the County of Los Angeles, FEMA accepts the 50-year burned and bulked flow rates (calculated per the County methods) as equivalent to the FEMA 100-year flow rates.

FINDINGS

The following sections summarize findings of the hydraulic and hydrologic analyses and preliminary crossing design, organized by watershed from west to east. Each watershed has been analyzed independently.

The hydrologic information includes peak flow rates at creek crossing locations for the 2-year and 50-year events for both clear water and the burned and bulked conditions as defined by the Los Angeles Public Works Departments.

Short-term impacts due to construction will be mitigated using standard methods and best management practices outlined in the appropriate NPDES permit. NPDES compliance documents will be prepared as part of the final design by others.

Proposed grading and improvements within the various watersheds are so minor as to not be calculable in the creek hydrology analysis. In order to determine the long-term, site specific impact of the proposed parking and camping improvements, a separate analysis was prepared comparing pre-project and post-project conditions at the individual sites for the water quality event and the 10-year rainfall event. Water quality impacts will be mitigated by the use of above-ground vegetated methods wherever possible. These will include passing un-concentrated flows over natural vegetation, vegetated filter strips or through bio-swales. Potential impacts from potable water spigots are mitigated with gravel or rock-filled drainage sumps. Where necessary and if feasible, infiltration best management practices may be implemented. These may include bio-detention, infiltration, or permeable paving materials.

Trails and associated improvements will be constructed in accordance with best practices of trail design and will therefore include drainage conveyances and erosion control devices necessary to minimize long-term water quality impacts. The grading involved in construction of the proposed trails is so minor as to have no calculable impact on peak event runoff or volumes.

The hydraulic information is currently given in a creek flow line profiles found later in the body of the Findings section. The profile graphically provides maximum depth of flow and slope of the creek at any particular location. Much more detailed information is contained in the appendices.

Creek crossing information includes a table of the flow width, average velocity for the 2-year and 50-year conditions (clear water and burned and bulked conditions), and stable rock size and weight (the size of a rock likely to remain in place given the anticipated flow velocity). Stable rock size is given in minimum rock dimension and by rock weight to assist in design of the creek crossings. These data are found later in the body of the Findings section.

Where bridges are not used for pedestrian creek crossings, the appropriately sized rocks (per the information in the tables provided below) should be placed diagonally across the creek to provide stepping stones. The diagonal placement will minimize the chance of blockage of the stones at any one particular location as well as the any potential rise in water surface elevation. Stones should be placed 18” to 30” apart for ease of stepping. Stones should be wedged, anchored or embedded into creek materials so as to provide a stable stepping platform.

Detailed mapping showing inundation limits, locations of proposed trails, and analysis are included in the appendices.

Figure B is a key map showing the locations of the various creek crossings.

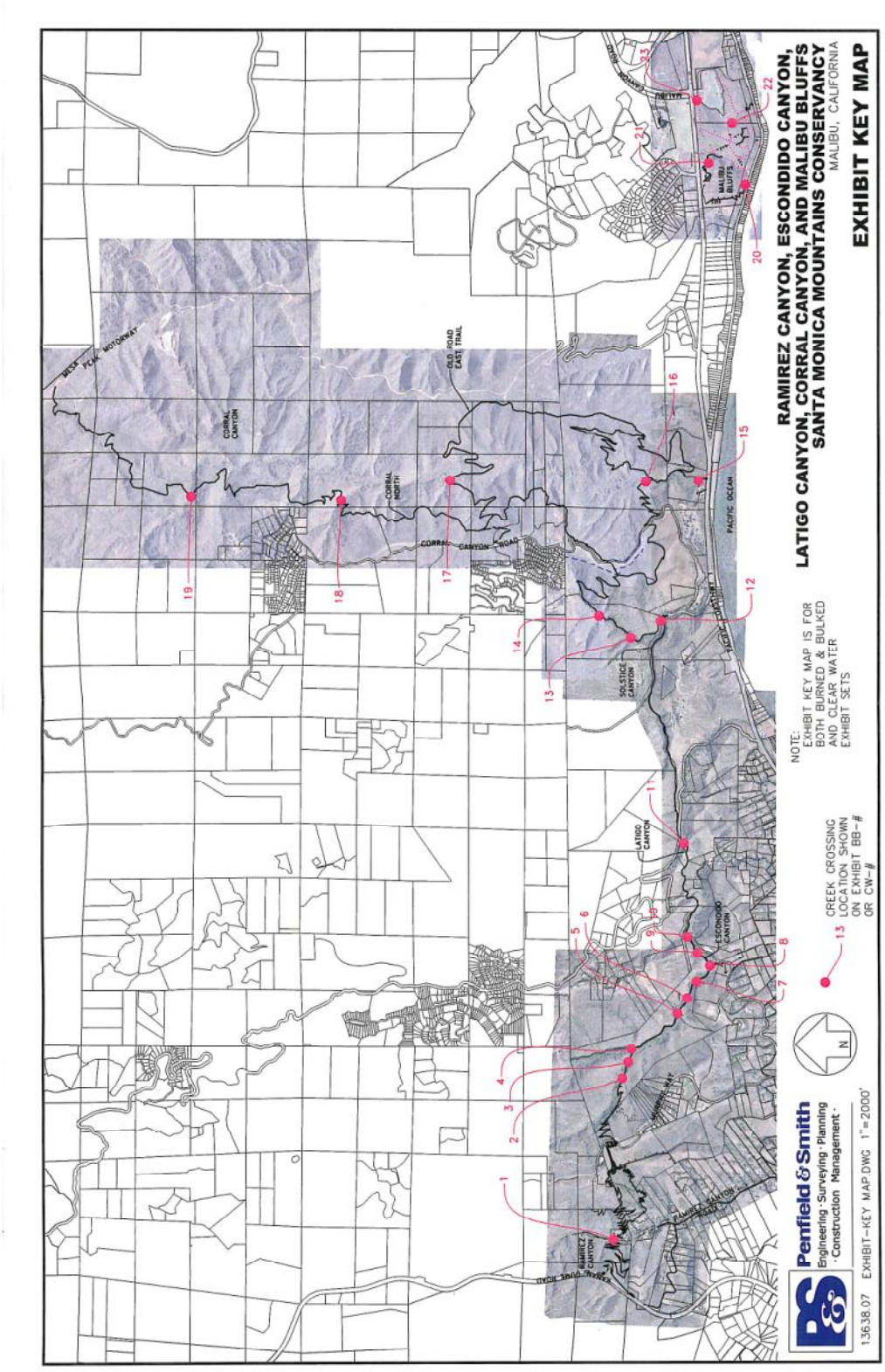

Figure B - Key Map

Ramirez Canyon

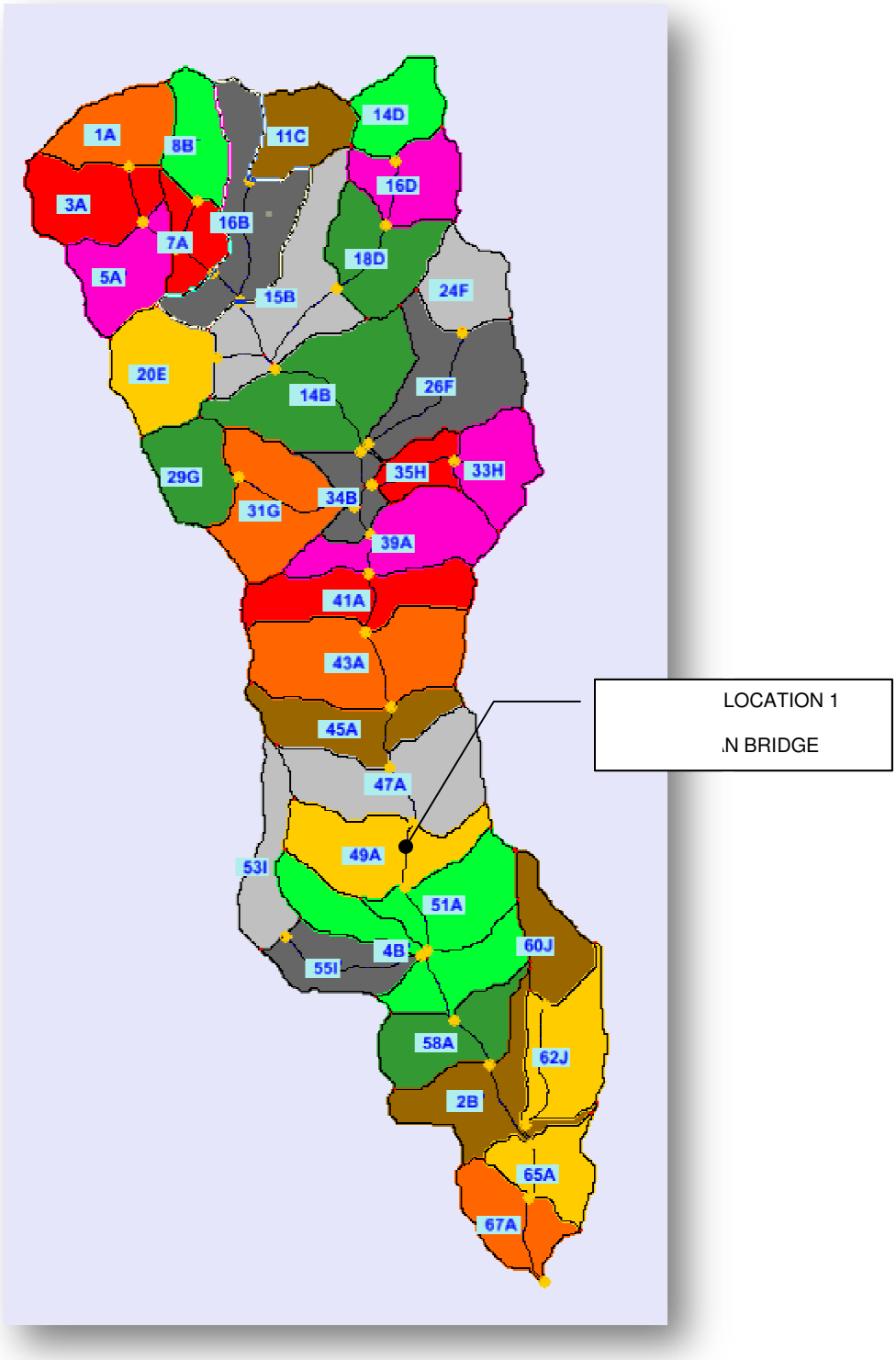

Figure C - Ramirez Canyon Watershed

Hydrology

Table 2 - Ramirez Canyon Clear Water Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
49A	50A	200	490	730	1,060	1,330	1,610

Table 3 - Ramirez Canyon Burned and Bulked Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
49A	50A	390	910	1,320	1,880	2,340	2,790

Table 4 - Ramirez Canyon Site Drainage Impacts

		Peak Flowrate, cfs		
Location	**Rainfall Event**	**Pre-Project**	**Post-Project**	**Increase**
Meadow Area	Water Quality (0.75")	0.02	0.02	0.00
	10-year	2.57	2.57	0.00
Kanan Dume Parking Area	Water Quality (0.75")	0.00	0.05	0.05
	10-year	0.47	0.54	0.07
Entry Area	Water Quality (0.75")	0.48	0.48	0.00
	10-year	27.83	28.24	0.41

Since proposed improvements in the Meadow Area are limited grading for campsites and a restroom facility, long-term drainage and water quality impacts can be mitigated by preventing the concentration of flows and directing runoff from the graded areas to existing vegetated areas.

Proposed parking facilities on Kanan Dume Road will be treated using a vegetated filter strip to remove pollutants. Increased flow rates may need to be addressed by the use of permeable paving materials or some other infiltration method.

Proposed parking facilities at the Ramirez Canyon Park Entry area will be treated using a vegetated filter strip and native vegetation. Increased flow rates may need to be addressed by the use of permeable paving materials or some other infiltration method.

Hydraulics

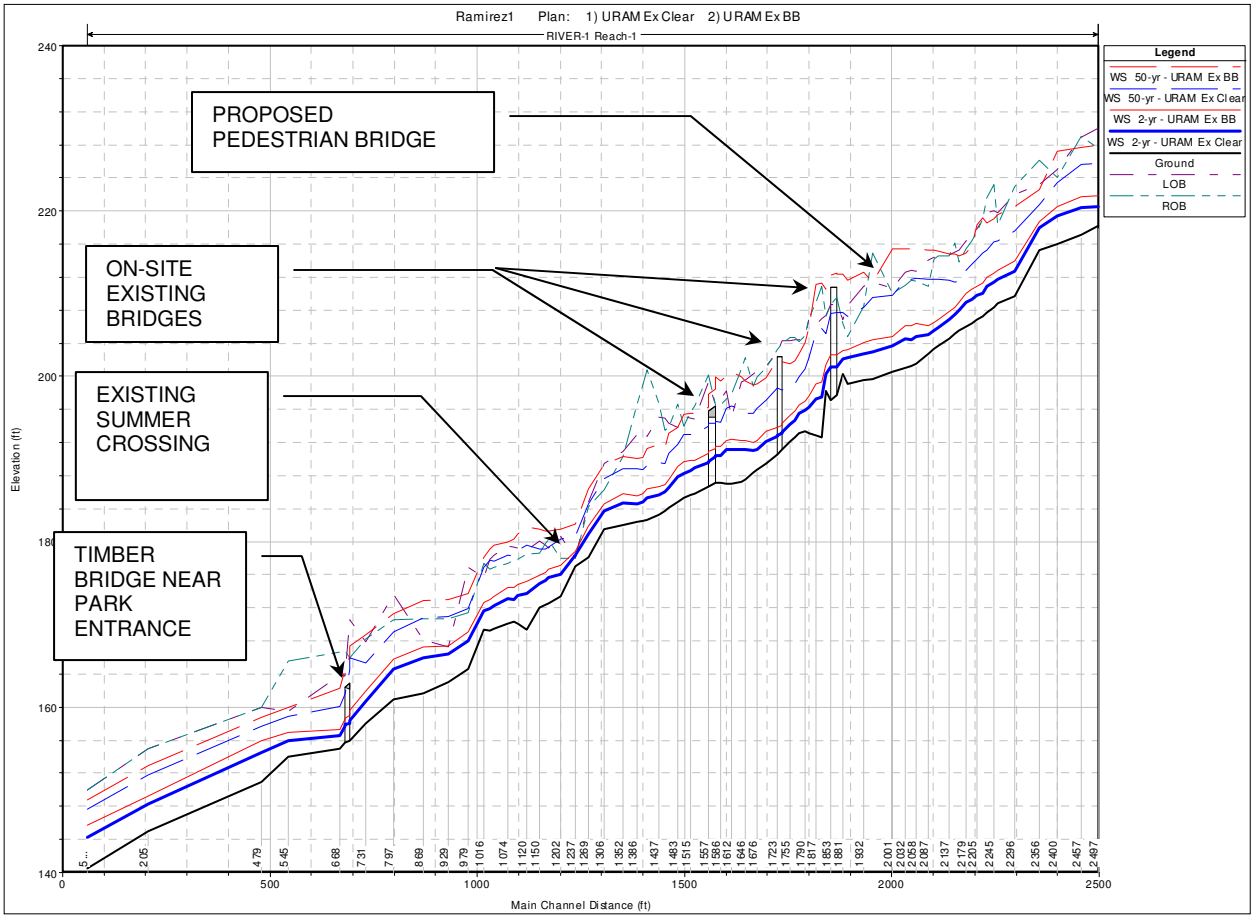

Figure D - Ramirez Creek Profile

Creek Crossings

Two bridge crossings were analyzed for Ramirez Creek. One is an existing wooden vehicular bridge located just downstream of the project entrance. The other is a proposed pedestrian bridge located generally in the mid-to lower meadow area. Approximate crossing characteristics are shown in Table 5 and Table 6.

Table 5 - Crossing Characteristics for Ramirez Creek, Clear Water

Location	Return Period	From Section	To Section	Flow Width (ft)	Average Velocity (fps)	Stable Rock (Size/Wt)
Ramirez	2-Year	1895	1895	15-18	3.31	7”/20#
Ramirez	50-year	1895	1895	15-18	8.36	29”/1200#

Table 6 - Crossing Characteristics for Ramirez Creek, Burned and Bulked

Location	Return Period	From Section	To Section	Flow Width (ft)	Average Velocity (fps)	Stable Rock (Size/Wt)
Ramirez	2-Year	1895	1895	15-18	4.65	9”/40#
Ramirez	50-year	1895	1895	15-18	10.96	53”/7300#

The vehicular bridge was found to be inadequate to pass the 50-year flow without overtopping. Preliminary analysis indicates that if the bridge were replaced with about a 34 foot wide bridge, it would likely pass the 50-year, clear water flow.

The pedestrian bridge placement is slightly more problematic due to the rugged terrain, brush and tree cover, tending to make the available topographic information difficult to use to accurately site the new pedestrian bridge. It will be more precisely sited during the final design process.

Escondido Canyon

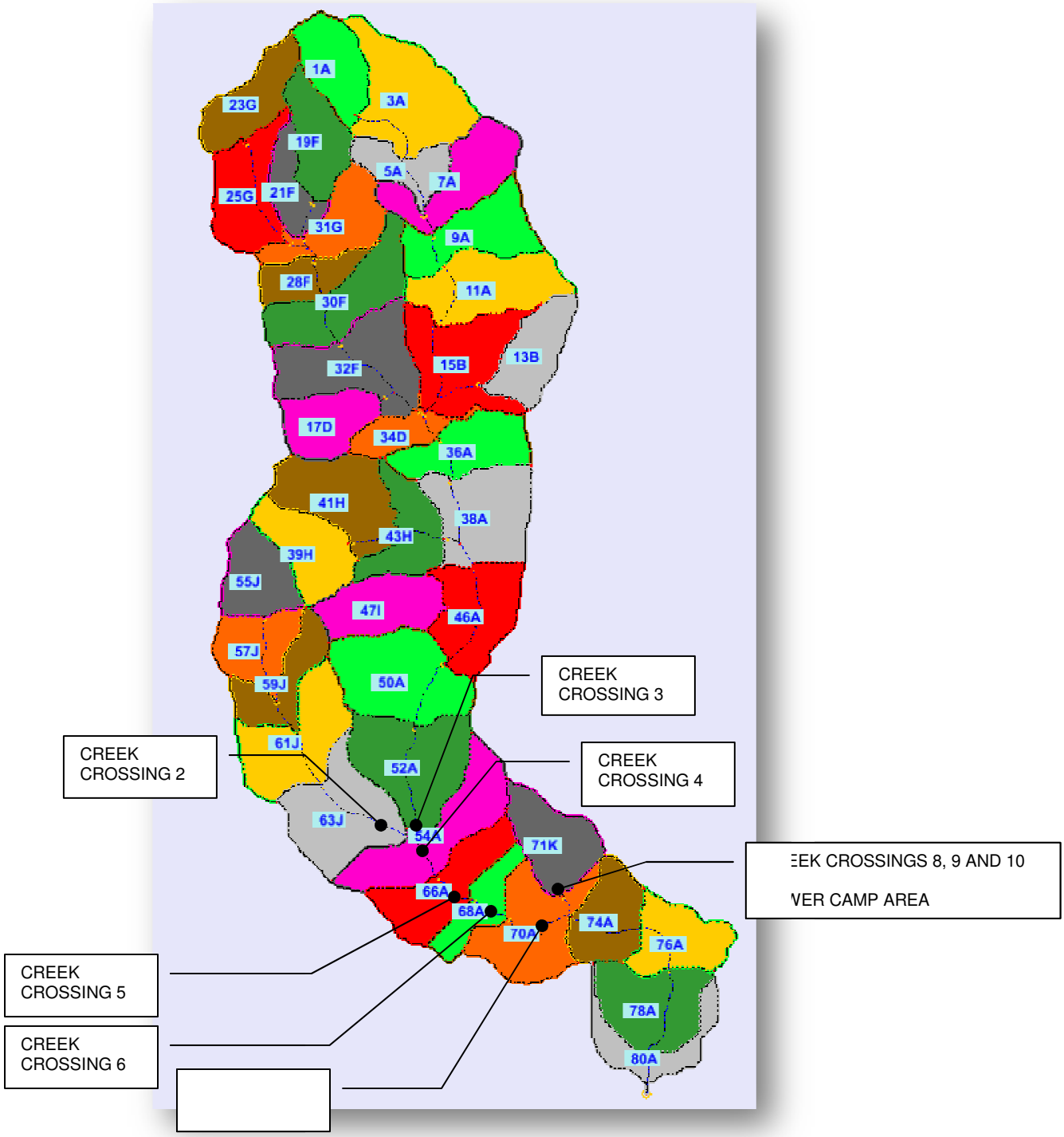

Figure E - Escondido Canyon Watersheds

Hydrology

Table 7 – Escondido Creek Clear Water Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
63J	64J	67	160	240	330	400	480
52A	53A	180	460	710	1,070	1,360	1,690
54A	65AJ	200	510	770	1,170	1,490	1,860
66A	67A	200	510	770	1,170	1,490	1,870
68A	69A	200	510	770	1,170	1,490	1,870
70A	73AK	200	510	780	1,180	1,490	1,890
71K	72K	25	47	62	81	94	110

Table 8 – Escondido Creek Burned and Bulked Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
63J	64J	160	640	460	620	740	870
52A	53A	510	1,110	1,600	2,270	2,810	3,360
54A	65AJ	550	1,210	1,740	2,470	3,070	3,680
66A	67A	550	1,210	1,740	2,480	3,080	3,690
68A	69A	550	1,210	1,740	2,480	3,080	3,700
70A	73AK	550	1,210	1,740	2,490	3,090	3,710
71K	72K	50	90	110	140	170	190

Table 9 - Escondido Canyon Site Drainage Impacts

		Peak Flowrate, cfs		
Location	**Rainfall Event**	**Pre-Project**	**Post-Project**	**Increase**
Parking and Upper Camp	Water Quality (0.75")	0.25	0.29	0.04
	10-year	20.48	20.48	0.00
Lower Camp	Water Quality (0.75")	0.04	0.04	0.00
	10-year	5.10	5.10	0.00

Proposed parking facilities at the Escondido Parking and Upper Camp Area will be treated using a vegetated filter strip located on the northerly side of the parking lot. Flow reduction may be addressed with detention within the limits of the parking lot or with infiltration methods.

Lower Camp facilities are limited to campsites and a restroom building. Water quality impacts can be addressed by directing non-concentrated flows to vegetated areas.

Hydraulics

The hydraulic analysis for Escondido Canyon has been divided into three reaches and designated as follows:

- Escondido – Main
- Escondido – FL2
- Escondido – FL3

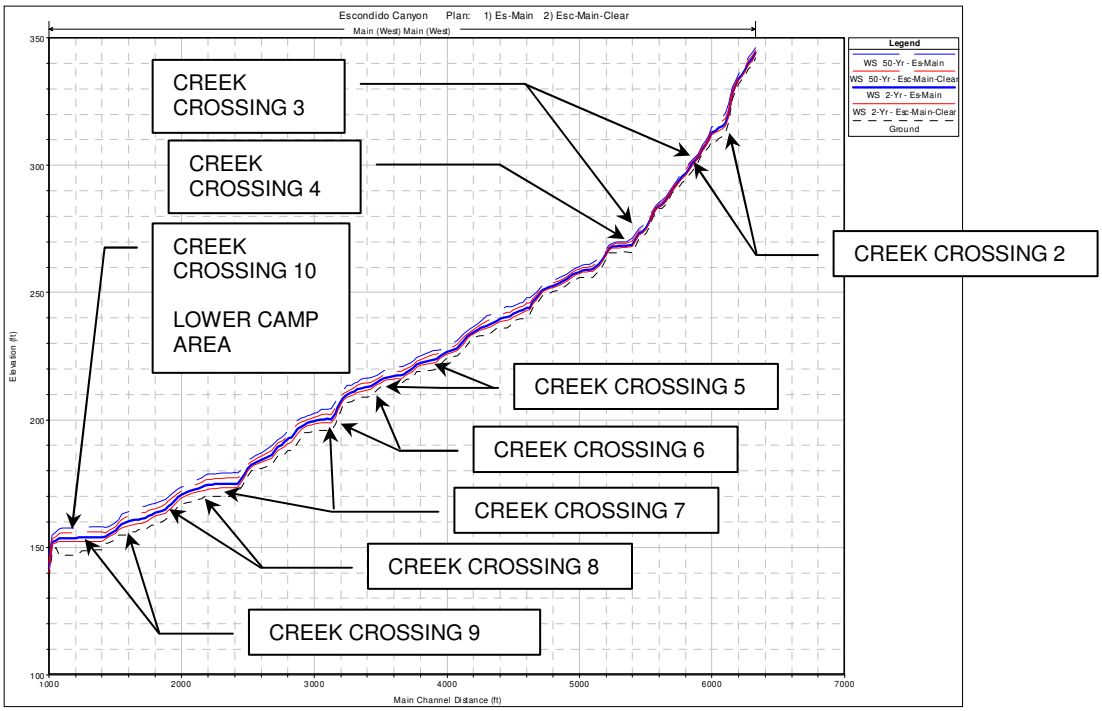

Figure F - Escondido - Main Profile

Some camp sites in the Lower Camp Area will be inundated during a 50-year event and should not be occupied if that level of storm is anticipated. Additionally, it is not practical to provide safe passage over Escondido Creek during larger storm events either. Maintenance of trails and camp sites after larger storm events is expected.

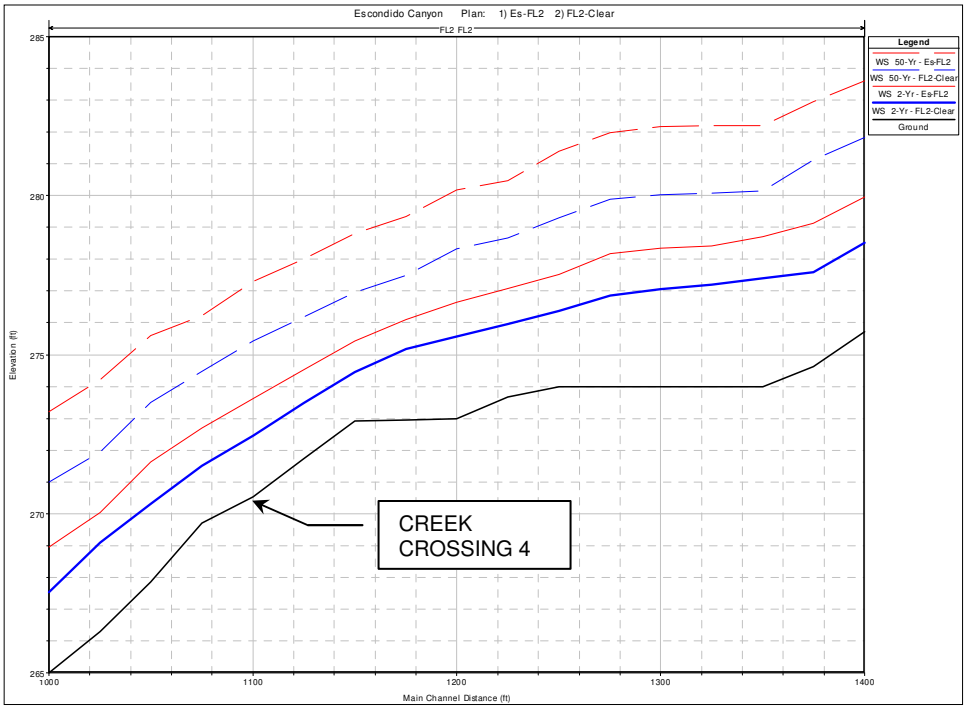

Figure G - Escondido - FL2 Profile

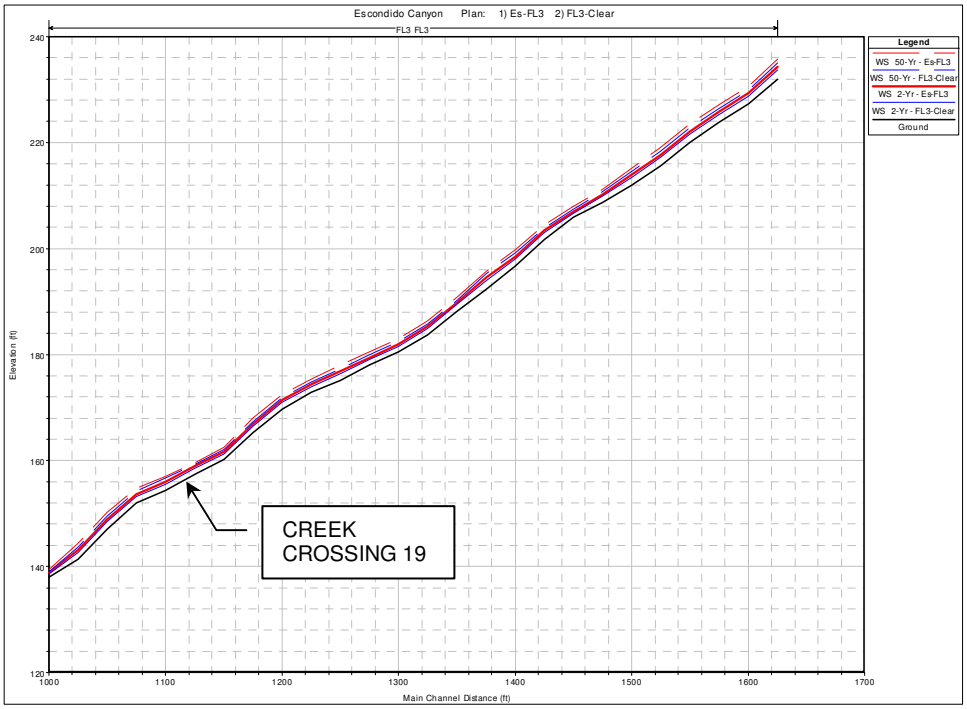

Figure H - Escondido - FL3

Creek Crossings

The Escondido Main creek crossing characteristics are listed in Table 10 and Table 11 below; (FL2) and (FL3) refer to the secondary drainage channels that flow to the Escondido Main Creek.

Table 10 - Crossing Characteristics for Escondido Creek, Clear Water

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Escondido (CW-2)	2-Year	61+00	58+75	11.99	5.67	13”/110#
Escondido (CW-2)	50-Year	61+50	58+75	30.24	7.87	26”/830#
Escondido (CW-3)	2-Year	58+75	54+50	22.65	4.71	9”/40#
Escondido (CW-3)	50-Year	58+75	54+50	50.12	6.49	18”/260#
Escondido (CW-4)	2-Year	54+50	54+00	17.21	4.99	10”/50#
Escondido (CW-4)	50-Year	54+50	54+00	34.1	7.28	22”/510#
Escondido (CW-4)	2-Year	11+00 (FL2)	11+00 (FL2)	28.21	6.15	16”/190#
Escondido (CW-4)	50-Year	11+00 (FL2)	11+00 (FL2)	56.83	10.50	48”/5400#
Escondido (CW-5)	2-Year	37+50	35+00	37.46	4.65	9”/40#
Escondido (CW-5)	50-Year	39+00	35+00	88.22	7.40	23”/570#
Escondido (CW-6)	2-Year	35+00	31+75	34.59	5.22	11”/70#
Escondido (CW-6)	50-Year	35+00	31+75	74.36	8.07	27”/970#
Escondido (CW-7)	2-Year	31+75	25+50	28.05	5.46	13”/90#
Escondido (CW-7)	50-Year	31+75	25+00	72.30	8.42	30”/1300#
Escondido (CW-8)	2-Year	21+75	20+00	26.28	5.15	11”/60#
Escondido (CW-8)	50-Year	22+00	19+00	72.26	8.18	28”/1100#
Escondido (CW-9)	2-Year	16+00	14+00	30.59	5.33	12”/80#
Escondido (CW-9)	50-Year	18+00	12+50	77.16	6.80	19”/340#
Escondido (CW-10)	2-Year	11+50	11+00	49.79	1.60	7”/20#
Escondido (CW-10)	50-Year	12+50	10+50	92.16	4.55	9”/30#
Escondido (CW-10)	2-Year	11+30 (FL3)	11+30 (FL3)	10.13	4.34	8”/20#
Escondido (CW-10)	50-Year	11+30 (FL3)	11+00 (FL3)	38.90	4.38	8”/30#

Table 11 - Crossing Characteristics for Escondido Creek, Burned and Bulked

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Escondido (BB-2)	2-Year	61+00	58+75	17.09	6.89	20”/370#
Escondido (BB -2)	50-Year	61+50	58+75	42.78	8.40	30”/1300#
Escondido (BB -3)	2-Year	58+75	54+50	33.09	5.53	13”/100#
Escondido (BB -3)	50-Year	58+75	54+50	63.57	7.36	23”/550#
Escondido (BB -4)	2-Year	54+50	54+00	23.83	6.08	15”/170#
Escondido (BB -4)	50-Year	54+50	54+00	44.90	8.20	28”/1100#
Escondido (BB -4)	2-Year	11+00 (FL2)	11+00 (FL2)	38.79	8.14	28”/1000#
Escondido (BB -4)	50-Year	11+00 (FL2)	11+00 (FL2)	70.24	12.85	77”/23000#
Escondido (BB -5)	2-Year	37+50	35+00	54.82	5.88	14”/140#
Escondido (BB -5)	50-Year	39+00	35+00	115.16	8.84	33”/1700#
Escondido (BB -6)	2-Year	35+00	31+75	53.66	6.43	17”/240#
Escondido (BB -6)	50-Year	35+00	31+75	90.83	9.61	40”/3000#
Escondido (BB -7)	2-Year	31+75	25+50	44.44	6.76	19”/330#
Escondido (BB -7)	50-Year	31+75	25+00	95.26	10.17	45”/4400#
Escondido (BB -8)	2-Year	21+75	20+00	45.28	6.47	18”/250#
Escondido (BB -8)	50-Year	22+00	19+00	105.24	9.60	39”/3000#
Escondido (BB -9)	2-Year	16+00	14+00	50.85	6.49	18”/260#
Escondido (BB -9)	50-Year	18+00	12+50	103.09	8.10	28”/990#
Escondido (BB -10)	2-Year	11+50	11+00	75.77	2.67	7”/20#
Escondido (BB -10)	50-Year	12+50	10+50	111.08	6.15	16”/190#
Escondido (BB -10)	2-Year	11+30 (FL3)	11+30 (FL3)	24.74	4.00	7”/20#
Escondido (BB -10)	50-Year	11+30 (FL3)	11+00 (FL3)	53.19	5.00	10”/50#

Note that some of the stable rock sizes may be unreasonably large and require either crossing design for a lesser event or relocation of the crossing to an area with lower flow velocities.

Latigo Canyon

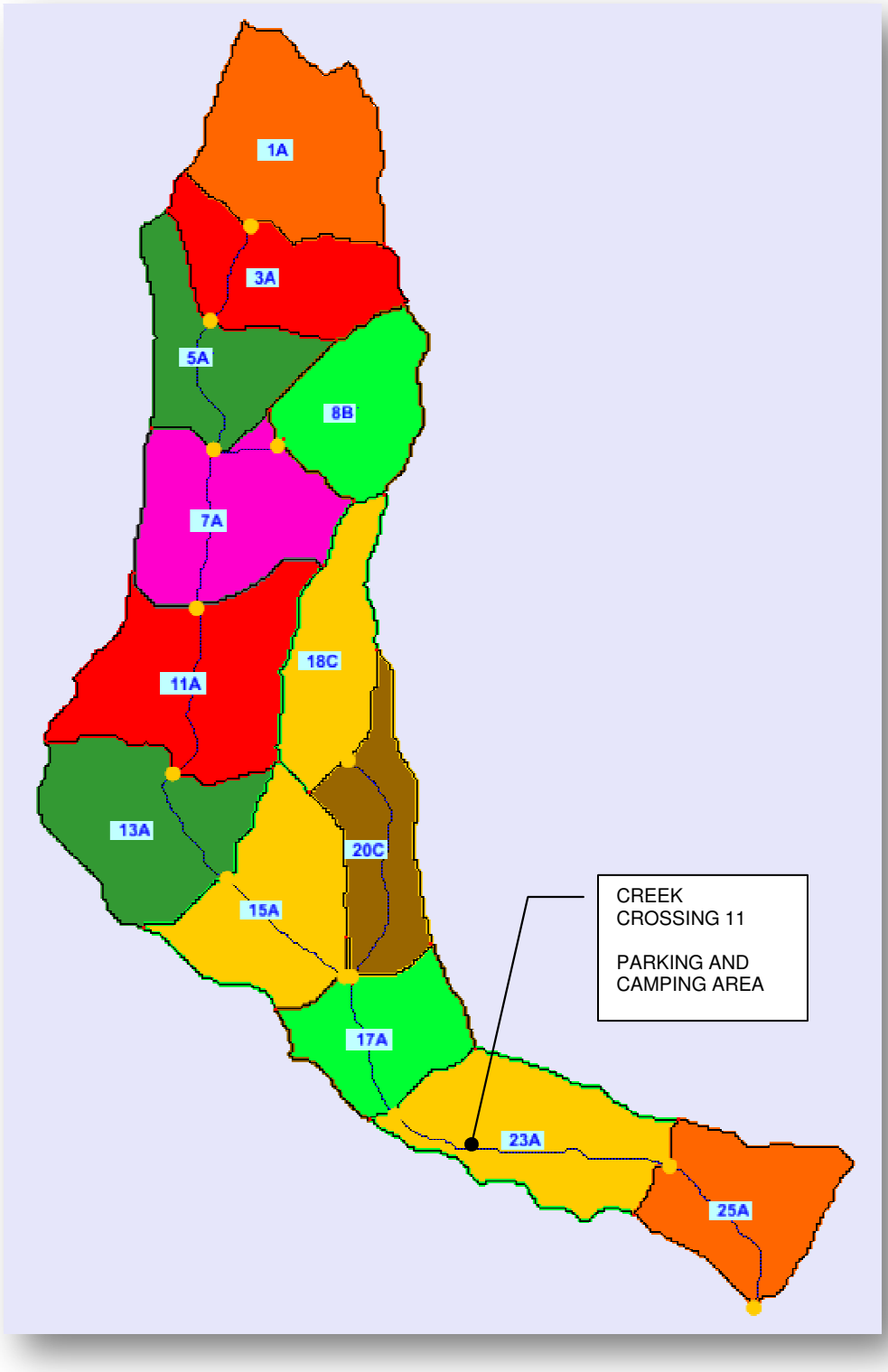

Figure I - Latigo Canyon Watershed

Hydrology

Table 12 - Latigo Creek Clear Water Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
23A	24A	67	150	220	330	450	570

Table 13 - Latigo Creek Burned and Bulked Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
23A	24A	170	360	540	800	1,010	1,230

Table 14 - Latigo Canyon Site Drainage Impacts

		Peak Flowrate, cfs		
Location	**Rainfall Event**	**Pre-Project**	**Post-Project**	**Increase**
Camping and Parking Area	Water Quality (0.75")	0.01	0.03	0.02
	10-year	1.46	1.55	0.09

The proposed camping and parking area will be treated using a vegetated filter strip along the northerly side of the parking lot and directing non-concentrated runoff to vegetated areas throughout the rest of the site. Increased peak runoff rates may be reduced by designing detention capabilities within the parking lot or by implementing infiltration methods (permeable paving materials, dry well, infiltration trench, etc).

Hydraulics

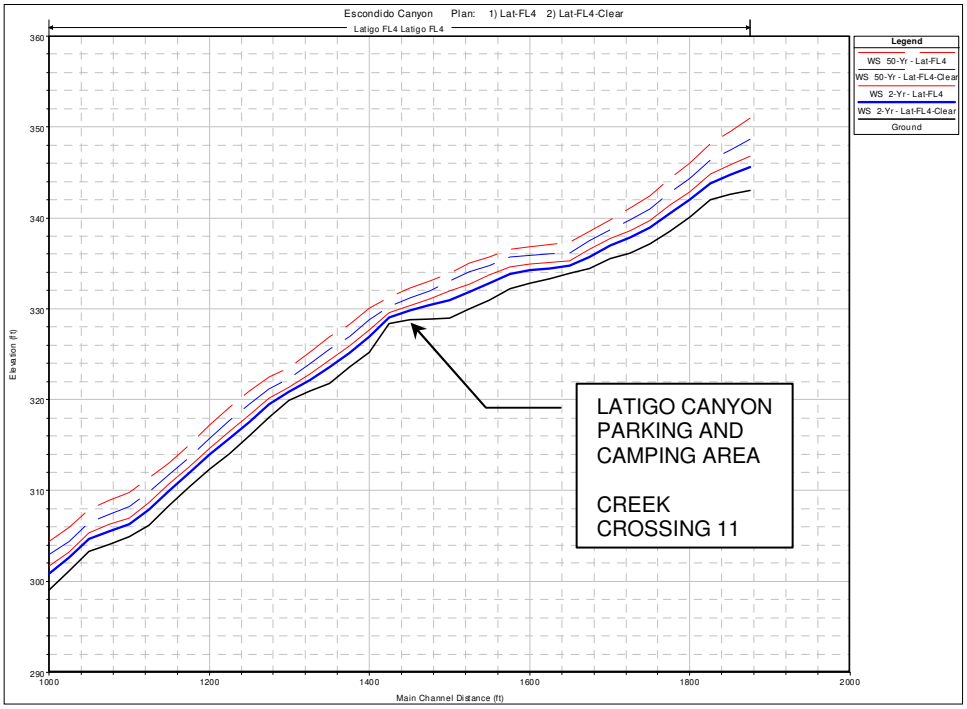

Figure J - Latigo Profile

Some camp sites in the Parking and Camping Area will be inundated during a 50-year event and should not be occupied if that level of storm is anticipated. Additionally, it is not practical to provide safe passage over Latigo Creek during larger storm events either. Maintenance of trails and camp sites after larger storm events is expected.

Creek Crossings

The creek crossing characteristics are shown in Table 15 and Table 16.

Table 15 - Crossing Characteristics for Latigo Creek, Clear Water

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Latigo (CW-11)	2-Year	14+25	14+25	32.99	4.03	7”/20#
Latigo (CW-11)	50-Year	14+25	14+25	52.23	6.56	18”/270#

Table 16 - Crossing Characteristics for Latigo Creek, Burned and Bulked

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Latigo (BB-11)	2-Year	14+25	14+25	40.10	5.18	11”/70#
Latigo (BB-11)	50-Year	14+25	14+25	65.39	7.96	27”/890#

Solstice/Dry Canyon

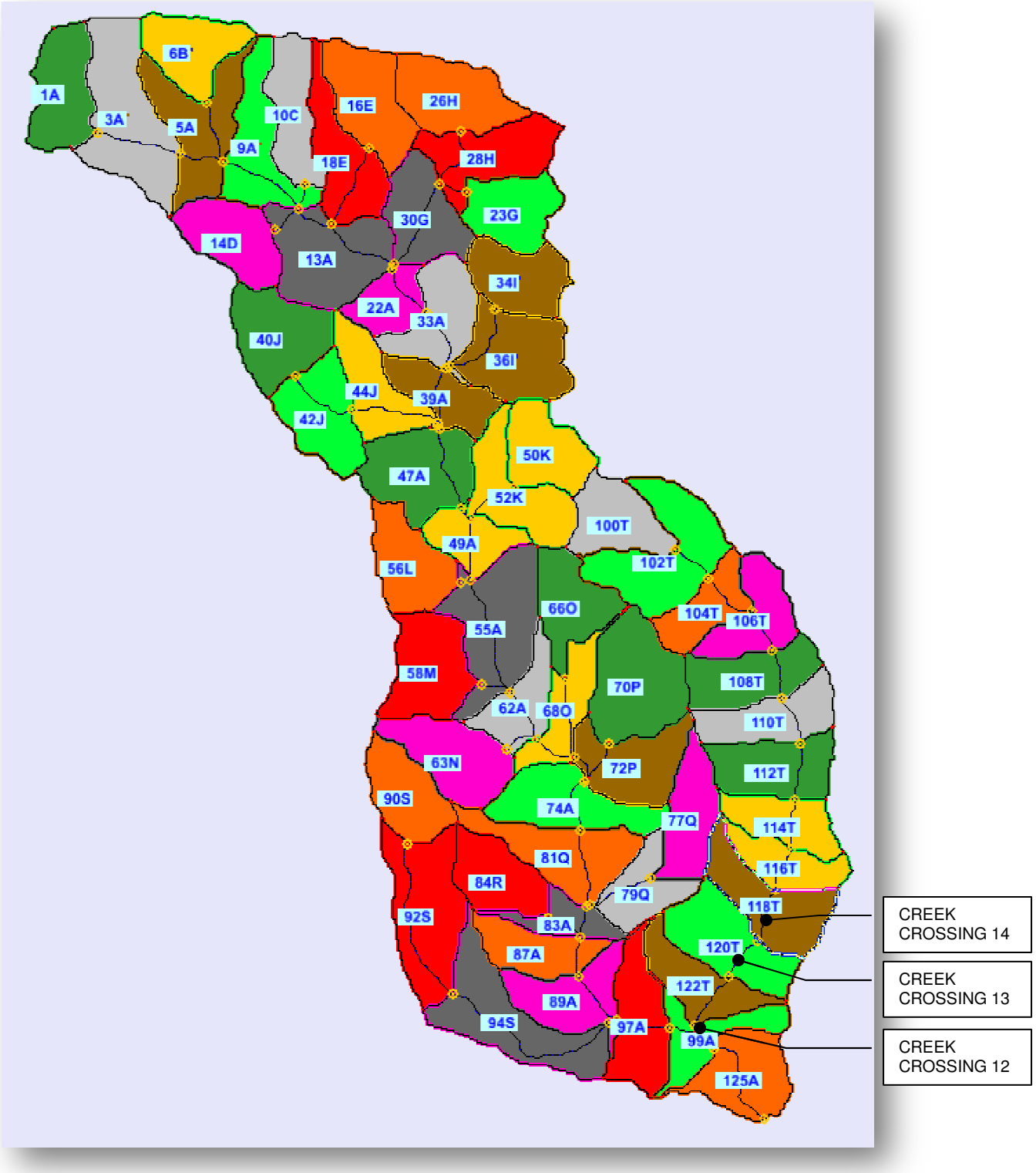

Figure K - Solstice/Dry Canyon Watersheds

Hydrology

Table 17 - Solstice Creek Clear Water Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
118T	119T	70	150	210	350	450	580
120T	121T	90	180	250	350	460	580
122T	123T	80	180	250	350	460	580
99A	124AT	210	490	790	1,280	1,690	2,190

Table 18 - Solstice Creek Burned and Bulked Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
118T	119T	160	350	530	770	950	1,160
120T	121T	200	390	540	790	970	1,180
122T	123T	190	390	540	790	970	1,190
99A	124AT	600	1,430	2,150	3,190	4,000	4,970

Hydraulics

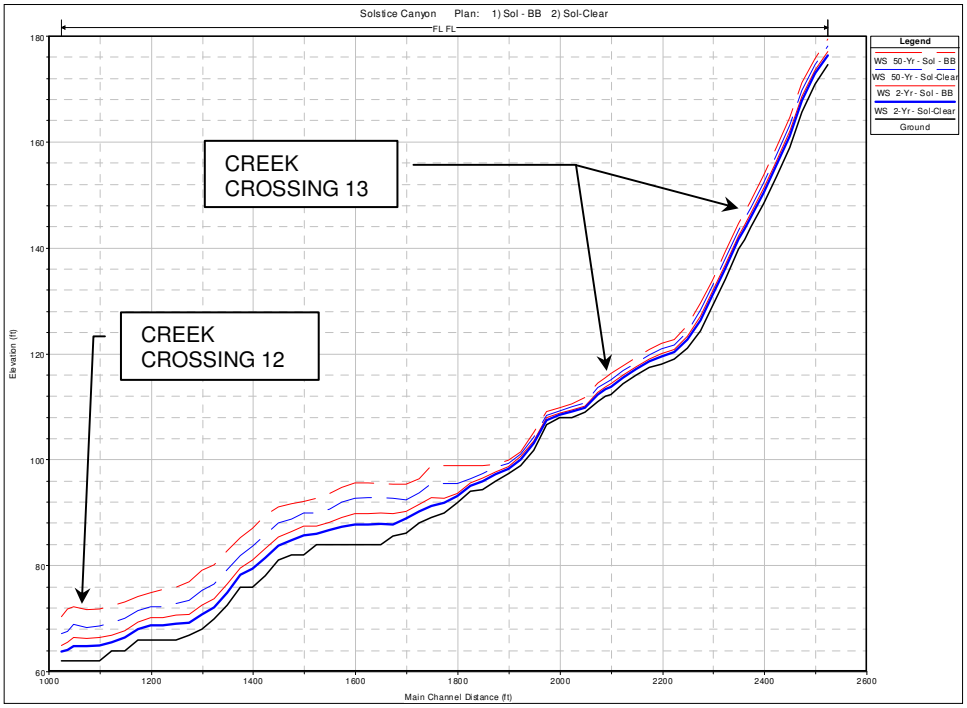

Figure L - Solstice Creek Profile

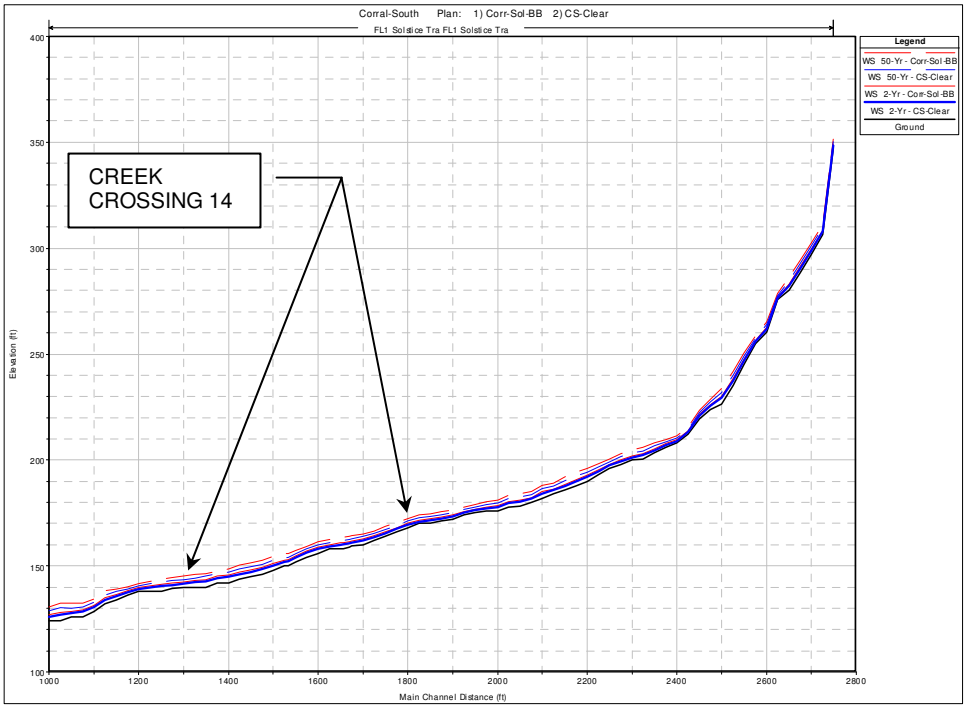

Figure M - Corral-Solstice Creek Profile

Creek Crossings

The Solstice Canyon creek was separated into two different HEC-RAS files, Solstice and Corral-Solstice and therefore has different creek flow line stationing. Creek characteristics are shown in Table 19 and Table 20.

Table 19 - Crossing Characteristics for Solstice/Dry Creeks, Clear Water

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Solstice (CW-12)	2-Year	10+50 (Solstice)	10+50 (Solstice)	39.51	2.79	7”/20#
Solstice (CW-12)	50-Year	10+50 (Solstice)	10+50 (Solstice)	58.71	6.45	17”/250#
Solstice (CW-13)	2-Year	23+75 (Solstice)	20+75 (Solstice)	22.39	5.15	11”/60#
Solstice (CW-13)	50-Year	25+00 (Solstice)	20+25 (Solstice)	40.07	7.40	23”/570#
Solstice (CW-14)	2-Year	17+25 (Corral-Solstice)	14+75 (Corral-Solstice)	15.11	5.67	13”/110#
Solstice (CW-14)	50-Year	18+00 (Corral-Solstice)	13+00 (Corral-Solstice)	28.25	8.03	27”/940#

Table 20 - Crossing Characteristics for Solstice/Dry Creeks, Burned and Bulked

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Solstice (BB-12)	2-Year	10+50 (Solstice)	10+50 (Solstice)	47.46	4.14	7”/20#
Solstice (BB-12)	50-Year	10+50 (Solstice)	10+50 (Solstice)	74.87	8.96	34”/1900
Solstice (BB-13)	2-Year	23+75 (Solstice)	20+75 (Solstice)	29.35	6.11	16”/180#
Solstice (BB-13)	50-Year	25+00 (Solstice)	20+25 (Solstice)	51.08	8.77	33”/1700#
Solstice (BB-14)	2-Year	17+25 (Corral-Solstice)	14+75 (Corral-Solstice)	20.65	6.67	19”/300#
Solstice (BB-14)	50-Year	18+00 (Corral-Solstice)	13+00 (Corral-Solstice)	42.83	8.90	34”/1800#

It is not practical to provide safe passage over Solstice Creek during larger storm events either. Maintenance of trails and camp sites after larger storm events is expected.

Corral Canyon

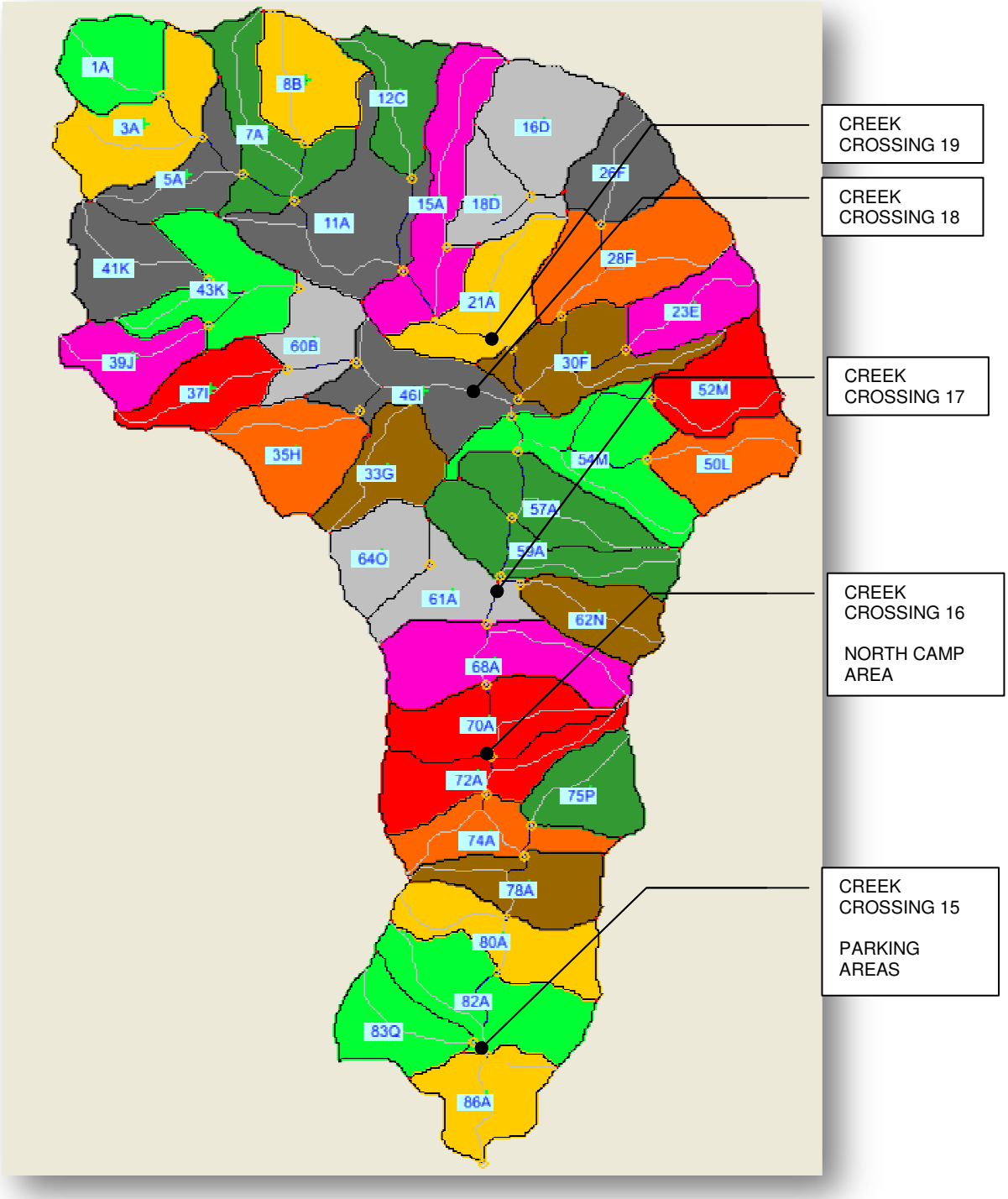

Figure N - Corral Canyon Watershed

Hydrology

Table 21 - Corral Canyon Clear Water Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
21A	22A	60	220	380	620	820	1,020
46I	49AI	120	410	670	1,130	1,520	1,930
61A	67AO	140	430	730	1,210	1,640	2,090
70A	71A	130	430	720	1,190	1,600	2,050
72A	73A	130	430	720	1,190	1,600	2,050
82A	85AQ	160	430	710	1,170	1,590	2,040
86A	87A	160	420	700	1,160	1,570	2,020

Table 22 - Corral Canyon Burned and Bulk Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
21A	22A	270	680	1,020	1,480	1,820	2,180
46I	49AI	480	1,220	1,850	2,720	3,400	4,080
61A	67AO	530	1,330	2,010	2,980	3,750	4,540
70A	71A	520	1,310	1,980	2,940	3,710	4,500
72A	73A	520	1,310	1,980	2,940	3,710	4,510
82A	85AQ	520	1,300	1,970	2,940	3,720	4,530
86A	87A	520	1,290	1,950	2,910	3,690	4,510

Table 23 - Corral Canyon Site Drainage Impacts

		Peak Flowrate, cfs		
Location	**Rainfall Event**	**Pre-Project**	**Post-Project**	**Increase**
Parking Areas	Water Quality (0.75")	0.21	0.21	0.00
	10-year	6.57	6.57	0.00
South Camp Area	Water Quality (0.75")	0.19	0.19	0.00
	10-year	13.63	13.63	0.00
North Camp Area	Water Quality (0.75")	0.11	0.11	0.00
	10-year	8.56	8.56	0.00

The proposed parking areas for Corral Canyon consist of a large existing parking lot and a small drop-off area. No water quality improvements are anticipated within the existing parking lot. Treatment at the drop-off area may use a vegetated filter strip, pervious paving materials or other infiltration method.

The proposed south and north camp facilities consist of camping sites and will have no measurable impact on runoff flow rate or volume. Water quality treatment will consist of directing non-concentrated flow to vegetated areas.

Hydraulics

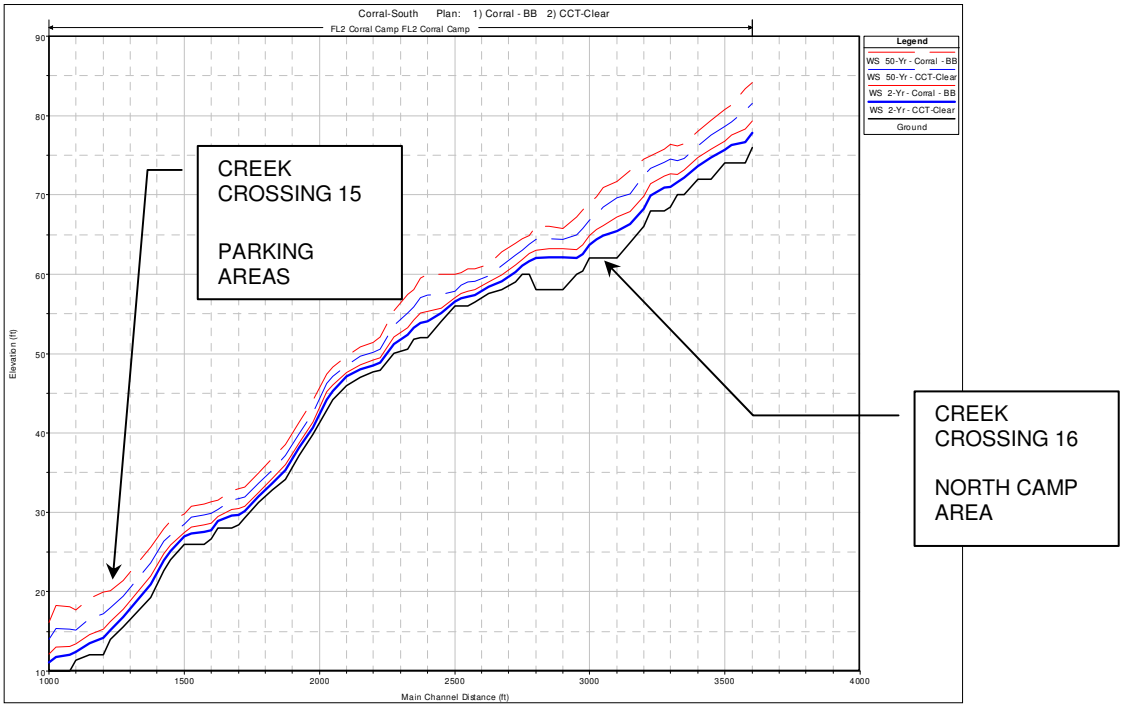

Figure O – Corral-South Creek Profile

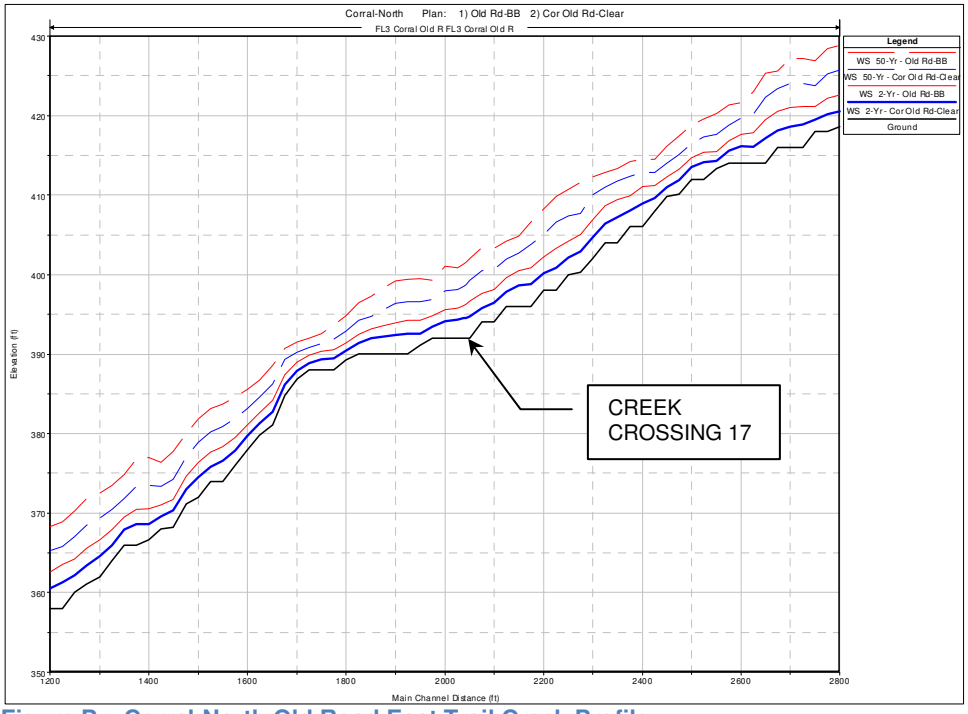

Figure P – Corral-North Old Road East Trail Creek Profile

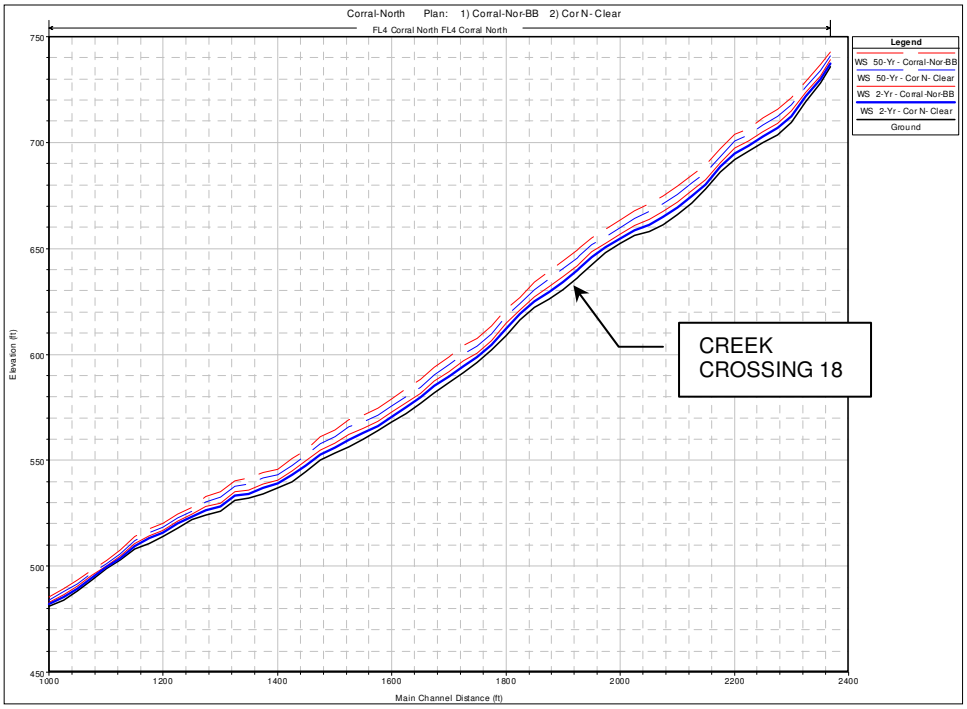

Figure Q – Corral-North Creek Profile

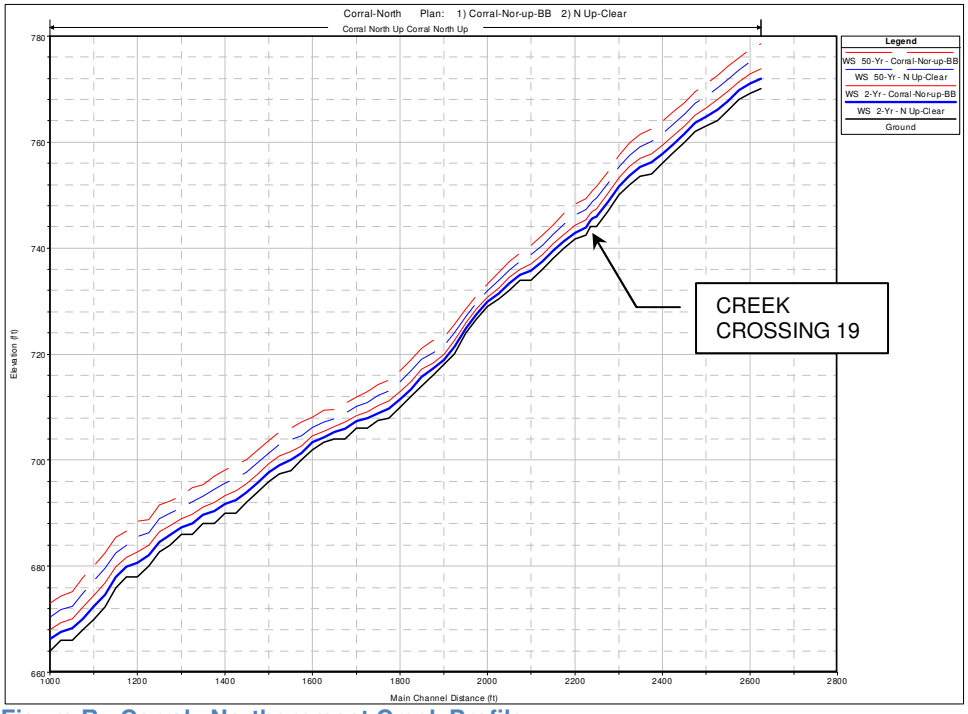

Figure R - Corral –Northernmost Creek Profile

It is not practical to provide safe passage over Corral Creek during larger storm events either. Maintenance of trails and camp sites after larger storm events is expected.

Creek Crossings

Corral Creek crossing characteristics are shown in Table 24, Table 25, Table 26, Table 27, and Table 28.

Table 24 - Crossing Characteristics for Corral –South Creek, Clear Water

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Corral-South (CW-15)	2-Year	12+25	12+25	37.68	5.18	11”/70#
Corral-South (CW-15)	50-Year	12+25	12+25	83.95	7.7	25”/720#
Corral-South (CW-16)	2-Year	30+50	30+50	22.37	4.76	9”/40#
Corral-South (CW-16)	50-Year	30+50	30+50	55.22	9.89	42”/3600#

Table 25 - Crossing Characteristics for Corral –South Creek, Burned and Bulked

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Corral-South (BB-15)	2-Year	12+25	12+25	62.04	6.48	18”/250#
Corral-South (BB-15)	50-Year	12+25	12+25	116.12	8.76	32”/1600#
Corral-South (BB-16)	2-Year	30+50	30+50	31.25	7.78	25”/770#
Corral-South (BB-16)	50-Year	30+50	30+50	88.74	11.60	61”/10800#

Table 26 - Crossing Characteristics for Corral – North Old Road East Trail Creek, Clear Water and Burned and Bulked

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Corral-Old Rd (CW-17)	2-Year	20+50	20+50	14.34	6.67	19”300#
Corral-Old Rd (CW-17)	50-Year	20+50	20+50	46.02	10.41	47”/5100#
Corral-Old Rd (BB-17)	2-Year	20+50	20+50	26.45	8.64	32”/1500#
Corral-Old Rd (BB-17)	50-Year	20+50	20+50	74.73	11.83	63”/12500#

Table 27 - Crossing Characteristics for Corral - North Creek, Clear Water and Burned and Bulked

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Corral-North (CW-18)	2-Year	19+25	19+25	10.64	7.57	24”/650#
Corral-North (CW-18)	50-Year	19+25	19+25	28.16	12.36	70”/17100#
Corral-North (BB-18)	2-Year	19+25	19+25	17.94	9.87	42”/3570#
Corral-North (BB-18)	50-Year	19+25	19+25	37.83	14.77	110”/65000#

Table 28 - Crossing Characteristics for Corral -Northernmost Creek, Clear Water and Burned and Bulked

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Corral-Northern (CW-19)	2-Year	22+35	22+35	16.31	4.95	10”/50#
Corral-Northern (CW-19)	50-Year	22+35	22+35	31.30	9.50	39”/2800#
Corral-Northern (BB-19)	2-Year	22+35	22+35	23.35	7.25	22”/500#
Corral-Northern (BB-19)	50-Year	22+35	22+35	40.61	11.30	57”/9000#

Note that some of the stable rock sizes may be unreasonably large and require either crossing design for a lesser event or relocation of the crossing to an area with lower flow velocities.

Malibu Bluffs

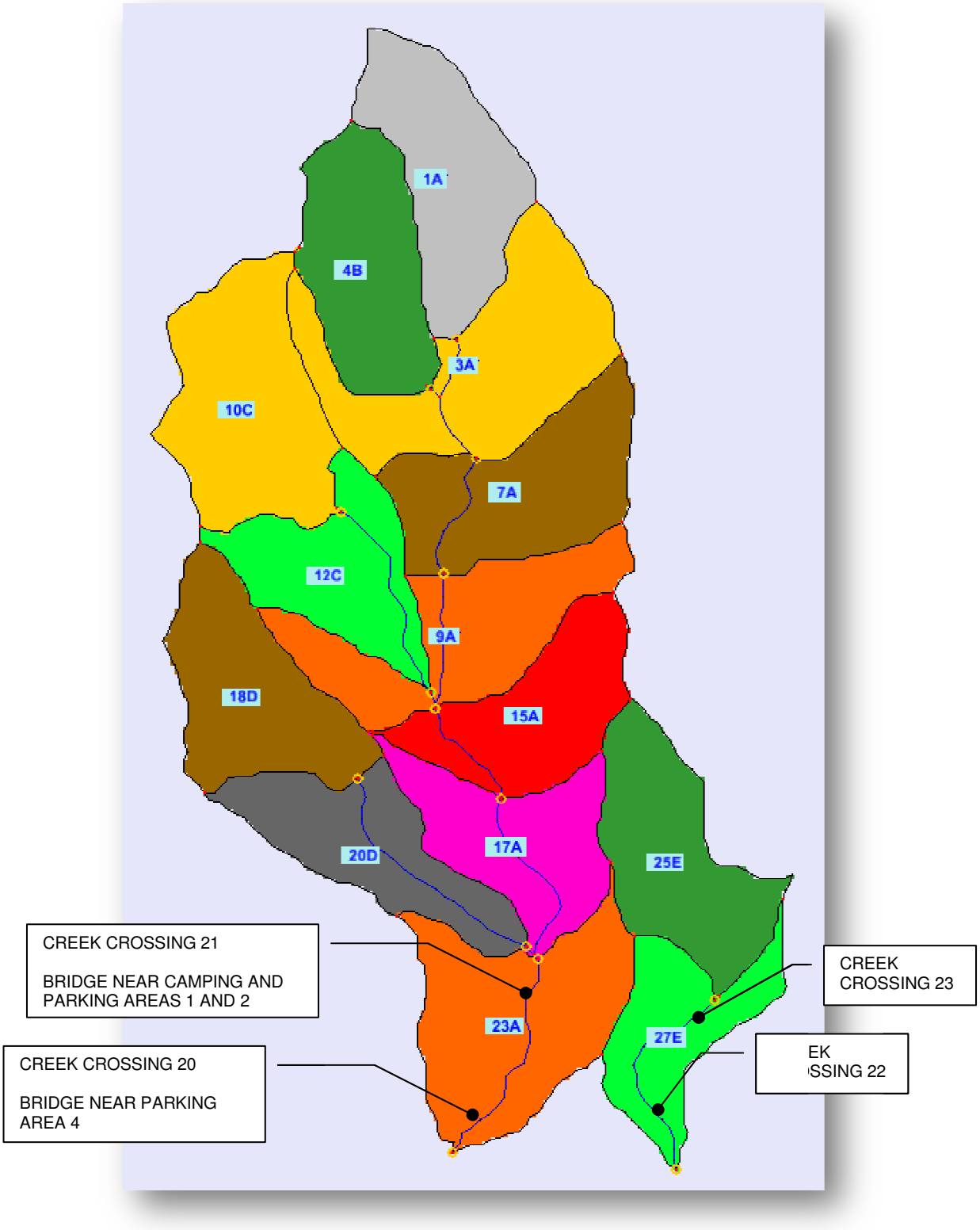

Figure S - Malibu Bluffs Watersheds

Hydrology

Table 29 - Malibu Bluffs Clear Water Peak Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
23A	24A	64	120	200	310	390	510
27E	28E	22	44	60	77	75	100
23A - west		6	11	14	18	18	24

Table 30 - Malibu Bluffs Burned and Bulked Flow Rates (cfs)

		Return Period, years					
Basin Name	**Outlet Connection**	**2**	**5**	**10**	**25**	**50**	**100**
23A	24A	100	220	340	520	640	810
27E	28E	30	60	80	100	100	140
23A - west		7	11	14	18	18	24

Table 31 - Malibu Bluffs Site Drainage Impacts

		Peak Flowrate, cfs		
Location	**Rainfall Event**	**Pre-Project**	**Post-Project**	**Increase**
Camping and Parking Area 1	Water Quality (0.75")	0.06	0.17	0.11
	10-year	4.51	4.51	0.00
Camping and Parking Area 2	Water Quality (0.75")	0.09	0.13	0.04
	10-year	6.63	6.63	0.00
Camping and Parking Area 3	Water Quality (0.75")	0.13	0.16	0.03
	10-year	8.32	8.32	0.00
Camping Areas 4 and 5	Water Quality (0.75")	0.25	0.25	0.00
	10-year	17.42	17.42	0.00
Parking Area 4	Water Quality (0.75")	0.01	0.02	0.01
	10-year	0.92	0.92	0.00

The proposed Camping and Parking Area 1, Camping and Parking Area 2, and Camping and Parking Area 3 include several camping sites, restroom, driveway and parking facilities. Treatment of paved driveway areas may consist of allow runoff from the road surfaces to leave

the edges of the road in a non-concentrated manner and flow across the vegetated slopes. Parking lot treatment may consist of constructing a bioswale or vegetated filter strip along the southerly side of the parking lot. This may require that the camp host site be moved or relocated. Campsites drainage can be directed in a non-concentrated manner to vegetated areas. Increased discharge from the site may need to be addressed by designing a portion of the parking lot to function as a detention basin or by the application of infiltration methods such as permeable paving materials.

The proposed Camping Areas 4 and 5 consist of several camping sites and a restroom. Water quality treatment will consist of directing non-concentrated runoff to adjacent vegetated areas. No increase in flow rate or volume is expected.

Proposed Parking Area 4 is a three space parking lot and restroom on Malibu Road. Water quality treatment may be addressed using permeable paving materials or other infiltration methods. Increased peak flow rate can be reduced by designing the parking lot to detain a small amount of storm water.

Hydraulics

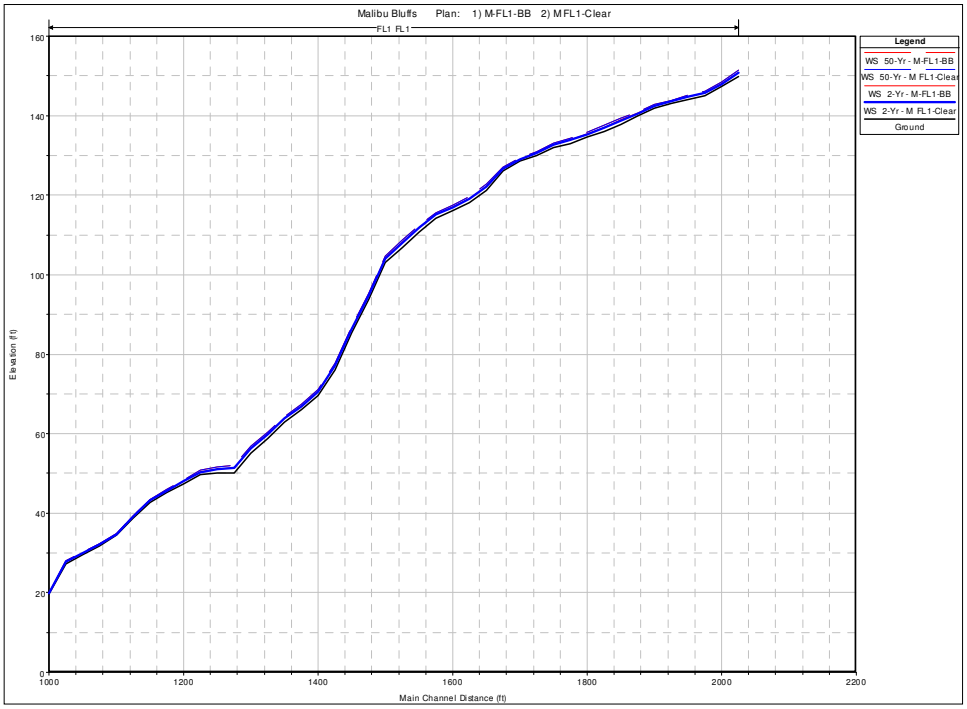

Figure T - Malibu Bluffs - FL1 Creek Profile

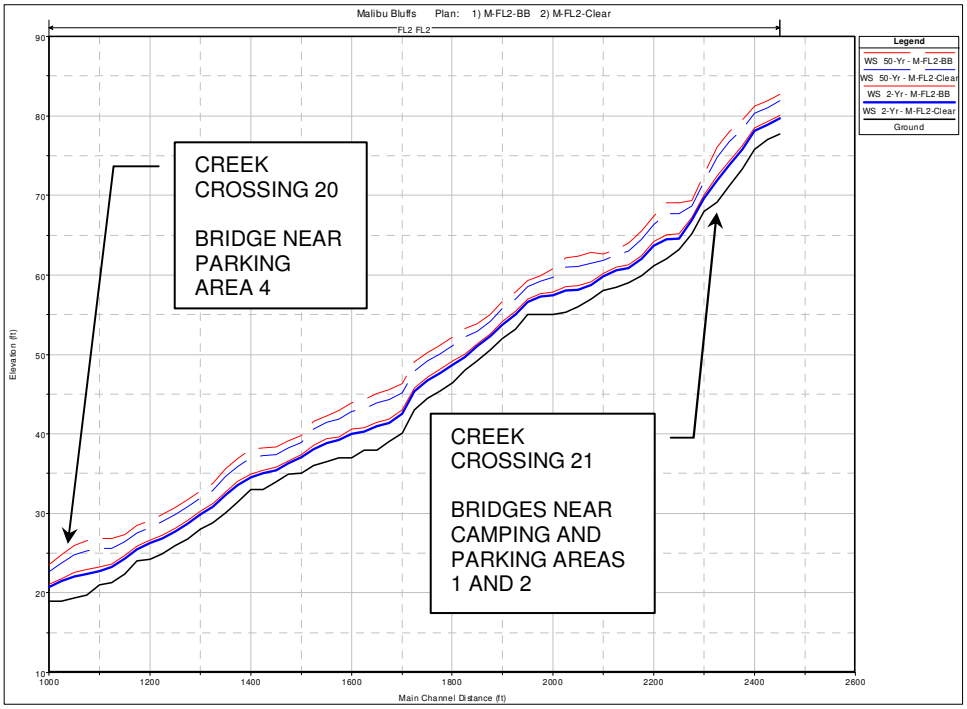

Figure U - Malibu Bluffs – FL2 Creek Profile

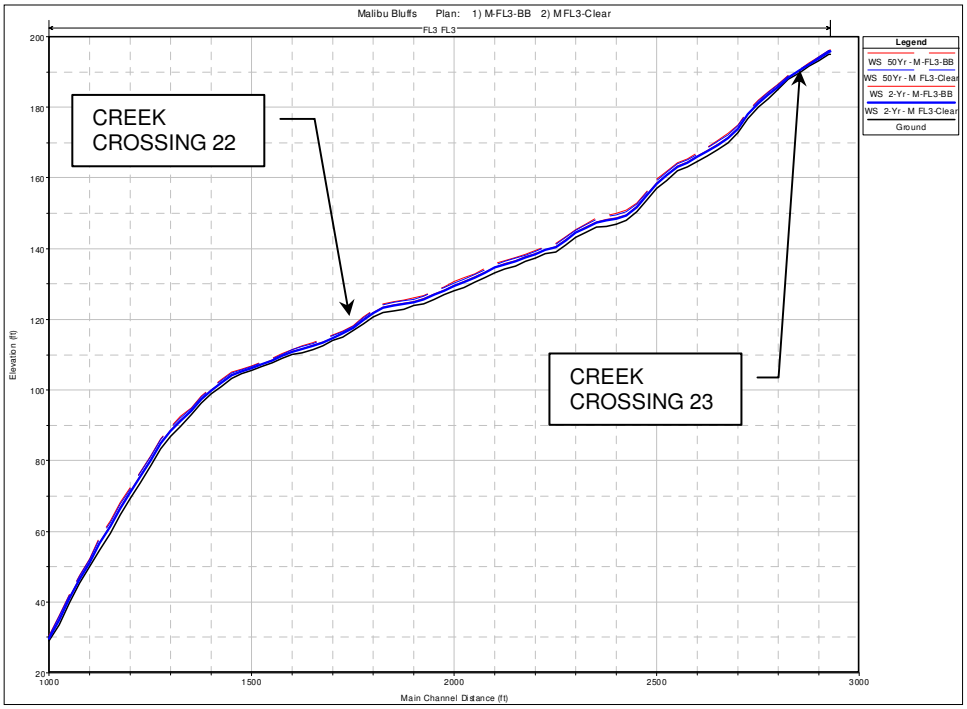

Figure V - Malibu Bluffs – FL3 Creek Profile

Creek Crossings

Creek crossing characteristics for the creeks passing through the Malibu Bluffs site are summarized in Table 32, Table 33, and Table 34.

Table 32 - Crossing Characteristics at Malibu Bluffs-FL1, Clear Water (CW) and Burned and Bulked (BB)

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Malibu- FL1 (CW)	2-Year	20+00	18+75	5.08	3.34	7”/20#
Malibu- FL1 (CW)	50-Year	20+00	18+75	6.92	4.41	8”/30#
Malibu- FL1 (BB)	2-Year	20+00	18+75	5.30	3.47	7”/20#
Malibu- FL1 (BB)	50-Year	20+00	18+75	6.92	4.41	8”/30#

Table 33 - Crossing Characteristics at Malibu Bluffs-FL2, Clear Water (CW) and Burned and Bulked (BB)

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Malibu- FL2 (CW-20)	2-Year	10+50	10+25	10.16	4.87	10”/50#
Malibu- FL2 (CW-20)	50-Year	10+50	10+25	19.74	7.85	26”/820#
Malibu- FL2 (CW-21)	2-Year	23+50	23+50	6.79	6.77	19”/330#
Malibu- FL2 (CW-21)	50-Year	23+50	23+50	14.20	9.67	40”/3100#
Malibu- FL2 (BB-20)	2-Year	10+50	10+25	11.82	5.69	14”/120#
Malibu- FL2 (BB-20)	50-Year	10+50	10+25	24.45	8.63	31”/1500#
Malibu- FL2 (BB-21)	2-Year	23+50	23+50	7.98	7.43	23”/580#
Malibu- FL2 (BB-21)	50-Year	23+50	23+50	17.44	10.60	49”/5800#

Table 34 - Crossing Characteristics at Malibu Bluffs-FL3, Clear Water (CW) and Burned and Bulked (BB)

Location (Exhibit Number)	Return Period	From Creek Section	To Creek Section	Average Flow Width (ft)	Average Velocity (ft/s)	Stable Rock (Size/Wt)
Malibu- FL3 (CW-22)	2-Year	17+75	17+50	12.29	3.92	7”/20#
Malibu- FL3 (CW-22)	50-Year	17+75	17+50	17.64	5.20	7”/20#
Malibu- FL3 (CW-23)	2-Year	28+75	28+50	41.45	2.60	7”/20#
Malibu- FL3 (CW-23)	50-Year	28+75	28+50	53.32	3.75	7”/20#
Malibu- FL3 (BB-22)	2-Year	17+75	17+50	13.43	4.20	7”/20#
Malibu- FL3 (BB-22)	50-Year	17+75	17+50	19.40	5.54	13”/100#
Malibu- FL3 (BB-23)	2-Year	28+75	28+50	43.75	2.89	7”/20#
Malibu- FL3 (BB-23)	50-Year	28+75	28+50	56.42	4.00	7”/20#

In some locations it may not be practical to provide safe passage over the creeks at Malibu Bluffs during larger storm events. Maintenance of trails and camp sites after larger storm events is expected.

RECOMMENDATIONS

Although the trail design is still in the preliminary phases, the information in this report provides a basis for additional detail in the design. At this time, we make the following recommendations:

- Trails and other facilities should be maintained outside of the 2-year clear water inundation limits wherever possible. This may require some adjustment of facilities from those positions shown on the current plans.
- Trails should be constructed in accordance with accepted current design practice for mountain trail design including the addressing of drainage, erosion control, and energy dissipation.
- Critical facilities, such as restrooms should be maintained outside of the 50-year burned and bulked inundation limits, if possible, or raised above the flooding elevation.
- If minimal creek crossing design is required, rock sizing should be at least as large as indicated for stable rock sizing for the 2-year clear water flow. A minimum rock size of 12” to 18” should be used to provide reliable and stable footing while crossing creeks.
- Stable rock sizing as shown in the Findings sections sometimes indicates unreasonable large rocks which are unlikely to be feasible to install. In these situations, there may be a need during final design to adjust the location of the crossing to one with lower flow velocities and/or use smaller rocks with the understanding that those crossings may require maintenance after larger storms. Other options in this situation may also include bridging the anticipated flow.
- Water quality and drainage design of the site facilities should take into account the suggestions specific to each site as indicated in the Findings section.

CONCLUSIONS

Based on the information supplied in the plans and developed in this report, the proposed improvements are feasible in addressing and mitigating the hydrologic and hydraulic impacts anticipated for this project to a less than significant level.

As long as Best Management Practices outlined in this report (or equivalent alternate practices) are applied during final design and construction in accordance with accepted methods, long-term water quality impacts from this project will be mitigated to a less than significant level.

APPENDICES