Soberanes Fire

Watershed Emergency Response

Team Report

CA-BEU-003422

September 29, 2016

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List of Abbreviations

BAER	Burned Area Emergency Response
BARC	Burned Area Reflectance Classification
BOF	California State Board of Forestry and Fire Protection
CAL FIRE	California Department of Forestry and Fire Protection
CalVeg	Classification and Assessment with Landsat of Visible Ecological Groupings
Caltrans	California Department of Transportation
CEG	Certified Engineering Geologist
CFS	Cubic Feet per Second
CGS	California Geological Survey
CVRWQCB	Central Valley Regional Water Quality Control Board
DWR	California Department of Water Resources
EHR	Erosion Hazard Rating
EWP	Emergency Watershed Protection Program
FEMA	Federal Emergency Management Agency
FRAP	Fire and Resource Assessment Program
FT	Flow Transference Method
GIS	Geographic Information System
GPS	Global Positioning Satellite
HEC-HMS	Hydraulic Engineering Center-Hydraulic Modeling System
HUC	Hydrologic Unit Code
LiDAR	Light Detection and Ranging
MPWMD	Monterey Peninsula Water Management District
NOAA	National Oceanographic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
PE	Professional Engineer
PG	Professional Geologist
PH	Professional Hydrologist (AIH)

RSAC	Remote Sensing Application Center
RI	Return Interval
RPF	Registered Professional Forester
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
VARs	Values at Risk
WERT	Watershed Emergency Response Team

1.0 Introduction

The following report presents the results of a rapid assessment of post-fire geologic and hydrologic hazards to life and safety (i.e., collectively known as "Values at Risk") for non-federal lands affected by the 2016 Soberanes Fire in Monterey County, California. Wildfire can have profound effects on watershed processes. Wildfire-induced loss of surface cover and enhancement of soil water repellency from wildfire can enhance runoff generation and the erosive power of overland flow, resulting in accelerated erosion of material from hillslopes. Increased runoff can also erode significant volumes of material stored within channels. A primary concern for burned watersheds is the increased potential for damaging flood flows and increased probability for debris flow occurrence.

Debris flows are among the most hazardous consequences of rainfall on burned hillslopes. Debris flows pose a hazard distinct from other sediment-laden flows because of their unique destructive power. Debris flows can occur with little warning and can exert great impulsive loads on objects in their paths. Even small debris flows can strip vegetation, block drainage ways, damage structures, and endanger human life. Additionally, sediment delivery from debris flows can "bulk" the volume of flood flows, creating an even greater downstream flooding hazard. As winter approaches, it is critical that people who live in and downstream from large fires implement emergency protection measures where appropriate, remain steadfast and alert of weather conditions, and be ready to evacuate if necessary during large winter storms.

When wildfire-induced threats to life and safety are present, a state team of civil engineers, engineering geologists and California Department of Forestry and Fire Protection (CAL FIRE) staff can be assembled into a Watershed Emergency Response Team (WERT) to assess potential hazards from post-fire debris flows, hyperconcentrated flows, and flood flows. CAL FIRE senior staff, along with the California Office of Emergency Services (CalOES), determined that a WERT was needed for the Soberanes Fire.

1.1 Background

Due to the large area of private land affected by the fire (Figure 1) and the risk to life-safety, a multi-agency WERT comprised of individuals with expertise in engineering geology, geomorphology, hydrology, forestry, GIS, and civil engineering was assembled for the Soberanes Fire (Table 1). WERT members were selected that either (1) have considerable post-fire assessment experience, or (2) are trainees. Following the selection of team members, the WERT compiled mapping products during the week of August 29th and met as a team to discuss deployment, which was scheduled for September 6, 2016. The WERT field eam was supported in the home offices by a select number of technical specialists including foresters, engineering geologists, GIS analysts, and a hydrologist.

On August 29, 2016, a United States Forest Service (USFS) Burned Area Emergency Response (BAER) team was deployed to the Soberanes Fire area. BAER teams perform similar work to the WERT (http://www.nifc.gov/BAER/Page/NIFC_BAER.html), with a primary focus on assessing hazards on federal lands (Figure 1). However, BAER teams regularly do a preliminary reconnaissance of Values at Risk (VARs) on private lands, and will typically

Figure 1. Overview Map
Soberanes Incident
CA-BEU-003422

generate soil burn severity maps that include portions of the burned area outside of federal lands. It was clearly recognized that in order to avoid duplication of efforts and make the most of mutual opportunities, it was critical for the WERT to coordinate with and compliment the efforts of the BAER team.

The complete WERT arrived at the Soberanes Incident area on September 6, 2016 and interfaced with the BAER team over the next two days (9/6 through 9/8) to ensure a complete transfer of information. The BAER team concluded their evaluation and departed the Soberanes Incident area on September 8, 2016. The BAER team report is available at the following link: [http://www.co.monterey.ca.us/oes/Soberanes-Post-Fire-and-Recovery-Information.asp.](http://www.co.monterey.ca.us/oes/Soberanes-Post-Fire-and-Recovery-Information.asp)

1.2 WERT Objectives

Primary objectives for a Phase I WERT effort are to conduct a rapid preliminary assessment to:

- Identify types and locations of on-site and downstream threats to public health or safety from landsliding, debris flows, flooding, road hazards, and other fire related problems.
- Develop preliminary emergency protective measures needed to avoid life-safety threats.

The Phase I WERT objectives are achieved through an explicit process which combines analysis, modeling, and professional judgement to assess risk to life, safety, and property (CAL FIRE, 2016). The process also emphasizes communication and outreach to inform responsible authorities and parties about post-fire watershed hazards (Figure 2).

The BAER team noted VARs on private land, but did not provide an in-depth assessment of potential hazard to these sites. The WERT assessment differs from the BAER team assessment in that it explicitly focuses on site-specific VARs located on private land that were affected by the Soberanes Fire (Figure 1). The WERT assessment also provides a much more focused look at VARs for non-federal lands. It should be noted however, that the assessment was conducted in an expedited manner to maximize the time for responsible parties to implement emergency mitigation activities prior to the onset of winter rains, and as such the WERT assessment should not be considered a detailed and comprehensive analysis of potential hazards.

Table 1. Phase I WERT team members.

Main Team			
Name	**Position**	**Agency**	**Expertise-Position**
Drew Coe, RPF #2981	Team Leader	CAL FIRE	Forestry/Hydrology
Dave Longstreth, CEG #2068	Co-Leader	CGS	Engineering Geology
Patrick Brand, CEG #2542	Team Member	CGS	Engineering Geology
Jonathan Woessner, RPF #2571	Team Member	CAL FIRE	Forestry
Jonathan Pangburn, RPF #2862	Team Member	CAL FIRE	Forestry
Trevor Morgan, PE #79967	Team Member	DWR	Civil Engineer/Hydrology
Stacy Stanish, RPF #3000	Team Member	CAL FIRE	GIS/Forestry/Biology
Christopher Gryszan, CEG #2640	Team Member	CGS	Engineering Geology
René Leclerc, PE #82180	Team Member	CVRWQCB	Civil Engineer/ Geomorphology
German Whitley	Team Member	Deer Creek Resources	GIS/Hydrology
Adjunct Team			
Jeremy Lancaster, CEG #2379	Team Member	CGS	Engineering Geology
Kelly Larvie	Team Member	CAL FIRE-FRAP	Research Analyst, GIS
Pete Roffers, PG #9100	Team Member	CGS	Engineering Geology, GIS
Solomon McCrea, CFM #3527	Team Member	CGS	Research Analyst, GIS
Pete Cafferata, PH #1676, RPF #2184	Team Member	CAL FIRE	Forestry/Hydrology

2.0 Methods

The BAER team provided the initial coarse scale assessment of the burned area (USFS, 2016). The WERT relied upon data and analysis performed by the USFS BAER team, and supplemented analysis based on specific values at risk and field observations. The following section briefly explains the office, modeling, and field methodologies used for assessing hazards to values at risk.

2.1 Pre-Field, Office Methods

In order to compare field observations with map and modeled data, ArcGIS[1] data were uploaded to the "Collector"[2] application on two iPads and multiple smart phones. Data from the Soberanes Fire Soil Burn Severity map (see Section 2.1.1) were added onto a topographic

[1] https://www.arcgis.com/features/index.html
[2] http://doc.arcgis.com/en/collector/

base layer using ArcGIS. Additional GIS layers added to the base layer included, but were not limited to:

- BARC field verification points and polygons
- VAR points and polygons from the BAER team
- Fire perimeter
- Fire control lines
- Fire history
- Basin-Indians Complex VAR points generated during the 2008 post fire assessment.
- United States Geological Survey (USGS) debris flow model segments and basin probabilities for 40 mm hr^{-1} storm
- BAER team "Pour Points"
- Watershed boundaries (HUC-12)
- Federal Emergency Management Agency (FEMA) Special Flood Hazard Areas
- Department of Water Resources (DWR) Special Awareness Floodplains
- Hydrography
- Building clusters
- State Responsibility Area (SRA)
- Ownership
- Roads
- Geology
- Slope gradient
- Topographic hillshade
- LiDAR imagery

The Collector application was the primary platform for collecting data to characterize the VARs, the nature of the hazard, and the potential emergency measures to mitigate the hazard. The information was georeferenced to a point or polygon for incorporation into ArcGIS. The Collector application was also capable of taking georeferenced photographs. All information entered into the Collector application was also recorded manually on datasheets.

Additionally, georeferenced Portable Document Format (pdf) maps were produced for team members to use as a back up to the "Collector" application. Maps including the most critical layers were converted to georeferenced pdf files. The pdf files were uploaded to WERT member's smart phones and iPads to use for supplementary and back-up data collection. Team members used the Avenza "PDF Maps"[3] application to track their locations in the field relative to mapped GIS features, and to take supplementary notes and photographs.

2.1.1 Soil Burn Severity Maps

The degree to which fire affects soil properties, along with other controlling factors, is important for predicting the potential for increased runoff and sedimentation (Keeley, 2009). Soil burn severity mapping reflects the spatial distribution of the fire's effects on the ground surface and soil conditions, and is needed in order to rapidly assess fire effects, identify potential values at

[3] http://www.avenza.com/pdf-maps

risk, and prioritize field assessment (Parsons et al., 2010). Soil burn severity is determined from Landsat satellite imagery-derived Burned Area Reflectance Classification (BARC) maps (http://www.fs.fed.us/eng/rsac/baer/barc.html). The BARC map is field verified using standardized methods to create a soil burn severity map (Parsons et al., 2010). The soil burn severity map for the Soberanes Fire was field verified and generated by the BAER team, and the WERT relied on the BAER team's soil burn severity map for their assessment. Appendix B shows the burn severity along with other information.

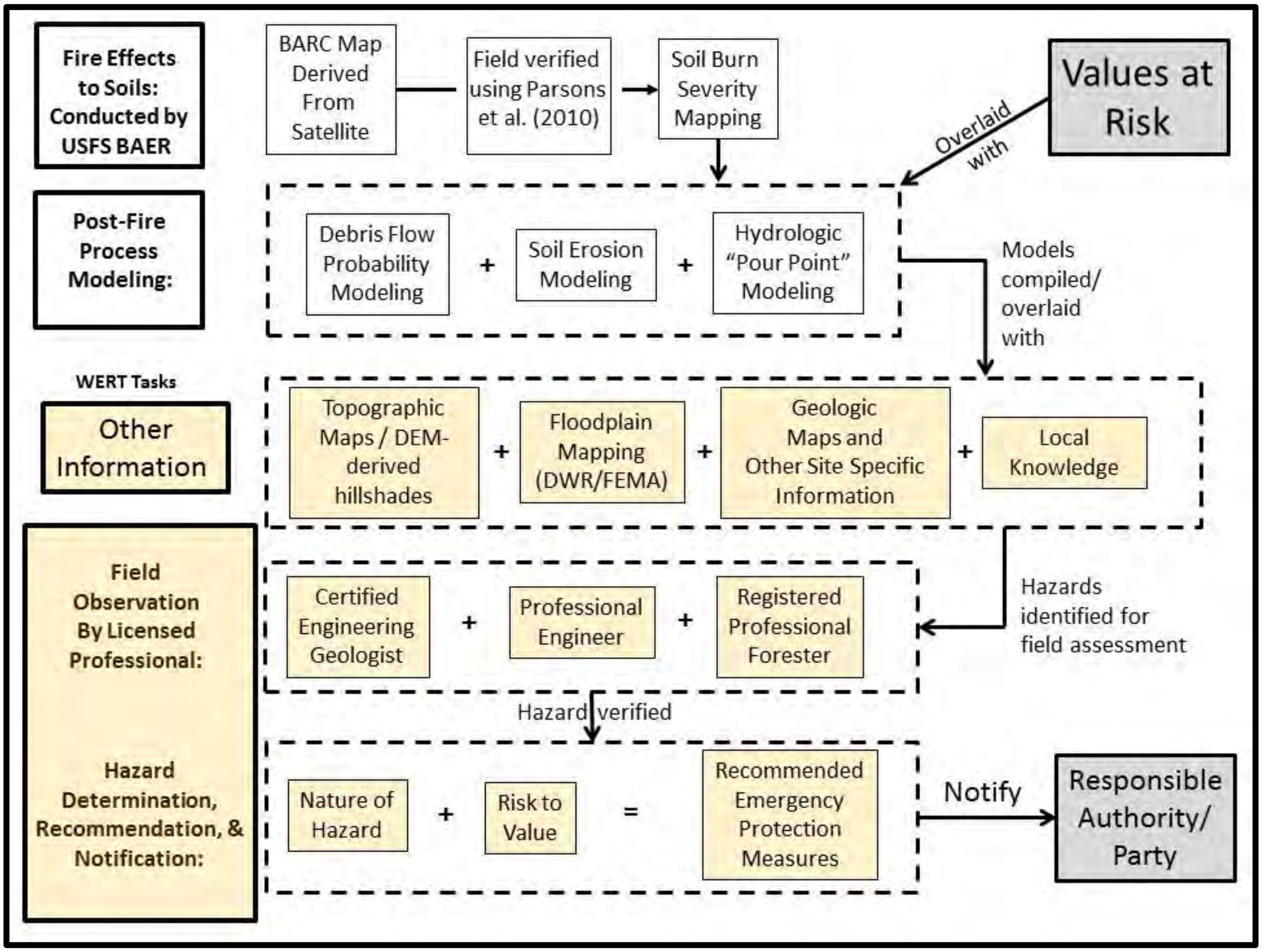

Figure 2. The process and methods for implementing a Phase I WERT for the Soberanes Fire.

2.1.2 Flood Hazard Maps

Flood hazard maps from the Federal Emergency Management Agency (FEMA) and the California State Department of Water Resources (DWR) were used in the WERT hazard assessment. FEMA flood hazard zone maps are available for areas subject to flooding from the burned area on the Carmel and Big Sur Rivers, Las Gazas Creek, and near the mouth of the Little Sur River. The DWR Awareness Floodplain Maps provide flood hazard mapping for communities not currently mapped by FEMA but where flood hazards are known to exist; other watersheds may also contain flood hazards but have not yet been assessed by FEMA or DWR. Awareness Floodplain Maps are available for parts of San Clemente and Pine Creeks draining to the Carmel River and for the lower Little Sur River. Both the FEMA and DWR maps show flood hazard zones that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year (i.e., a 100-year flood event). It should be noted however that due to the effects of fire, these probabilities are likely elevated from those that the maps represent.

Flood history information was obtained from the FEMA Flood Insurance Study for Monterey County (FEMA 2009) and from United States Geological Survey (USGS) stream flow records at the following gages:

- Big Sur River Near Big Sur (Gage No. 11143000) - Unregulated[4]
- Carmel River at Robles Del Rio (Gage No. 11143200) – Low flow regulated by Los Padres Reservoir 11 mi upstream
- Carmel River Near Carmel (Gage No. 11143250) – Low flow regulated by Los Padres Reservoir

FEMA maps and Flood Insurance Study information were obtained from the FEMA Map Service Center web site at: http://msc.fema.gov/portal/advanceSearch.

DWR Floodplain Awareness Maps were obtained from DWR at: http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fes/awareness_floodplain_maps/.

USGS stream flow records were obtained from the USGS at: http://waterdata.usgs.gov/ca/nwis/sw.

2.2 Modeling Methods

Various models were used to prioritize field reconnaissance and inform professional judgement. The models used in the assessment are summarized in the following sections.

2.2.1 USGS Post-fire Debris Flow Model

The USGS assessment uses results of the soil burn severity map along with empirical models to estimate the likelihood and potential volume of debris flows for selected basins in response to a design storm. The empirical models are based upon historical debris-flow occurrence and magnitude data, storm rainfall conditions, terrain and soils information, and burn-severity data from recently burned areas (Staley et al., 2016). Post-fire debris-flow likelihood, volume, and combined hazards are estimated at both the drainage-basin scale and in a spatially distributed manner along the drainage network within each basin. The characteristics of basins affected by

[4] A regulated river is one where downstream flows are altered by a major hydromodification (e.g. a large dam).

the fire were calculated using a geographic information system (GIS) with a minimum area of 0.2 km^2 and a maximum area of 8.0 km^2. Debris-flow likelihood and volume were estimated for each basin outlet as well as along the upstream drainage networks.

The US Geological Survey (USGS) preliminary hazard assessment of the Soberanes Fire can be accessed at:
http://landslides.usgs.gov/hazards/postfire_debrisflow/2016/20160722soberanes/

The USGS post-fire debris flow hazard model was employed for the Soberanes Fire to assist in the WERT's assessment of locations where hazards to life and property may exist. The debris flow likelihood maps based on the 28 mm hr^{-1} (1.1 in hr^{-1}) design rainfall are presented in Appendix B, and illustrate the likelihood of debris flows occurring in response to a more frequent precipitation event. The WERT team used the USGS model results based on the 40 mm hr^{-1} (1.6 in hr^{-1}) event to aid in our field assessment of values at risk. This less frequent and possibly extreme precipitation event emphasizes areas for field teams to focus their observations.

The debris flow likelihood maps categorize the results for each basin in percent likelihood with five groups:

- very low (0 to 20%)
- low (21 to 40%)
- moderate (41 to 60%)
- high (61 to 80%), and
- very high (81 to 100%)

By varying the precipitation input parameters, the basin probability analyses indicate that: when using the 20 mm hr^{-1} (0.78 in hr^{-1}) precipitation event, 62 of 435 basins have likelihood of 50% or greater to produce debris flow[5]; when using the 24 mm hr^{-1} (0.94 in hr^{-1}) precipitation event, 147 of 435 basins have likelihood of 50% or greater to produce debris flow; when using the 28 mm hr^{-1} (1.1 in hr^{-1}) precipitation event, 215 of 435 basins have likelihood of 50% or greater to produce debris flows; and, when using the 40 mm hr^{-1} (1.6 in hr^{-1}) event 312 of 435 basins have likelihood of 50% or greater to produce debris flows. In addition to the debris flow likelihood at the basin-scale, model outputs also include drainage network debris flow likelihood, or segment probability.

The USGS stream watch segments shown in the model results indicate the presence of drainages within and below the burn area that can be impacted by the combined effects of debris flows and floods generated from one or more tributaries. These are areas where a combination of runoff hazards may be present, and where flood hazards analyses should consider bulking factors for modeling the increase in runoff volume due to the contribution of sediment and debris.

[5] This precipitation input approximates historic debris flow triggering thresholds as discussed in the Debris Flow Precipitation Thresholds section of this report

For watersheds burned in the Soberanes Fire, these results give an indication of potential post-fire watershed response. It is important to note that the USGS probability and volume models provide debris flow hazards results for a single precipitation event. However, an additional hazard to be considered is the coupled result from several small debris flow or sediment-laden runoff events that load channel networks, followed by one large intense precipitation event that mobilizes this sediment as a large debris flow.

The USGS model results do not constitute a site-specific analysis of debris flow hazards. Additional on-the-ground evaluation should be conducted by qualified and licensed professionals where necessary. The model results are also limited in that they do not show hazards for basins that are less than 0.2 km^2 (~50 acres) in area, and do not specifically articulate hazards in areas where one or more tributaries may contribute flood and debris flows (watch segments), as discussed above. The hazards in burn areas that do not show a modeled result are therefore undefined by the model, but may be present. Similarly, for areas not shown as having a segment debris flow hazard associated with a drainage network, a hazard may still be present, yet undefined because the segment model results are limited based on the resolution of the input digital elevation (DEM) model. Additionally, other hillslope processes such as rock falls and debris slides are not included in the model results.

2.2.2 USGS Magnitude and Frequency Regression Model

The pre-fire and adjusted design flows for the affected watersheds were obtained from the U.S. Forest Service BAER Team hydrology analysis report (USFS, 2016a). Due to the lack of historic streamflow data in the affected watersheds and rapid assessment for the hydrology report, the U.S. Forest Service BAER team calculated design flow estimates based on a document titled "Methods for Determining Magnitude and Frequency of Floods in California, Based on Data through Water Year 2006" (Gotvald et al., 2012). This is an empirical model based on gauge data. These estimates assume pre-fire soil infiltration and ground cover conditions.

The BAER Team utilized "pour points" to analyze the contribution of runoff at basin outlets and to assess potential values at risk within the fire. These basins are various sizes and are determined by the desired outlet or "pour point" above a value at risk or area of concern. The BAER team calculated 32 "pour point" locations. Additional "pour point" locations were added by the WERT and analyzed at the 10-year return interval.

To determine the impact of the wildfire on first year post-fire peak flows, the total acres and acres burned at high, moderate, and low soil burn severity for each HUC 12 watershed was determined (see Table 2). Then a simple equation included in Foltz et al. (2009) was used to predict first year increases following the fire:

$$M = 1 + \left[\frac{Percent\ Runoff\ Increase_{(H+M)}}{100\%} \times \frac{(A_h + A_m)}{A_T}\right] + \left[\frac{Percent\ Runoff\ Increase_{(L)}}{100\%} \times \frac{A_L}{A_T}\right]$$

$$Q_{T10} = 2.0(Q_{10})\left[\frac{A_h + A_m}{A_T}\right] + \left(\frac{Q_{10} + Q_{25}}{2}\right)\left[\frac{A_L}{A_T}\right] + (Q_{10})\left[\frac{A_U}{A_T}\right]$$

A_H = High burn severity area within the watershed (acre or mi^2)
A_M = Moderate burn severity area within the watershed (acre or mi^2)
A_L = Low burn severity area within the watershed (acre or mi^2)
A_U = Unburned area within the watershed (acre or mi^2)
A_T = Total watershed area (acre or mi^2)
Q_{T10} = Total post fire adjusted discharge
Q_{10} = 10-year return interval flow
Q_{25} = 25-year return interval flow
M = Flow modifier

Limited studies and guidelines exist to determine the appropriate modifier or percent runoff increase for high and moderate soil burn severity. As stated in Foltz et al. (2009), US Forest Service BAER specialists have used a 100% runoff increase (i.e., a doubling of the runoff amount) for high/moderate soil burn severity areas in the first year after a severe wildfire. This simple approach appears reasonable for the Soberanes Fire and was used for post-fire flood analysis. The low burn 10-year peak was calculated as the average between the 10- and 25-year flows, or an average of a 20% increase in runoff due to low soil burn severity.

These post-fire flow increases are generally consistent with data presented by Moody and Martin (2001). They state that Rowe et al. (1949) has been used for post-fire flow modification evaluation in southern California for decades, and that for the first year after the wildfire, the ratio of post fire flow to pre-fire flow increases from 2 to 3 fold for less frequent, large magnitude storms (5 to 100-year recurrence intervals).

2.2.3 Surface Erosion Modeling Using ERMiT and GeoWEPP

The BAER team used the Erosion Risk Management Tool (ERMiT) (Robichaud, 2007) to model pre-fire and post-fire surface erosion (i.e., sheet and rill erosion) response by each soil map unit. ERMiT simulations for the 10-year recurrence storm are included in this report (Figure 8). In addition, Dr. Mary Ellen Miller (Research Engineer, Michigan Technological University) modeled surface erosion for a 10-year recurrence interval storm using GeoWEPP – the geographical interface for the Water Erosion Prediction Project (Renschler, 2003). The GeoWEPP model results are included in Appendix E. The surface erosion maps indicate watersheds that can be expected to generate the highest levels of hillslope erosion. This hillslope erosion can subsequently affect roads and drainage systems within the watershed, fill watercourses with high levels of sediment, and bulk flood flows with higher than typical sediment loads.

2.3 Field Methods

An initial calibration training was conducted by the WERT within the Palo Colorado area. The purpose of the training was to provide consistency in team member observations and documentation of potential hazard locations. An Excel spreadsheet titled "Burn Site Evaluation Summary" (Appendix D) was developed and used to compile notes during site specific observations. Data from the sheet were also collected using the Collector application on iPads and smart phones. The summary sheet logs the type of at-risk feature (e.g., a house or bridge), the address or general location, the Global Positioning System (GPS) location (WGS 84 datum), the type of hazard (e.g., flooding, debris flow, culvert plugging), the likelihood of hazard occurrence, and whether the hazard poses a risk to life-safety and/or property.

After the site specific training, the WERT broke into two teams and began assessing areas of concern. The WERT conducted a site-specific evaluation of Values at Risk (VARs) collected by the BAER team along with additional locations discovered during the evaluation. Areas where there were concentrations of residential homes, businesses, State Parks, and public infrastructure received the greatest attention. Field observations were conducted from September 7-12, 2016. The interior of the Soberanes burn area is in the Los Padres National Forest where campgrounds, trails, and scattered cabins were identified by the USDA Forest Service Burned Area Emergency Response (BAER) team. Road-related features, such as culverts and bridges, were surveyed at major drainage crossings. The California Department of Transportation (Caltrans) is identifying road-related high-value sites along State Highway 1.

The VARs assessed by the WERT include possible loss of life and property due to an elevated potential for increased streamflows, hyperconcentrated flows, debris torrents, debris flows, rock fall, and associated slope movement. VARs were assessed using the USGS post-fire debris flow modeling data for the 40 mm/hr 15-minute rainfall intensity (probability hazard), FEMA 100-year flood plain mapping, soil burn severity data, topography, aerial imagery, hillshade, slope, fire history, 2008 Basin-Indians Complex hazard points (SEAT, 2008), watershed boundaries (HUC-12[6]), DWR awareness floodplains, building clusters, ownership, and roads. Team members confirmed hazards based on site specific observations and interpretation of active geomorphic processes and landforms (Figure 3). When appropriate, team members noted preliminary or possible emergency protective measures.

It should be noted that the observations included in this report are not intended to be fully comprehensive and/or conclusive, but rather to serve as a preliminary tool to assist emergency responding agencies (e.g., CAL FIRE, County of Monterey, Caltrans, US Forest Service, Office of Emergency Services, Natural Resource Conservation Service, utility companies, and other responsible agencies) in the development of more detailed post-fire emergency response plans. **It is intended that the emergency responding agencies will use the information presented in this report as a preliminary guide to complete their own more detailed evaluations and develop detailed emergency response plans and mitigations.**

[6] A HUC-12 subwatershed is typically 15,000 to 40,000 acres in size.

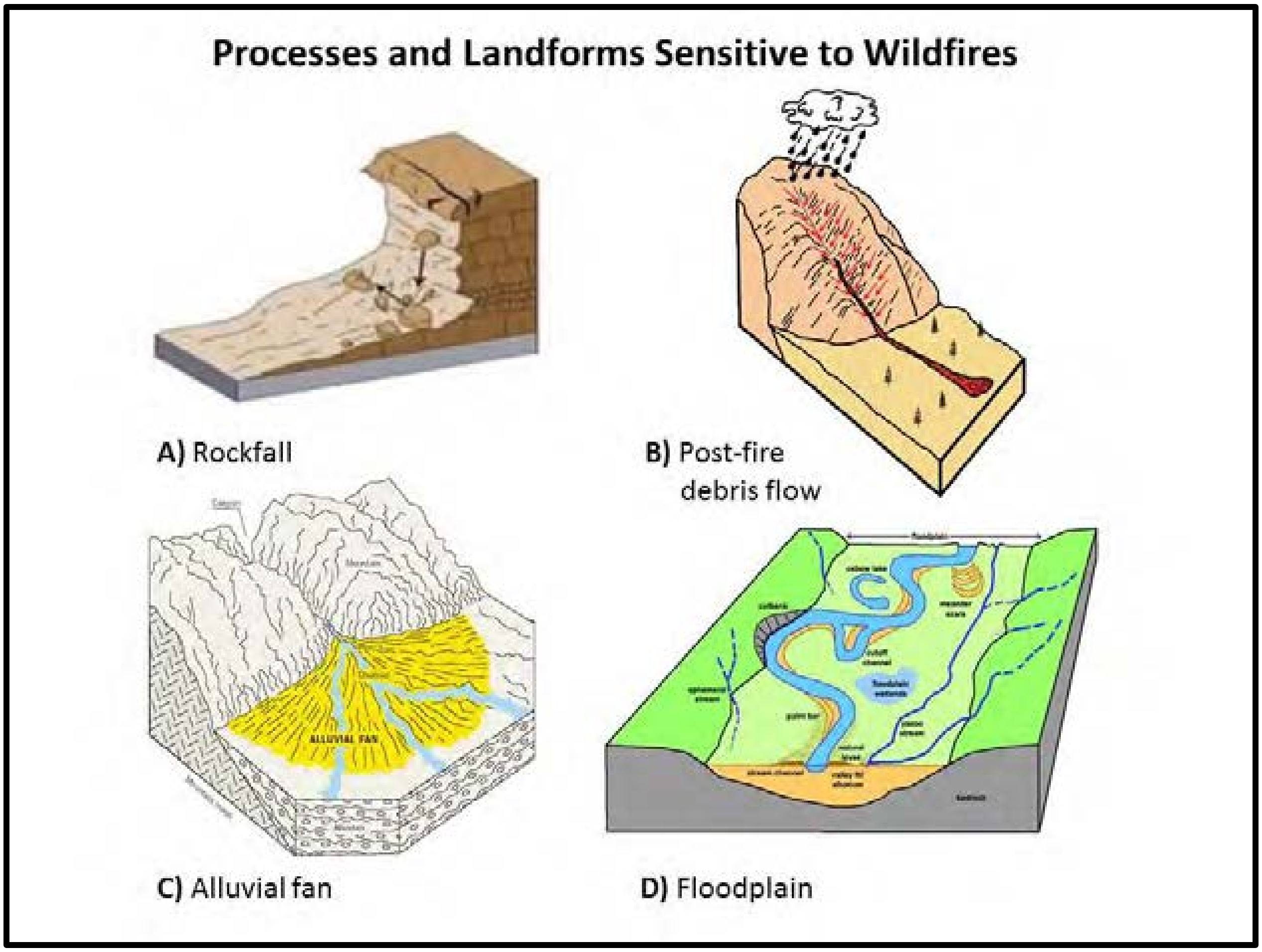

Figure 3. Geomorphic processes and landforms considered by WERT personnel to verify and assess hazards for VARs on the Soberanes Fire. VARs potentially subject to these geomorphic processes or located within or adjacent to these landforms were generally assigned a higher risk.

2.4 Scale of Analysis

The assessment area was broken into three units of watershed scale, or watershed tiers, for organization and ease of analysis:

- Tier 1 – Large watersheds
- Tier 2 – Sub-watersheds
- Tier 3 – "Pour point" watersheds

Communities and specific Values at Risk were assessed hierarchically using a nested watershed approach. The following figures (Figure 4 and Figure 5) describe how the various watersheds were nested.

The WERT looked at the potential for watershed-related hazards for the portion of the Soberanes Fire area covered by the USFS BAER Team (USFS, 2016). The one exception is that additional hydrologic assessment (i.e., pour point modeling) was performed for the Big Sur

River watershed using BARC data that was not field verified (Figure 1; note differences between BAER and WERT team analysis boundaries). Since active fire was in the upper Big Sur River watershed, the WERT members were not able field verify soil burn severity. However, it was necessary to use this data to look the potential for flooding along the Big Sur River adjacent to the community of Big Sur.

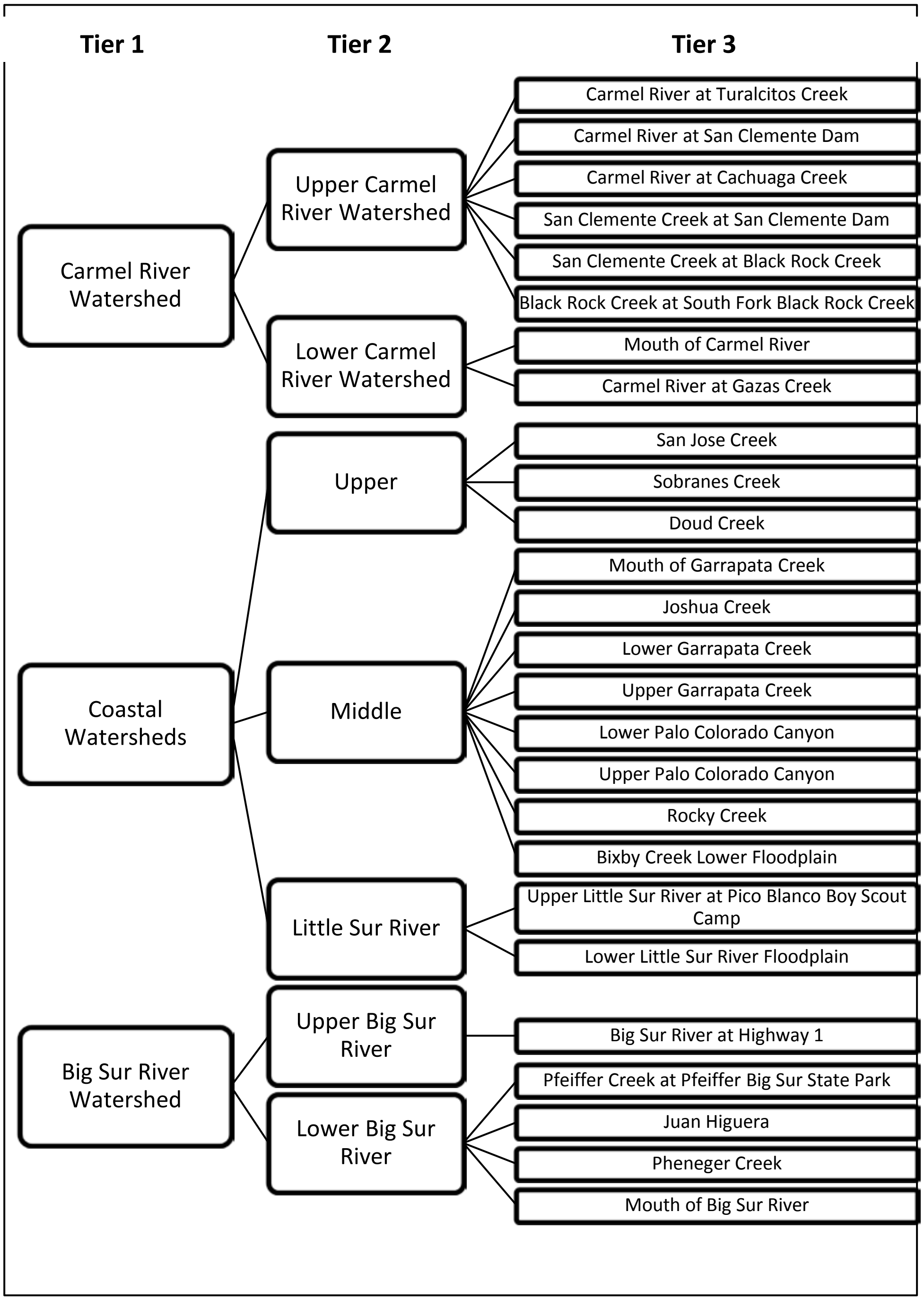

Figure 4. Tiered analysis levels

Figure 5. Tiered watershed map for the Soberanes Fire showing how the assessment area is broken into 1) large watersheds, 2) sub-watersheds, and 3) "pour point" watersheds.

3.0 Physical Setting

The following section discusses the physical setting of the Soberanes burn area pre- and post-fire. Since the footprint of the Soberanes Fire determines the specific area of description, the summary of the fire is discussed first.

3.1 Soberanes Fire Summary

The Soberanes Fire began on July 22, 2016 from an illegal campfire in Garrapata State Park, Monterey County. The CAL FIRE San Benito-Monterey Unit (BEU) took incident command on the first day and as the fire progressed south towards federal land within the first week, the USFS joined CAL FIRE in unified command. On the first day, the Soberanes Fire burned over 700 acres; the first week the fire burned over 27,000 acres; and within the first month it burned over 86,000 acres. At the time of development of this document, the fire had burned over 105,000 acres with 60% containment and it was still burning within containment lines to the south. Tje USFS has taken over incident command. There was one fatality associated with the fire that occurred during the first week, and at the date of this publication, 57 homes had been destroyed. It should be noted that since the homes were destroyed, the WERT did not specifically address hazards at these locations.

Detailed information is provided at: http://inciweb.nwcg.gov/incident/4888/

3.2 Vegetation

Vegetation in the burn area is a composite of grass lands, oak woodlands, chaparral, mixed hardwood/conifer, coast redwood and coastal scrub. Sudden oak death (*Phytophthora ramorum*) is also prevalent (http://www.suddenoakdeath.org/) within portions of the burn area, resulting in large amounts of down woody debris.

3.3 Rainfall/Climate

Average rainfall in the burn area ranges from 17 to 45 inches per year. Precipitation occurs almost entirely as rain, with rare occasions of snow at the highest elevations. Rain-on-snow events are possible but they typically are rare events. The fire area can be described as having a typical Mediterranean climate with warm dry summers and cool wet winters. Fog persists along the coast line in the summer. The 1-year recurrence interval, 15-minute rainfall magnitude ranges from 0.414 inches near Big Sur Lodge to 0.314 inches in the community of San Clemente Rancho (i.e., confluence of San Clemente and Black Rock Creeks). The 10-year recurrence interval, 15-minute rainfall magnitude ranges from 0.679 inches near Big Sur Lodge to 0.532 inches in the community of San Clemente Rancho (http://hdsc.nws.noaa.gov/hdsc/pfds/).

3.4 Regional Geologic Setting

The Soberanes Fire burn area is located in the central part of the Coast Ranges geomorphic province (CGS, 2002). This area contains several major bedrock units in two major structural blocks, both of which are west of the San Andreas fault (Rosenberg and Wills 2016, Appendix A). The Salinian block, which lies between the San Andreas fault and the Sur-Nacimiento fault, is comprised primarily of Paleozoic metamorphic rocks, named the Sur Series, and Mesozoic granitic rocks. Deep weathering of many Salinian block rocks has broken down mineral grains leading to "decomposed" or weakened rocks. For example, quartz-diorite (granitic) units (Map unit Kqd) tend to be dark gray, containing 20 to 25 percent mafic minerals (biotite and hornblende) that often tend to rapidly weather to clay minerals. Areas underlain by these rocks tend to be deeply weathered on higher slopes and overlain by weak colluvium. A large portion of the burn area is underlain by granitic rock. The granitic rocks are deeply weathered producing soils that are detachable and easily erodible. Soils and weathered bedrock on steep slopes in these areas can be expected to erode and transport sediment to watercourse drainages. The weak weathered rock and colluvium over much of the surface of the granitic rocks is prone to debris flows triggered by intense rainfall (Wills et al., 2001). West of the Sur-Nacimiento fault, the Nacimiento Block contains rocks of the Franciscan Complex. This area was attached to the North American Plate along a series of boundary faults, one of which is inferred to be the Sur-Naciemento fault. The Franciscan Complex is comprised dominantly of greywacke sandstone, with sand-sized material containing abundant feldspar and rock fragments within a matrix of silt and clay. Included in the Franciscan Complex are volcanic rocks, some of which include evidence that they were extruded in a deep marine environment. The rocks of the Franciscan Complex tend to be weak, intensely sheared and slightly metamorphosed.

Throughout the area bedrock units are locally overlain by Tertiary age continental and marine sedimentary rocks comprised on sandstone and mudstone, respectively, and Quaternary alluvial deposits. Quaternary units of significance are debris fan deposits mapped along and near the coast, from Carmel Highlands to the south of the Big Sur River (Map units Qydf and Qdf). A description of the geologic units within the Soberanes Fire area is included in the map explanation to the Regional Geologic Map (Appendix A).

Topography within the burn area ranges from gentle to very steep, with elevations ranging from about 200 feet above mean sea level along the western margin of the fire to an elevation of over 4,800 feet where the fire burned near Ventana Double Cone. Local extremes in relief occur in small catchments along the Big Sur River, where elevation changes measured from canyon mouth to crest of 3,000 feet occur over a map distance of less than 2 miles. The burn area lies below the elevation generally subject to rain-on-snow events, although snow may occasionally fall near the higher peaks. Much of the mountainous portion of the burn area drains into numerous watersheds that drain to the larger Big Sur River, Little Sur River, Carmel Valley River, and the Coastal Frontal Drainages (i.e., west facing slopes along the western portion of the burn area that drain into the Pacific Ocean via numerous west-flowing watercourses).

3.4.1 Post-fire Surficial Processes

The principal concern with the Soberanes Fire area is an increase in the potential for in-channel streamflow, hyperconcentrated flows, debris torrents, and debris flows derived from erosion. The primary mechanisms for this are increases in runoff resulting from reductions in interception resulting from the loss of live vegetation, reductions in infiltration due to the removal of soil cover, soil water repellency, and from the loss of mechanical support along stream channels. Also of concern is the long-term loss of mechanical support of hillslope materials that was provided by vegetation and vegetative litter.

In areas of high and moderate burn severity, water repellant soils can develop where waxy substances released by plant materials during hot fires follow thermal gradients into the soil and condense onto soil particles. Additionally the headwaters of these watersheds are very steep. Dry ravel (i.e., downslope mobilization of loose bedrock, soils, and sediment wedges accumulated behind vegetation removed during the fire) was observed on very steep slopes in numerous locations in the burn area. The loose materials may become mobilized into sediment-laden runoff during heavy rains, leading to the development of debris flows and debris torrents that may flow downstream from the watershed headwater source areas (Figure 6). The magnitude of post-fire damage will ultimately be determined by the intensity and duration of storms that impact the burn area, particularly during the winter of 2016-17.

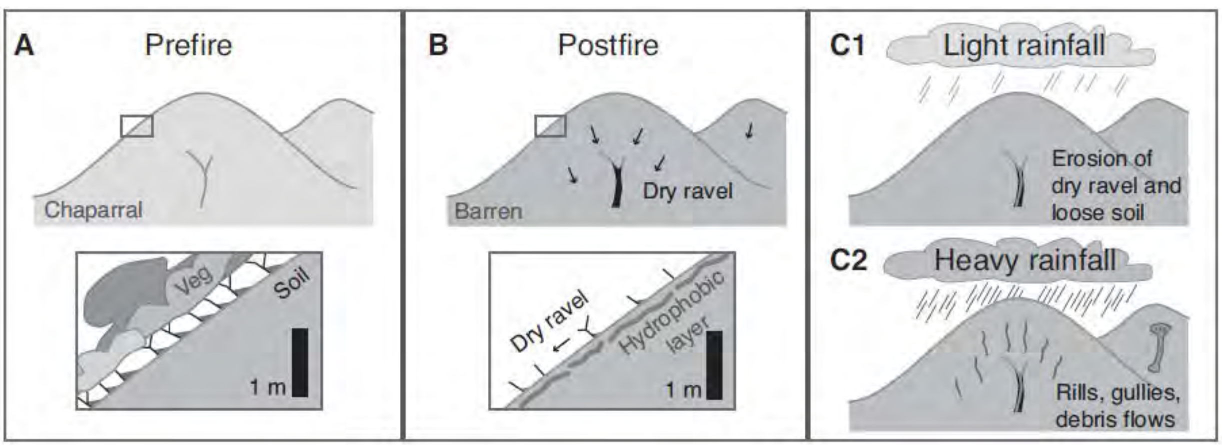

Figure 6. An illustration of the effects of wildfire on geomorphic processes for a steep, chaparral landscape. (A) Before a wildfire, the dense chaparral vegetation (veg) and organic debris retain sediment that had been mobilized downslope by diffusive processes. (B) During and immediately after a wildfire, the combustion of vegetation and organic debris above the ground reduces surface roughness and release retained soil as dry ravel, which accumulates as talus in colluvial hollows, hillslope toes, and stream channels. The high temperature of chaparral fire also creates a hydrophobic layer beneath the soil surface. (C1) and (C2) Sediment erosion and transport processes during post-fire rainfall are highly dependent upon rainfall intensity. Whereas light rainfall will result in the erosion of loose soil and dry ravel talus, heavy rainfall will generate overland flow at rates that can cut rills and gullies into the soil and potentially generate debris flows and induce downstream flooding (modified from Warrick et al., 2012).

3.4.2 Post-fire Debris Flow History

Records indicate that since the late 1800s there have been 10 large wildfires in the Big Sur area (Henson and others, 1996; Longstreth, 2013). Documentation of historic post-fire debris flow events in the general area affected by the Soberanes Fire is generally limited to locations near the Big Sur River along Pacific Coast Highway. However, studies on post-fire dry ravel erosion suggest that debris flows may have occurred in the Upper Carmel River following the Marble Cone Fire (Richmond, 2009). In the area of Julia Pfeiffer Burns State Park, numerous steep tributary watersheds issue on to debris fans. These fan-shaped landforms are formed where debris flows travel down the canyons of the small streams that drain into the Big Sur River (Wills et al., 2001). These fans provide a record of past debris flows and sediment-laden floodwaters and are also indicative of locations where future events may occur. Historic debris flows documented along the Big Sur River and south to Julia Pfeiffer Burns State Park indicate that since 1908 a minimum of nine documented debris flow events have occurred following wildfire (Cleveland, 1973; Jackson, 1977; JRP Historical Consulting Services, 2001; Wills et al., 2001; Longstreth, 2013).

After the Molera Fire burned approximately 4,300 acres in August of 1972, debris flows issued from Pfeiffer-Redwood Creek, Juan Higuera Creek, and Pheneger Creek on several occasions from October through November 1972. A partial volume estimate of 10,000 cubic yards was provided for some of these debris flows (Cleveland, 1973). Over this period, debris flows blocked Pacific Coast Highway and numerous homes and businesses were inundated with mud and water. At Big Sur Village, the November 15, 1972 debris flow damaged a cement block building, post office, mobile home, and 12 cars. The Basin Complex and Indians Fires burned the same area in June of 2008. A State Emergency Assessment Team (SEAT) documented the potential for burned watersheds to produce post-fire debris flows and recommended areas for emergency protective measures (SEAT, 2008). In April 2009 debris flows estimated to be 8,000 cubic yards in volume issued from several steep hillslopes that drain into Pfeiffer-Redwood Creek. Slopes were eroded with thousands of rills and gullies up to 1 foot wide and six inches deep. Pfeiffer-Redwood Creek was scoured to a depth of 12 feet, moving boulders 3 feet in diameter. As it flowed downstream, the debris flow plugged culverts, overtopped bridges, and flowed through the state park where it came to rest in a parking lot and State Route 1. Vehicles in the parking lot were damaged and Highway 1 was temporarily blocked with debris. Because this location had been identifed as a potential site for impact from post-fire debris flows, barriers (K-rails) had been placed to divert sediment from flowing into the State Park Lodge and offices (Longstreth, 2013). The following list provides a summary of the readily available documented post-fire debris flow history and associated precipitation and fire information along the coast from Big Sur River to Julia Pfeiffer Burns State Park.

Date	Measured Precipitation	Fire Name
1908, 1909, 1910	(Precipitation unknown)	Unknown
12 October 1972	0.82 in hr^{-1}	Molera

15 October 1972	0.73 in hr^{-1}	Molera
15 November 1972	0.44 in 15 minutes	Molera
August 1978	(Precipitation unknown)	Marble Cone
February 1986	(Precipitation unknown)	Rat Creek - Gorda
7 April 2009	0.84 in hr^{-1}	Basin Complex - Indians

3.4.3 Post-fire Debris Flow Precipitation Thresholds

Precipitation thresholds are developed by the identification of debris flow response in burned watersheds and comparing them with locally recorded rainfall at different durations (Cannon et al., 2008). The use of these empirically defined thresholds is a common way of representing debris flow potential in a recently burned area. Above the threshold, there is an increase in the likelihood of debris flow, whereas below the threshold, there is a lower likelihood of debris flow initiation. Instrumentation and measurements of post-fire debris flows in the Transverse Ranges has suggested that thresholds for periods less than 30 minutes are considered the best predictor of post-fire debris flows events (Kean et al. 2011; Staley et al. 2013). The USGS Post-Wildfire Landslides team and the National Oceanic and Atmospheric Administration - National Weather Service (NWS), typically work together to set thresholds used for rainfall alerts. Where possible, the NWS uses a radar and rain gages along with established rainfall thresholds that are known to trigger flash floods and debris flows, to issue watches and warnings for areas recently burned by wildfire.

The historic debris flow precipitation thresholds documented for the steep watersheds in the vicinity of the Julia Pfeiffer Burns State Park suggest that at 1-hour durations, precipitation on the order of 0.73 inches (19 mm) may be enough to generate debris flows. However, this comparison is under the assumption that burn extent and severity, topographic characteristics, and sediment availability, are similar between watersheds issuing past debris flows and those burned by the Soberanes Fire. In addition, intense, short duration precipitation, such as the 0.44 inch in 15 minutes (1-hour rate of 1.76 inches) in November 1972, may represent a precipitation threshold that if broadly distributed, would cause wide spread debris flow response in the burn area.

The USGS post-fire debris flow model's "design storm" precipitation inputs provide the flexibility to show debris flow model results at or near known thresholds as well as results for extreme rainfall. For this assessment the WERT agreed that the 28 mm hr^{-1} is reasonably close to the hourly precipitation that has triggered debris flows. Furthermore, the 40 mm hr^{-1} threshold, while not shown on the maps in Appendix B, represents an extreme precipitation condition where if broadly distributed could initiate widespread debris flows with associated magnitudes (i.e., volumes) exceeding historically documented events.

3.5 Regional Fire History

The northern third of the burn area has little to no recently recorded fire history, and this largely corresponds with the highest proportions of moderate and high soil burn severity. The southern two-thirds of the burn area have had multiple fires, and the recurrence interval of fire in this area is approximately 10-15 years (Figure 7).

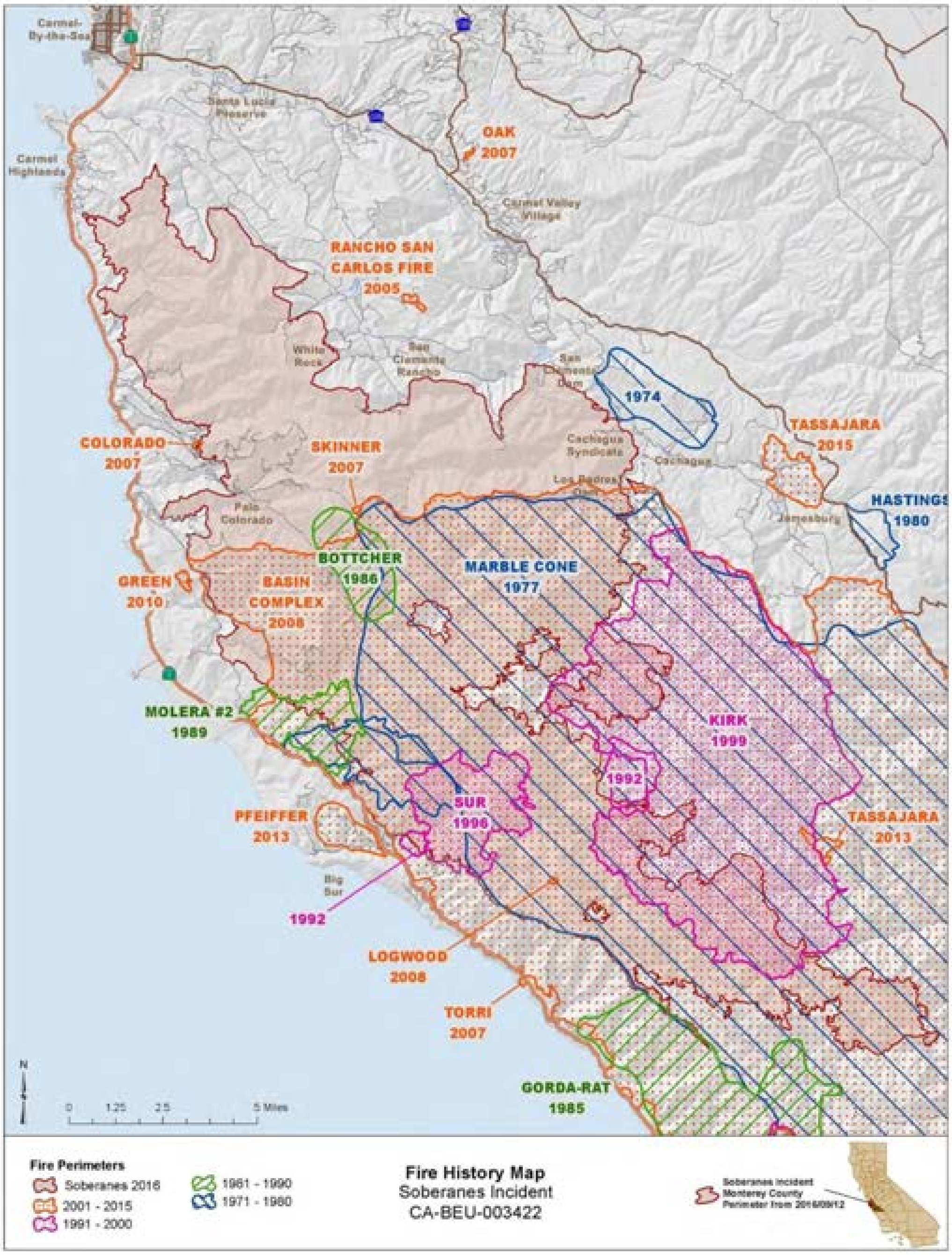

Figure 7. Fire history map for the Soberanes Fire

3.6 Post-Fire Sediment Production

The pre-fire erosion hazard rating is generally high to extreme for the area affected by the Soberanes Fire (Appendix F). For assessing post-fire surface erosion hazard, ERMiT (Erosion Risk Management Tool)[7] was used to predict post-fire sediment production from sheetwash

[7] http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/ermit/ermit.pl

and rilling. Model predictions for the 10-year recurrence interval runoff event suggest that the highest rates of surface erosion are from steep areas burned at moderate and high soil burn severity. Rates of surface erosion for the 10-year event are estimated to be greater than 5 to 10 tons per acre (Figure 8). These rates have a 10 percent probability of exceedance. Hillslope erosion in these watersheds erosion can be expected to affect roads and drainage systems, fill watercourses with high levels of sediment, and bulk flood flows with higher than typical sediment loads.

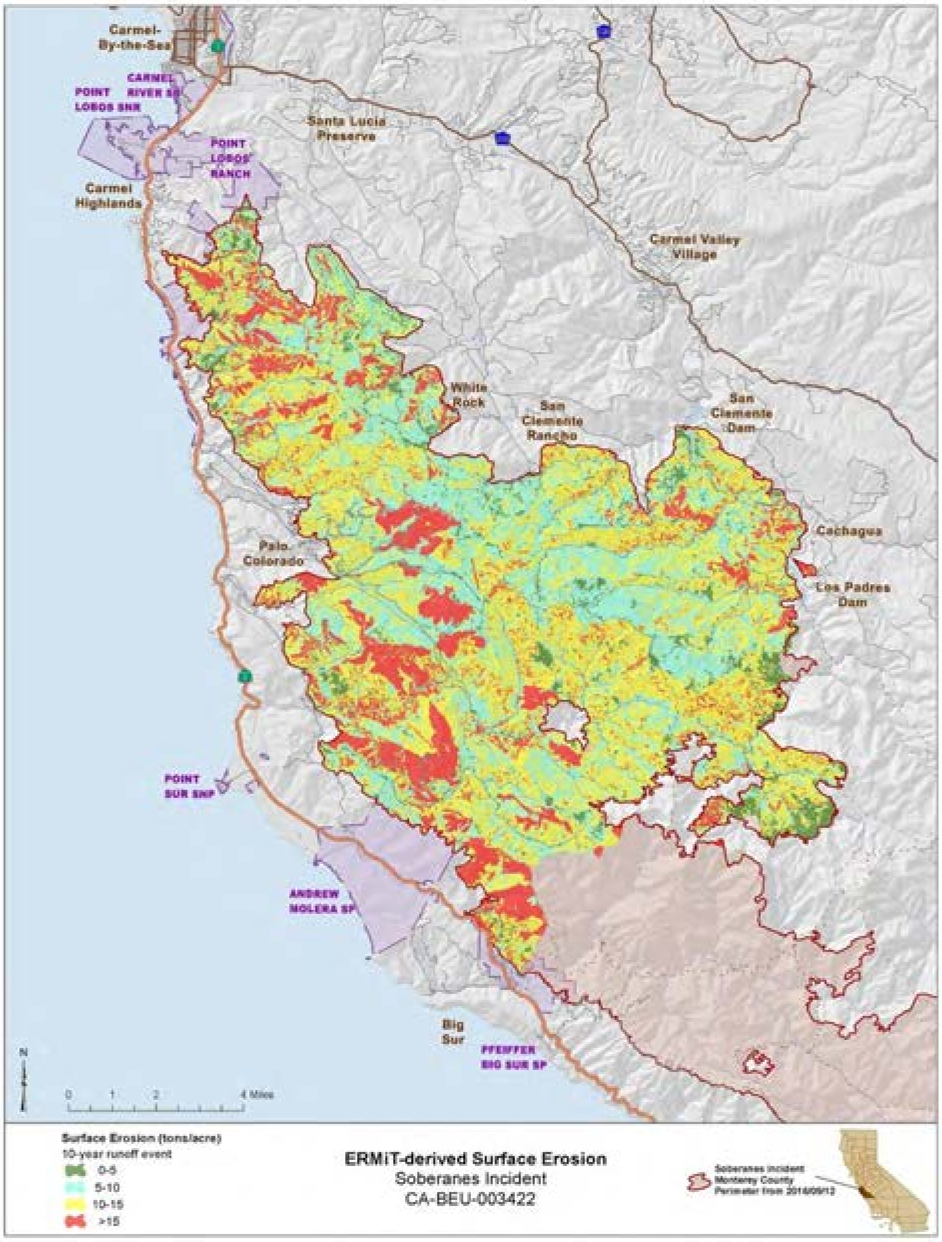

Figure 8. Predicted surface erosion rates for the 10-year runoff event within the Soberanes burn area.

3.7 Flooding

3.7.1 Flooding Information – Carmel Watershed

FEMA flood hazard maps were obtained for the Carmel River from the river mouth upstream to Los Padres Dam. FEMA flood hazard maps were also obtained for portions of Las Gazas Creek, including the community of Santa Lucia Preserve (Appendix B). DWR Awareness Floodplain maps were obtained for San Clemente Creek from San Clemente Dam (decommissioned) upstream along Dormody Road to the confluence of Black Rock Creek, and on the lower 2 miles of Pine Creek (Appendix B).

River levees and a dam are located downstream of the burn area and provide limited flood protection on the Carmel River. Levees are present on the lower Carmel River but are not certified by FEMA (FEMA 2009). Consequently, they do not provide flood protection for the 100-year flood event. The Los Padres Dam was constructed in 1949 for water supply purposes. The dam is not used for flood storage, although some flood storage is available when the reservoir is not full. The San Clemente Dam, located further downstream, was decommissioned and removed as of August 31, 2015. All elements of the decommissioning project, including a re-routing of the Carmel River as part of a fish passage restoration project, are scheduled for completion by October 31, 2016. Long-term sedimentation has averaged 1.4 yd^3/ac/yr (262 m^3/km^2/yr), based on bathymetric data (Minear and Kondolf 2009). Sedimentation in Los Padres Reservoir during the winter following the Marble-Cone fire of 1977 effectively doubled the long-term rate of reservoir filling (Hecht 1981, 2000).

Two USGS stream gages are located downstream of the burned area on the Carmel River. The first is approximately 3 miles upstream of the mouth of the Carmel River at Carmel (Gage No. 11143250) and has records from 1963 to present (Figure 9-Carmel Gage Plot).

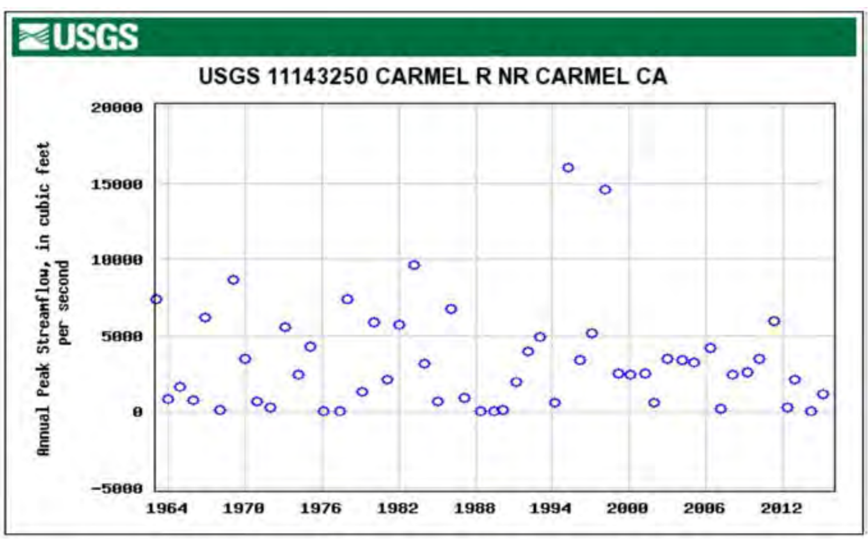

Figure 9. Annual peak flows on Carmel River near Carmel (USGS Gage No. 11143250). Peak flows for the gage were affected by upstream dams.

The second gage is located further upstream at Robles Del Rio in the Carmel Valley (Gage No. 11143200) and has records from 1957 to present (Figure 10). The highest peak flows recorded at both gages occurred in 1995 and 1998. The largest was in 1995 when a peak flow of 16,000 cfs was recorded at the Carmel gage (No. 11143250) and is roughly equivalent to a 30-year flood event.

The Flood Insurance Study (FEMA 2009) reports several years where flood damage occurred in portions of Monterey County, the most recent of which occurred in 1983, 1995 and 1998, but no specific information regarding flood damage is provided for the Carmel River.

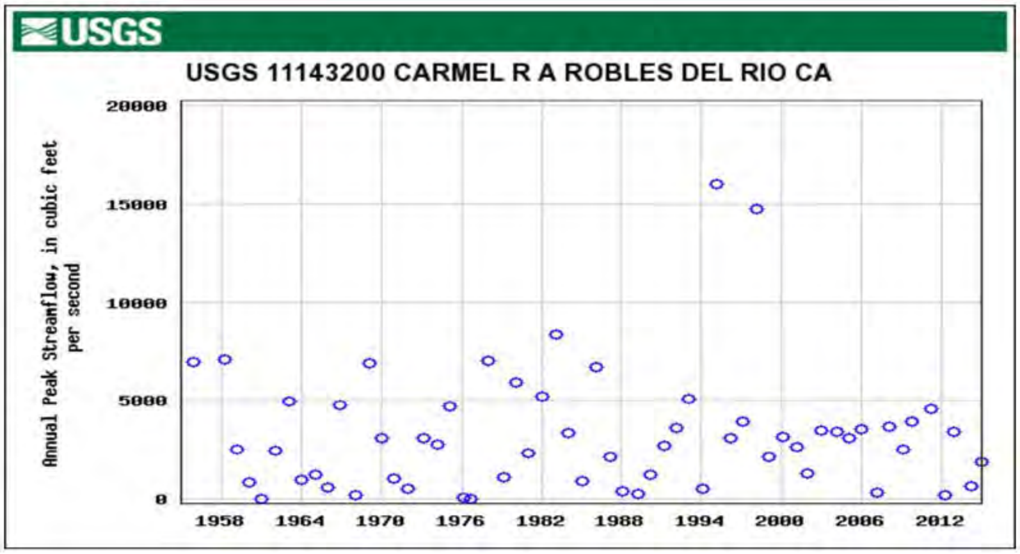

Figure 10. Annual peak flows on Carmel River at Robles Del Rio (USGS Gage No. 11143200). Peak flows for the gage were affected by upstream dams.

3.7.2 Flooding Information - Coastal Watersheds and Big Sur Watershed

Except on the lower parts of the Big Sur and Little Sur Rivers, no flood hazard maps are available on coastal watersheds draining from the burn area between San Jose Creek to the north and the Big Sur River to the south. FEMA flood hazard maps were obtained from the mouth of the Big Sur River to about 2 miles upstream of State Highway 1. Flood hazard maps were also obtained for the lowermost section of the Little Sur River from FEMA and for an additional 8 to 9 miles upstream of State Highway 1 from DWR Awareness Floodplain Maps (Appendix B).

An unregulated USGS stream gage is located approximately 1 mile upstream of State Highway 1 on the Big Sur River at Big Sur (Gage No. 11143250). Figure 11 shows annual peak flows recorded at the stream gage from 1950 to present. Larger peak flows occurred in 1978, 1995 and 1998, with the largest flood peak on record in 1978 at 10,700 cfs which is approximately a 200-year flood based on stream flow return interval calculations from Peak FQ http://water.usgs.gov/software/PeakFQ/.

The Flood Insurance Study (FEMA 2009) reports several years where flood damage occurred in portions of Monterey County, the most recent of which occurred in 1983, 1995 and 1998, but no specific information regarding flood damage is provided for the coastal watersheds described in this section.

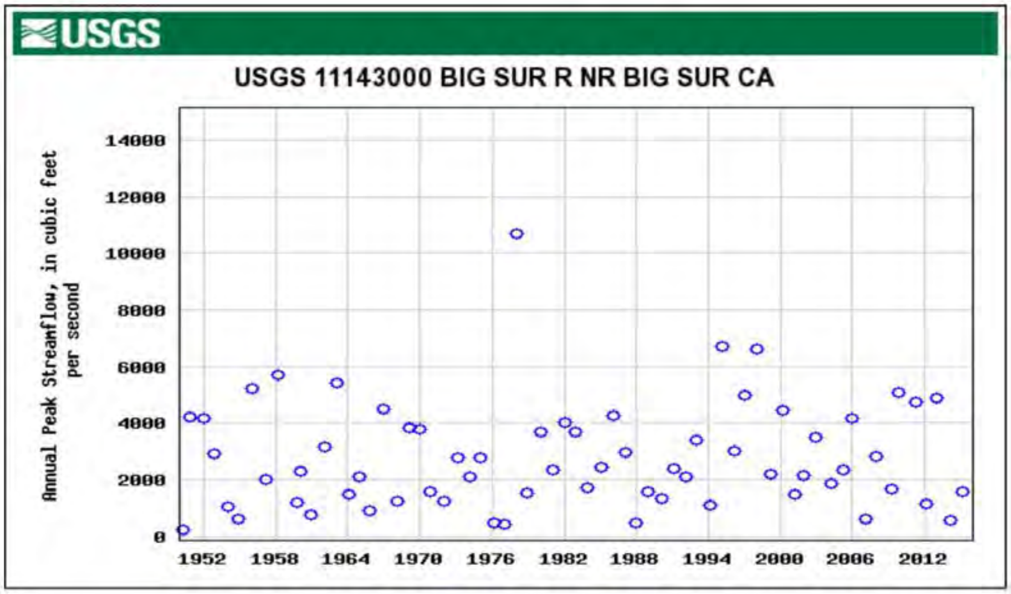

Figure 11. Annual peak flows on Big Sur River near Big Sur (USGS Gage No. 11143000).

3.8 Development and Key Infrastructure

Development in the assessment area is concentrated in the valley along the Carmel and Big Sur Rivers. A community is centered along the Palo Colorado Canyon Road. Small groupings of residences are also located along the bottom of some of the coastal drainages. In addition, small groupings of cabins are found in the upper Carmel River watershed. Two dams along the Carmel River are within assessment area as well.

3.9 Areas/Communities of Interest

3.9.1 **State Highway 1 -** The Highway traverses the length of the coast, west of the fire. The burn area drains through approximately 20 watercourse crossings along State Highway 1 from the Carmel River bridge in the north to the Big Sur River bridge in the south. Crossings consist of bridges, steel culverts and concrete box culverts. Maintenance of State Highway 1 falls under the jurisdiction of the California Department of Transportation (Caltrans).

3.9.2 **California State Parks** - Parks are located within and downstream of the burn area from Pfeiffer Big Sur State Park in the South to Carmel River State Beach. State Park facilities occur along watercourses that receive drainage from the burn area and have the potential to receive flood and debris flows. Facilities include camp grounds, picnic areas, road crossings, Big Sur

Lodge, parking lots, maintenance facilities and a waste water treatment plant. Specific State Park facilities are discussed below, based on their location within specific watersheds.

3.9.3 **The Santa Lucia Preserve –** The Santa Lucia Preserve is a 20,000 acre private preserve southwest of the Carmel River Valley. Most of the Preserve drains into the Lower Carmel River area, though a small portion drains to the Upper Carmel River area via San Clemente Creek. Three hundred home sites and several recreational facilities (golf courses, summer camps, etc.) are located within the Preserve. The Soberanes Fire encroached into some of the watersheds within the Preserve, creating a hazard for flooding and debris flows along San Jose Creek, Salsipuedes Creek, Los Gazas Creek, San Clemente Creek, and several tributaries.

3.9.4 **Carmel, Carmel Valley and Carmel Valley Village** - These communities are all located within the Carmel River Valley, which is a northwest to southeast oriented drainage that flows for approximately 16 miles from San Clemente Dam to the Pacific Ocean. The river valley varies in width from less than ¼ mile to more than ¾ mile at it widest point and is generally composed of unconsolidated alluvial sediments with mixtures of well sorted sands, gravels and boulders and is vegetated with a moderately dense to dense stand of cottonwoods and alders. The active river channel itself varies in width, is generally unconfined, with a gentle to moderate gradient. Based on a review of aerial photos and our site analysis, hundreds of residential homes exist within the floodplain of the Carmel River Valley. In addition, based on our review of FEMA flood maps, a large portion of the river valley is within the 100-year floodplain.

3.9.5 **White Rock** – White Rock is a private community and hunting club at the southern terminus of Robinson Canyon Road. The community consists of numerous cabins built on south-facing slopes that descend to Black Rock Creek and also along the base of Black Rock Creek. White Rock Lake is a man-made lake constructed on Black Rock Creek at the eastern end of the community. The Soberanes Fire burned the slopes upstream and opposite the White Rock community, creating a hazard for flooding and debris flows in the community along Black Rock Creek.

3.9.6 **San Clemente Rancho -** This is a private community and hunting reserve located at the eastern terminus of Dormody Road. The community generally consists of numerous cabins built on an alluvial fan at the mouth of Black Rock Creek and along a DWR Awareness Floodplain associated with San Clemente Creek. Trout Lake is a man-made impoundment constructed on San Clemente Creek at the eastern end of the community. The Soberanes fire burned most of the Black Rock Creek and South Fork Black Rock Creek watersheds that drain into the community, creating a hazard for flooding and debris flows in the community along Black Rock Creek and flooding along San Clemente Creek. Grim (2016) provides a detailed report on the life-safety hazards located in this area.

3.9.7 **Cachagua Syndicate Camp -** This is an 80-acre private community and commune located off Cachuaga Road along the segment of Carmel River between San Clemente Reservoir and Los Padres Reservoir. The community consists of numerous cabins constructed along the Carmel River floodplain. There are also privately owned properties/residences located upstream of the Syndicate Camp and along the hillslopes below the burned area. The Soberanes Fire burned a significant portion of the Carmel River drainage area upstream of the community, creating a hazard for flooding along Carmel River and debris flows along tributary channels.

3.9.8 **Cachagua –** This is a small community located at the confluence of Cachagua Creek and the Carmel River. Numerous residences and a community park facility are located within the FEMA 100-year floodplain along the Carmel River and at the confluence with Cachagua Creek. The Soberanes Fire burned a significant portion of the Carmel River drainage area upstream of the community, creating a hazard for flooding in this area.

3.9.9 **Lower San Jose Floodplain** - State Parks housing is located along the flood plain and is at risk to flooding. The house closest to the creek is no longer in use.

3.9.10 **Lower Garrapata/Joshua Creek Community** – This community consists of the Garrapata Creek watershed downstream from Wildcat Canyon (including the Joshua Creek watershed). The community is comprised of scattered residences and private properties, and residences are generally located low on the slopes in close proximity to Joshua Creek or Garrapata Creek. The Soberanes fire burned most of the Wildcat Canyon, Joshua Creek, and Upper Garrapata Creek watersheds, creating a hazard for debris flows and flooding along Garrapata Creek, Joshua Creek, and tributary channels.

3.9.11 **Palo Colorado –** This area consists of a community of homes centered along Palo Colorado Road in portions of the Garrapata, Palo Colorado and Rocky Creek watersheds. Numerous residences and crossing structures are within close proximity to the watercourses. Topography is generally steep narrow canyons with gentler slopes on the ridges and along the watercourse. Palo Colorado road is a single lane, county maintained road and the main egress road for the community. Significant portions of the upper watersheds were burned. There is past history of flooding along the road during large rain events. Significant tanoak mortality is visible along the watercourses, resulting in numerous down tan-oak trees within and adjacent to the channel. The watercourse crossings along the road may be susceptible to debris and flood flows.

3.9.12 **Bixby Flood plain Homes** - This group of residences is located along Bixby Creek, approximately 1 mile up-stream of Bixby Bridge/California State Highway 1. Vehicular access to the community is provided via the Coast Road, which intersects with State Highway 1, just north of Bixby Bridge. From the Coast Road, access to the community is provided through two wooden gates located where the Coast Road crosses Bixby Creek. The homes are scattered along the north and south sides of the creek, generally within 60- to -100 feet of the active channel. Flood terrace deposits flank the active channel and are generally 80- to 120- feet wide. Based on field observations, the homes within this community appear be at risk for potential flooding and debris flow hazards.

3.9.13 **Pico Blanco Boy Scout Camp –** The camp is located at the southeastern terminus of Palo Colorado Canyon Road along the Little Sur River. The site features numerous campgrounds, several permanent non-residential structures (lodge, trading post, boat house), a permanent caretakers residence, chapel, and dam/aquatics facility. Some facilities located along the Little Sur River are located within a DWR Awareness Floodplain, and others are located along tributary channels that drain the steep slopes adjacent to the camp. Palo Colorado Road is the sole vehicular access for the camp and has been subject to flooding during large rain events. The fire burned the slopes surrounding the camp and most of the Little Sur River drainage area upstream of the camp, creating a hazard of flooding along the Little Sur River and debris flows from tributary channels.

3.9.14 **Old Coast Road –** This road runs from the north side of the Bixby Creek Bridge, down across Bixby Creek, Up Sierra Creek, across Little Sur River, up the South Fork of Little Sur and back to Highway 1 near Molera State Park. All watersheds above the road were burned to some degree. Three crossings on the road could be subject to debris and flood flows, making the road impassable.

3.9.15 **Pfeiffer Big Sur State Park –** This State Park is situated along the banks of the Big Sur River below the confluence of Doland and Ventana Creeks. Depending on the severity of winter and spring rains, it is anticipated that the effects of the high and moderate burn severity in the watersheds of Doland Creek, Ventana Creek, Pfeiffer Redwood Creek, and the Upper Big Sur River will increase and magnify the size and intensity of flooding and debris flows on the Big Sur River within the park.

Campsites, roads, bridges and infrastructure within Pfeiffer Big Sur State Park are likely to sustain moderate to major damage. Particular concern is expressed along Pfeiffer Redwood Creek where post-fire debris flows impacted park grounds in 1973 (Cleveland, 1973) and in 2009 (Longstreth, 2013). Also of concern is the parks sewage treatment facility, scattered campgrounds, and associated structures. Bridges and culverts situated along Pfeiffer Redwood Creek are considered to be at risk for breaching or overtopping by flood waters or debris flows, with the resulting flows directed towards the park lodge (Big Lodge Sur) and parking lot. State Highway 1 opposite the entrance to the park may be undercut or removed by erosion (outside edge of meander) resulting from in-channel floods, hyperconcentrated floods, debris torrents, or debris flows on the Big Sur River.

3.9.16 **Big Sur Resorts -** Private campgrounds, cabins, resorts, shops, and other businesses are located along the bottom of Big Sur drainage. Photographs and anecdotal evidence obtained and viewed during the field visit suggest the site is subject to flooding, debris flows, and rock fall during heavy rains following fires. Cleveland (1973) documents flooding and damaging mudslides that occurred after the 1972 fires in the Big Sur watershed. It is anticipated that the effects of the high and moderate burn severity in the watersheds (Pheneger Creek, Juan Higuera Creek, Pfeiffer Redwood Creek, Upper Big Sur River) that drain to the developed Big Sur area will increase and magnify the size and intensity of flooding and mud flows, depending on the severity of winter and spring rains.

3.9.17 **Juan Higuerra Creek –** This creek drains to and under State Highway 1 via a bridge continuing through a culvert prior to entering Big Sur River. If the culvert plugs the creek can be diverted to what appears to be a small alluvial plain that contains scattered residential structures and the Big Sur Grange. Cleveland (1973) documents flooding and damaging mudslides that occurred after the 1972 fires in this area. It is anticipated that the effects of the high and moderate burn severity in the Juan Higuerra watershed will increase and magnify the size and intensity of flooding and the probability on debris flows, depending on the severity of winter and spring rains.

3.9.18 **Pheneger Creek** – This creek drains to and under Highway 1 via a metal culvert that will likely plug in the event of a debris flow event. The culvert drains to Big Sur Village containing business structures. Cleveland (1973) documents flooding and damaging mudslides that occurred after the 1972 fires in this area. It is anticipated that the effects of the high and moderate burn severity in the Juan Higuerra watershed will increase and magnify the size and intensity of flooding and the probability of debris flows, depending of the severity of winter and spring rains.

3.9.19 **Andrew Molera State Park –** This State Park is located along the floodplain near the mouth of the Big Sur River. The walk-in campground in the northern portion of the park is located on a floodplain that is about 10 to 15 feet above the active Big Sur River channel. Similarly the horse stables, barn, and residential structures at the southeast end of the park are located on a floodplain about 15 feet above the Big Sur River. Depending on the severity of winter and spring rains, it is anticipated that the effects of the high and moderate burn severity in the watersheds of Big Sur River will increase and magnify the size and intensity of flooding within the park.

4.0 Analysis and Observations

4.1 Soil Burn Severity

Rainfall intensity and the proportion of the watershed burned at moderate to high soil burn severity drives the potential for watershed response. Figures in Appendix B show the distribution of soil burn severity across the Soberanes Fire area. The proportion of “pour point” watersheds burned at low, moderate, high soil burn severity is summarized in Table 2.

Table 2. Soil burn severity summary for "Pour Point" watersheds

Watershed "Pour Point"	% of Watershed					
			Burn Severity			
	Unburned	Burned	Low/Very Low	Moderate	High	No data
Carmel River @ Mouth	83.3%	16.7%	8.0%	8.2%	0.3%	0%
Carmel River @ Los Gazas	79.9%	20.1%	9.7%	9.9%	0.4%	0%
Carmel @ Tularcitos	78.7%	21.3%	9.8%	10.8%	0.4%	0%
San Clemente @ SC dam	53.7%	46.3%	24.3%	20.7%	1.4%	0%
San Clemente @ Black Rock	96.1%	3.9%	2.7%	1.2%	0.0%	0%
Black Rock Creek	8.4%	91.6%	47.5%	41.3%	2.8%	0%
Carmel @ SC Dam	49.4%	50.6%	22.5%	26.4%	0.8%	1%
Carmel @ Cachuaga	57.2%	42.8%	16.1%	24.9%	0.6%	1%
Big Sur River @ Mouth	30.8%	69.2%	17.0%	33.0%	3.6%	16%
Juan Higuera Creek	13.6%	86.4%	12.4%	74.0%	0.0%	0%
Phenegan Creek	65.6%	34.4%	11.4%	22.8%	0.1%	0%
Pfieffer Redwood Creek	0.0%	100.0%	33.7%	66.1%	0.2%	0%
Upper Big Sur River @ 101 Bridge	23.4%	76.6%	18.7%	35.0%	4.3%	19%
San Jose Creek	68.4%	31.6%	18.7%	12.6%	0.3%	0%
Malpaso Creek	24.9%	75.1%	46.9%	27.9%	0.3%	0%
Soberanes Creek	9.5%	90.5%	40.6%	49.3%	0.6%	0%
Doud Creek	8.7%	91.3%	19.8%	65.4%	6.0%	0%
Rocky Creek	4.3%	95.7%	18.5%	66.1%	11.1%	0%
Joshua Creek	6.0%	94.0%	16.1%	70.4%	7.6%	0%
Lower Garrapata	12.2%	87.8%	9.4%	71.2%	7.2%	0%
Upper Garrapata	1.4%	98.6%	9.9%	77.5%	11.2%	0%
Lower Palo Colorado	61.4%	38.6%	5.2%	32.7%	0.7%	0%
Upper Palo Colorado	9.0%	91.0%	12.5%	76.6%	1.8%	0%
Bixby Creek	26.4%	73.6%	26.5%	42.7%	4.4%	0%
Lower Little Sur	11.9%	88.1%	28.3%	59.3%	0.3%	0%
Upper Little Sur @ Boy Scout	8.1%	91.9%	21.2%	70.0%	0.3%	0%

4.2 Flood Flow Model Results

Predicted percentage increases for a 10-year flood flow are shown below in Table 3. Refer to Appendix C for specific "pour point" discussion and Figure 5 (or Appendix B) for location of "pour point" watersheds.

Table 3 –Increased flow from pre-fire condition summary. Post-fire increases greater than 50 percent are highlighted in red.

ID	Watershed	Increased Flow From Pre-Fire Conditions*	Post Fire Adjusted Return Interval*
1	Pheneger Creek	25%	25
2	Juan Higuera Creek	77%	50
3	Pfeiffer Redwood Creek	73%	50
4	Little Sur River	65%	50
7	Rocky Creek	81%	100
8	Palo Colorado Lower Canyon	35%	25
9	Palo Colorado Upper RD crossing	81%	100
10	Garrapatos RD	90%	100
11	Mouth of Garrapata	80%	50 - 100
12	Doud Creek	75%	25 - 50
17	Soberanes Creek	55%	25 - 50
18	Malpaso Creek	39%	25
19	Carmel River	19%	25
20	San Clemente Creek/San Clemente Dam	29%	25
23	Carmel @ Cachuaga	16%	25
21	San Jose Creek	19%	25
25	Middle Little Sur	74%	50 - 100
27	San Clemente Creek/Dormody RD	3%	10
28	Black Rock Creek	54%	25 - 50
30	Bixby Creek on Coast Road	61%	25 - 50
N1	Carmel River Watershed	15%	25
N2	Carmel River Upstream of Las Gazas Creek	17%	25
N3	Carmel River Upstream of Tularcitos Creek	18%	25
N4	Joshua Creek	82%	50
N5	Lower Garrapata	81%	50 - 100
N6	Upper Big Sur River @ 101 Bridge	57%	50
N7	Big Sur River @ Mouth	53%	25 - 50

** Calculated for the 10 year return interval*

4.3 Debris Flow Model Results

Refer to the USGS model results map in Appendix B and discussion in Appendix C and the Basin Flow Probability Map in Appendix H.

4.4 Emergency Determination - Exigencies

The emergency to values at risk from geologic and hydrologic hazards (i.e., debris landslides, debris flows, rockfall, and flooding) caused by the fire include adverse effects for the health and safety of people, residences, roads and bridges within the wildfire area. Of particular concern is the potential risk for loss of life and property in moderate to high soil severity burn areas within the wildland/urban interface. Based on the WERT field observations, particular concern for the potential risk for loss of life and limb downslope of high and moderate soil severity burn areas exist at the Big Sur, Lower Bixby Creek community, Palo Colorado communities, Garapata/Joshua Creek communities, and San Clemente Rancho.

Table 4: Exigency summary table for the 2016 Soberanes Fire

Resources at Risk	**Likelihood**	**Consequence**	**Risk Rating**
Campgrounds, facilities, and structures on the **Big Sur River** (flooding)	Possible to Likely	Medium to High	Medium to High
Residences and State Highway 1 within and near **Juan Higuera Creek** (debris flow)	Possible to Likely	High	High
Residences, State Highway 1, and Big Sur near **Pfeiffer Redwood Creek** (debris flow)	Likely to Very Likely	Medium to High	High to Very High
Residences, structures, State Highway 1 near **Pheneger Creek** (debris flow)	Likely to Very Likely	Medium to High	High to Very High
Residences located near or with the lower reach of **Bixby Creek** (debris flow and/or flooding)	Possible to Likely	Medium to High	High
Residences and road infrastructure in the Palo Colorado Communities drained by **Garrapato Creek, Palo Colorado Canyon, Rocky Creek, Turner Creek, Mill Creek** (debris flow and/or flooding)	Likely to Very Likely	Medium to High	High to Very High
Residences and road infrastructure in the Palo Colorado Communities drained by **Joshua Creek and Garrapato Creek** (debris flow and/or flooding)	Possible to Likely	Medium to High	High
Residences and road infrastructure in the San Clemente Rancho drained by **South Fork Black Rock, Black Rock, and San Clemente Creeks** (debris flow and/or flooding)	Possible to Likely	Medium to High	High

*****qualitative ratings based upon observed field conditions by licensed professionals.

4.5. General Recommendations

- Early Warning Systems

Existing early warning systems should be used and improved such that residents can be alerted to incoming storms, allowing enough time to safely vacate hazard areas. In areas where cell reception is poor or non-existent methods should be developed to effectively contact residents.

This may include contacts made by mutual water companies located within the general area (B. Hecht, Balance Hydrologics, Berkeley, CA, personal communications.

Currently, Monterey County has an ALERT flood warning system in place that may need repair or upgrading after the Soberanes Fire (see below and: http://www.mcwra.co.monterey.ca.us/flood_warning/ALERT_system.php

Flood Warning

ALERT Flood Warning System

Following the Marble Cone fire of 1977, Monterey County began the installation of one the first ALERT flood warning networks anywhere. ALERT (Automated Local Evaluation in Real Time) is a communications protocol that was developed by the National Weather Service in the 1970's. ALERT is a reliable, low cost method of transmitting environmental data from remote sites to a central database in real time. ALERT compatible hardware and software has continued to improve and is currently being used for environmental monitoring and flood warning systems throughout the world.

The current Monterey County ALERT flood warning system is operated and maintained by the Monterey County Water Resources Agency. The system consists of approximately 50 remote sites located throughout the major watersheds of Monterey County. These remote sites measure a variety of environmental factors including rainfall, water level, and air temperature that are used to forecast flooding and monitor storm events..

Data from the Monterey County flood warning system can be monitored by MCWRA staff through a secure web based interface from any computer or mobile device with internet access and a web browser. The modern web based system, in conjunction with the redundant ALERT radio backbone, allow reliable access to real time hydrologic data in even the worst storm conditions. Data from the Monterey County flood warning system is used to support flood monitoring operations by the Water Resources Agency as well as the National Weather Service, and the California Nevada River ForecastCenter.

Emergency-response and public-safety agencies are faced often with making decisions and deploying resources both well in advance of each coming winter storm and during storms themselves. Information and methodology critical to this process is provided for by the USGS open file report OF10-1039 that can be accessed at: http://pubs.usgs.gov/of/2010/1039/pdf/OF10-1039.pdf.

For post-fire debris flow hazards, warnings with practical lead times of several hours must come from a combination of weather forecasts, rainfall measurements of approaching storms, and debris-flow triggering thresholds. The USGS has worked together with the National Weather Service (NWS) to provide guidance for post-fire debris flow thresholds that may be used by the NWS for "watch" and "warning" notifications: http://landslides.usgs.gov/hazards/warningsys.php

- <u>Road Drainage Systems and Storm Patrols</u>

Existing road drainage systems should be inspected by the appropriate controlling agency to evaluate potential impacts from floods, hyperconcentrated floods, debris torrents, debris flows and sedimentation resulting from storm events. Additional modeling of sedimentation can be done through the use of sedimentation models such as ERMiT and WEPP.

- <u>Structure Protection</u>

Possible structure protection measures should be coordinated through Monterey County OES and the NRCS. Debris flow mitigation measures can consist of K--Rails, H-beams with wood lagging, plywood, sand bagging, and Muscle Wall installations. For the 2008 Basin-Indians Complex, limited options were available in some locations due to access issues and access-driven costs (Fisher et al. 2009), and these could be significant constraints for post-fire construction work for some parts of the Soberanes Fire footprint and downstream locations.

- <u>Temporary Housing</u>

When there is need for temporary housing or new building construction for residents displaced by the fire, site-specific evaluation of hazards for temporary housing should be conducted by a qualified professional and in accordance with the local lead agency . The following factors should be considered as part of the evaluation.

<u>On hillslopes above potential temporary housing and building sites:</u>

Could runoff from the hillslope concentrate in swales and small drainages and flow onto the site, and flood or otherwise damage the proposed structure, or present a life-safety hazard?

- ✓ Is the hillslope behind the structure steep and erodible, where rilling, gullying, or shallow failures could deliver a sufficient volume of sediment and debris to damage the proposed structure or pose a life-safety hazard?
- ✓ Are large rocks, boulders, or other material present on the slope that pose a rock- or debris fall hazard that could impact the proposed structure, or present a life-safety hazard?
- ✓ Is there evidence of recent or impending erosion or mass wasting that could damage the proposed structure or pose a life/safety hazard (e.g. debris torrents/flows, deep-seated slides or slumps)?

<u>On hillslopes below potential temporary housing and building sites:</u>

- ✓ Is there evidence of recent or impending fill slope landslide-type failures that indicate an elevated risk of building pad failure?
- ✓ Is the building pad located above a watercourse where normal- or flood flows could potentially erode the toe of the slope and trigger failure?

If any of these conditions are present, then mitigations need to be implemented, or alternative sites need to be identified and evaluated. Technical experts such as licensed engineers or geologists may be needed to support the evaluation.

4.6 Localized Observations and Recommendations

4.6.1 Lower Carmel

4.6.1.1 Lower Carmel @Mouth

- **Specific Observations -** One specific observation (VAR 569) was made in the mouth of the Carmel River watershed. This consists of a bathroom and parking lot at Carmel State Beach. The parking lot and bathroom structure are located in the FEMA 100-year flood zone. The parking lot and bathroom structure appear to be at a moderate risk of flooding. During our evaluation we spoke with a representative of California State Parks (Mr. John Hiles) who indicated that the parking lot regularly floods. Mr. Hines indicated that sand bagging is usually used to minimize flooding of the parking lot and bathroom structure.
- **General Recommendations**
  - Develop flood protection measures for the Carmel State Beach parking lot and bathroom structure.
  - Even though the Carmel River is not modeled as a “watch stream”, because the area drains a large area flood hazards analyses may need to consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.

4.6.1.2 Gazas Creek @ Carmel River

- **Specific Observations -** Five specific observations were made in the Carmel River – Las Gazas watershed (VAR 144-147 and 162). Four of the locations consist of road watercourse crossings (two culverts, a bridge and a footbridge) in the Santa Lucia Preserve. The risk to property and life at these locations appears low. The final location consists of residences located in the FEMA 100-year flood zone near the confluence of Las Gazas Creek and the Carmel River. Because of the potential for increased flooding, the risk to life and property was recorded as high.
- **General Recommendations**
  - Develop an early warning system for residents in the FEMA 100-year flood zone (VAR 162).
  - Develop a storm watch patrol for points in the Santa Lucia Preserve (VAR 144 - 147) so that watercourse crossings may be observed for blockage and cleaned out during and after storms.

4.6.2 Upper Carmel

4.6.2.1 Carmel River @Tularcitos Creek

- **Specific Observations -** One specific observation (VAR 200) was made within the Carmel River at Tularcitos pour point. This consists of a fish hatchery that is operated by the Monterey Peninsula Water Management District (MPWMD). The hatchery located in close proximity to the FEMA 100-year flood zone was assessed to be at a relatively low risk from flooding.

4.6.2.2 San Clemente

- **Specific Observations**
  - San Clemente Rancho Community (VAR 148-152) It is anticipated that the effects of the generally low and moderate burn severity of the slopes in the Black Rock Creek watershed may increase and magnify the size and intensity of flooding, debris flows, and mud flows depending on the severity of the winter and spring rains. A number of homes and associated infrastructure were observed on an alluvial fan at the base of Black Rock Creek and may be impacted by potential debris flow and/or flooding. A number of homes, associated infrastructure, and a community center were noted in close proximity to San Clemente Creek from the confluence with Black Rock Creek to Trout Lake (a man-made lake on San Clemente Creek). These features may be impacted by potential flooding. An early warning system tied to prediction of incoming storm events will allow inhabitants to vacate buildings prior to triggering rainfall events. Storm patrol between and during large rainfall events in order to keep culverts and drainage structures functional can help maintain road access.
  - White Rock Community (VAR 153-154) It is anticipated that the effects of the generally low and moderate burn severity of the slopes in the Black Rock Creek watershed may increase and magnify the size and intensity of flooding and debris flows, depending on the severity of the winter and spring rains. A residence and a bridge that appears to be the only access to several residences upstream are located in the floodplain of Black Rock Creek and may be impacted by potential flooding and/or debris flows. An early warning system tied to prediction of incoming storm events will allow inhabitants to vacate buildings prior to triggering rainfall events. Storm patrol between and during large rainfall events in order to keep culverts and drainage structures functional can help maintain road access.
- **General Recommendations**
  - A bulking factor for flow analysis should be considered for “watch stream” segments when designing mitigations. It has been our experience that a bulking factor of at least 50 percent has been used in other post-fire responses.
  - White Rock Community, Rancho San Clemente Community (VAR 148-154): Early warning system, storm patrol.

4.6.2.3 Carmel River @ San Clemente Dam

- **General Observations**
  - (VARs 155, 156, 159, 163, 201) It is anticipated that the effects of the generally moderate burn severity of the slopes that drain into the Carmel River may increase and magnify the size and intensity of flooding, depending

on the severity of the winter and spring rains. A number of homes, cabins, and associated infrastructure were noted in close proximity to the Carmel River in this area. These features may be impacted by potential flooding. An early warning system tied to prediction of incoming storm events will allow inhabitants to vacate buildings prior to rainfall. Storm patrol between and during large rainfall events in order to keep culverts and drainage structures functional can help maintain road access.

  - (VARs 157-158) It is anticipated that the effects of the generally low and moderate burn severity of the northeast facing slopes that drain into the Carmel River may increase the potential for debris flows, depending on the severity of the winter and spring rains. A residence and a culvert along a road that appears to be the only access route are located across or in close proximity to channels and may be impacted by potential debris flows. An early warning system tied to prediction of incoming storm events will allow inhabitants to vacate buildings prior to triggering rainfall events. Storm patrol between and during large rainfall events in order to keep culverts and drainage structures functional can help maintain road access.
- **General Recommendations**
  - Because "watch stream" flood hazards are present, any flood analyses should consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.
  - An early warning system tied to predicted storm events should be developed for these areas. Because cell reception is poor in these areas, a reverse 911 or "Nixle" system may not provide an adequate warning system.

4.6.2.4 Carmel River @ Cachuaga

- **General Observations** - USGS modeled "watch streams" drain into the Los Padres Dam.
- **Specific Observations** - None. No specific features or locations were identified.
- **General Recommendations**- Because "watch stream" flood hazards are present, any flood analyses should consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.

4.6.3 Upper Coastal Waterheds

4.6.3.1 San Jose Creek

- **Specific Observations**
  - (VAR 143 and 630) This group of residences is located at the base of White Rock Ridge, within the headwaters of San Jose Creek, which experienced low to high burn severity. Specifically, both of the homes have been constructed on debris/alluvial fans that drain the burned areas. It is anticipated that the effects of the low to high burn severity in the watershed that drains to the homes will increase and magnify

the size and intensity of rainfall runoff that could lead to debris flows, and mud flows, depending on the severity of winter and spring rains. Such flows and flooding may likely impact the residences.

- (VAR 570) This point is located in Carmel River State Beach, where San Jose Creek drains into the Pacific Ocean. It is anticipated that the effects of the low to high burn severity within the headwaters of the watershed will increase and magnify the size and intensity of rainfall runoff that could lead to flooding depending, on the severity of winter and spring rains. Such flooding may likely impact the existing residential structures within low lying areas.

- **Recommendations**
  - Follow recommendations in Appendix D.

4.6.3.1.1 Malpaso, Soberanes and Doud Creeks

- **Specific Observations**
  - VAR 165 is located within the mid-stream portion of the Malpaso Creek watershed, which experienced low to moderate burn severity. Specifically, this point is located adjacent to the Malpaso Water District facilities that consist of several wells and a conveyance pipeline. It is anticipated that the effects of the low to moderate burn severity in the watershed that drains towards the Malpaso Water District facilities will increase and magnify the size and intensity of rainfall runoff that could lead to flooding, debris flows, and mud flows, depending on the severity of winter and spring rains. Such flows and flooding may likely impact the existing infrastructure.
  - Refer to Appendix D for VAR 571 and 572.
- **Specific Recommendations**
  - Follow specific recommendations in the Appendix D.

4.6.4 Middle Coastal Watersheds

4.6.4.1 Joshua Creek/Lower Garrapata Creek

- **General Observations**
- (VARS: 109-126) This group is located at the base of the headwaters of Joshua Creek which experienced low to high burn severity. Dry ravel was observed on the very steep slopes (greater than 100%) that form the upper headwater slopes. It is anticipated that the effects of the low to high burn severity in the watershed that drains to the residential area will increase and magnify the size and intensity of rainfall runoff that could lead to flooding, debris flows, and mud flows, depending on the severity of winter and spring rains. Such flows and flooding may likely impact homes and existing infrastructure, including a bridge that provides access to a residence, culverts (some of which are plastic and have melted), the road prism and several water tanks that were placed within the active channel.
- (VAR 127-131) This group of residences is located near the confluence of Joshua and Garrapata Creeks which experienced moderate burn severity. It

is anticipated that the effects of the moderate burn severity in the watershed that drains towards Lower Garrapata Creek will increase and magnify the size and intensity of rainfall runoff that could lead to flooding, depending on the severity of winter and spring rains. Such flows and flooding may likely impact the existing residential structures that are located within the floodplain, as well as infrastructure, including watertanks.

- **General Recommendations**
    - VAR 109-126, Perform storm patrols and monitor road drainage infrastructure. Replace any existing plastic culverts that were destroyed in the fire.
    - VAR 127-131, Perform storm patrols and monitor road drainage infrastructure.

4.6.4.2 Palo Colorado Community

- **General Observations**
  (see site-specific descriptions for VARs 100-108, 132-141, 500-550 and 625-627; Appendix D).

  It is anticipated that the effects of the generally moderate burn severity of the slopes in the greater Palo Colorado community will increase and magnify the size and intensity of flooding, debris flows, and mud flows, depending on the severity of the winter and spring rains. The greater Palo Colorado community includes a group of residences in or in close proximity to channels that are subject to potential debris flows and/or flooding. This includes residences along Palo Colorado Canyon Road, in the Green Ridge Road area, in the Hoist area, and in the Garrapatos Road area. Additionally, a number of residences in these areas are accessed via watercourse crossings (i.e., bridges, culverts) that may be impacted by potential flooding and debris flows. Palo Colorado Canyon Road serves as the primary ingress/egress route for all of these communities and it was observed that this road crosses numerous watercourses that may be impacted by potential flooding and/or debris flows. An early warning system tied to prediction of incoming storm events will allow inhabitants to vacate buildings prior to triggering rainfall events. Storm patrol between and during large rainfall events in order to keep culverts and drainage structures functional can help maintain road access. Clearing the channel and floodplain of debris at recommended locations can improve flow and prevent debris from becoming mobilized in debris flows or floods, which can help to maintain functionality of drainage structures.
- **Specific Recommendations:**
- Follow specific recommendation for VARs provided in Appendix D.
- **General Recommendations:**

- Because “watch stream” flood hazards are present, any flood analyses should consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.
- An early warning system tied to predicted storm events should be developed for the Palo Colorado and Lower Bixby communities. This includes residential structures and road drainage features along Palo Colorado Road. Because cell reception is poor in these areas a reverse 911 or “Nixle” system may not provide an adequate warning system.

4.6.4.3 Bixby Creek

- **General Observations**
  - (VAR 552-561) This group of residences and a bridge is located at the base of the headwaters of the Bixby Creek, which experienced moderate to high burn severity. Dry ravel was observed on the very steep slopes (greater than 100%) that form the upper headwater slopes along Long, Skinner and Mescal Ridges. It is anticipated that the effects of the moderate to high burn severity in the watershed that drains to the residential area will increase and magnify the size and intensity of rainfall runoff that could lead to flooding, debris flows, and mud flows, depending on the severity of winter and spring rains. Such flows and flooding may likely impact homes and existing infrastructure, including several bridges that provide access to some of the residences.
  - (VAR 603-612) This group of culverts and one residence is located near the base of the headwaters of the Sierra Creek, which experienced moderate burn severity. Dry ravel was observed on the very steep slopes (greater than 100%) that form the upper headwater slopes along the south side of Mescal Ridge. It is anticipated that the effects of the moderate burn severity in the watershed that drains along the Coast Road will increase and magnify the size and intensity of rainfall runoff that could lead to flooding, debris flows, and mud flows, depending on the severity of winter and spring rains. Such flows and flooding may likely impact the existing infrastructure, including the culverts and road prisms.

- **General Recommendations:**
  - Because “watch stream” flood hazards are present, any flood analyses should consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.
  - An early warning system tied to predicted storm events should be developed for the Palo Colorado and Lower Bixby communities. This includes residential structures and road drainage features along Palo Colorado Road. Because cell reception is poor in these areas, a reverse 911 or “Nixle” system may not provide an adequate warning system.

4.6.5 Little Sur

4.6.5.1 Upper Little Sur Boy Scout Camp

- **General Observations:**

  The Pico Blanco Boy Scout Camp (VAR 101) is located at the base of the headwaters of the Little Sur River, which experienced high and moderate burn severity. Dry ravel was observed on the very steep slopes (greater than 100%) that form the upper headwater slopes that overlook the camp area. It is anticipated that the effects of the high and moderate burn severity in the watershed that drain to the camp area will increase and magnify the size and intensity of rainfall runoff that could lead to flooding, debris flows, and mud flows, depending on the severity of winter and spring rains. Such flows and flooding may likely impact existing infrastructure, including a concrete dam, boat house, spring box and water filtration system, and campgrounds located along the bottom of the Little Sur River or below steep slopes that drain to the river. The access road leading to the Boy Scout Camp that crosses several streams experienced moderate burn severity; it is evaluated and commented on in the USFS BAER report (USFS, 2016). Their report contains specific recommendations regarding the access road that can be found at the following link (http://inciweb.nwcg.gov/incident/5017/). The WERT did not evaluate the camp access road. If the road is damaged, access may be cut off from the camp during and following heavy rains. Also, during the WERT visit, the team met an aborist (Mr. Frank Ono, F.O. Consulting) who was evaluating tree fall hazard. Mr. Ono indicated that there appears to be a significant tree fall hazard in the camp area.

- **General Recommendations**
  - The Boy Scout Camp should be closed during storm events in order to minimize potential risk to life.
  - Because the Little Sur River is modeled as a “watch stream” a bulking factor for flow analysis should be considered when designing mitigations. It has been our experience that a bulking factor of at least 50 percent has been used in other post-fire responses.
  - Follow recommendations provided in the BAER analysis of the camp access road.
  - Follow recommendations regarding tree hazards (F.O. Consulting).

4.6.5.2 Lower Little Sur

- **Specific Observations:**

  Refer to VAR 613 (see Appendix D). Only one specific observation was made in the lower Little Sur River watershed. This consists of a bridge crossing of the river. The bridge appeared to span the river and is located relatively high over the river. There appeared to be a low risk of damage to the bridge.

Conducting storm patrols after winter storms will enable evaluation of whether the bridge is at risk of being blocked with debris or damaged.

- **General Recommendations:**
  - Conduct storm patrols of the bridge during and following storm events.
  - Because the Little Sur River is modeled as a “watch stream,” flood hazards analyses may need to consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.

4.6.6 Big Sur River

- **Specific Observations:**
  - See site-specific descriptions for points 562-568, 573-581 and 614-624, Appendix D).
  - Historic debris flows documented along the Big Sur River and south to Julia Pfeiffer Burns State Park indicate that since 1908 a minimum of nine debris flow events have occurred following wildfire (Cleveland, 1973; Jackson, 1977; JRP Historical Consulting Services, 2001; Wills et al., 2001; Longstreth, 2013) with the most recent debris flows occurring after the 2008 Basin-Indians Complex fire. Cleveland (1973) documents flooding and damaging mudslides that occurred after the smaller 1972 fires in the Big Sur watershed. Campgrounds, cabins, resorts, shops, and other businesses are located along the bottom of Big Sur Drainage. It is anticipated that the effects of the moderate burn severity in the watersheds (Pheneger Creek, Juan Higuera Creek, Pfeiffer Redwood Creek) that drain to the developed Big Sur area and State Park areas (Andrew Molera and Pfeiffer Big Sur State Park) will increase and magnify the size and intensity of flooding, debris flows, and mud flows, depending on the severity of the winter and spring rains. Past mitigations have included placement of structures (K-Rails, H-beams with wood lagging, plywood, sand bagging) to direct flow to areas where debris will be minimized from impacting infrastructure. An early warning system tied to prediction of incoming storm events will allow inhabitants to vacate buildings prior to triggering rainfall events.
- **Specific Recommendations:**
  - Follow emergency protective measures listed in Appendix D.
- **General Recommendations:**
  - Develop an early warning system.
  - State Park campgrounds at Andrew Molera and Pfeiffer Big Sur State Parks within the 100-year FEMA flood zone should be closed during storm events.
  - Because the Big Sur River is modeled as a “watch stream”, a bulking factor for flow analysis should be considered when designing mitigations. The bulking factor should be used to estimate areas of potential flooding exceeding the FEMA 100-year flood zone. It has been our experience that a bulking factor of 50 percent has been used in other post-fire responses.

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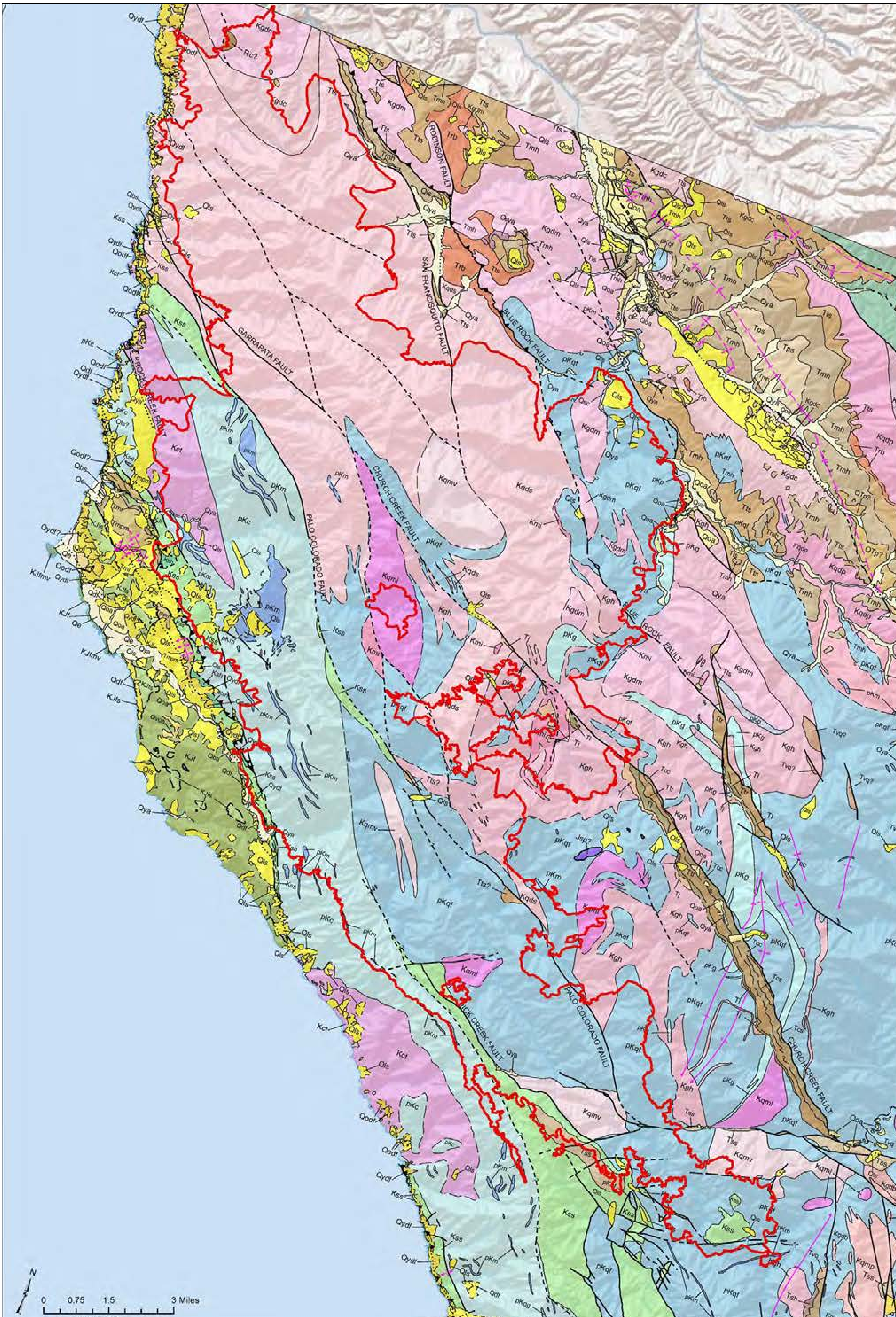


Appendix A
Geology Map
Soberanes Incident
CA-BEU-003422

Source : Preliminary Geologic Map of the Point Sur 30' x 60' Quadrangle , California. Rosenberg and Wills, 2016

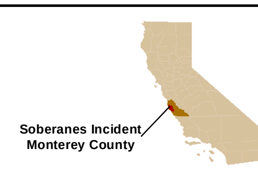
Soberanes Incident
Monterey County
Perimeter from 2016/09/12

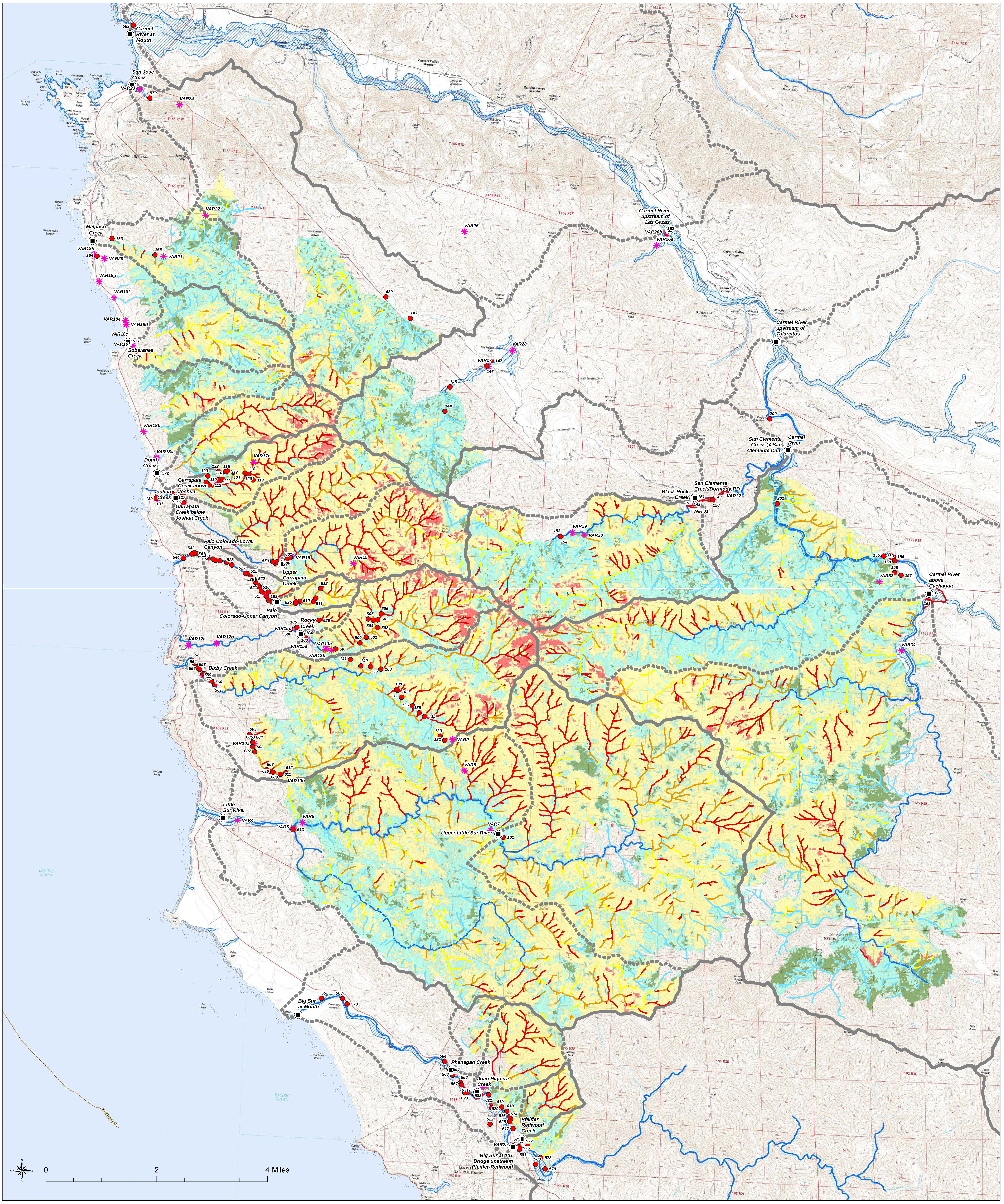
Geologic Map Units - Soberanes Burn Area

af	Artificial fill
Qsc	Modern stream channel deposits
Qdf, Qydf, Qodf	Debris fan
Qls	Landslide deposits
Qya, Qoa	Alluvium
Tmpm	Miguelito member - Pismo Formation
Tmr	Rincon Shale
Tts, Tss	Marine Sandstone
Tl	Lucia Shale
Tj	Junipero Sandstone
Tc	Carmelo Formation
Ksh	Marine Shale
Kss	Marine Sandstone
Kgdc, Kqds, Kgh, Kmi, Kqml, Kct	Salinas Complex Granitic Rocks
KJf	Greywacke and melange - Franciscan Complex
Jsp	Serpentinite - Franciscan Complex
pKc, pKg, pKp, pKqf, pKm	Salinas Complex Metamorphic Rocks
	Geologic contact: Solid where accurately located, dashed where inferred, dotted where concealed.
	Fault: Solid where accurately located, dashed where inferred, dotted where concealed.

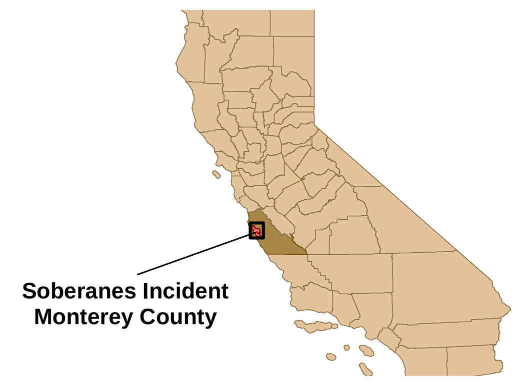
Map units generalized from Preliminary Geologic Map of the Point Sur 30' x 60' Quadrangle, California. Rosenberg and Wills, 2016

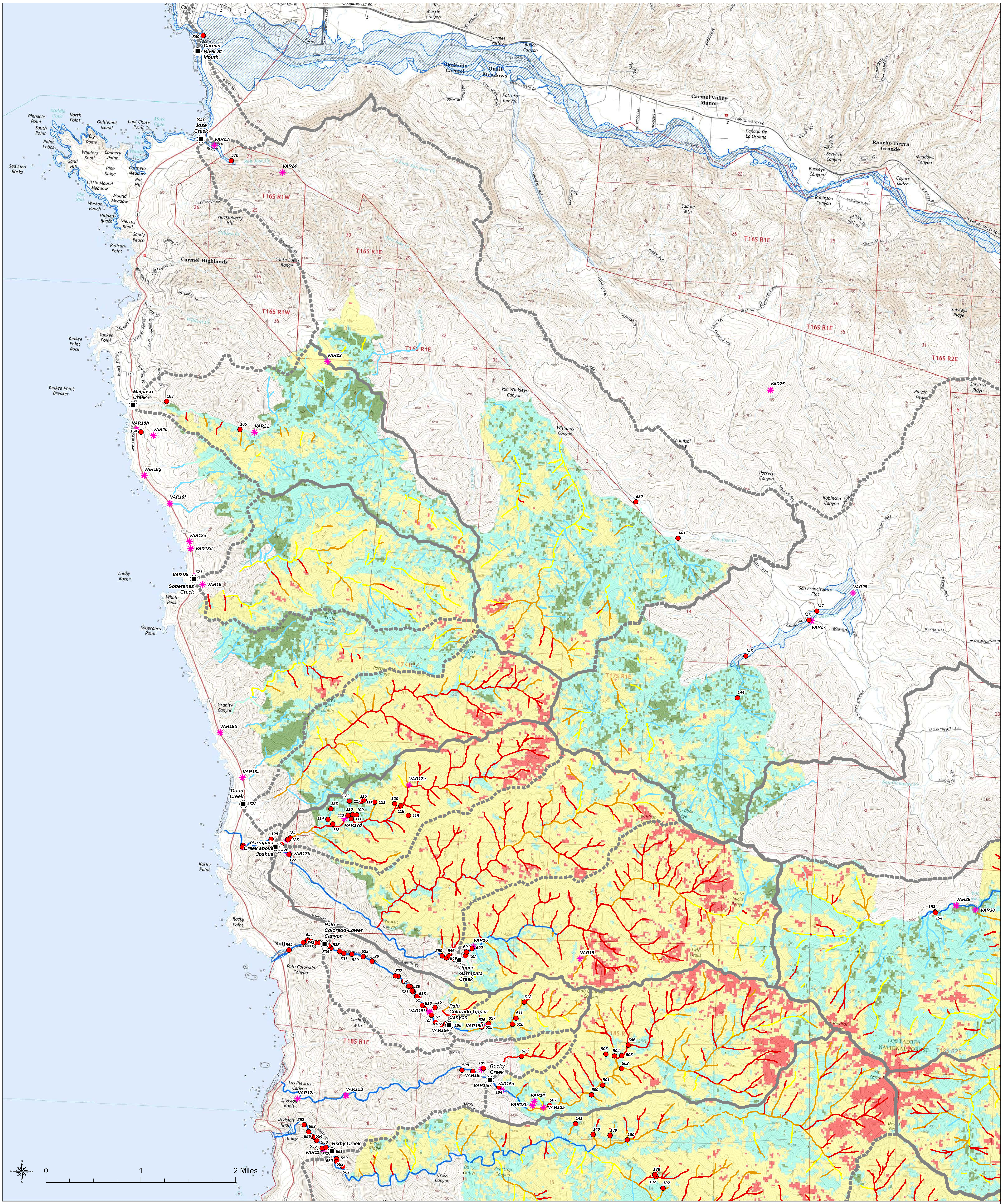
Geology Map
Soberanes Incident
CA-BEU-003422





Appendix B
Values at Risk
Soberanes Incident
CA-BEU-003422





- Pour Points
- BAER Identified Values at Risk (VAR)
- WERT Values at Risk - Points
- WERT Values at Risk - Polygon
- Analysis Tier 3
- USGS Model Watch Stream
- DWR Awareness Floodplains
- FEMA Special Flood Hazard Area

Debris Flow Prediction
15 min 28 mmh
- 0-20%
- 20-40%
- 40-60%
- 60-80%
- 80-100%

Soil Burn Severity
- Unburned/Very Low
- Low
- Moderate
- High

Appendix B
Values at Risk - Coastal
Soberanes Incident
CA-BEU-003422

Pour Points
BAER Identified Values at Risk (VAR)
WERT Values at Risk - Points
WERT Values at Risk - Polygon
Analysis Tier 3
USGS Model Watch Stream
DWR Awareness Floodplains
FEMA Special Flood Hazard Area

Debris Flow Prediction
15 min 28 mmh
0-20%
20-40%
40-60%
60-80%
80-100%

Soil Burn Severity
Unburned/Very Low
Low
Moderate
High

Appendix B
Values at Risk - Big Sur
Soberanes Incident
CA-BEU-003422

Appendix B
Values at Risk - Carmel
Soberanes Incident
CA-BEU-003422

Appendix C. Flood and Debris Flow Model Results and Discussion

1. Lower Carmel

1.1. **Mouth**

1.1.1. **Flood Flow Model Results -** The WERT added a pour point at the mouth of Carmel River to better understand the effects of the burn area on the entire Carmel watershed. See table 4 for model results on pour point N1. Pour point N1 analyzes approximately 255 sq. miles of watershed area of which 8.5% had a high or moderate burn severity classification. The pour point was analyzed for a 10 year flood event. The adjusted post fire design flow modifier for pour point 35 was calculated at 1.15. Therefore, flows at the mouth of the Carmel River are estimated to be 1.15 times (15% increase) in pre-fire flow values. Results from the flood model show that a 10 year event at the mouth of the Carmel River is approximately in the magnitude of a 25 year event in pre-fire conditions.

1.1.2. **Debris Flow Model Results-** Because a reltively small area of this watershed was burned (17 percent) very little USGS debris flow modeling results (28mm/hr design storm) appears to impact this water shed. The modeling indicates modeled debris flows in headwater tributaries high in the watershed with probabilities generally ranging from 40 to 100 percent. The USGS debris flow modeling does not shows the Carmel River as a “watch stream”, however a FEMA 100-year flow zone along the Carmel River.

1.2. **Gazas Creek @ Carmel River**

1.2.1. **Flood Flow Model Results -**The WERT added a pour point at the downstream confluence of the Carmel River and Las Gazas Creek to better understand the effect of the burn area on the lower Carmel watershed. See table 4 for model results on pour point N2. Pour point N2 analyzes approximately 211 sq. miles of watershed area of which 10.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point N2 was calculated at 1.17. Therefore, flows at the downstream confluence of the Carmel River and Las Gazas Creek are estimated to be 1.17 times (17% increase) pre-fire flow values. Results from the flood model show that a 10 year event at the confluence of the Carmel River and Las Gazas Creek is approximately in the magnitude of a 25 year event in pre-fire conditions.

1.2.2. **Debris Flow Model Results** - Because a relatively small area of this watershed was burned (20 percent) very little USGS debris flow modeling results (28mm/hr design storm) appears to impact this water shed. The modeling indicates modeled debris flows in headwater tributaries high in the watershed with probabilities generally ranging from 40 to 100 percent. The USGS debris flow modeling does not shows the Carmel River as a “watch stream”, however a FEMA 100-year flow zone along the Carmel River.

2. Upper Carmel

2.1. **Carmel River @Tularcitos Creek**

2.1.1. **Flood Flow Model Results-**The WERT added a pour point at the downstream confluence of the Carmel River and Turalcitos Creek to better understand the effect of the burn area on the upper Carmel watershed. See table 4 for model results on pour point N3. Pour point N3 analyzes approximately 184.3 sq. miles of watershed area of which 14.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point N3 was calculated at 1.18. Therefore, flows at the downstream confluence of the Carmel River and Turalcitos Creek are estimated to be 1.18 times (18% increase) pre-fire flow values. Results from the flood model show that a 10 year event at the confluence of the Carmel River and Turalcitos Creek is approximately in the magnitude of a 25 year event in pre-fire conditions.

2.1.2. **Debris Flow Model Results -**Because a relatively small area of this watershed was burned (20 percent) very little USGS debris flow modeling results (28mm/hr design storm) appears to impact this water shed. The modeling indicates modeled debris flows in headwater tributaries high in the watershed with probabilities generally ranging from 40 to 100 percent. The USGS debris flow modeling does not shows the Carmel River as a “watch stream”, however a FEMA 100-year flow zone along the Carmel River.

2.2. San Clemente @ San Clemente Dam

2.2.1. **Flood Flow Model Results -**The WERT used an existing BAER pour point 20 (Appendix B) in San Clemente Creek at the San Clemente Dam (decommissioned). See Table 3 for model results on pour point 20. Pour point 20 analyzes approximately 16.7 sq. miles of watershed area of which 22% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 20 was calculated at 1.29. Therefore, flows on the San Clemente Creek at San Clemente Dam (decommissioned) site are estimated to be 1.29 times (29% increase) pre-fire flow values. Results from the flood model show that a 10 year event on the San Clemente Creek at San Clemente Dam (decommissioned) is approximately in the magnitude of a 25 year event in pre-fire conditions

2.2.2. **Debris Flow Model Results-**Only a small portion of the headwaters of this drainage area burned. USGS debris flow modeling results (28mm/hr design storm) shows a 0 to 20 percent probability of debris flows for headwater tributaries that drain into Upper San Clemente Creek. These tributaries are more than 4 miles upstream from the confluence of San Clemente Creek and Black Rock Creek.

2.3. Carmel River @ San Clemente Dam

2.3.1. **Flood Flow Model Results -** The WERT used an existing BAER pour point 19 (Appendix B) in Carmel River at the San Clemente Dam (decommissioned). See table 3 for model results on pour point 19. Pour point 19 analyzes approximately 125.5 sq. miles of watershed area of which 17.5% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 19 was calculated at 1.19. Therefore, flows on the Carmel River at San Clemente Dam (decommissioned) site are estimated to be 1.19 times (19% increase) pre-fire flow values. Results from the flood model show that a 10 year event on the Carmel River at San Clemente Dam (decommissioned) is approximately in the magnitude of a 25 year event in pre-fire conditions.

2.3.2. Debris Flow Model Results The fire did not burn the Lower San Clemente watershed below the confluence of Upper San Clemente Creek and Black Rock Creek. The USGS debris flow modeling results (28mm/hr design storm) do not identify additional debris flow segments downstream of the confluence.

2.4. **San Clemente Creek @ Black Rock**

2.4.1. **Flood Flow Model Results-** The WERT used an existing BAER pour point 27 (Appendix B) on San Clemente Creek at Dormody Road. See table 3 for model results on pour point 27. Pour point 27 analyzes approximately 5.8 sq. miles of watershed area of which 1.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 27 was calculated at 1.03. Therefore, flows on the San Clemente Creek at Dormody Road are estimated to be 1.03 times (3% increase) pre-fire flow values. Results from the flood model show that a 10 year event on the San Clemente Creek at Dormody Road is comparable in magnitude of a 10 year event in pre-fire conditions.

2.4.2. **Debris Flow Model Results** Only a small portion of the headwaters of this drainage area burned. USGS debris flow modeling results (28mm/hr design storm) shows a 0 to 20 percent probability of debris flows for headwater tributaries that drain into Upper San Clemente Creek. These tributaries are more than 4 miles upstream from the confluence of San Clemente Creek and Black Rock Creek.

2.5 Black Rock @ SF Black Rock Creek

2.5.1 Flood Flow Model Results - The WERT used an existing BAER pour point 28 (Appendix B) at the confluence of Black Rock Creek and South Fork Black Rock Creek. See Table 3 for model results on pour point 28. Pour point 28 analyzes approximately 8.2 sq. miles of watershed area of which 44.1% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 28 was calculated at 1.54. Therefore, flows at the confluence of Black Rock Creek and South Fork Black Rock Creek are estimated to be 1.54 times (54% increase) pre-fire flow values. Results from the flood model show that a 10 year event at the confluence of Black Rock Creek and South Fork Black Rock Creek is approximately in the magnitude of a 25 to 50 year event in pre-fire conditions.

2.5.2 Debris Flow Model Results - USGS debris flow modeling results (28mm/hr design storm) generally shows a 40 to 100 percent probability of debris flows for headwater tributaries that drain into Black Rock Creek and South Fork Black Rock Creek. The model results generally show a 0 to 60 percent probability for north facing slopes and 60 to 100 percent probability of debris flows for south facing slopes along the main stems of both Black Rock Creek and South Fork Black Rock Creek. The results also indicate that the main stem of Black Rock Creek is a “watch stream”. It should be understood that the slopes in this area may be impacted directly by debris flows, while the main stem of Black Rock Creek may be impacted by the combined effects of debris flow and floods, including increased sediment and debris generated from upstream tributaries.

2.6 Carmel River @ Cachuaga

2.6.1 Flood Flow Model Results The WERT used an existing BAER pour point 23 (Appendix B) at the confluence of Carmel Creek and Cachuaga Creek. See Table 4 for model results on pour point 23. Pour point 23 analyzes approximately 108.9 sq. miles of watershed area of which

10.7% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 23 was calculated at 1.16. Therefore, flows at the confluence of Carmel Creek and Cachuaga Creek are estimated to be 1.16 times (16% increase) pre-fire flow values. Results from the flood model show that a 10 year event at the confluence of Carmel Creek and Cachuaga Creek is approximately in the magnitude of a 25 year event in pre-fire conditions.

2.6.2 Debris Flow Model Results -USGS debris flow modeling results (28mm/hr design storm) shows the majority of modeled debris flows in headwater tributaries (Ventana Mesa Creek and Rattlesnake Creek) that drain into the Carmel River generally ranging with probabilities between 60 to 100 percent. These drainages drain to the portion of the Carmel River that drains into the Los Padres Dam. The USGS debris flow modeling shows the lower Ventana Mesa Creek and Rattlesnake Creek as “watch streams”. The USGS stream watch segments shown in the model results indicate the presence of drainages within and below the burn area that can be impacted by the combined affects of debris flows and floods generated from tributaries. These are areas where a combination of runoff hazards may be present, and where flood hazards analyses may be need to consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.

3 Upper Coastal Watersheds

3.1 San Jose Creek

3.1.1 **Flood Flow Model Results -** The WERT used an existing BAER pour point 21 (Appendix B) on the mouth of San Jose Creek at Carmel River State Beach. See Table 3 for model results on pour point 21. Pour point 21 analyzes approximately 14.1 sq. miles of watershed area of which 16.1% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 21 was calculated at 1.19. Therefore, flows at San Jose Creek at Carmel River State Beach are estimated to be 1.19 times (19% increase) pre-fire flow values. Results from the flood model show that a 10 year event at San Jose Creek at Carmel River State Beach is approximately in the magnitude of a 25 year event in pre-fire conditions.

3.1.2 **Debris Flow Model Results -** USGS debris flow modeling results (28mm/hr design storm) generally shows a 20 to 100 percent probability of debris flows for the headwater tributaries that drain north facing slopes from the ridge line of White Rock Ridge. These drainages drain towards two residential homes, MP 143 and 630, which are located on debris/alluvial fans adjacent to San Jose Creek. Downstream, San Jose Creek drains towards residential structures located within Carmel River State Beach, MP 570. It should be understood that although Carmel River State Beach is not located within an area of mapped debris flow hazards, it could be impacted directly by flood flows that travel through the area via San Jose Creek. The USGS debris flow modeling does not show San Jose Creek as a “watch stream”.

3.2 Malpaso, Soberanes and Doud Creeks

3.2.1 Flood Flow Model Results

- **Soberanes Creek**: Pour point 17 analyzes approximately 3 sq. miles of watershed area of which 50.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 17 was calculated at 1.55. Therefore, flows at Soberanes

Creek at Soberanes State Park are estimated to be 1.55 times (55% increase) pre-fire flow values. Results from the flood model show that a 10 year event at Soberanes Creek at Soberanes State Park is approximately in the magnitude of a 25 to 50 year event in pre-fire conditions. See Table 3 for model results on pour point 17.

- **Doud Creek:** Pour point 12 analyzes approximately 2.7 sq. miles of watershed area of which 71.3% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 12 was calculated at 1.75. Therefore, flows at Daud Creek near Highway 1 are estimated to be 1.75 times (75% increase) pre-fire flow values. Results from the flood model show that a 10 year event at Daud Creek near Highway 1 is approximately in the magnitude of a 25 to 50 year event in pre-fire conditions. See Table 3 for model results on pour point 12.
- **MalPaso -** Pour point 18 analyzes approximately 3.3 sq. miles of watershed area of which 28.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 18 was calculated at 1.39. Therefore, flows in Malpaso Creek Near Highway 1 are estimated to be 1.39 times (39% increase) pre-fire flow values. Results from the flood model show that a 10 year event in Malpaso Creek is approximately in the magnitude of a 25 year event in pre-fire conditions. See Table 3 for model results on pour point 18.

3.2.2 Debris Flow Model Results -The principal tributaries that the USGS modeling shows as probable debris flow locations are Malpaso Creek, Soberanes Creek, and Doud Creek (listed from north to south). The USGS debris flow modeling results (28mm/hr design storm) generally shows a 60 to 100 percent probability of debris flows for the Malpaso and Doud Creek and a 40 to 100 percent probability for Soberanes Creek. These drainages are not shown as “watch streams”. However, it should be understood that infrastructure along these creeks could be impacted by increased flows (flooding) containing and bulked by sediment and debris

3. Middle Coastal Watersheds

3.1. Joshua Creek

3.1.1. Flood Flow Model Results- The WERT added a pour point on Joshua Creek upstream of the Garrapata Creek confluence. Pour point N4 analyzes approximately 2.1 sq. miles of watershed area of which 77.9% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point N4 was calculated at 1.82. Therefore, flows on Joshua Creek upstream of the Garrapata Creek confluence are estimated to be 1.82 times (82% increase) pre-fire flow values. Results from the flood model show that a 10 year event on Joshua Creek upstream of the Garrapata Creek confluence is approximately in the magnitude of a 50 year event in pre-fire conditions. See Table 3 for model results on pour point N4.

3.1.2. Debris Flow Model Results USGS debris flow modeling results (28mm/hr design storm) generally shows a 60 to 100 percent probability of debris flows for headwater tributaries. These drainages drain to the portion of Joshua Creek that flows towards infrastructure including culverts, residential access bridges, a residence and several water tanks. The USGS debris flow modeling does not show Joshua Creek as a “watch stream”. It should be understood that the existing homes and infrastructure could be impacted directly by debris flows or indirectly via sediment and debris that travels through the area via Joshua Creek.

3.2 Garrapata Creek-

3.2.1 Flood Flow Model Results Lower Garrapata -The WERT added a pour point on Garrapata Creek upstream of the Joshua Creek confluence. Pour point N5 analyzes approximately 8.4 sq. miles of watershed area of which 78.4% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point N4 was calculated at 1.81. Therefore, flows on Garrapata Creek upstream of the Joshua Creek confluence are estimated to be 1.81 times (81% increase) pre-fire flow values. Results from the flood model show that a 10 year event on Garrapata Creek upstream of the Joshua Creek confluence is approximately in the magnitude of a 50 to 100 year event in pre-fire conditions. See table 4 for model results on pour point N5.

3.2.2 Flood Flow Model Results Mouth of Garrapata The WERT used an existing BAER pour point #11. See table 4 for model results on pour point 11. Pour point 11 analyzes approximately 10.5 sq. miles of watershed area of which 78.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point N8 was calculated at 1.80. Therefore, flows at the mouth of Garrapata Creek are estimated to be 1.80 times (80% increase) pre-fire flow values. Results from the flood model show that a 10 year event on the mouth of Garrapata Creek is approximately in the magnitude of a 50 to 100 year event in pre-fire conditions.

3.2.3 Debris Flow Model Results - USGS debris flow modeling results (28mm/hr design storm) do not show a probability of debris flows for Lower Garrapata Creek. However, this drainage does drain an area of Upper Garrapata Creek and Joshua Creek that have a 60 to 100 percent probability of debris flows. In addition, Garrapata Creek, including Lower Garrapata Creek is shown as a “watch stream”. Lower Garrapata Creek drains towards several residences and associated infrastructure, including water wells (VARS 127-131). It should be understood that the residences and infrastructure could be impacted directly by debris flows or indirectly via sediment and debris that travels through the area via Joshua and Upper Garrapata Creeks.

3.3 Garrapatos Road (Upper Garrapata Creek)

3.3.1 Flood Flow Model Results - The WERT used an existing BAER pour point 10 on upper Garrapata Creek in the Garapatos Road Community. Pour point 10 analyzes approximately 4.3 sq. miles of watershed area of which 88.8% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 10 was calculated at 1.90. Therefore, flows at Upper Garrapata Creek in the Garapatos Community are estimated to be 1.90 times (90% increase) pre-fire flow values. Results from the flood model show that a 10 year event in upper Garrapata Creek is approximately in the magnitude of a 100 year event in pre-fire conditions. See Table 3 for model results on pour point 10.

3.3.2 Debris Flow Model Results - USGS debris flow modeling results (28mm/hr design storm) generally shows a 60 to 100 percent probability of debris flows for tributaries that drain into Garrapata Creek and along the upper segment of Garrapata Creek. The results also indicate that the main stem of Garrapata Creek is a “watch stream”. It should be understood that slopes in the Upper Garrapata Creek watershed and Garrapata Creek may be impacted directly by debris flows, while the lower reach of Garrapata Creek may be impacted by the combined effects of debris flow and floods, including increased sediment and debris generated from upstream tributaries.

3.4 Lower Palo Colorado

3.4.1 Flood Flow Model Results - See Table 3 for model results on pour point 8. Pour point 8 analyzes approximately 1.9 sq. miles of watershed area of which 33.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 8 was calculated at 1.35. Therefore, flows at lower Palo Colorado Canyon are estimated to be 1.35 times (35% increase) pre-fire flow values. Results from the flood model show that a 10 year event in lower Palo Colorado Canyon is approximately in the magnitude of a 25 year event in pre-fire conditions. See Table 3 for model results on pour point 8.

3.4.2 Debris Flow Model Results - In addition to the debris flow modeling for Upper Palo Colorado (discussed above), USGS debris flow modeling results (28mm/hr design storm) shows a 60 to 100 percent probability of debris flows for two tributaries that drain south facing slopes within the burn area. The results also indicate that the main stem of Palo Colorado is a “watch stream”. It should be understood that the south facing slopes in this area may be impacted directly by debris flows, while Palo Colorado may be impacted by the combined effects of debris flow and floods, including increased sediment and debris generated from upstream tributaries.

3.5 Upper Palo Colorado-

3.5.1 Flood Flow Model Results-The WERT used an existing BAER pour point 9 (Appendix B) on upper Palo Colorado at the upper road crossing. Pour point 9 analyzes approximately 0.7 sq. miles of watershed area of which 78.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 9 was calculated at 1.81. Therefore, flows at upper Palo Colorado are estimated to be 1.81 times (81% increase) pre-fire flow values. Results from the flood model show that a 10 year event in upper Palo Colorado is approximately in the magnitude of a 100 year event in pre-fire conditions. See Table 3 for model results on pour point 9.

3.5.2 Debris Flow Model Results USGS debris flow modeling results (28mm/hr design storm) generally shows a 60 to 100 percent probability of debris flows for tributaries that drain into Palo Colorado, and a 60 to 80 percent probability of debris flow along Palo Colorado. The USGS debris flow modeling shows the lower segment of Palo Colorado in this area as a “watch stream”. It should be understood that the slopes in this area and Palo Colorado may be impacted directly by debris flows. Palo Colorado may also be impacted by the combined effects of debris flow and floods, including increased sediment and debris generated from upstream tributaries.

3.6 Rocky Creek

3.6.1 Flood Flow Model Results - The WERT used an existing BAER pour point 7 (Appendix B) on Rocky Creek near the Hoist community. Pour point 7 analyzes approximately 3.5 sq. miles of watershed area of which 77.3% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 7 was calculated at 1.81. Therefore, flows in Rocky Creek near the Hoist community are estimated to be 1.81 times (81% increase) pre-fire flow values. Results from the flood model show that a 10 year event in Rocky Creek is approximately in the magnitude of a 100 year event in pre-fire conditions. See Table 3 for model results on pour point 7.

3.6.2 Debris Flow Model Results USGS debris flow modeling results (28mm/hr design storm) generally shows a 60 to 100 percent probability of debris flows for tributaries that drain into Rocky Creek, and a 60 to 80 percent probability of debris flow along the upper main stem of Rocky Creek. The results also indicate that the lower main stem of Rocky Creek is a "watch stream". It should be understood that slopes in the upper reaches of Rocky Creek may be impacted directly by debris flows, while the lower reaches may be impacted by the combined effects of debris flow and floods, including increased sediment and debris generated from upstream tributaries.

3.7 Bixby Creek

3.7.1 Flood Flow Model Results -The WERT used an existing BAER pour point #30 (Appendix B) on Bixby Creek at Coast Road near the lower flood plain community. Pour point 30 analyzes approximately 11 sq. miles of watershed area of which 54.4% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 30 was calculated at 1.61. Therefore, flows in lower Bixby Creek are estimated to be 1.61 times (61% increase) pre-fire flow values. Results from the flood model show that a 10 year event in the lower Bixby Creek area is approximately in the magnitude of a 25 to 50 year event in pre-fire conditions. See Table 4 for model results on pour point 30.

3.7.2 Debris Flow Model Results

- Lower Bixby Creek. USGS debris flow modeling results (28mm/hr design storm) generally shows a 60 to 100 percent probability of debris flows for headwater tributaries that drain south facing slopes from the ridge line of Long Ridge and the north facing slopes of Mescal and Skinner Ridges. These drainages drain to the portion of Bixby Creek that flows towards an existing bridge (where the Coast road crosses Bixby Creek) and a group of residential homes, VARs 554 through 561. The USGS debris flow modeling shows Bixby Creek as a "watch stream". It should be understood that the existing homes and infrastructure could be impacted directly by debris flows or indirectly via sediment and debris that travels through the area via Bixby Creek.

- Coast Road. USGS debris flow modeling results (28mm/hr design storm) generally shows a 40 to 100 percent probability of debris flows for headwater tributaries that drain the south facing slopes of Mescal Ridge/Bonifacio Hill. This drainage drains to a portion of Sierra Creek that flows through multiple culverts along the Coast Road and adjacent to one existing residence, VARs 603 through 612. Sierra Creek does converge with Bixby Creek approximately ¾ of a mile downstream of VAR 603, however it is not shown as a "watch stream". It should be understood that the infrastructure and residence could be impacted directly by debris flows or indirectly via sediment and debris that travels through the area via Sierra Creek.
- Mill Creek and Turner Creek USGS debris flow modeling results (28mm/hr design storm) generally shows a 60 to 100 percent probability of debris flows for tributaries that drain south facing slopes in this area and a 0 to 60 percent probability for tributaries that drain north facing slopes in this area. The results show a 60 to 80 percent probability of debris flow along the main stem of Turner Creek, and a 60 to

100 percent probability of debris flow along the main stem of Mill Creek. It should be understood that slopes in the Mill Creek and Turner Creek watershed may be impacted directly by debris flows.

4. Little Sur

4.1. Upper Little Sur/ Boy Scout

4.1.1. Flood Flow Model Results -The WERT used an existing BAER pour point 25 (Appendix B) in the middle Little Sur River area near the Pico Blanco Boy Scouts Camp. Pour point 25 analyzes approximately 18.3 sq. miles of watershed area of which 70.2% had a high or moderate burn severity classification. The pour point was analyzed for a 10 year flood event. The adjusted post fire design flow modifier for pour point 25 was calculated at 1.74. Therefore, flows near the Boy Scout Camp at pour point 25, middle Little Sur, are estimated to be 1.74 times (74% increase) pre-fire flow values. Results from the flood model show that a 10 year event in the middle Little Sur River area is approximately in the magnitude of a 50 to 100 year event in pre-fire conditions. See Table 3 for model results on pour point 25.

4.1.2. Debris Flow Model Results - USGS debris flow modeling results (28mm/hr design storm) generally shows a 60 to 100 percent probability of debris flows for headwater tributaries that drain south facing slopes from the ridge line from Devils Peak/Skinner Ridge to Uncle Sam Mountain. The USGS debris flow modeling of north facing slopes in the watershed shows a lower probability of debris flows (generally ranging from 20 to 60 percent) compared to the south facing slopes. These drainages drain to the portion of the Little Sur River that drains to the Pico Blanco Boy Scout Camp, and the USGS debris flow modeling shows Little Sur River as a “watch stream”. It should be understood that the campground could be impacted by directly by debris flows or indirectly via sediment and debris that travels through the campground via Little Sur River.

4.2 Lower Little Sur

4.2.1 Flood Flow Model Results -. Pour point 4 analyzes the entire Little Sur watershed area. Pour point 4 analyzes approximately 40 sq. miles of watershed area of which 59.6% had a high or moderate burn severity classification. The pour point was analyzed for a 10 year flood event. The adjusted post fire design flow modifier for pour point 4 was calculated at 1.65. Therefore, flows near the mouth of Little Sur River at Highway 1 are estimated to be 1.65 times (65% increase) of pre-fire flow values. Results from the flood model show that a 10 year event at the mouth of Little Sur River is approximately in the magnitude of a 50 year event in pre-fire conditions. See Table 3 for model results on pour point 4.

4.2.2 Debris Flow Model Results - USGS debris flow modeling results (28mm/hr design storm) shows the majority of modeled debris flows in headwater tributaries that drain south facing slopes from the ridge line that descends from Bixby Mountain. The debris flow modeling indicates probabilities generally ranging from 60 to 100 percent. These drainages drain to the portion of the Little Sur River which outlets to the Pacific Ocean. The USGS debris flow modeling shows the lower Little Sur River as a “watch stream”. The USGS stream watch segments shown in the model results indicate the presence of drainages within and below the burn area that can be impacted by the combined effects of debris flows and floods generated from tributaries. These are areas where a combination of runoff hazards may be present, and where flood hazards analyses may be need to consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris

5. Big Sur River

5.1. Flood Flow Model Results-

5.1.1. Upper Big Sur - Pour point N6 analyzes approximately 49.1 sq. miles of watershed area of which 51.9% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point N6 was calculated at 1.57. Therefore, flows on Big Sur River at the Highway 1 bridge are estimated to be 1.57 times (57% increase) pre-fire flow values. Results from the flood model show that a 10 year event on Big Sur River at Highway 1 Bridge is approximately in the magnitude of a 50 year event in pre-fire conditions. See Table 3 for model results on pour point N6.

5.1.2. Pfeiffer Creek - Pour point 3 analyzes approximately 0.9 sq. miles of watershed area of which 65.9% had a high or moderate burn severity classification. The pour point was analyzed for a 10 year flood event. The adjusted post fire design flow modifier for pour point 3 was calculated at 1.73. Therefore, flows on Pfeiffer Creek upstream of Big Sur confluence are estimated to be 1.73 times (73% increase) pre-fire flow values. Results from the flood model show that a 10 year event on Pfeiffer Creek is approximately in the magnitude of a 50 year event in pre-fire conditions. See Table 3 for model results on pour point 3.

5.1.3. Juan Higuerra Creek- Pour point 2 analyzes approximately 1.8 sq. miles of watershed area of which 74.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 2 was calculated at 1.77. Therefore, flows in Juan Hiquera Creek Near Highway 1 are estimated to be 1.77 times (77% increase) pre-fire flow values. Results from the flood model show that a 10 year event in Juan Hiquera Creek is approximately in the magnitude of a 50 year event in pre-fire conditions. See Table 3 for model results on pour point 2.

5.1.4. Pheneger Creek- Pour point 1 analyzes approximately 0.8 sq. miles of watershed area of which 23.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point 1 was calculated at 1.25. Therefore, flows in Pheneger Creek near Highway 1 are estimated to be 1.25 times (25% increase) pre-fire flow values. Results from the flood model show that a 10 year event in Pheneger Creek is approximately in the magnitude of a 25 year event in pre-fire conditions. See Table 3 for model results on pour point 1.

5.1.5. Molera State Park- Pour point N7 analyzes approximately 58.7 sq. miles of watershed area of which 47.2% had a high or moderate burn severity classification. The adjusted post fire design flow modifier for pour point N7 was calculated at 1.53. Therefore, flows at the mouth of Big Sur River are estimated to be 1.53 times (53% increase) pre-fire flow values. Results from the flood model show that a 10 year event on the mouth of the Big Sur River is approximately in the magnitude of a 25 to 50 year event in pre-fire conditions. See Table 3 for model results on pour point N7.

5.2 Debris Flow Model Results

The principal tributaries that the USGS modeling shows as probable debris flow locations are Pheneger Creek, Juan Higuera Creek, and Pfeiffer Redwood Creek, all of which are perched above the resort and State Park communities of Big Sur. The USGS debris flow modeling results (28mm/hr design storm) generally shows a 60 to 100 percent probability of debris flows for the Pheneger Creek, Juan Higuera Creek, and Pfeiffer Redwood Creek drainages. These drainages drain to the Big Sur River that the USGS debris flow modeling shows as a “watch stream”. It should be understood that infrastructure along the “watch stream”, in this case the Big Sur River, could be impacted by increased flows (flooding) containing and bulked by sediment and debris.

Appendix C. Flood and Debris Flow Model Results

	Watershed Acres			Burn Severity				Post Fire 10 year Discharge (CFS)					Pre Fire Discharge				Times Increase (10yr)
Watershed	Watershed Acres	Average Precip	Watershed Miles^2	Miles^2 High	Miles^2 Moderate	Miles^2 Low	Miles^2 Unburned	Discharge High	Discharge Moderate	Discharge Low	Discharge Unburned	Total Discharge	Q10	Q25	Q50	Q100	x increase flow
1. Pheneger Creek	522	36	0.82	0.00	0.19	0.07	0.56	0.4	68.4	14.8	102.9	186.6	149.6	219.8	277.8	328.1	1.25
2. Juan Higuera Creek	1,165	38	1.82	0.00	1.35	0.21	0.26	0.2	470.1	45.4	45.5	561.3	317.6	458.7	573.8	673.2	1.77
3. Pfeiffer Redwood Creek	545	37	0.85	0.00	0.56	0.24	0.05	0.6	208.5	55.1	8.5	272.7	157.7	231.1	291.4	343.8	1.73
4. Little Sur River	25,607	40	40.01	0.12	23.74	10.13	6.02	29.2	5716.0	1462.0	752.4	7959.6	4817.0	6735.0	8273.4	9610.8	1.65
7. Rocky Creek	2,225	45	3.48	0.39	2.30	0.61	0.18	160.4	952.8	149.4	38.3	1300.9	720.7	985.3	1193.2	1364.5	1.81
8. Palo Colorado Lower Canyon	1,195	28	1.87	0.01	0.61	0.09	1.15	2.7	129.9	13.1	123.2	268.8	198.8	315.6	417.6	513.0	1.35
9. Palo Colorado Upper RD crossing	442	36	0.69	0.01	0.53	0.09	0.06	4.6	194.0	19.4	11.5	229.5	126.5	187.0	237.0	280.7	1.81
10. Garrapatos RD	2,734	44	4.27	0.48	3.31	0.39	0.09	187.5	1301.9	90.6	18.5	1598.5	839.3	1151.4	1397.2	1601.1	1.90
11. Garrapata Creek at Trout Farm	6,696	39	10.46	0.76	7.42	0.96	1.32	209.8	2061.3	161.6	187.7	2620.4	1452.3	2066.9	2564.6	2997.2	1.80
12. Doud Creek	1,740	35	2.72	0.16	1.78	0.42	0.35	47.5	517.4	76.4	51.7	693.1	395.4	583.6	739.6	877.6	1.75
17. Soberanes Creek	1,929	30	3.01	0.02	1.49	1.03	0.34	4.4	331.9	146.9	38.5	521.6	336.4	520.7	678.8	824.4	1.55
18. Malpaso Creek	2,109	28	3.30	0.01	0.92	1.18	1.19	2.3	182.0	150.5	119.0	453.8	326.5	515.5	680.1	834.2	1.39
19. Carmel River	80,320	37	125.50	0.52	16.47	11.20	97.31	90.5	2850.0	1178.9	8834.8	12954.1	10856.9	15567.3	19419.7	22888.7	1.19
20. San Clemente Creek/San Clemente Dam	10,666	33	16.67	0.23	3.45	3.56	9.43	45.3	681.1	438.5	957.0	2121.9	1645.0	2461.3	3146.7	3771.7	1.29
21. San Jose Creek	9,041	27	14.13	0.05	1.78	2.12	10.17	7.0	256.2	198.4	750.6	1212.1	1015.1	1623.7	2159.7	2673.4	1.19
23. Carmel @ Cachuaga	69,682	39	108.88	0.27	11.43	7.37	89.81	52.9	2224.6	863.8	9160.7	12302.1	10597.1	14924.7	18419.9	21515.4	1.16
25. Middle Little Sur	11,685	47	18.26	0.05	12.78	3.38	2.05	15.8	4413.3	683.0	365.0	5477.1	3153.1	4222.5	5054.3	5740.4	1.74
27. San Clemente Creek/Dormody RD	3,697	31	5.78	0.00	0.07	0.11	5.60	0.1	14.1	14.5	602.5	631.3	610.6	934.4	1210.2	1463.5	1.03
28. Black Rock Creek	5,233	37	8.18	0.23	3.38	3.45	1.12	62.2	917.7	570.9	155.3	1706.1	1109.7	1599.4	1999.3	2349.9	1.54
30. Bixby Creek on Coast Road	7,057	36	11.03	0.49	5.51	3.13	1.90	119.8	1357.0	472.7	239.9	2189.3	1357.9	1974.1	2480.7	2929.8	1.61
N3 Carmel River Upstream of Tularcitos Creek	117,952	31	184.30	0.75	19.88	18.06	145.60	92.1	2436.3	1390.3	9397.7	13316.4	11290.8	17080.4	21999.2	26635.1	1.18
N2 Carmel River Upstream of Las Gazas Creek	135,034	30	210.99	0.77	20.79	20.40	168.48	88.6	2401.3	1486.7	10266.5	14243.0	12186.9	18561.7	24004.9	29167.5	1.17
N1 Carmel River Watershed	163,046	29	254.76	0.77	20.79	20.40	212.81	78.2	2118.7	1325.9	11463.2	14986.0	12983.4	20129.6	26310.8	32259.6	1.15
N4 Joshua Creek	1329	35	2.08	0.16	1.46	0.33	0.12	46.7	435.2	61.8	18.6	562.3	309.2	458.5	582.5	692.3	1.82
N5 Lower Garrapata	5,371	40	8.39	0.60	5.98	0.79	1.02	180.3	1786.0	142.6	156.1	2265.0	1254.1	1772.8	2190.7	2550.6	1.81
N6 Upper Big Sur River @ 101 Bridge	31,404	45	49.07	2.78	22.69	12.13	11.46	785.7	6408.9	2010.3	1683.2	10888.0	6929.6	9330.9	11209.8	12790.2	1.57
N7 Big Sur River @ Mouth	37,561	43	58.69	2.72	25.01	12.89	18.07	675.1	6202.9	1896.7	2334.3	11109.0	7279.2	9989.5	12138.0	13983.0	1.53

Appendix D: Values at Risk Matrix

This table and general recommendations are part of a larger document and therefore should be used in conjunction with that document in order to implement the recommendations provided

Community	Site Number	Address	Field Observation	Hazard Category	Feature	Feature Category	Hazard to Life	Hazard to Property	In FEMA/DWR 100 yr floodplain	Preliminary Emergency Protective Measures	Subwatershed (Tier 2)	Pour Point	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
Andrew Molera State Park	562	Off Highway 1	Campsites in floodway	debris flow / flood	Camp	Recreation	high	low	yes	Close lower two campsites and early warning system	Lower Big Sur	N7	36.28665N	121.85073W
Andrew Molera State Park	563	Off Highway 1	Campsites in floodway	debris flow / flood	Camp	Recreation	high	low	yes	early warning system	Lower Big Sur	N7	36.28691N	121.84385W
Andrew Molera State Park	573	Andrew Molera State Park	Flooding of state park residential structures, earthen berm breached	flood	Park facilities and buildings	State Park	low	moderate	yes	Install muscle wall across breach in berm	Lower Big Sur	N7	36.28556N	121.84229W
Big Sur Resorts	564	Brewer Bridge - Clear Ridge Road	Bridge crossing to residential neighborhood	flood	Bridge	drainage structure	low	low	yes	storm patrol	Lower Big Sur	N7	36.27177N	121.80987W
Big Sur Resorts	565	Big Sur River Inn off Highway 1	Shops and resorts in floodway. Also two residences on west side of Big Sur River	flood	Infrastructure	multiple	high	high	yes	early warning system	Lower Big Sur	N7	36.26978N	121.80842W
Big Sur Resorts	566	Big Sur Campground off Highway 1	Big Sur campground, especially sites along river	flood	Infrastructure	recreational	high	high	yes	no camping during storm events	Lower Big Sur	N7	36.26646N	121.80438W
Big Sur Resorts	567	Riverside campground off Highway 1	Plugging of Concrete low water concrete crossing. Campsites near river.	flood	Infrastructure	recreational	high	high	yes	no camping during storm events, storm patrol	Lower Big Sur	N7	36.26592N	121.80403W
Big Sur Resorts	568	Santa Lucia Camp off Highway 1	Campground near river	flood	Infrastructure	recreational	high	low	no	no camping during storm events	Lower Big Sur	N7	36.26829N	121.80706W
Big Sur Resorts	614	Highway 1 at Pheneger Creek	6' culvert plug and diversion to Big Sur Village	debris flow / flood	Culvert	drainage structure	high	high	no	storm patrol	Lower Big Sur	N7	36.26949N	121.80720W
Big Sur Resorts	615	road at Juan Higara Creek	6' culvert plug and diversion to Big Sur grange within FEMA zone	debris flow / flood	Culvert	drainage structure	moderate	high	yes	storm patrol	Lower Big Sur	N7	36.26334N	121.79956W
Big Sur Resorts	616	Highway 1	Plugging of 18" culvert	debris flow	Culvert at Highway 1	drainage structure	low	moderate	no	Storm patrol	Lower Big Sur	N7	36.25821N	121.78811W
Big Sur Resorts	617	State park road	Residential structures along banks of channel	debris flow	Several houses	home	moderate	moderate	no	early warning system	Lower Big Sur	N7	36.25513N	121.78676W
Big Sur Resorts	618	Highway 1	Plugging 36" culvert, inlet appears to be cleaned out regularly, significant quantity of LWD in channel immediately upstream	debris flow	Culvert	drainage structure	low	high	no	Storm patrol, channel clearance	Lower Big Sur	N7	36.25958N	121.78905W
Big Sur Resorts	619	Private road/highway 1	Private abandoned road with switchback at channel, culvert under switchback with recently excavated inlet and newer standpipe at inlet. If plugged, diversion down insloped private road onto Highway 1. Also standpipe at recently exc. culvert inlet at Highway 1	debris flow	Culverts, highway 1	drainage structure	moderate	moderate	no	Storm patrol, diversion structure	Lower Big Sur	N7	36.26061N	121.79072W
Big Sur Resorts	620	Fernwood Campground and Resort off Highway 1	Fernwood campground/resort located in FEMA 100 yr flood plain along Big Sur River, tents, trailers, mobile and modular homes	flood	Campground facility	recreational	high	high	yes	no camping during storm events	Lower Big Sur	N7	36.26032N	121.79388W
Big Sur Resorts	621	St. Francis of the Redwood Church off Highway 1	St Francis of the redwoods church facility adjacent to Big Sur River, partially in FEMA 100 yr floodplain	flood	Church facility	other	high	high	no	early warning system	Lower Big Sur	N7	36.26365N	121.79516W
Big Sur Resorts	622	Highway 1	Several private residences located partially on FEMA 100 yr floodplain along Big Sur River, signs for "river house" and "tee house"	flood	Houses	home	high	high	no	early warning system	Lower Big Sur	N7	36.25593N	121.79424W
Big Sur Resorts	623	Private road	Bridge in FEMA floodplain, access to four residential houses	flood	Bridge	drainage structure	moderate	moderate	yes	storm patrol	Lower Big Sur	N7	36.26400N	121.80190W
Big Sur Resorts	624	private road	Several houses located across bridge on FEMA floodplain	flood	Houses	home	high	high	yes	early warning system	Lower Big Sur	N7	36.26391N	121.80287W
Big Sur Resorts	628	Pfeiffer-Big Sur State Park	Channel appears to drain into wastewater facility	debris flow	Wastewater treatment facility	State Park	high	high	no	diversion structure	Lower Big Sur	N7	36.25694N	121.78790W

Note: These results were based upon a rapid review so that as much time as possible was allowed for emergency measures to be put in place before winter storms

Community	Site Number	Address	Field Observation	Hazard Category	Feature	Feature Category	Hazard to Life	Hazard to Property	In FEMA/DWR 100 yr floodplain	Preliminary Emergency Protective Measures	Subwatershed (Tier 2)	Pour Point	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
Big Sur Resorts	631	Highway 1	River cabins downslope from ripple wood cabins sign on highway, numerous cabins on FEMA floodplain	flood	Cabins	home	high	high	yes	no camping during storm events	Lower Big Sur	N7		
Cachagua community	160	Nason road	Trailer park and other residences on FEMA floodplain and expansive flat area at confluence of Cachagua Creek and Carmel River	flood	Trailer park	multiple	high	high	yes	early warning system	Upper Carmel	23		
Cachagua community	161	Nason road	Community park with swimming hole and recreation facilities on edge of FEMA floodplain. Park and children's center on broad flat area adjacent to channel	flood	Park, children center, swimming and rec	multiple	moderate	moderate	yes	early warning system	Upper Carmel	23		
Cachagua syndicate camp	155	private road	Hughes residence in FEMA floodplain	flood	House	home	low	low	yes	early warning system	Upper Carmel	19	36.40955N	121.67608W
Cachagua syndicate camp	163	private road	Numerous residences in Carmel River floodplain, 1995 flooding reported	flood	houses	home	high	high	yes	early warning system	Upper Carmel	19		
Carmel	569	Carmel River State Beach	Bathroom and parking lot in flood zone from Carmel River exit	flood	Infrastructure	recreational	no	moderate	yes	early warning system, staging, sandbag, muscle wall, etc	Lower Carmel	N1	36.53857N	121.92743W
Carmel Valley Village	162	Garzas Road and Boranda Road area	numerous residences within FEMA floodplain	flood	Residential community	home	high	high	yes	early warning system	Lower Carmel	N2	36.49104N	121.75123W
Coast Road	551	Coast Road Bridge on Bixby Creek	Bridge	debris flow / flood	Bridge	drainage structure	low	moderate	no	storm patrol	Middle Coastal	30	36.36952N	121.89244W
Coast Road	552	39020 Coast Road	House is raised but structural suports in floodplain. Accessed via footbridge across channel.	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	30	36.37334N	121.89790W
Coast Road	553	Coast Road - address not recorded	House in floodplain	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	30	36.37232N	121.89697W
Coast Road	554	39122 Coast Road	House, accessed via foot bridge in floodway	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	30	36.37166N	121.89639W
Coast Road	555	39198 Coast Road	Bridge access to house	debris flow / flood	Bridge	drainage structure	low	moderate	no	early warning system	Middle Coastal	30	36.37149N	121.89578W
Coast Road	556	39208 Coast Road	House in floodway	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	30	36.37104N	121.89540W
Coast Road	557	39340 Coast Road	House in floodway	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	30	36.36990N	121.89428W
Coast Road	558	Coast Road - address not recorded	House in floodway	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	30	36.37004N	121.89354W
Coast Road	559	39475 Coast Road	House, accessed via foot bridge in floodway	debris flow / flood	House and foot bridge	home	high	high	no	early warning system	Middle Coastal	30	36.36842N	121.89147W
Coast Road	560	39509 Coast Road	House in floodway	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	30	36.36796N	121.89139W
Coast Road	561	39561 Coast Road	House, accessed via foot bridge in floodway	debris flow / flood	House and bridge	home	high	high	no	early warning system	Middle Coastal	30	36.36728N	121.89021W
Garrapata Creek	127	36001 Garrapata Trout Farm Road	Number of residences/cabins constructed on floodplain and adjacent to side channel, some elevated on posts	debris flow / flood	Houses/cabins at Weston property	home	high	high	no	early warning system	Middle Coastal	N5	36.41442N	121.90333W
Garrapata Creek	128	Garrapata Trout Farm Road	Airstream trailer in probable floodplain, adjacent stretch of road constructed in floodplain, only access for several residences upstream	flood	Airstream trailer	home	moderate	moderate	no	early warning system	Middle Coastal	N5	36.41662N	121.90687W
Garrapata Creek	130	35681 Garrapata Trout Farm Road	Private Residence on floodplain	flood	Houses	home	moderate	high	no	early warning system	Middle Coastal	N5	36.41543N	121.91213W
Garrapata Creek	131	35681 Garrapata Trout Farm Road	Cal American water company well that reportedly pumps water across creek to several residemces	flood	Water supply	utilities	no	moderate	no	early warning system	Middle Coastal	N5	36.41520N	121.91219W
Garrapata State Park	571	Highway 1	Potential Debris flow and flooding hazard to box culvert under highway 1 . Culvert is 8 feet tall, 6 feet wide	debris flow / flood	Box culvert	State Park	moderate	high	no	early warning system , communicate with CalTrans	Upper Coastal	17	36.45596N	121.92367W
Garrapata State Park	572	Highway 1	Box culvert under highway 1, culvert is 7 feet tall, 6 feet wide, approx 35 feet fill over culvert	debris flow / flood	Box culvert	State Park	low	low	no	early warning system, storm patrol	Upper Coastal	12	36.42182N	121.91204W
Garrapatos Road	545	Bridge over Garrapatos Road	Bridge crossing over Garrapata Creek. Potential scour and debris plugging	debris flow / flood	Bridge	drainage structure	low	moderate	no	storm patrol	Middle Coastal	N5	36.39985N	121.87265W
Garrapatos Road	546	5910 Garrapatos Road	House at base of channel near confluence with potential debris flow channel	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	N5	36.40021N	121.87216W

Note: These results were based upon a rapid review so that as much time as possible was allowed for emergency measures to be put in place before winter storms

Community	Site Number	Address	Field Observation	Hazard Category	Feature	Feature Category	Hazard to Life	Hazard to Property	In FEMA/DWR 100 yr floodplain	Preliminary Emergency Protective Measures	Subwatershed (Tier 2)	Pour Point	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
Garrapatos Road	547	5933 Garrapatos Road	Foot bridge and house near channel floodway	debris flow / flood	Foot bridge and house	home	high	high	no	early warning system	Middle Coastal	N5	36.39977N	121.87127W
Garrapatos Road	548	59625 Garrapatos Road	Bridge crossing to residential properties	debris flow	Bridge	drainage structure	low	moderate	no	storm patrol	Middle Coastal	N5	36.39973N	121.87076W
Garrapatos Road	549	5947 Garrapatos Road	Bridge crossign to residential properties, plugging, scouring, etc	debris flow / flood	Bridge	drainage structure	low	moderate	no	storm patrol	Middle Coastal	10	36.39992N	121.86997W
Garrapatos Road	550	Garrapatos Road	Potential for scour and road fill failure along outside edge of creek. Residents reported that road prism failed during 1998 flooding.	debris flow / flood	Road	miscellaneous	moderate	moderate	no	storm patrol	Middle Coastal	N5	36.40015N	121.87350W
Hoist	500	Main access to community	Potential for plugging of 18-inch diameter culvert	debris flow	Culvert	drainage structure	no	high	no	Clean culvert, storm patrol	Middle Coastal	7	36.38011N	121.84403W
Hoist	501	38809 Palo Colorado Canyon Road	House within potential debris flow path	debris flow	House	home	high	high	no	early warning system	Middle Coastal	7	36.38168N	121.84203W
Hoist	502	Not recorded	potential for debris flow at low water ford crossing	debris flow	ford crossing	drainage structure	no	low	no	Storm patrol	Middle Coastal	7	36.38435N	121.83859W
Hoist	503	Not recorded	36" culvert plugging potential	debris flow	Culvert	drainage structure	no	moderate	no	Storm patrol	Middle Coastal	7	36.38632N	121.83868W
Hoist	504	Not recorded	36" culvert plugging potential	debris flow	Culvert	drainage structure	no	moderate	no	Storm patrol	Middle Coastal	7	36.38622N	121.84008W
Hoist	505	38753 Palo Colorado Canyon Road	Yurt-cabin. Swale behind house/yurt	debris flow	House	home	moderate	moderate	no	early warning system	Middle Coastal	7	36.38643N	121.84170W
Hoist	506	38741 Palo Colorado Canyon Road	Home on edge of creek	debris flow	House	home	high	high	no	early warning system	Middle Coastal	7	36.38798N	121.83755W
Joshua Creek	109	Private road	Potential for plugging of 48-inch diameter culvert from debris flow, possible diversion onto paved road	debris flow	Culvert/road	drainage structure	low	moderate	no	Storm patrol	Middle Coastal	N4	36.42097N	121.89093W
Joshua Creek	110	Private road	Burned out ditch relief culvert, erosion potential	other	Private road	drainage structure	no	moderate	no	Repair/replace culvert	Middle Coastal	N4	36.42098N	121.89171W
Joshua Creek	111	Jeep road	Stringer bridge for jeep road on Joshua Creek, very little capacity, likely to overtop or blow out	debris flow / flood	Stringer bridge	drainage structure	low	low	no	Storm patrol	Middle Coastal	N4	36.42035N	121.89194W
Joshua Creek	112	Private road	48" culvert with dug out inlet, debris flow plugging potential	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	N4	36.42083N	121.89257W
Joshua Creek	113	Private road	Erosion of burned out ditch relief culvert	other	Private road	drainage structure	low	low	no	Repair/replace culvert	Middle Coastal	N4	36.41940N	121.89535W
Joshua Creek	114	Private road	24" plastic culvert, potential for plugging at inlet, outlet is burned, extent of damage unknown	debris flow	Culvert, road	drainage structure	low	low	no	Storm patrol, repair/replace culvert	Middle Coastal	N4	36.42006N	121.89634W
Joshua Creek	115	Private road	Burned out culvert crossing with two water tanks in channel below road, potential for debris flow to impact road/water tanks	debris flow	Road and water tanks	multiple	low	moderate	no	Storm patrol	Middle Coastal	N4	36.42303N	121.89043W
Joshua Creek	116	Private road	Steel plate Bridge with gabion abutments	debris flow	Bridge	drainage structure	low	low	no	Storm patrol	Middle Coastal	N4	36.42309N	121.89009W
Joshua Creek	117	Private road	Water supply/spring with steel pipes in channel that drain to tanks at VAR 115, likely to be destroyed in debris flow	debris flow	Water supply	other	low	moderate	no	Storm patrol	Middle Coastal	N4	36.42331N	121.88967W
Joshua Creek	118	Private road	Debris flow- potential for scour around right abutment of bridge, plugging with large woody debris	debris flow / flood	Bridge	drainage structure	low	moderate	no	Storm Patrol	Middle Coastal	N4	36.42272N	121.88272W
Joshua Creek	119	Private road	Segment of road with at least 3 burned out plastic ditch relief culverts	other	Private Road	drainage structure	low	low	no	Repair/replace culverts	Middle Coastal	N4	36.42128N	121.88120W
Joshua Creek	120	Private road	Potential for plugging of culvert	debris flow	Culvert	drainage structure	low	moderate	no	Storm patrol	Middle Coastal	N4	36.42297N	121.88390W
Joshua Creek	121	Private road	Burned out culvert, potential for plugging and/or erosion	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	N4	36.42305N	121.88770W
Joshua Creek	122	Private road	Potential for culvert plugging	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	N4	36.42301N	121.89244W
Joshua Creek	123	Private road	Potential for culvert plugging	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	N4	36.42171N	121.89587W
Joshua Creek	124	35811 Garrapata Trout Farm Road	Residence/studio near channel, resident reports 98 flood came very close. Resident report that home is not primary residence	debris flow / flood	Studio/residence	home	moderate	high	no	early warning system	Middle Coastal	N4	36.41694N	121.90325W

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Joshua Creek	125	35811 Garrapata Trout Farm Road	Low bridge span, lots of large woody debris observed upstream, small sheds on either side on floodplain, previous Arizona crossing destroyed in 98 (reported by owner)	debris flow / flood	Bridge,water tank, and two sheds	multiple	low	high	no	Storm Patrol	Middle Coastal	N4	36.41668N	121.90371W
Joshua Creek	126	36001 Garrapata Trout Farm Road	6' culvert, potential plugging/overtopping hazard, upstream landowner reports that 98 flood destroyed previous bridge at this location	debris flow / flood	Culvert	drainage structure	low	moderate	no	Storm patrol	Middle Coastal	N4	36.41591N	121.90488W
Juan Higuera Creek	582	Not recorded	Debris flow	debris flow / flood	Homes and big Sur grange	home	high	high	yes	early warning system	Lower Big Sur	N7		
Little Sur	613	Old Coast Road	Bailey Bridge	Flood	Bridge	drainage structure	no	low	yes	storm patrol	Little Sur	4	36.33046N	121.86257W
Malpaso creek	165	San Remo Road	Water wells and conveyance pipeline located near/within river channel	debris flow / flood	Water wells and conveyance pipeline	utilities	low	high	no	storm patrol	Upper Coastal	18	36.47881N	121.91668W
NPWMD fish hatchery	200	Near San Clemente Dam	Flooding, no inhabitants	flood	Hatchery infrastructure	other	no	low	no	Remove pumps next to active channel prior to winter rains	Upper Carmel	N3	36.44396N	121.71513W
Old Coast Road	603	Old Coast Road	Potential for plugging of 48" diameter culvert and diversion down road	flood	Culvert	drainage structure	no	moderate	no	storm patrol, install critical dip	Middle Coastal	30	36.35469N	121.87819W
Old Coast Road	604	Old Coast Road	Potential for plugging of 48" diameter culvert and diversion down road.	flood	Culvert	drainage structure	no	moderate	no	storm patrol, install critical dip	Middle Coastal	30	36.35408N	121.87734W
Old Coast Road	605	Old Coast Road	Potential for plugging of 60" diameter culvert . No access past locked gate.	debris flow / flood	Culvert	drainage structure	no	moderate	no	storm patrol	Middle Coastal	30	36.35269N	121.87699W
Old Coast Road	606	Old Coast Road	Potential for plugging of two 48" diameter culverts and diversion down road.	debris flow / flood	Culvert	drainage structure	no	moderate	no	storm patrol, install critical dip	Middle Coastal	30	36.35153N	121.87696W
Old Coast Road	607	Old Coast Road	Potential for plugging of 48" diameter culvert and diversion down road.	debris flow / flood	Culvert	drainage structure	no	moderate	no	storm patrol, install critical dip	Middle Coastal	30	36.35021N	121.87621W
Old Coast Road	608	Old Coast Road	Potential for plugging of 48" diameter culvert and diversion down road.	debris flow / flood	Culvert	drainage structure	no	moderate	no	storm patrol, install critical dip	Middle Coastal	30	36.34572N	121.87202W
Old Coast Road	609	Old Coast Road	Potential for plugging of 48" diameter culvert and diversion down road.	debris flow / flood	Culvert	drainage structure	no	low	no	storm patrol, install critical dip	Middle Coastal	30	36.34531N	121.87066W
Old Coast Road	610	Old Coast Road	Old cabin on floodplain	debris flow / flood	House	home	high	high	no	early warning system (if inhabited)	Middle Coastal	30	36.34515N	121.87000W
Old Coast Road	611	Old Coast Road	24" plastic pipe-burned out ditch relief culvert. Potential for road collapse	Other	Culvert	drainage structure	no	high	no	Replace culvert	Middle Coastal	30	36.34471N	121.86754W
Old Coast Road	612	Old Coast Road	Potential for flooding and plugging of 48" diameter culvert	debris flow / flood	Culvert	drainage structure	no	moderate	no	storm patrol	Middle Coastal	30	36.34514N	121.86586W
Palo Colorado	100	Turner Creek bridge along Palo Colorado Canyon Road	potential scour to bridge abutment, may undermine foundation, crib wall burned, road access pico blanco Boy Scout camp	debris flow	Bridge	drainage structure	low	moderate	no	early warning system	Middle Coastal	30	36.37352N	121.83684W
Palo Colorado	102	Below Palo Colorado Canyon Road	potential debris flow over road and down steep slope toward residence	debris flow	Residence	home	moderate	moderate	no	early warning system, diversion structures	Middle Coastal	30	36.36643N	121.82969W
Palo Colorado	103	38115 Palo Colorado Canyon Road	60"' culvert with half plugged 48" overflow culvert, plugging potential, neighbors reported past plugging and blow out	debris flow / flood	Culvert	drainage structure	low	moderate	no	Storm patrol, clean out overflow culvert	Middle Coastal	7	36.38147N	121.86319W
Palo Colorado	104	38115 Palo Colorado Canyon Road	Residence in close proximity to floodplain	flood	House	home	high	high	no	early warning system	Middle Coastal	7	36.38063N	121.86156W
Palo Colorado	105	Palo Colorado Canyon Road	30" culvert - potential plugging from debris flow/flood	debris flow / flood	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	7	36.38333N	121.86463W
Palo Colorado	106	Palo Colorado Canyon Road	6.5' culvert with plugging potential, upstream appears to be old skid trail with high volume of stored sediment, would divert down road to next crossing	flood	culvert	drainage structure	low	moderate	no	Storm patrol	Middle Coastal	9	36.38982N	121.87128W
Palo Colorado	107	Palo Colorado Canyon Road	6.5' Culvert with plugging potential and potential diversion down Palo Colorado Canyon Road	flood	Culvert	drainage structure	low	moderate	no	Storm patrol	Middle Coastal	8	36.38982N	121.87216W

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Palo Colorado	108	37732 Palo Colorado Canyon Road	6' culvert at driveway, overhanging stringer logs at outlet, plugging potential, would divert toward residence	flood	Culvert and residence	home	high	high	no	early warning system, Storm patrol	Middle Coastal	8	36.39102N	121.87496W
Palo Colorado	132	Palo Colorado Canyon Road	potential plugging of 24" culvert	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	30	36.35571N	121.81500W
Palo Colorado	133	Palo Colorado Canyon Road	potential plugging of 18" culvert, crib logs along outside edge of road are burned with near vertical crumbling fill exposed	debris flow	Culvert/road	drainage structure	low	moderate	no	Storm patrol	Middle Coastal	30	36.35678N	121.81659W
Palo Colorado	134	Palo Colorado Canyon Road	Bridge over Mill Creek. Possible debris jam and overtopping	debris flow	Bridge	drainage structure	low	low	no	Storm patrol	Middle Coastal	30	36.36167N	121.82193W
Palo Colorado	135	Palo Colorado Canyon Road	potential plugging of 24" culvert with standpipe inlet	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	30	36.36259N	121.82372W
Palo Colorado	136	Palo Colorado Canyon Road	potential plugging of 36" culvert	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	30	36.36431N	121.82596W
Palo Colorado	137	Palo Colorado Canyon Road	potential plugging of 36" culvert	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	30	36.36818N	121.83112W
Palo Colorado	138	Palo Colorado Canyon Road	potential plugging of 30" culvert	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	30	36.36844N	121.83135W
Palo Colorado	139	Palo Colorado Canyon Road	potential plugging of 36" culvert and diversion down road	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	30	36.37407N	121.84015W
Palo Colorado	140	Palo Colorado Canyon Road	potential plugging of 12" culvert with diversion potential	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	30	36.37409N	121.84336W
Palo Colorado	141	Palo Colorado Canyon Road	potential plugging of standpipe inlet and diversion down road	debris flow	Culvert	drainage structure	low	low	no	Storm patrol	Middle Coastal	30	36.37558N	121.84677W
Palo Colorado	507	38711 Palo Colorado Canyon Road	potential for scour, noted steel tank and large woody debris within active channel	debris flow	Bridge	drainage structure	low	high	no	storm patrol	Middle Coastal	7	36.37819N	121.85181W
Palo Colorado	508	38250 Palo Colorado Canyon Road	55" culvert with plugging potential	debris flow / flood	Culvert	drainage structure	no	moderate	no	Storm patrol	Middle Coastal	7	36.38287N	121.86867W
Palo Colorado	509	38240 Palo Colorado Canyon Road	Squashed culvert 5'x6' with plugging potential	debris flow / flood	Culvert	drainage structure	no	moderate	no	Storm patrol	Middle Coastal	7	36.38276N	121.86660W
Palo Colorado	510	Green Ridge Road	24" culvert with potential plugging	debris flow / flood	Culvert	drainage structure	no	moderate	no	Storm patrol	Middle Coastal	9	36.39027N	121.85960W
Palo Colorado	511	Green Ridge Road	12" culvert with potential plugging	debris flow / flood	Culvert	drainage structure	no	moderate	no	Storm patrol	Middle Coastal	9	36.39123N	121.85898W
Palo Colorado	512	Green Ridge Road	36"x48" culvert with plugging potential	debris flow / flood	Culvert	drainage structure	no	moderate	no	Storm patrol	Middle Coastal	9	36.39374N	121.85756W
Palo Colorado	513	37740 Palo Colorado Canyon Road	5' culvert at driveway for 37740 Palo Colorado	flood	Culvert	drainage structure	no	moderate	no	Storm patrol, stream clearing	Middle Coastal	8	36.38997N	121.87410W
Palo Colorado	514	37748 Palo Colorado Canyon Road	6' culvert at driveway for 37748 Palo Colorado	flood	Culvert	drainage structure	no	moderate	no	Storm patrol, stream clearing	Middle Coastal	8	36.38966N	121.87297W
Palo Colorado	515	37715 Palo Colorado Canyon Road	Potential for debris flow/flooding diversion on to Garrapatos Road	debris flow / flood	Road	drainage structure	low	moderate	no	Storm patrol	Middle Coastal	8	36.39222N	121.87435W
Palo Colorado	516	37699 Palo Colorado Canyon Road	Home near Palo Colorado Creek	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	8	36.39196N	121.87627W
Palo Colorado	517	37691 Palo Colorado Canyon Road	Home near Palo Colorado Creek	debris flow / flood	House	home	high	high	no	early warning system	Middle Coastal	8	36.39244N	121.87675W
Palo Colorado	518	37523 Palo Colorado Canyon Road	House near Palo Colorado Creek, noted railroad ties along bank - potential bank scour	flood	House	home	high	high	no	early warning system	Middle Coastal	8	36.39343N	121.87746W
Palo Colorado	519	37497 Palo Colorado Canyon Road	5' diameter culvert under driveway to house, potential plugging	flood	Culvert/driveway	drainage structure	low	high	no	early warning system and storm patrol	Middle Coastal	8	36.39377N	121.87789W
Palo Colorado	520	37455 Palo Colorado Canyon Road	Concrete box culvert 5'x10', potential plugging	flood	Road	drainage structure	low	high	no	storm patrol, clear debris from house pad above	Middle Coastal	8	36.39447N	121.87861W
Palo Colorado	521	37452 Palo Colorado Canyon Road	Home near Palo Colorado Creek	flood	House	home	high	high	no	early warning system	Middle Coastal	8	36.39463N	121.87881W
Palo Colorado	522	37400 Palo Colorado Canyon Road	Crossing under Palo Colorado Canyon Road. 6' diameter culvert connected to 8' diameter culvert is undermined	flood	Road	drainage structure	low	high	no	storm patrol, repair undermine culvert	Middle Coastal	8	36.39526N	121.87922W
Palo Colorado	523	Bridge to Garrapatos Road	Bridge west of intersection of Garrapatos and Palo Colorado Canyon Road	flood	Bridge	drainage structure	low	moderate	no	Storm patrol, early warning system	Middle Coastal	8	36.39526N	121.87952W
Palo Colorado	524	37341 Palo Colorado Canyon Road	Home near Palo Colorado Creek channel	flood	House	home	high	high	no	early warning system	Middle Coastal	8	36.39601N	121.88043W
Palo Colorado	525	37315 Palo Colorado Canyon Road	House, garage, and driveway bridge on Palo Colorado Creek. House is above channel, garage is lower and at higher risk. Driveway bridge at moderate risk.	flood	House/Bridge	home/drainage structure	low	moderate	no	early warning system, storm patrol	Middle Coastal	8	36.39599N	121.88048W
Palo Colorado	526	37305 Palo Colorado Canyon Road	Driveway bridge to house at risk, house above street elevation	flood	Bridge	drainage structure	low	moderate	no	early warning system, strom patrol	Middle Coastal	8	36.39670N	121.88158W

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Palo Colorado	527	37295 Palo Colorado Canyon Road	Foot bridge access to house	flood	Foot Bridge	drainage structure	low	moderate	no	early warning system	Middle Coastal	8	36.39674N	121.88214W
Palo Colorado	528	Palo Colorado Canyon Road	5' diameter culvert under Palo Colorado Canyon Road	flood	Culvert	drainage structure	no	high	no	storm patrol, stream clearance	Middle Coastal	8	36.39877N	121.88663W
Palo Colorado	529	Palo Colorado Canyon Road	Culvert - 5' diameter. Concrete wingwalls under Palo Colorado Canyon Road	Flood	Culvert	drainage structure	no	low	no	Channel clearance, storm patrol	Middle Coastal	8	36.39942N	121.88838W
Palo Colorado	530	37029 Palo Colorado Canyon Road	Two foot bridges access house under construction. Palo Colorado Creek makes meander at house	Flood	House	home	low	moderate	no	early warning system	Middle Coastal	8	36.39970N	121.89055W
Palo Colorado	531	37021 Palo Colorado Canyon Road	foot bridge access to patio	Flood	Patio	foot bridge and patio	low	moderate	no	early warning system	Middle Coastal	8	36.39979N	121.89205W
Palo Colorado	532	37013 Palo Colorado Canyon Road	Driveway bridge to access house. House not at risk.	Flood	Bridge	drainage structure	no	moderate	no	early warning system	Middle Coastal	8	36.40005N	121.89286W
Palo Colorado	533	37005 Palo Colorado Canyon Road	Foot bridge to house and propane tank	Flood	Bridge	drainage structure	no	moderate	no	early warning system	Middle Coastal	8	36.40044N	121.89453W
Palo Colorado	534	Palo Colorado Canyon Road	Driveway bridge to access house. House not at risk.	Flood	Bridge	drainage structure	no	moderate	no	early warning system	Middle Coastal	8	36.40077N	121.89488W
Palo Colorado	535	36971 Palo Colorado Canyon Road	House near Palo Colorado Creek	Flood	House	home	high	high	no	early warning system	Middle Coastal	8	36.40084N	121.89499W
Palo Colorado	536	36967 Palo Colorado Canyon Road	Lower house, foot bridge near Palo Colorado Creek channel	Flood	House	home	high	high	no	early warning system	Middle Coastal	8	36.40111N	121.89562W
Palo Colorado	537	36963 Palo Colorado Canyon Road	Cabin built over watercoure, was told water flows through windows during flood flows	Flood	House	home	high	high	no	early warning system	Middle Coastal	8	36.40116N	121.89575W
Palo Colorado	538	36959 Palo Colorado Canyon Road	Deck foundations could scour, and foot bridge that accesses house at risk	Flood	House	home	moderate	high	no	early warning system	Middle Coastal	8	36.40121N	121.89670W
Palo Colorado	539	36955 & 36951 Palo Colorado Canyon Road	Potential scour of foundations for driveway bridges. Homes not at risk.	Flood	Bridge	drainage structure	low	moderate	no	early warning system	Middle Coastal	8	36.40117N	121.89748W
Palo Colorado	540	36947 Palo Colorado Canyon Road	Driveway bridge to access house. House not at risk.	Flood	Bridge	drainage structure	low	moderate	no	early warning system	Middle Coastal	8	36.40133N	121.89832W
Palo Colorado	541	36943 Palo Colorado Canyon Road	House low in channel. Foundation piers scoured and appear unsafe.	Flood	House	home	high	high	no	early warning system	Middle Coastal	8	36.40153N	121.89901W
Palo Colorado	542	36925 Palo Colorado Canyon Road	Residence accessed via foot bridge over creek, potential scour of structural footings in channel flood zone	Flood	Foot bridge	home	high	high	no	early warning system	Middle Coastal	8	36.40136N	121.89896W
Palo Colorado	543	36935 and 36933 Palo Colorado Canyon Road	Bridge and water supply pipes within active channel	Flood	Residential access and infrastructure	home	low	moderate	no	early warning system	Middle Coastal	8	36.40112N	121.89979W
Palo Colorado	544	Palo Colorado Canyon Road	8'x6' concrete box culvert. Poor condition	Flood	Culvert	road	no	moderate	no	storm patrol	Middle Coastal	8	36.39987N	121.90242W
Palo Colorado	600	5953 Garrapatos Road	Home, driveway, bridge, walkway, and propane tank at risk to flooding	flood	house	home	high	high	no	early warning system	Middle Coastal	10	36.40150N	121.86794W
Palo Colorado	601	5922 Garrapatos Road	5th wheel, outbuildings, and pedestrian bridge at risk to flooding	flood	house	home	moderate	high	no	early warning system	Middle Coastal	10	36.40093N	121.86895W
Palo Colorado	602	Garrapatos Road	Road at risk to flooding and washout which may limit access to upstream. Currently armored with crib logs.	flood	road	other	no	moderate	no	early warning system	Middle Coastal	10	36.40038N	121.86909W
Palo Colorado	625	Green Ridge Road area	Potential plugging of 2x36" culvert crossing, only access to house.	debris flow / flood	Culverts	drainage structure	low	moderate	no	Storm patrol	Middle Coastal	9	36.38959N	121.86540W
Palo Colorado	626	Green Ridge Road area	Tributary crossing with no drainage structure, drains on to road and down to main channel at point 625, debris piled immediately upstream of the road	debris flow	Road	drainage structure	low	moderate	no	storm patrol	Middle Coastal	9	36.38994N	121.86535W
Palo Colorado	627	Green Ridge Road area	Plugging of burned out culvert that goes under bocce ball court and parking area with sheds, plugging and overtopping may direct flow towards residence	debris flow	House, pad w/ bocce court and sheds	home	moderate	high	no	early warning system, replace culvert, diversion structure	Middle Coastal	9	36.39018N	121.86412W
Pfeiffer-Big Sur State Park	574	Highway 1	large waste treatment facility, existing H-beam and wood lagging protects facility infrastucture from debris flow; additional protection needed	debris flow	Offices and generator	State Park	high	high	no	Install k rail along buildings, remove hazard trees perched over facilities	Lower Big Sur	N7	36.25754N	121.78769W

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Pfeiffer-Big Sur State Park	575	Highway 1	Potential debris flow into Pfeiffer/Big Sur-Redwood Creek Lodge, parking lot, highway 1, and drainage structures. Documented history of debris flow in this area	debris flow	Pfeiffer Big Sur Lodge	State Park	high	high	no	Protect north and east sides of lodge with k rails, block half of access road above lodge with k rail. Close parking lot during winter	Lower Big Sur	N7	36.25099N	121.78639W
Pfeiffer-Big Sur State Park	576	Pfeiffer-Big Sur Road	potential flooding of Junior Ranger building and lift station that pumps sewage	flood	Building, lift station	State Park	low	moderate	no	Sand bagging and plywood	Upper Big Sur	N6	36.25045N	121.78456W
Pfeiffer-Big Sur State Park	577	Pfeiffer-Big Sur Road	Potential debris flow route into restroom building in campground	debris flow	Bathrooms	State Park	low	low	no	Sand bagging and plywood	Upper Big Sur	N6	36.25068N	121.78174W
Pfeiffer-Big Sur State Park	578	Day use entrance road	Rock fall hazard and debris flow impacts to road , this road is main public access .	rock fall, debris flow	Road	State Park	moderate	moderate	yes	early warning system, general awareness, develop rock fall hazard mitigation	Upper Big Sur	N6	36.24790N	121.77736W
Pfeiffer-Big Sur State Park	579	Pfeiffer-Big Sur State Park Employee Housing	potential flooding of residential housing	flood	homes	State Park	low	moderate	yes	early warning system, muscle wall to close the breach in the berm. Berm wraps around housing buildings	Upper Big Sur	N6	36.24504N	121.77578W
Pfeiffer-Big Sur State Park	580	Pfeiffer-Big Sur Road	Potential flooding in campground area	flood	Recreation	State Park	moderate	moderate	yes	Close during raiming season	Upper Big Sur	N6	36.24605N	121.77889W
Pfeiffer-Big Sur State Park	581	Pfeiffer-Big Sur Campground	Lift station for sewage, generator, important infrastructure	flood	Recreation, Infrastructure	State Park	low	high	yes	Sand bagging , plywood	Upper Big Sur	N6	36.24985N	121.78435W
Pico Blanco Boy Scout camp	101	End of Palo Colorado Canyon Road	Campsites in close proximity to channel / on floodplain	debris flow / flood	Boy Scout camp	recreational	high	moderate	yes	During storm events close campground by closing access road past gate	Little Sur	25	36.33116N	121.79461W
San Clemente Rancho	148	Black Rock Road	Number of homes constructed on boulder strewn alluvial fan at mouth of Black Rock Creek	debris flow / flood	Numerous residences	home	high	high	yes	early warning system	Upper Carmel	28		
San Clemente Rancho	149	Dormody Road	Numerous houses constructed on floodplain or close to channel, along San Clemente Creek below Black Rock Creek alluvial fan	debris flow / flood	Houses	home	high	high	yes	early warning system	Upper Carmel	20		
San Clemente Rancho	150	Dormody Road	Community center and recreational facilities in floodplain	debris flow / flood	Community center	recreational	high	high	no	early warning system	Upper Carmel	20	36.42210N	121.73231W
San Clemente Rancho	151	Dormody Road	Debris flow/flooding impact at bridge and other crossing structures on Black Rock Creek alluvial fan	debris flow / flood	Bridge/other crossing structures on fan	drainage structure	moderate	high	no	early warning system, storm patrol	Upper Carmel	20	36.42240N	121.73841W
San Clemente Rancho	152	18 Dormody Road	Backwater flooding immediately upstream of confluence with Black Rock Creek	flood	House	home	high	high	no	early warning system	Upper Carmel	27	36.42244N	121.73921W
San Jose Creek	570	San Jose Creek Canyon Road	state park residences located on floodplain	flood	Residences	State Park	low	moderate	yes	early warning system, implement state parks previous mitigations	Upper Coastal	21	36.51970N	121.92092W
Santa Lucia Preserve	143	54 Rancho San Carlos Road	Residence under construction on alluvial fan adjacent to tributary channel	debris flow	Residence	home	low	low	no	early warning system	Upper Coastal	21	36.46562N	121.83299W
Santa Lucia Preserve	144	Garzas Trail	Potential plugging of approx 60" culvert crossing on dirt road at locked gate. Unclear if additional residence upstream	debris flow / flood	Culvert	drainage structure	low	low	no	Storm patrol	Lower Carmel	N2	36.44174N	121.82028W
Santa Lucia Preserve	145	Garzas Trail	Bridge in FEMA floodplain	flood	Bridge	drainage structure	low	low	yes	Storm patrol	Lower Carmel	N2	36.44818N	121.81909W
Santa Lucia Preserve	146	Rancho San Carlos Road	10' x 4' squash culvert on Las Gazas Creek, appears undersized based on channel width	flood	Culvert	drainage structure	low	low	yes	Storm patrol	Lower Carmel	N2	36.45414N	121.80752W
Santa Lucia Preserve	147	Foot path in summer camp	Footbridge with center pier subject to flooding	flood	Foot bridge	drainage structure	low	low	yes	Storm patrol	Lower Carmel	N2	36.45557N	121.80613W
Santa Lucia Preserve	630	46 Rancho San Carlos Road	Residence appears to be constructed on edge of alluvial fan, potential debris flow impact	debris flow	house	home	low	low	no	early warning system	Upper Coastal	21	36.47085N	121.84128W
Upper Carmel River	156	private road upstream of syndicate	A-frame residence Immediately adjacent to active channel, footbridge over river behind house	flood	Private residence	home	high	high	no	early warning system	Upper Carmel	19	36.40957N	121.67300W

Note: These results were based upon a rapid review so that as much time as possible was allowed for emergency measures to be put in place before winter storms

Community	Site Number	Address	Field Observation	Hazard Category	Feature	Feature Category	Hazard to Life	Hazard to Property	In FEMA/DWR 100 yr floodplain	Preliminary Emergency Protective Measures	Subwatershed (Tier 2)	Pour Point	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
Upper Carmel River	157	Private road	Debris flow - House in close proximity to channel, locked gate and fence	debris flow	House	home	moderate	moderate	no	early warning system	Upper Carmel	19	36.40472N	121.67023W
Upper Carmel River	158	Private road	potential plugging 18" culvert, evidence of previous plugging	debris flow	Culvert	drainage structure	low	moderate	no	Storm patrol	Upper Carmel	19	36.40534N	121.67236W
Upper Carmel River	159	Private road	Bridge, reportedly OK in 95 flood	flood	Bridge	drainage structure	low	low	yes	storm patrol	Upper Carmel	19	36.40850N	121.67243W
Upper Carmel River	201	Private road, upstream of San Clemente Dam site	Hunting cabin, uninhabited	flood	hosue	recreational	no	low	no	None needed	Upper Carmel	19	36.42189N	121.71134W
White Rock	153	Robinson Canyon Road	Low bridge crossing with several homes upstream	debris flow / flood	Bridge	drainage structure	low	moderate	no	Storm patrol	Upper Carmel	20	36.41062N	121.78097W
White Rock	154	94 Robinson Canyon Road	House in floodplain with sandbag wall showing evidence of recent flooding	debris flow / flood	House	home	high	high	no	early warning system	Upper Carmel	20	36.41052N	121.78090W

* gray = larger communities rather than individual features

Note: These results were based upon a rapid review so that as much time as possible was allowed for emergency measures to be put in place before winter storms

General Recommendations

Early Warning System - Existing early warning systems should be used and improved such that residents can be alerted to incoming storms, allowing enough time to safely vacate hazard areas. Practical lead times of several hours must come from a combination of weather forecasts, rainfall measurements of approaching storms, and debris-flow triggering thresholds. Please see text (Section 4.5, general recommendations) for a discussion.

Storm Patrol - Existing road drainage systems should be inspected for damage or plugging by the appropriate controlling agency to evaluate potential impacts from floods, hyperconcentrated floods, debris torrents, debris flows and sedimentation resulting from storm events.

Structure Protection - Please see text (Section 4.5, general recommendations) for a discussion.

Temporary Housing - Please see text (Section 4.5, general recommendations) for a discussion.

i. **Lower Carmel @Mouth**
- Develop flood protection measures for the Carmel State Beach parking lot and bathroom structure.
- Flood hazards analyses may need to consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.

ii. **Gazas Creek @ Carmel River**
- Develop an early warning system for residents in the FEMA 100-year flood zone (VAR 162).
- Develop a storm watch patrol for points in the Santa Lucia Preserve (VAR 144 - 147) so that watercourse crossings may be observed for blockage and cleaned out after storms.

iii. **San Clemente**
- A bulking factor to flow analysis should be considered for “watch stream” segments when designing mitigations. It has been our experience that a bulking factor of 50 percent has been used in other post-fire responses.
- *White Rock Community, Rancho San Clemente Community* (VAR 148-154): Early warning system, storm patrol

iv. **Carmel River @ San Clemente Dam**
- Because “watch stream” flood hazards are present any flood analyses should consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.
- An early warning system tied to predicted storm events should be developed for these areas. Because cell reception is poor in these areas a reverse 911 or “nixle” system may not provide an adequate warning system.

v. **Carmel River @ Cachuaga**
- Because “watch stream” flood hazards are present any flood analyses should consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.

vi. **Joshua Creek/Lower Garrapata Creek**
- Storm Patrol, Replace any existing plastic culverts that were destroyed in the fire.

vii. Palo Colorado Community

- Because “watch stream” flood hazards are present any flood analyses should consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.
- An early warning system tied to predicted storm events should be developed for the Palo Colorado and Lower Bixby communities. This includes residential structures and road drainage features along Palo Colorado Road. Because cell reception is poor in these areas a reverse 911 or “nixle” system may not provide an adequate warning system.

viii. Bixby Creek

- Because “watch stream” flood hazards are present any flood analyses should consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris.
- An early warning system tied to predicted storm events should be developed for the Palo Colorado and Lower Bixby communities. This includes residential structures and road drainage features along Palo Colorado Road. Because cell reception is poor in these areas a reverse 911 or “nixle” system may not provide an adequate warning system.

ix. Upper Little Sur Boy Scout

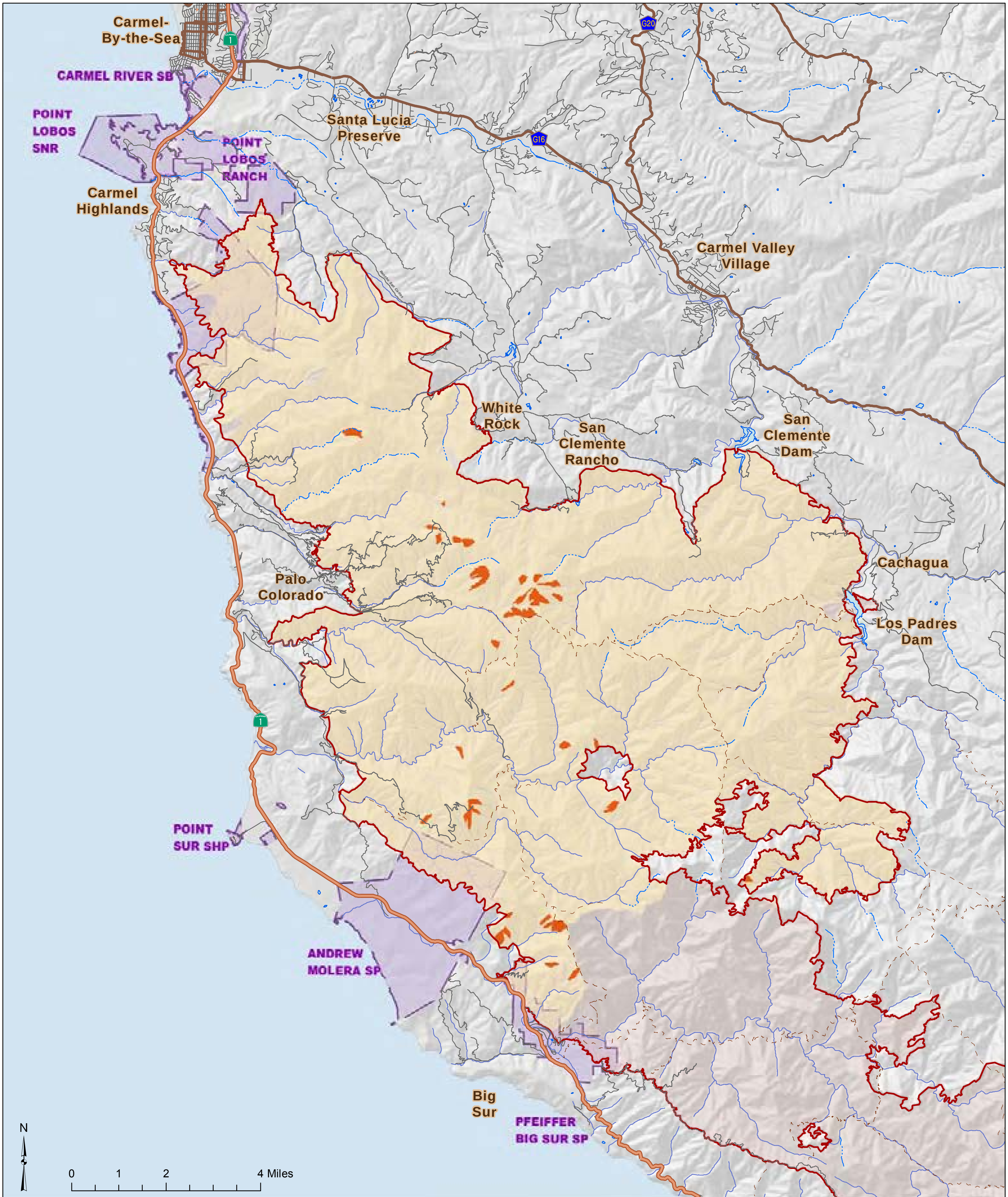
- Camp should be closed during storm events in order to minimize potential risk to life.
- Because the Little Sur River is modeled as a “watch stream” a bulking factor to flow analysis should be considered when designing mitigations. It has been our experience that a bulking factor of 50 percent has been used in other post-fire responses.
- Follow recommendations provided in the BAER analysis of the camp access road.
- Follow recommendations regarding tree hazards (F.O. Consulting).

x. Lower Little Sur

- Conduct storm patrols of the bridge following storm events.
- Because the Little Sur River is modeled as a “watch stream” flood hazards analyses may be need to consider bulking factors to model the increase in runoff volume due to the contribution of sediment and debris

xi. Big Sur River

- Develop an early warning system.
- State Park campgrounds at Andrew Molera and Pfeiffer Big Sur State Parks within the 100 year FEMA flood zone should be closed during storm events.
- Because the Big Sur River is modeled as a “watch stream” a bulking factor to flow analysis should be considered when designing mitigations. The bulking factor should be used to estimate areas of potential flooding exceeding the FEMA 100-year flood zone. It has been our experience that a bulking factor of 50 percent has been used in other post-fire responses.



Sediment Production (tons/acre)

10-year storm event

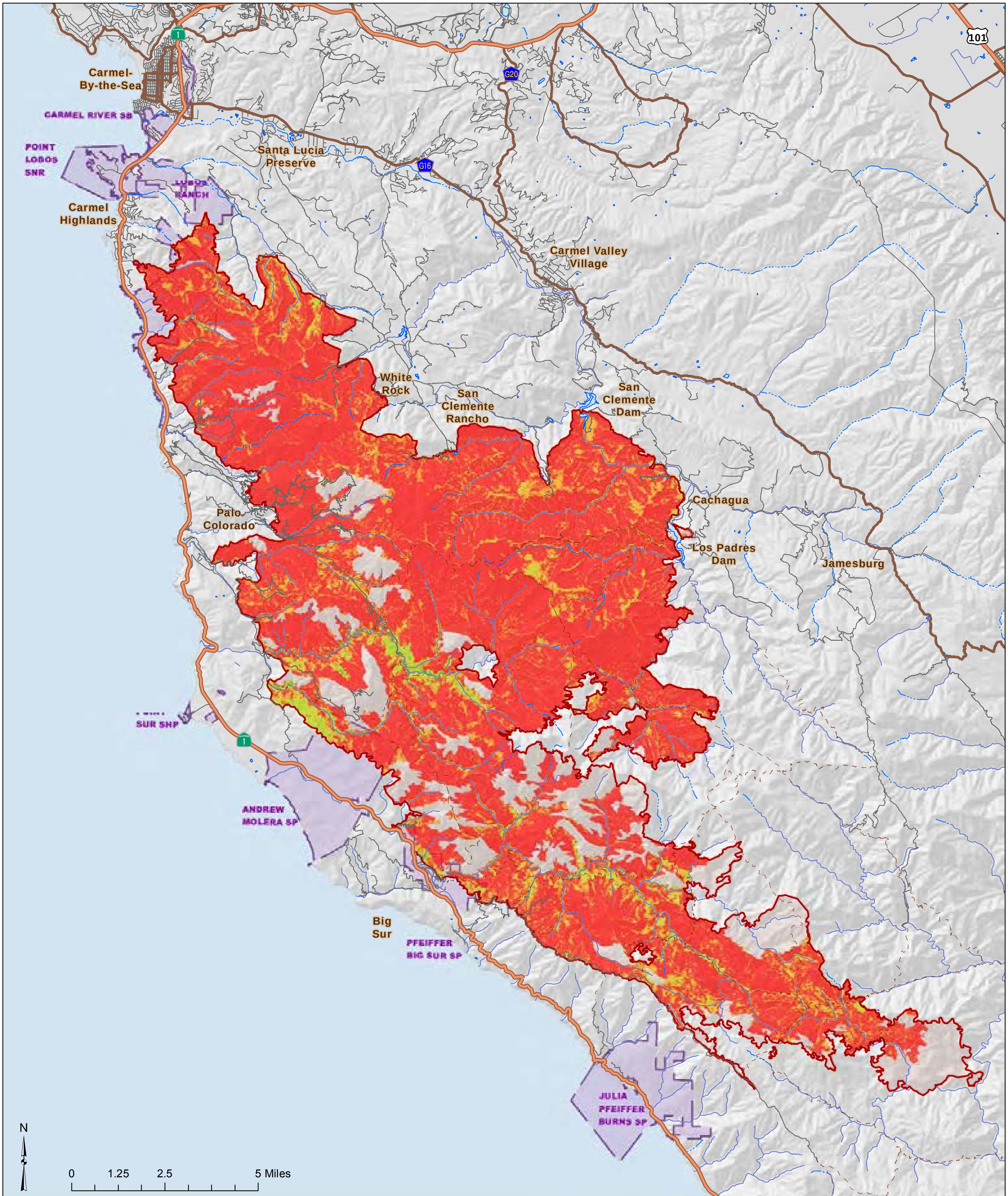
0-5

>5

Appendix E
GeoWEPP Derived Surface Erosion
Soberanes Incident

CA-BEU-003422

Soberanes Incident
Monterey County
Perimeter from 2016/09/12



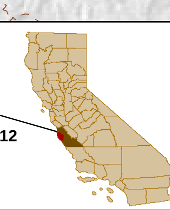
Erosion Hazard Rating

- Extreme
- High
- Low
- Moderate

Appendix F
Erosion Hazard Rating Map
Soberanes Incident

CA-BEU-003422

Soberanes Incident
Monterey County
Perimeter from 2016/09/12



Appendix G. Soberanes BAER Risk Matrix

Soberanes BAER Risk Matrix

VAR	Latitude	Longitude	Value at Risk	WERT Team Notes
1	36°14'57.09"N	121°46'44.21"W	Main stem of the Big Sur River and any issue with increased flow	Assessed, hazards noted
2a	36°15'3.15"N	121°47'12.01"W	Big Sur Lodge culvert/parking lot	Assessed, hazards noted
2b	36°15'9.31"N	121°47'3.73"W	Road/structures along Creek	Assessed, hazards noted
3a	36°15'51.09"N	121°47'57.17"W	General HUC8 debris flow potential	Assessed, hazards noted
3b	36°15'56.19"N	121°47'49.43"W	Debris flow potential and flooding impacts to structures	Assessed, hazards noted
3c	36°16'15.02"N	121°48'14.75"W	Debris fow hazard and flooding potential to structures	Assessed, hazards noted
4	36°19'55.81"N	121°52'50.95"W	Mouth of Little Sur structures. El Sur Ranch road	Behind Lock gate, inaccessible no apparent structures
5	36°19'51.14"N	121°51'44.87"W	Green bridge on Old coast ridge road	Assessed, hazards noted
6	36°19'56.66"N	121°51'34.89"W	Structure in Little Sur?	Assessed, hazards noted
7	36°19'58.29"N	121°47'55.39"W	Boy Scout Camp	Assessed, hazards noted
8	36°20'52.89"N	121°48'29.67"W	Botchers Gap to Boy Scout camp road. FS maintained	Verified by BAER Team
9	36°21'21.79"N	121°48'45.44"W	Botchers Campground	Verified by BAER Team
10a	36°21'8.49"N	121°52'35.69"W	Old Coast ridge road west of Green bridge	Assessed, hazards noted
10b	36°20'41.22"N	121°51'54.83"W	Old coast road and private access road above	Assessed, hazards noted
11	36°22'10.21"N	121°53'38.11"W	Mouth of Bixby Creek development	Assessed, hazards noted
12a	36°22'38.11"N	121°53'57.63"W	Structures in lower creek mouth north of Bixby	Not assessed behind locked gate, inaccessible - possible well
12b	36°22'41.33"N	121°53'25.14"W	Possible structure in canyon n of Bixby	Not assessed behind locked gate, inaccessible - possible primative camsite
13a	36°22'40.29"N	121°51'10.82"W	Palo Colorado road bridge	Assessed, hazards noted
13b	36°22'40.90"N	121°51'18.38"W	Palo Colorado Road - dry ravel, plugged culvert, side channel, debris flow potential. This section has Mo. County maintenance	Assessed, hazards noted
14	36°22'43.35"N	121°51'17.22"W	Private drive above Palo Colorado	Assessed, hazards noted
15a	36°22'48.68"N	121°51'39.87"W	Roads/homes in Palo Colorado.	Assessed, hazards noted
15b	36°22'54.33"N	121°51'47.38"W	Palo Colorado Bridge	Assessed, hazards noted
15c	36°22'59.51"N	121°51'53.84"W	Palo Colorado Bridge	Assessed, hazards noted
15d	36°23'23.56"N	121°51'51.43"W	Roads/homes in Palo Colorado	Assessed, hazards noted
15e	36°23'23.38"N	121°52'17.83"W	Palo Colorado bridge	Assessed, hazards noted
15f	36°23'29.49"N	121°52'31.27"W	Roads/homes in Palo Colorado	Assessed, hazards noted
16	36°24'6.65"N	121°52'3.68"W	Private road and home in drainage N of Palo Colorado Road	Assessed, hazards noted
17a	36°24'54.79"N	121°54'43.11"W	Garrapata Creek roads/structures	Assessed, hazards noted
17b	36°24'52.46"N	121°54'12.43"W	Garrapata Creek roads/structures	Assessed, hazards noted
17c	36°24'59.89"N	121°54'13.79"W	Garrapata Creek roads/structures	Assessed, hazards noted
17d	36°25'13.11"N	121°53'35.43"W	Garrapata Creek roads/structures	Assessed, hazards noted
17e	36°25'33.46"N	121°52'53.01"W	Garrapata Creek roads/structures	Assessed, hazards noted
18a	36°25'32.77"N	121°54'46.13"W	Hwy 1 culverts/underpasses Caltrans examining many of these. Contact Caltrans	Caltrans Jurisdiction
18b	36°25'56.86"N	121°55'3.05"W	Hwy 1 culverts	Caltrans Jurisdiction
18c	36°27'22.11"N	121°55'26.18"W	Hwy1	Assessed, hazards noted
18d	36°27'37.02"N	121°55'29.34"W	Hwy1 culverts	Caltrans Jurisdiction
18e	36°27'40.75"N	121°55'30.62"W	Hwy1 culverts	Caltrans Jurisdiction
18f	36°28'1.35"N	121°55'45.09"W	Hwy 1	Caltrans Jurisdiction
18g	36°28'15.88"N	121°56'3.51"W	Hwy1	Caltrans Jurisdiction
18h	36°28'40.97"N	121°56'10.63"W	Hwy 1	Caltrans Jurisdiction
19	36°27'17.67"N	121°55'20.21"W	Soberanes Cr. roads/structures	Discussed with State Parks - SP removing foot bridge
20	36°28'37.89"N	121°55'58.80"W	Creek crossing on pvt road	Assessed, no hazards noted
21	36°28'42.66"N	121°54'50.00"W	San Remo Road	Assessed, hazards noted
22	36°29'23.52"N	121°54'3.16"W	Roads/homes above Carmel highlands	Assessed, no hazards noted
23	36°31'18.94"N	121°55'27.38"W	San Jose Creek residence/roads	Assessed, hazards noted
24	36°31'6.10"N	121°54'40.19"W	San Jose Canyon Creek road	Assessed, no hazards noted
25	36°29'20.14"N	121°49'1.14"W	Carmel River/Sediment+flow issues	Assessed, hazards noted
26a	36°29'16.30"N	121°45'16.42"W	Possible increased flow near Carmel Valley. Only a small portion of upper watershed burned.	Assessed, hazards noted
26b	36°29'28.41"N	121°45'5.06"W	Possible increased flow near Carmel Valley. Only a small portion of upper watershed burned.	Assessed, hazards noted
27	36°27'14.64"N	121°48'25.39"W	San Carlos Summer Camp	Assessed, hazards noted
28	36°27'31.05"N	121°47'58.14"W	San Carlos reservoir	Assessed, no hazards noted
29	36°24'42.31"N	121°46'37.56"W	White Rock gun club road	Assessed, hazards noted
30	36°24'40.43"N	121°46'24.03"W	White Rock Lake	Assessed, no hazards noted
31	36°25'14.00"N	121°44'18.72"W	Dormody Road and structures	Assessed, hazards noted
32	36°25'29.94"N	121°43'40.56"W	Reservoir	Assessed, no hazards noted
33	36°16'10.53"N	121°48'26.58"W	Road/structures	Assessed, hazards noted
34	36°23'6.05"N	121°40'8.23"W	Los Padres Reservoir - sedimentation and increased water input	Assessed, no hazards noted
35	36°26'9.09"N	121°42'30.74"W	Water diversion and conveyance of San Clemente dam infrastructure	Assessed,no hazards noted
36	37° 3'37.80"N	121° 4'33.72"W	Water diversion and conveyance of San Luis dam infrastructure	N/A
other			Trout Farm road (1 main creek crossing at un-named creek in sec 20 near BM 3349) county	Assessed, no hazards noted
other			Botcher Gap Camp fencing FS	Forest Service
other			Aquatics species of Big Sur, Little Sur, and Carmel Rivers county	N/A
other			Sur areas Pvt	N/A
other			county	N/A
other			Loss of soil productivity in high to moderate SBS areas. Pvt & FS	N/A
other			Loss of soil due to OHV cross-country riding	N/A

Appendix H. List of Contacts

NAME	AGENCY	E-MAIL	PHONE
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(EWP)			
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Monterey County Public Information Officer		carrollm@co.monterey.ca.us	
Nathan Rezeau, Agency Administrator	U.S. Forest Service	nrezeau@fs.fed.us	805-925-9538
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Ryan Turner P.E., G.E.,	California Department of Transportation		(805) 549-3750 Office
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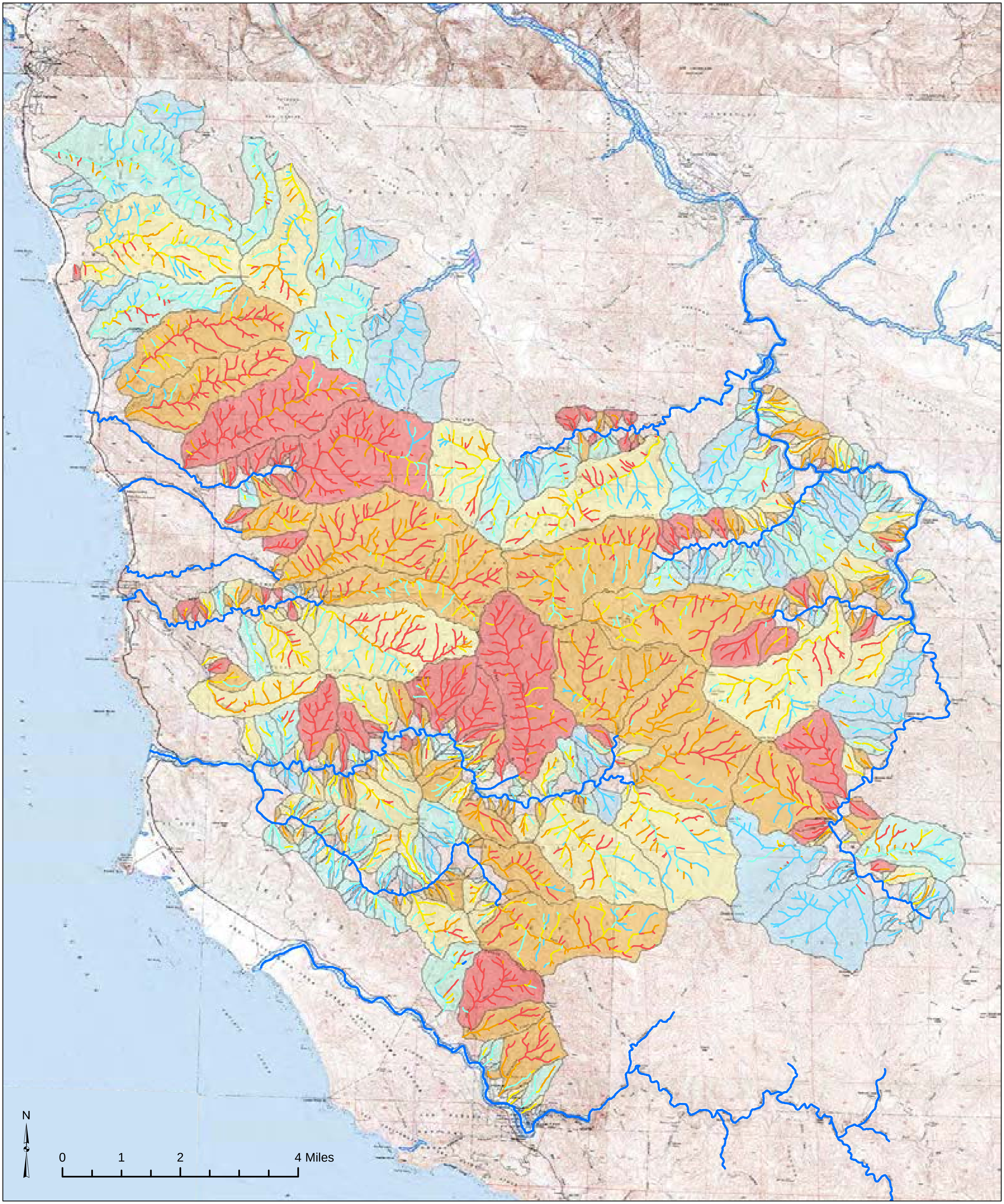
Dennis Staley US Geological Survey	Geologic Hazards Science Center		303-273-8568
Tom Paulino	Sen. Feinsten's Office	Tom_Paulino@feinstein.senate.gov	



USGS Model Watch Stream
DWR Awareness Floodplain
FEMA Special Flood Hazard Area

Debris Flow Probablility
15 min, 28 mmh

0-20%	0-20%
20-40%	20-40%
40-60%	40-60%
60-80%	60-80%
80-100%	80-100%

Appendix I
Debris Flow Probability, 28 mmh
Soberanes Incident
CA-BEU-003422