WATERSHED ASSESSMENT

BLUE CUT FIRE

SAN BERNARDINO NATIONAL FOREST

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I. RESOURCE CONDITION ASSESSMENT

A. RESOURCE SETTING

The Blue Cut fire burned 36,240 acres, the majority of the fire within the lower and upper Cajon Wash watersheds on the San Bernardino National Forest. The fire burned in surrounding watersheds such as North Fork Lytle Creek along the southern perimeter and Manzanita Creek along the northern perimeter, and burned into the high desert regions to the north. The fire burned between 2,400 feet elevation at Cajon Wash to 6,955 feet elevation on Lytle Creek Ridge in the San Gabriel Mountains. The Cajon Wash and tributaries dominate the watershed setting of the fire, and the San Gabriel Mountain Range to the west have elevations reaching 10,000 feet at the head of North Fork Lytle Creek. The drainage headwaters are steep and confined, flowing into extended and anastomosed low gradient channels and washes (alluvial fans and plains) with wide valleys such as Cajon Canyon, Lone Pine Canyon and Lower Cajon Wash. Lytle Creek and Cajon Wash merge below the mountains and flow into the Santa Ana River near San Bernardino.

Most of the streams have seasonal flow, usually from large storm events or during wet winter rain seasons and typically turn dry during the summer. Cajon Wash and Lytle Creek have sections of perennial stream flow. Primary streams can flow for extended periods during wet winters further down reaches and reach the Santa Ana River to the Pacific Ocean. The northern streams beyond the Cajon watershed flow into the Mojave River system to sinks. Streams can flood during storms and flow at high rates during the winter. In 1938 and 1969 when significant storms occurred, Lytle Creek near the mouth of the canyon had peak flows estimated to be 26,000 and 35,900 cubic feet per second, respectively.

The majority of precipitation in the area occurs from October through April, with the bulk coming from December through March. Summers are warm and occasional summer convective storms, or monsoon storms can produce sudden and heavy rainfall that can cause flooding. Snowfall occurs in elevations above 5,000 feet in winter and high elevation snowpack can develop. Annual precipitation is greatest within the upper Lytle Creek watershed along the south facing front of the San Gabriel range. The upper reaches of the Cajon watershed tend to have lower annual precipitation due to rain shadowing as storms release the bulk of precipitation on the San Gabriel Range before reaching the upper Cajon watershed.

The San Gabriel range rises abruptly from coastal valleys in an east to west orientation, where moisture from Pacific frontal systems is directed from the south to southwest. Storms tend to build along the range causing an orographic lift effect that can lead to significant amounts of precipitation if storm dynamics are in place. Average annual precipitation in Upper Lytle watershed is near 40 inches, 20 inches in the lower Cajon Wash, and 15 inches in the northern area of the fire near Baldy Mesa and Manzanita Creek. Powerful winter storms that tap into deep sub-tropical moisture can create high, intense rainfall rates on mountain slopes and are the storms that can cause significant flooding and debris flows in the major drainages. Although not common, these storms tend to be warmer with high snow levels, and warm heavy rain on existing snowpack can cause even larger floods that have historically caused damage to roads and infrastructure along the major streams and alluvial fans.

1. Beneficial Uses and Water Quality

a) Beneficial Uses of Water – Santa Ana River Water Quality Control Board (SARWQCB), State of California)

Beneficial Uses (BU's) are the natural and human uses of surface water and are defined in the State of California Water Quality Control Board Basin Plans. These beneficial uses must be maintained.

Two major watersheds within the Blue Cut Fire area fall under the Santa Ana River Water Quality Control Board's jurisdiction: Lytle Creek and Cajon Canyon Creek. Both streams fall within the same Hydrologic Unit Code (Cajon Canyon Creek – Lytle Creek HUC 1807020300305). Beneficial Uses of water of these streams, classified as inland surface waters within the Santa Ana River watershed, as referenced from the Santa Ana River Water Quality Board Basin Plan (SARWQCB 1995), included on the following tables:

Table 1: Beneficial Uses of Water for Lytle Creek

Beneficial Use Code	**Lytle Creek** (HUC 1807020300305)
MUN	Municipal and Domestic Supply
AGR	Agricultural Supply
GWR	Groundwater Recharge
IND	Industrial Service Supply
PROC	Industrial Process Supply
REC-1	Water Contact Recreation
REC-2	Non-contact Water Recreation
COLD	Cold Freshwater Habitat
WILD	Wildlife Habitat
RARE	Rare, Threatened or Endangered Species
POW	Hydropower Generation

Table 2: Beneficial Uses of Water for Cajon Canyon Creek

Beneficial Use Code	**Cajon Canyon Creek** (HUC 1807020300305)
MUN	Municipal and Domestic Supply
GWR	Groundwater Recharge
REC-1	Water Contact Recreation
REC-2	Non-contact Water Recreation
COLD	Cold Freshwater Habitat
WILD	Wildlife Habitat
RARE	Rare, Threatened or Endangered Species

b) *Threats to Water Quality and Beneficial Uses of Water*

Peak flow increases from the fire will also be bulked by ash, debris and other floatable and transportable material within stream channel areas of the fire. Temporary episodes of water quality degradation and fine siltation is likely during the first year after the fire to Cajon Canyon Creek and major tributaries. Less severe and localized water quality impacts to North Fork Lytle Creek below burned tributaries upstream and adjacent to the Lytle Creek residential area and downstream could occur. Beyond the first year, post-fire water quality impacts will be lessened as the burned watersheds recover. Beneficial uses listed above in Tables 1-2 could experience temporary impacts post-fire.

B. POST-FIRE SOIL SURVEY RESULTS

The BAER soils scientists field verified the Burn Area Reflectance Classification (BARC) map, which is used to estimate soil burn severity (SBS). Description of methods (both development of the BARC and field verification methods) to determine SBS are described in detail in the Blue Cut Fire Soils Report. Soil burn severity ratings include careful consideration of factors such as, amount and condition of residual ground cover, viability of native seed banks, condition of residual fine roots, degree of fire-induced water-repellency, soil physical factors (texture, structural stability, porosity, restricted drainage), soil chemical factors (oxidation, altered nutrient status), and topography (slope gradient, length, and profile), and the length of time heat from the fire has been in contact with the soil (residence time). Hydrologic function, runoff, and erosion potential are influenced by pre-fire, fire, and post-fire environments. Final ratings for SBS of the Blue Cut Fire are listed in Table 3 (Appendix A, Map 1).

Table 3: Blue Cut BAER Soil Burn Severity (2/Sept/2016)

Soil Burn Severity	Acres	% Fire Area
Unburned/Very Low	6,205	17%
Low	12,505	35%
Moderate	15,678	43%
High	1,852	5%
Total:	36,240	

II. IDENTIFICATION OF VALUES AT RISK, RISK DETERMINATION, AND TREATMENT RECOMMENDATIONS

A. ON-THE-GROUND FINDINGS

An initial list of potential values at risk was identified by the team early in the assessment process. According to policy direction, such values are determined as critical if they fall within the categories below.

Table 4: Taken from FSH BAER Direction

HUMAN LIFE AND SAFETY
Human life and safety on National Forest System (NFS) lands.
PROPERTY
Buildings, water systems, utility systems, roads and trails, dams, wells and other significant improvements on NFS lands.
NATURAL RESOURCES
Water used for municipal, domestic, hydropower, or agricultural supply or waters with special Federal or State designations on NFS lands.

Some of the potential critical values identified included:

- Life and Safety
  - Forest Service recreation areas, such as campgrounds, picnic areas, and recreation residences at risk from flooding, erosion, sedimentation, debris flow, and rock fall.
  - Low-water crossings at risk of flooding, sedimentation, erosion, and debris flow.

    - Private residences off forest at risk from flooding, erosion, sedimentation, debris flows, and rock fall.
- Property
    - Infrastructure, transmission lines, pipelines, road, railroads, highways, special uses on the forest, and dams at risk from flooding, erosion, sedimentation, debris flow, and rock fall.
    - Private property at risk from flooding, sedimentation, erosion and debris flow, and rock fall.
    - Forest Service roads, trails, and facilities at risk from flooding, erosion, debris flow, and rock fall.
- Natural Resources
    - Domestic water at risk from ash and sediment.
    - Water bodies (Lost Lake) at risk from ash and sediment.
    - Downstream water quality at risk from hazardous material burned in the fire.
    - T & E species habitat at risk from flooding, sedimentation, erosion, and debris flow.

These values were assessed in the field and through runoff, erosion, and debris flow modelling. Assessment results of on-the-ground findings/observations, modeling results, risk determinations, and recommended treatments are discussed in detail in the following sections and Table 5.

Figure 1. Several Values At Risk were identified in the assessment: private residences, roads, railroads, highways, utility lines, transmission lines, T&E species habitat, etc.

Table 5: Values at Risk: Field Observations, Risk Assessment and Recommended Treatments, Blue Cut Fire

Assessment Site	Values at Risk	Observations	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment Recommendation
Sheep Canyon Debris Basin	Property	Risk of sedimentation and erosion. Debris basin has storage capacity. Outlet has some erosion near spillway.	Very Likely	Minor	Low	No treatment
Sheep Canyon Road 2N56 Low Water Crossing	Property	Risk of flooding and sedimentation. Loss of access. Crossing is located in a depositional area.	Likely	Major	Very High	Advise Engineering Staff. Recommend closure.
Applewhite Road 2N55 at Sheep Canyon Culvert	Property	Risk of flooding, debris flow, road damage, diversion potential. Culvert drains main stem and additional hillslope/swale drainages diverted by road ditches. Sediment charged swales with material that could be mobilized.	Likely	Major	Very High	Advise Engineering Staff of findings. Upgrade culvert capacity and storm patrol. Temporary road closure.
Lytle Creek Senior Community Center	Life and Safety, Property	Risk of flooding and undercutting. Building on high terrace out of hazard from flooding. Located on opposite side of creek (cut bank bend) from burned slope.	Possible	Moderate	Intermediate	No treatment
Lytle Creek Road/Sheep Canyon Culvert	Property	Risk of road and property damage due to flooding, plugging and diversion potential. Drains to Applewhite Picnic area. Concrete tunnel has potential to plug, may be undersized for modeled flows and additional post-fire sediment estimates. If tunnel plugs, water and sediment could either flow into the Applewhite Picnic area (lower half) or down Lytle Creek road for some distance. (See modeled pour point.)	Likely	Major	Very High	Consult with SB County Public Works. Close lower portion of Applewhite Picnic Area.
Forest Service Applewhite Campground	Life and Safety, Property	Risk of flooding, debris flow, rock fall, and sedimentation. Poses a safety threat to visitors. Site is located at the base of a steep, burned slope with sediment charged slopes and evidence of instability.	Likely	Major	Very High	Close campground.
Middle Fork Bridge – Lytle Creek Residential Area	Life and Safety, Property	Risk of flooding, sediment delivery and damage to homes and bridge. Several homes are located within the floodplain of the stream. Given the close proximity to the burn area, sediment loads and discharge will increase due to post-fire effects. (See modeled pour points.)	Possible	Major	High	Visited site with NRCS. Inform County. Advise Engineering Staff of hazard.
South Fork Lytle Creek/Bonita	Life and Safety	Risk of flooding and sedimentation, possible safety concern. Site is located downstream of	Possible	Moderate	Intermediate	No treatment recommended.

Assessment Site	Values at Risk	Observations	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment Recommendation
Flat Dispersed Recreation Sites		the burn area and will experience increased discharge and sediment loads; however, modeled flows did not indicate flows would be significantly increased (pour point Middle Fk. Lytle Crk Bridge). Water quality may be decreased due to post-fire erosion upstream.				
City of Fontana Water District on Lytle Creek (Intake Facility)	Property, Municipal Water supply	Risks of sedimentation, ash, and water quality degradation. Not at risk of flooding as a result of the fire.	Likely	Moderate	High	Consult and inform agency of risk.
Lytle Creek Recreation Residences	Life and Safety, Property	Risk of minor flooding and sedimentation for three of the recreation residences (#52, #50, #48). Rec cabins are located at the base of short, steep, sediment charged, burned slopes that direct runoff towards the cabins (swales). Remaining recreation residences not at risk.	Likely	Major	Very High	Recommend working with the County for erosion control and FS staff for clearance on ground disturbing activities.
Road 2N53 Applewhite Rd.	Property	Risk of road erosion, rock fall, loss of water control, diversion potential, debris flow. Road is partially located at the base of steep, sediment charged, burned slopes and climbs up the steep burned hillside. Evidence of past debris flows at channel crossings.	Likely	Major	Very High	Inform FS Engineering Staff of concerns. Close road and add additional drainage control structures.
Lost Lake Day Use Recreation Site	Resource	Risk of sedimentation, loss of lake capacity, OHV incursion and trampling induced erosion. Site is located on flat terrain (see modeling discussion) and was determined not to be at risk of significant sedimentation or loss of lake capacity due to post-fire effects. Due to lack of vegetation, OHV incursion and trampling may increase erosion at site and prevent vegetation response.	Possible	Moderate	Intermediate	Recommend fencing and barrier to prevent OHV access and manage recreational use of the site.
Road 3N49 Low Water Crossings	Property	Risk of flooding, debris flow, erosion, sedimentation, road damage. Crossing across Lone Pine Canyon is at risk of flooding (see modeling, pour point) during storm events. This crossing also has sediment charged, burned swales draining to it. Swale drainage has been diverted to the crossing because of the road and other spur locations near the crossing. Second crossing is located upstream of pour point Railroad 2 (see modeling for	Very Likely	Major	Very High	Consult with LADWP on closure and adding drainage control structures.

Assessment Site	Values at Risk	Observations	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment Recommendation
		trends in expected flows/erosion). Site has evidence of past debris flows and high sediment bed loads. Crossing has diversion potential that would result in at least 100 feet of road damage. Site is at risk of debris flows and washout.				
Lone Pine Canyon Private Property and Residences	Life and Safety, Property	Risk of flooding, sedimentation, erosion, property damage, and water quality impacts from burned structures. See discussion of post-fire hazards to structures on alluvial fans and drainages below burned slopes in modeling sections. See discussion of hazmat effects to water quality from burned structures.	Likely	Major	Very High	Recommend coordination with NRCS. Inform County of hazmat concerns.
Lone Pine Canyon Road and Low Water Crossings	Property	Risk of flooding, stream migration, sedimentation, erosion. Loss of Access. There are several low water crossings that are at risk of flooding and transporting large sediment bedloads. Crossings may become impassible during storm events due to post-fire runoff and erosion.	Very Likely	Major	Very High	Consult with SB County Public Works
Highway 2 Culverts east of Wrightwood, CA	Property	Risk of Flooding, sedimentation, Highway damage. The basin has a flat area that could provide sediment storage; however, there is a gully downslope that would drain directly onto the highway. There is a perched culvert intended to drain the basin, but the gully is lower than the culvert inlet. See modeled pour point HWY 2 for estimates on discharge/sediment. Burned slopes in the area are sediment charged. Additionally, there is illegal OHV use/access of the site that could increase erosion potential and slope instability.	Possible	Major	High	Consult with Caltrans. Addressing the gully would potentially address the OHV access as well. Gully is used for OHV access.
Community of Wrightwood, CA	Property	Risk of flooding. Site visit determined neighborhood is not at risk.	Unlikely	Minor	Low	Not at risk. No treatment.
Highway 138 and Culverts (East side to Cajon Pass)	Property	Risk of flooding, sediment, plugged culverts, erosion, Highway impacts. Two main stem culverts were observed. Both have trash racks and large capacity to pass flows. One has sediment storage capacity, the other does not. The modeled pour point HWY 138 Xing 1 has erosion around the culvert inlet.	Possible	Major	High	Consult with Caltrans

Assessment Site	Values at Risk	Observations	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment Recommendation
Horse Thief Canyon Private Property - Cajon Pass Hwy 138	Life and Safety, Property	Potential risk of flooding and property damage. Field visit verified no risk to Horse Thief community from post-fire effects. Burned area has flatter terrain and lower SBS, very little burned acreage. OHV incursion is an existing issue.	Unlikely	Major	Intermediate	No treatment recommended.
Cajon Junction Culverts I-15	Property	Basin above 1-15 culvert drains across side road (lacks culvert) and leads to I-15 culvert through area with easily eroded material/existing gullies. Burned basin above has significant material that could be mobilized due to post-fire effects.	Unlikely	Major	Intermediate	Consult with Caltrans
Culverts under I-15	Property, Life and Safety	Risk of plugged culverts and flooding onto highway.	Likely	Major	Very High	Consult with Caltrans.
Road near burned McDonalds/Gas Station (Pour point Cajon Junction)	Life and Safety, Property	Risk of flooding and sedimentation. Burned basin drains to road that has no culvert. Burned basin above has significant material that could be mobilized due to post-fire effects Drainage leads to I-15 culvert through area with easily eroded material/existing gullies.	Likely	Major	Very High	Consult with Caltrans.
Mormon Rocks Fire Station	Property	Risk of flooding and sedimentation. Burned slopes are steep and have sediment charged swales/drainages. Small ditch and berm that protect Fire Station from runoff are insufficient in size for post-fire discharge and erosion. Small ditch is filled in and drains to plugged culvert.	Possible	Moderate	Intermediate	Consult with Engineering Staff. Enhance berm to protect station from increased sediment delivery. Increase capacity of drainage ditch. Clear out culvert.
Highway 138 Culverts Cajon Canyon	Property	Risk of flooding, erosion, sedimentation,, Highway damage. Drainages are expected to experience increased post-fire flows and sediment delivery (see modeling). Braided channel systems.	Very Likely	Major	Very High	Consult with Caltrans
Private Property and Residences in upper Cajon Canyon	Life and Safety, Property	Risk of flooding, sedimentation, erosion, property damage, and water quality impacts from burned structures. See discussion of post-fire hazards to structures on alluvial fans and drainages below burned slopes in modeling sections. See discussion of hazmat effects to water quality from burned structures.	Likely	Moderate	High	Recommend coordination with NRCS. Inform County of hazmat concerns.

Assessment Site	Values at Risk	Observations	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment Recommendation
FS Road 3N25 and 3N35A Low Water Crossing	Property	Risk of flooding, erosion, sedimentation, and road damage. Drainage is a braided channel that will experience increased post-fire flows and sediment delivery.	Likely	Major	Very High	Consult with Engineering Staff. Close road. Add drainage control structures to disperse road runoff.
FS Road 3N24 OHV Area to I-15 and open burned areas	Resources	Threat to soil productivity and soil erosion, expansion of unauthorized OHV trails. Burned areas are now accessible to increased unauthorized OHV access that will increase erosion and sedimentation.	Very Likely	Moderate	Very High	Install barriers and increase patrols to manage unauthorized use.
Union Pacific and BNSF Railways Infrastructure and Culverts	Life and Safety, Property, Commerce	Risk of flooding, major property damage, debris flows, rock fall, loss of commerce. Railways are located downstream of steep, burned, sediment charged drainages with a history of instability and debris flows. Several sites are at **very high risk of damage**.	Very Likely	Major	Very High	Consult UP and BNSF
PCT Railroad Underpass (crossing through culvert)	Life and Safety, Property	Risk of flooding, and property damage. Hikers cross railway through a large culvert that is expected to experience increases in post-fire discharge and sediment (modeled pour point). Trail at that site is located in a wash and below another tributary. During a storm, hikers would be at risk. Trail will washout.	Likely	Major	Very High	Advise Local PCT group. Signage of potential danger to hikers. Site will need post-storm trail maintenance.
Keenbrook Debris Basin and Spillway	Life and Safety, Property	Risk of flooding and property damage, debris flows, erosion. Steep, burned, sediment charged slopes prone to debris flows drain to the basin. One side of the basin could be compromised by hillslope drainage and current channel alignment. Spillway is being undermined. Drains to undersized culvert below railway. Site will experience significant increases in sediment and discharge (pour point Railroad 4).	Very Likely	Major	Very High	Work with adjacent landowner (half of the dam and basin are not on FS land). Coordinate and work with railroad companies to develop solution. Further coordination between agencies needed to develop plan. Recommend dam enhancement.
Keenbrook well	Life and Safety	Risk of individual falling into exposed dam.	Possible	Major	High	Replace dam cover. (Or address well during Keenbrook debris basin work).
Railway Access Road, Cajon Wash and Blue Cut, 2N89	Life and Safety, Property	Flooding, debris flows, rock fall hazard. Steep, burned, sediment charged slopes prone to debris flows drain to road. Upslope roads need drainage control structures to prevent cascading effects of concentrated flow and increased post-fire erosion and discharge.	Very Likely	Major	Very High	Consult with Engineering staff and interagency coordination with railroad agencies.

Assessment Site	Values at Risk	Observations	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment Recommendation
Cajon Boulevard (Highway 66)	Life and Safety, Property	Rock fall, sedimentation, minor flooding. Burned areas upslope may contribute increased discharge and sediment to roads below. Steep, burned slopes may produce rock fall.	Very Likely	Major	Very High	Consult with SB County Public Works
Heritage Sites (3) Lone Pine Canyon	Resources	Low threat of flooding. Sites are located in various places but away from main drainages. Sites may experience some sedimentation and flooding due to post-fire effects.	Possible	Minor	Low	No treatment recommended.
Upper Lytle Canyon Road 3N06 and 3N33	Property	Flooding and debris flows, high rock fall hazard. 3N06 has significant rock fall hazard from burned slopes. Steep, burned, sediment charged slopes prone to debris flows drain to road both roads. 3N33 is near a flat area that will provide some sediment storage.	Very Likely	Moderate	Very High	Consult with Engineering Staff. Address diversion potential of North Fork Lytle Creek down 3N06. Add additional drainage control structures on 3N33. Close both roads.
Burned residences, outbuildings, etc.	Resources, Life and Safety	Hazmat refuse migration to Forest lands and degradation of water quality. Several structures and other property were burned by the fire and now pose threats to water quality. Some of the burned items/structures were located in floodplains, channels, or on slopes that could deliver hazmat to channels. Some local residence use surface water for domestic use. See discussion on hazmat.	Very Likely	Moderate	Very High	Consult with SB County
LADWP Power Towers, Cajon Canyon	Property	Slope erosion hazard to towers from runoff and increased erosion. Some towers are located in areas that could be undermined by increased post-fire runoff.	Likely	Major	Very High	Consult with LADWP
SCE Power line poles and access roads	Property	At risk of erosion and debris flows. Some locations of poles are near channels or drainages downstream of burned areas. Access roads are at risk of flooding, erosion, and damage.	Likely	Major	Very High	Consult with SCE.
Applewhite Picnic Area (FS)	Life and Safety, Property	Possible flooding and sedimentation if culvert upstream plugs. Potential cascading effects of post-fire increases in sediment and discharge. There are two upstream culverts that have potential to plug. If culverts plug, sediment and water would be diverted and flow through the lower third of the picnic area. See model results at pour point Sheep Creek and Lytle Cr Rd Xing.	Likely	Major	Very High	Close lower section of picnic area at crossing outlet.

Assessment Site	Values at Risk	Observations	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment Recommendation
Mountain Lakes (Gate) Resort in Lytle Creek (Glen Ranch)	Life and Safety, Property	High potential for debris flows, flooding, sedimentation. Edge of resort area is located at the base of steep, burned slopes with sediment charged drainages and swales. Slopes have evidence of instability and history of debris flows. Poses a safety threat to anyone at the base of the slopes. Increased sediment could pose a threat to infrastructure and storm drainage system. Currently, there are several locations flows could be diverted down roads. Post-fire flows/sediment can plug the existing drainage system, which is primarily an underground storm drainage system. Storm drains lead directly to the lake. Lake will experience increased turbidity and sedimentation. Grate at the culvert outlet has existing sediment plug and may be susceptible to plugging with post-fire sediment. This would cause the drainage system to back up. Small bridge at the outlet of the large culvert that drains to the lake is at risk (only has 6 inches of clearance for flow).	Very Likely	Major	Very High	Recommend cooperation with NRCS. Recommend creating system to clean out vertical drains within the campground area. Recommend fixing breached sediment berm designed to catch flow. Recommend closure of campsites and areas nearest the burn area. Recommend removal of transportable structures away from the base of burned slopes. Recommend private property owner consult with engineer to upgrade/manage drainage system to handle post-fire flows/sediment.
Lytle Creek Road – Low Water Xing above Recreation Residences	Life and Safety, Property	Debris flows to crossing possible, hazard to vehicles. Crossing is located just over a berm. If crossing floods or has sedimentation due to post-fire effects, drivers will not see hazard with enough time to stop. Berm was constructed to protect downstream community from debris flows. Basin draining to crossing has history of debris flows.	Very Likely	Major	Very High	Consult Engineering Staff. Post signs of potential hazards. Close portion of road.
Low Water Crossing Lower Lytle Creek Road	Life and Safety, Property	Crossing will not likely be affected by small area of fire effect in relation to the overall size of the watershed, is known to be affected by large watershed scale floods. Additionally, the crossing is located several miles downstream.	Unlikely	Major	Intermediate	Consult with SB County Public works
Large culvert I-15, above Cajon Junction on west side	Property	Large 8 x 12 culvert ¾ plugged with sediment.	Likely	Major	Very High	Consult with Caltrans

Assessment Site	Values at Risk	Observations	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment Recommendation
Kinder-Morgan Petroleum Pipelines	Property	Potential for pipeline damage in drainages from flooding, debris flows, incision. Actual location of lines is unknown. However, if buried lines cross drainages or areas prone to debris flows, lines could be uncovered or compromised.	Likely	Major	Very High	Consult with Kinder-Morgan.
Southern California Gas	Property	Potential for pipeline damage in drainages from flooding, debris flows, incision. Actual location of lines is unknown. However, if buried lines cross drainages or areas prone to debris flows, lines could be uncovered or compromised	Likely	Major	Very High	Consult with Southern California Gas
ATT Fiber optic underground line	Property	Potential for pipeline damage in drainages from flooding, debris flows, incision. Actual location of lines is unknown. However, if buried lines cross drainages or areas prone to debris flows, lines could be uncovered or compromised	Likely	Major	Very High	Consult with ATT
Domestic Water Use	Life and Safety	Risk of sediment, ash, hazmat runoff to water quality.	Very Likely	Moderate	High	Consult with RWQCB.
House (Blue Cut)	Property. Life and Safety	Flooding, sediment, erosion, and debris flow. Structure is located near upstream road crossing in pour point Railroad 3. Area is prone to debris flows, and will experience increased post-fire flows and erosion (see modeling). Structure is located on a steep embankment above the stream channel. Post-fire flows/debris flows could cause embankment erosion.	Likely	Moderate	High	Recommend to NRCS

B. MODELING FOR POST-FIRE EFFECTS

1. Hydrologic Modeling

a) Hydrologic Model and Design Storm Description

The analysis for pre- and post- fire hydrologic response and probability of flows is based on the probability of a 2-year storm occurring in the fire area. The 2-year design storm has a 50% chance of occurring in any given year, and a 97% chance of occurring in the next five years. Conversely, there is a 3% chance that the 2 year storm event will not occur in the next 5 years (during the recovery period). A damaging storm expected to occur within the fire burned area is a short duration, high intensity storm, such as the 2 year recurrence interval, 30 minute duration storm with approximately 0.54 inches of precipitation (NOAA, 2014).

It is important to note that any VAR found to be at risk during the 2 year event will still be at risk during greater events. Several locations within the analyzed area have an inherent risk of flooding and debris flows in greater recurrence interval storms. We have included information for recurrence interval storms for both ~5 year and ~10 year peak flows and erosion rates.

In analyzing the change in watershed response, the pre-fire discharge must be calculated and estimated. The pre-fire design flow is the flow responsible for forming present day channel conditions and flows used to estimate proper performance of culverts and other drainage structures. Pre-fire design flows assume pre-fire infiltration and ground cover conditions.

To execute the models, catchments were delineated above specific pour points. A pour point is the outlet of a catchment through which all runoff in the catchment passes through. Several pour points of different sizes were established across the burned area to capture the estimated increase in hydrologic response the fire might produce (Appendix A, Maps 1, 2, 3, 4). These catchments and pour points were selected to represent the **general characteristics** of the potential post-fire affects on hydrologic processes, erosion, and sediment delivery. Some pour points were selected based on locations of specific VARs; however, not all VAR locations were modeled. The modeled locations and mapped subwatersheds <u>DO NOT</u> represent the only locations at risk of altered hydrologic processes, and increased erosion and sediment delivery. Results of the modeling are intended to reflect **general trends** in the burned area and to highlight potential risks across the broader area for further analysis (example: railroad pour points) or for the specific VAR selected (example: specific T&E wildlife concern). More analysis is required for a detailed map of all specific locations that may be at risk from post-fire effects.

Two models were used to determine pre- and post-fire discharges in the assessment watersheds. The primary model used for the burned area was the model designed by Rowe, Countryman, and Storey (RCS), 1949. Kinoshita, Hogue, and Napper, 2014 validated continued use and applicability of this model for Southern California. The model designed by RCS provides data for pre- and post-fire discharges and erosion rates in southern California watersheds. Individual rates for various subwatersheds were developed over long observation periods. The analysis in this report is based on the information in Tables 63, 63, 65, and 98 (RCS, 1949). On-the-ground observations were integrated into the model to account for local basin and burn pattern characteristics. Adjustments to the model were based on: percent of low soil burn severity exhibiting high water repellency, terrain, location of low SBS on the landscape in relation to high and moderate SBS, slope, existing landslides, and soil characteristics.

Hydrologic design information for the RCS hydrologic model is based on the 24 hour duration storm, Table 6. The 2 year, 24 hour duration storm anticipated for these subwatersheds is 6.03 inches (NOAA,

2014). However, although the RCS model is based on the 24 hour duration storm, the anticipated storm expected to occur within the fire burned area that could produce damaging post-fire effects is a short duration, high intensity storm (used as the design storm), Table 7 (NOAA, personal communication). Characteristics of the design storm are listed in Table 7 (Appendix B).

Table 6: Hydrologic Design Factors for RCS

A. Estimated Vegetative Recovery Period	5-10
B. Design Chance of Success	95%
C. Equivalent Design Recurrence Interval	2 years
D. Design Storm Duration	24 hours
E. Design Storm Magnitude	6.03 inches
G. Estimated Reduction in Infiltration	57% across fire
Ga. Estimated Reduction in Infiltration	25% of acres categorized as Low SBS

Table 7: Hydrologic Design Factors for Design Storm

A. Estimated Vegetative Recovery Period	3 to 10 years	3 to 10 years	3 to 10 years
B. Design Chance of Success	80%	75%	70%
C. Equivalent Design Recurrence Interval	2-yr and 5-yr	5-yr	10-yr
D. Design Storm Duration	30 min.	2 hrs.	6 hrs.
E. Design Storm Magnitude	0.54 in	2.05 in.	4.88 in.
F. Design Flow	83.2 cfs/sq.mi.	161 cfs/sq.mi.	250 cfs/sq.mi.
G. Estimated Reduction in Infiltration	57%	57%	57%
H. Adjusted Design Flow	159 cfs/sq.mi.	308 cfs/sq.mi.	478 cfs/sq.mi.

A second model was used to determine pre- and post-fire discharges in areas not covered by the RCS model. This model was developed by Waananen and Crippen (1977) was also used to predict pre-fire discharges at different recurrence intervals. Waananen and Crippen developed regional equations that estimate discharge of various return intervals based on watershed characteristics. The adjusted post-fire peak flows are calculated using the same relationships as design flow; however, runoff response is estimated by assuming an increased runoff commensurate with soil burn severity in terms of recurrence interval. A modifier is determined based on percent runoff increase and percent moderate and high SBS in the watershed. The modifier is applied to the peak flows estimated by regional equations. For Southern California, the primary characteristics that affect regional equations are precipitation and basin size. The USGS StreamStats website was used to gather the data for these areas (example: Manzanita Wash).

Bulking of Flows: Following fire events, discharge may be bulked due to the increase in sediment and erosion, which may occur following fire as a result of debris flows/torrents. Following the 2003 Cedar Fire on the Cleveland National Forest, non-bulked results calculated using Rowe, Countryman and Storey were compared to a modified rational equation model which considered bulked flow using the U.S. Army Corps of Engineers Los Angeles district method for prediction of debris yield (2000). This comparison found that predicted bulked flows were 2.14 times larger than unbulked flows. Post-fire flow estimates should be multiplied by 2.14 to approximate bulked flows. This added volume is NOT reflected in the modeling results.

b) Hydrologic Modeling Results

The increase in peak flows is most applicable during the first to second year of recovery, as hydrologic response will decrease in subsequent years as vegetation re-establishes. Drought conditions in the first year of recovery can delay vegetation response, hence delay recovery to pre-fire conditions. The results of the hydrologic analysis find that most of the subwatersheds that contain burned area will respond to the 2 year recurrence interval storm with greater runoff, erosion, and sediment delivery to streams than typically seen in a 2 year recurrence interval storm (Table 8, Appendix A, Maps 1, 2, 3, 4, and Appendix C). The modeled subwatersheds are representative of the various catchments draining to the pour points and within similar catchments in the fire burned area; however, the pour points DO NOT represent the ONLY locations at risk. The models represent general trends in increases of runoff that will be observed across and below the fire affected area.

Modeling results of small catchments containing large percentages of moderate and high soil burn severity and steep slopes exhibit the greatest increases in peak flow, erosion, and sediment delivery, such as Railroad catchments 2-6. Estimated post-fire runoff in a 2 year design storm could resemble runoff similar to peak flow discharges with recurrence intervals of 6 to 10 years (vs. 2 year recurrence interval peak flow). The 5 year design storm in these catchments are estimated to produce discharges similar to a 90 to 100 year storm. These catchments contain very high percentages of high SBS, steep slopes, and on-the-ground observations of sediment charged channels. The combination of these characteristics pose a very high risk to these areas. Again, the modeled catchments are NOT the only locations at risk but represent the trends that can be expected in catchments with similar characteristics.

Figure 2. Potential for cascading effects and drainage control failures from combination of land activities.

Similar concerns are applicable to the recreation residences and recreation areas in Lytle creek (modeled by pour points Lytle Resort 1&2). In these small, steep burned basins, estimated post-fire runoff in a 2 year design storm could resemble runoff similar to peak flow discharges with recurrence intervals of 5 years (vs. 2 year recurrence interval peak flow). The primary concern for these sites is related to not only the close proximity of to the burn area but the combination of increased runoff, erosion and sediment delivery (discussed in the erosion section), and on-the-ground field observations of sediment charged channels. Some of these hillslopes and swales do not normally have overland flow (pre-fire conditions). With post-fire effects on increased discharge, there may be formation of channels and drainage in areas where water has not flowed in pre-fire conditions. Field surveys identified some areas had inadequate drainage control structures or lacked drainage control structures altogether, leaving the sites ill prepared to handle increased post-fire discharge and overland flow.

Figure 3. Infrastructure on private property downslope of steep burned drainages are at risk of increased post-fire discharge, debris flow, rockfall, erosion, and sedimentation.

Infrastructure, roads, homes, communities, and crossings located along stream channels, on alluvial fans, or near swales downstream of the fire burn area will be at higher risk from the estimated increases in discharge. These areas are most likely to flood because of proximity to drainage paths. Several pour points were selected to model low-water crossings and alluvial fans (see maps for pour point locations and Table 8 for results). All locations are expected to experience increased flows.

Stream crossings (represented by pour point modeling of: Lone Pine Canyon at LADWP Rd Xing; Sheep Creek and Lytle Cr Rd Xing; and Pioneer & Hwy 138 Xing) are subject to flooding and may be hazardous during storm events. (See erosion section on plugging of culverts due to increased post-fire sediment.) This is especially true for low water crossings. Modeled estimates of flow indicate the 2 year design storm may result in peak flows similar to a 4 year peak flow. The 5 year design storm is expected to produce runoff similar to a 12 year peak flow. On-the-ground observations indicated most stream channels in the fire burn area are braided channel systems subject to migration and have high sediment

loads. It is expected that roads within the burn perimeter that have exhibited pre-fire erosion and flooding hazards will have increased risk of erosion and flooding due to the fire. Again, the modeled crossings are NOT the only locations at risk but results represent the trends that can be expected at other crossings with similar characteristics downstream of the fire burn area.

Figure 4: Stream crossings draining basins with high and moderate SBS are at risk of flooding, increased sedimentation, and plugging. Plugged culverts can divert water and sediment to other locations not equipped to handle runoff. Diverted flow has potential to cause gullying, property damage, and risks to life and safety. Low water crossings could be dangerous for drivers to cross during post-fire storm events.

Drainage paths on alluvial fans are subject to migration, so areas that have not previously experienced concentrated runoff or have defined channels may develop them. For example, modeled results of pour points at the West Cajon Valley wash, Cajon Wash 2, and Lone Pine Canyon indicate increased hydrologic response below steep, burned slopes onto alluvial fans containing downslope infrastructures and homes. Peak flows in the 2 year design storm will respond with peak flows similar to 5 to 10 year recurrence interval peak flows. The 5 year design storm is expected to result in peak flows similar to 15 to 25 year recurrence interval peak flows. (Increased sediment also needs to be considered and is discussed in the erosion modeling section). Some of these communities have wide, braided channels leading from the steep slopes in the burned area down into the community. In some cases, once drainage channels have reached community boundaries, the channels have been altered and/or dissipate into vegetation. With the fire effects on hydrologic response, these areas are expected to experience redefining of the channel, potentially migration of the channel, runoff in areas previously not experiencing concentrated runoff, erosion, or sedimentation, and increased erosion/flooding in areas already experiencing flooding and erosion pre-fire. Again, the modeled catchments are NOT the only locations at risk but results represent the trends that can be expected in catchments and areas with similar characteristics.

Figure 6: Several communities are located on alluvial fans below steep, burned slopes. The headwaters of the burned slopes are inherently unstable with evidence of active pre-fire mass wasting and high erosion rates. Increased post-fire hillslope instability and changes to current drainage patterns in these areas is expected putting the communities at risk of post-fire effects.

Buried infrastructure (such as buried transmission lines) could be at risk of exposure from increased flows that scour out swales, channels, and drainages (where infrastructure crosses these features). (Risks from debris flows are discussed in the debris flow section of this report.) In areas where transmission lines or pipes cross above these features above ground, there may be risks associated from the combination of increased flows, post-fire sediment increases, and woody debris. It is recommended that a closer analysis is completed on buried infrastructure as the FS did not receive sufficient information to analyze risks to these features.

Pour points selected specifically for concerns to wildlife habitat include Sheep Creek Wildlife Habitat, Lost Lake, and HWY 138 Xing 1. Expected fire effects for hydrologic response in Sheep Creek Wildlife Habitat pour point is increased flows (2 year event will respond like a 5 year event). This site is located in a steeper, transport section of the stream channel and will most likely experience incision and down-cutting; however, most of the riparian area did not burn and will help minimize erosion potential and effects from increased flows.

Lost Lake is located in flat terrain, with soils that have high infiltration rates, and a small catchment area. The hydrologic response is expected to be minimal, with only a slight increase in discharge.

Habitat downstream of HWY 138 Xing 1 pour point will experience increases in flooding potential (2 year design storm runoff will respond like a 4 year peak flow). This section of the channel is wider, braided, and more of a depositional area. The stream channel may experience some post-fire effects such as channel migration, filling in of pools, and erosion; however, riparian vegetation is expected to respond/re-establish quickly, which will help stabilize the area. Additionally, leading to the habitat in this area are three tributaries, one of which (modeled) has a large depositional area upstream of the HWY 138 crossing. This depositional area will help minimize post-fire hydrologic and sedimentation effects.

TABLE 8: Comparison of Pre and Post-Fire Discharge at Selected Sites (pour points) intended to provide general trends of flooding risk. Percent increase in discharge represents the percent above normal. All pour points exhibit increases in flows compared to pre-fire discharge.

Pour Point	Pre-Fire Discharge			Post-Fire Discharge			Post-Fire Discharge Compared to Pre-Fire Discharge			% Increase in Discharge*
	~Q2	Q5-6	Q10-12	~Q2	Q5-6	Q10-12	~Q2	Q5-6	~Q10-12	Q2
Cajon Junction (near Mcdonalds)	6	9	13	10	16	22	~Q10	~Q25	~Q80	67%
Cajon Wash 1 (Below fire area)	3,130	5,376	7,819	4,354	7,096	10,045	~Q4	~Q11	~Q26	39%
Cajon Wash 2 (above community)	9	16	22	18	27	37	~Q8	~Q25	~Q80	100%
Hwy 138 Xing 1 (above wildlife habitat)	46	77	110	68	109	149	~Q4	~Q12	~Q28	48%
Hwy 2 (basin near HWY)	7	13	19	11	18	24	~Q4	~Q9	~Q20	57%
Lone Pine Canyon (hillside wash)	3	6	10	8	14	21	~Q10	~Q25	~Q75	167%
LonePineCanyon at LADWP Rd Xing	407	772	1,270	625	1,092	1,729	~Q4	~Q10	~Q25	54%
Lost Lake	2	4	7	3	6	9	~Q3	~Q8	~Q25	50%
Lytle Creek above community	875	1,754	2,823	900	1,795	2,880	~Q2	~Q5	~Q10	3%
Lytle Resort 1 (swale)	1	2	3	2	3	4	~Q5	~Q12	~Q40	100%
Lytle Resort 2 (swale)	0	1	1	1	1	2	~Q5	~Q12	~Q40	150%
Manzanita Wash	10	57	143	12	68	171	~Q3	~Q6	~Q12	20%
Middle Fk Lytle Cr Bridge	981	1,966	3,163	1,033	2,050	3,282	~Q3	~Q6	~Q13	5%
PCT at RR Culvert Xing	70	119	169	117	184	251	~Q5	~Q20	~Q40	67%
Pioneer & Hwy 138 Xing	126	214	304	201	317	435	~Q4	~Q13	~Q30	60%
Railroad1	19	36	59	43	72	111	~Q8	~Q20	~Q50	126%
Railroad2	13	25	41	34	55	84	~Q10	~Q24	~Q80	162%
Railroad3	6	11	18	15	24	37	~Q10	~Q25	~Q80	150%
Railroad4	38	68	98	109	167	218	~Q13	~Q90	>Q100	187%
Railroad5	8	14	21	23	35	46	~Q15	~Q100	>Q100	188%
Railroad6	3	6	8	9	14	18	~Q25	~Q100	>Q100	200%
Railroad7	15	25	35	25	39	53	~Q5	~Q20	~Q50	67%
Sheep Creek and Lytle Cr Rd Xing	23	46	73	39	71	110	~Q4	~Q12	~Q30	70%
Sheep Creek Wildlife Habitat	9	17	29	16	27	43	~Q5	~Q12	~Q26	78%
West Cajon Valley wash	37	63	89	60	94	129	~Q5	~Q15	~Q40	62%

**All percentages are increases above normal.*

2. Erosion Modeling

(For information on debris flows and debris flow hazards, see separate discussion specifically about debris flows and slope instability inherent to the burn area.).

a) Erosion Model Description

Three methods were utilized in estimating erosion throughout the fire area (not including debris flows modeling). The Blue Cut Fire Soils Report discusses the ERMiT and Erosion Hazard Rating (EHR) modeling methods and description of findings. Additionally, annual erosion rates can be determined using Rowe, Countryman and Storey (RCS), 1949. In RCS, 1949, erosion rates post-fire are found to be proportional to "acres burned". As with the hydrologic modeling, "acres burned" can be adjusted based on several site specific characteristics. Tables 9 and 10 display estimates of increased erosion modeled from the three methods following the fire. These values can be used to estimate general trends across the burn area. Additionally, on-the-ground surveys observed sediment charged swales, channels, and hillslopes. This sediment could be readily mobilized given the increase in runoff potential and lack of vegetative cover/stabilization. Sediment laden areas will contribute to the increase risk of erosion and sedimentation from the burned area to downslope areas.

b) Erosion Model Results

All the modeled subwatersheds will experience increases in erosion with the greatest increases occurring in subwatersheds with the most burned acres and the steepest slopes. Subwatersheds with a large percentage of unburned acres or flatter terrain exhibit less of an increase; however, areas within these subwatersheds that are in close proximity to the burn may still have increased sediment beyond that which resulted in modeling. For example, campsites, recreation residences, and private land adjacent to burned slopes will experience increased sediment delivery from burned slopes despite the results modeled for the larger watershed (such as pour points: Middle Fk Lytle Cr Bridge; and Lytle Creek). Some smaller basins (adjacent to infrastructure in Lytle Creek) were modeled to establish estimates of sediment delivery trends for short, steep, burned slopes in the area. Short steep slopes in the area are expected to deliver ~1300% of normal sediment delivery (pour points Lytle Resort 1 & 2). As with other areas, several of these steep slopes were observed to have sediment charged channels, swales, and hillsides that will contribute to the sediment delivery risk.

Some areas (homes, infrastructure, and recreation sites) along the creek or in the floodplain downstream of the burn area are susceptible to post-fire effects although they may not be located IN the burn perimeter. This also applies to communities and infrastructure located on alluvial fans below the burn area (example pour points: Lone Pine Canyon; and Cajon Wash 2). Post-fire effects of increased sediment and increased flows can alter existing channel characteristics such as filling in of pools or other depositional areas, erosion of banks, braiding of channels, migration of existing channel locations, down-cutting of channels in transport sections, sedimentation, etc.. Eroded material off the burn area may contain woody debris that can become lodged, trap sediment, and alter flow patterns or plug culverts. Plugging of culverts can divert water and sediment down roads or into locations it normally does not flow. Channel diversion can result in catastrophic road failure and flooding/sedimentation in areas where flow and sediment has been diverted. Runoff channels on alluvial fans are subject to migration naturally and with the additional increase in flow and sediment, areas below the burn area can expect changes to existing runoff patterns (as described above).

TABLE 9: Comparison of Pre and Post-Fire Erosion at Selected Sites (pour points) intended to provide general trends of post-fire erosion potential.

Pour Point	Erosion in Cubic Yards Per Year (RCS model)			Erosion Hazard Rating
	Pre-Fire	Post-Fire	% Increase	
Cajon Junction (near Mcdonalds)	185	3,859	1986%	Very High
Cajon Wash 1 (Below fire area)	108,749	1,050,385	866%	--
Cajon Wash 2 (above community)	307	6,585	2045%	Very High
Hwy 138 Xing 1 (above wildlife habitat)	2,323	36,212	1459%	High
Hwy 2 (basin near HWY)	138	1,364	888%	Very High
Lone Pine Canyon (hillside wash)	144	4,301	2887%	Very High
LonePineCanyon at LADWP Rd Xing	18,488	196,457	963%	Very High*
Lost Lake	129	2,080	1512%	Low
Lytle Creek above community	49,396	76,632	55%	Very High*
Lytle Resort 1 (swale)	53	745	1306%	Very High
Lytle Resort 2 (swale)	14	194	1286%	Very High
Manzanita Wash	--	--	--	Moderate
Middle Fk Lytle Cr Bridge	55,359	111,609	102%	Very High*
PCT at RR Culvert Xing	2,342	37,634	1507%	Very High
Pioneer & Hwy 138 Xing	4,206	60,758	1345%	High
Railroad1	850	20,720	2338%	Very High
Railroad2	584	17,437	2886%	Very High
Railroad3	258	7,686	2879%	Very High
Railroad4	1,333	29,072	2081%	Very High
Railroad5	281	6,119	2078%	Very High
Railroad6	72	1,569	2079%	Very High
Railroad7	486	8,181	1583%	High
Sheep Creek and Lytle Cr Rd Xing	1,282	18,590	1350%	Very High
Sheep Creek Wildlife Habitat	408	5,998	1370%	Very High
West Cajon Valley wash	1,237	18,225	1373%	Very High

TABLE 10: Comparison of Pre and Post-Fire Erosion at Selected Railroad crossings intended to provide general trends of post-fire erosion potential off slopes above the railroad. Table displays results from three models. RCS estimates annual erosion. ERMiT estimates erosion given a specific storm event.

Pour Point	Erosion in Tons Per Year (RCS)			Erosion Hazard Rating	Tons of Sediment per Event (ERMiT)		
	Pre-Fire	Post-Fire	% Increase		2 year RI	5 year RI	10 year RI
Railroad1	1,530	37,297	2338%	Very High	5,019	14,072	20,094
Railroad2	1,051	31,387	2886%	Very High	5,828	15,984	23,456
Railroad3	465	13,834	2875%	Very High	2,748	8,264	12,239
Railroad4	2,400	52,330	2080%	Very High	6,826	20,023	29,828
Railroad5	506	11,014	2077%	Very High	1,642	4,474	6,534
Railroad6	130	2,825	2073%	Very High	685	2,002	3,000
Railroad7	874	14,725	1585%	High	1,502	3,904	5,498

Some watersheds draining to several VARs, such as the modeled Railroad 1-7 pour points, exhibit increases of sediment from approximately 2,000%-3,000% of normal. These modeled subwatersheds are representative of the various catchments draining to the railroad crossings below fire burned slopes; however, they DO NOT represent the ONLY locations at risk. The models represent general trends that will be observed across the area. Table 10 displays comparisons of the three erosion models. All three models indicate high erosion and sediment delivery off these slopes and drainages.

Figure 7: Debris flow prone headwaters and drainages that are sediment charged pose risks to several VARs located downslope below the burn area. Photo was taken from a railroad crossing looking upstream.

Figure 8: Several crossings below major roads and highways are at risk of plugging. The culvert in this photo is a >10 ft diameter culvert (not a bottomless arch) that is more than 2/3 plugged. Increased sediment delivery could cause plugging of the culvert, resulting in road failure and flooding.

Pour points selected specifically for concerns to wildlife habitat include Sheep Creek Wildlife Habitat, Lost Lake, and HWY 138 Xing 1. Expected post-fire erosion potential in Sheep Creek Wildlife Habitat pour point is an increase of 1370% and was rated as a Very High EHR. This site is located in a steeper, transport section of the stream channel and will most likely experience incision and down-cutting; however, most of the riparian area did not burn and will help minimize erosion potential and effects from increased flows.

Lost Lake is located in flat terrain, with soils that have high infiltration rates, and a small catchment area. Based on site specific field observations, the RCS erosion modeling for this site over-estimates the increase in sediment delivery to Lost Lake. Erosion and sedimentation of the Lost Lake pour point modeled area will experience increases in sediment but not at the level RCS modeled. The EHR model rated this area as Low Erosion Hazard Rating, which is more applicable based on field observations. Because this site is a recreational area, there is potential for increased erosion due to trampling and soil disturbance (OHV and hikers) before vegetation can re-establish.

Habitat downstream of HWY 138 Xing 1 pour point will experience increases in sediment delivery (approximately 1500% increase and rated as High EHR). This section of the channel is wider, braided, and more of a depositional area. The stream channel may experience some post-fire effects that are related to increased flows and sediment delivery such as channel migration, filling in of pools, and erosion; however, riparian vegetation is expected to respond/re-establish quickly, which will help stabilize the area. Additionally, leading to the habitat in this area are three tributaries, one of which (modeled) has a large depositional area upstream of the HWY 138 crossing. This depositional area will help minimize post-fire hydrologic and sedimentation effects.

3. Debris Flow Modeling

The Blue Cut Fire occurred in a landscape characterized by debris flow and landslide processes, as indicated by alluvial fan deposits below steep slopes with visible relic and active headscarps. Debris flows can occur in any rock type, but are most common in metamorphic and sedimentary rocks. Debris flows can be initiated on slopes of 20° (36%) and greater. They can deliver quantities ranging between 100 – 1,000,000 cubic yards of rock, sediment and large woody material, depending on rainfall amounts, slope, and amount of unconsolidated soil, rock and sediment material available. Debris flows most commonly occur in burned areas within the 2-year span of time after the fire, in areas of moderate and high soil burn severity.

Debris flows, erosion, and peak stream flows were modeled for the Blue Cut Fire. The various models utilize different types of rain storm conditions. The damaging storm (selected design storm) expected to occur within the fire burned area is a short duration, high intensity storm, such as the 2 year recurrence interval, 30 minute duration storm (Table 7). The selected design storm in Table 7 was compared to post-fire debris flow observations and modeling conducted for Southern California by Cannon, Boldt, Laber, Kean and Staley, 2011. Based on this study, the design storm selected for the fire burn area is very likely to produce debris flows of a sizeable volume.

As described in the Hydrologic Modeling section, the RCS hydrologic model is based on a 24-hour duration rain event. The peak stream flow model results represent a predicted volume comprised principally by water and secondarily by sediment. The peak stream flows predicted by the RCS model do not include volumes of material that have the potential to be delivered by debris flows.

Debris flows are most likely to occur as a result of short duration, high-intensity rain storms; therefore, the USGS Debris Flow model calculated results for 15-minute storms. Debris flows can result in volumes of sediment, rock, organic material and water transported down slopes and stream channels that are orders of magnitude greater than the volumes of peak stream flows predicted by hydrologic models, such as the RCS model that was utilized by the Forest Service BAER Team. Debris flow likelihood, volume and the combined hazard of these was modeled by the U.S. Geological Survey for the Blue Cut Fire. Empirical spatial calculation was performed remotely by the USGS. Parameters of the model included soil burn severity, terrain, channel confinement, soil K factor, rain storm intensity and duration, and historical debris flow data. Floods, including sediment-laden flash floods are not predicted in the USGS debris flow model. Further information about the USGS debris flow modeling results are filed in the USDA Forest Service, Blue Cut Fire BAER electronic records.

USGS modeling results for debris flows as a result of the Blue Cut fire were generated remotely utilizing the soil burn severity map (field verified and adjusted by the BAER team); however, field observations of active landslides (0.25-10 acres each) in the Keenbrook, Blue Cut, and Lower Lytle Creek areas within Cajon Canyon, in the southernmost portion of the fire, were not accounted for in the USGS-generated debris flow model results. Field observations of watersheds on the west side of Cajon Canyon (labeled watersheds, Railroad 1-6) where high and moderate burn severity occurred, revealed soil and sediment accumulations around the base of stems of burned chaparral vegetation, due to a pre-fire closed-canopy, old-growth chaparral condition. This soil and sediment accumulation on hillslopes is readily available for mobilization in the first rain events after the fire. Field observations found that the USGS-debris flow model underestimates the likelihood, volume, and combined hazard of debris flows in the Keenbrook and Blue Cut areas in Cajon Canyon.

Based on field observations, Soil Erosion Hazard Rating (EHR) mapping as a product of the ERMiT model, more closely reflects the degree of hazard for debris flows to occur in modeled debris flow basins (Appendix D, Maps 1, 2, 3, 4). EHR and comparison of the design storm with the Southern California

post-fire debris flow study (Cannon et.al, 2011) are expected to more adequately represent debris flow hazard potential. See Appendix D for maps displaying the Erosion Hazard Ratings for the fire area. Overall, there is a high risk of post-fire debris flows throughout several locations in the burned area, especially in areas that have evidence of active landslides and scarps.

Figure 8: Headwaters leading to Keenbrook dam have significant amounts of sediment that are expected to be mobilized in the design storm listed. Risk of erosion, increased discharge, and debris flows in these areas is expected to increase significantly due to post-fire effects.

Figure 9: Slopes have evidence of active and historic slope failures.

Figure 10: Debris flow prone headwaters and drainages that are sediment charged pose risks to several VARs located downslope or on alluvial fans below the burn area. Photo is of private property located on an alluvial fan adjacent to a drainage that has a history of debris flows. Basin drains to at least one road crossing, then two railroad crossings before reaching main drainage below. Potential for catastrophic, cascading failure is high.

Hillslope treatments were considered as a means of reducing the likelihood of debris flows, particularly for the watersheds with greatest effect to the railroads along Cajon Canyon. Scientific studies consistently show that hillslope treatments such as hydro-mulch, straw mulch, and wood/straw mulch are effective on burned slopes less than 60%. Watersheds were analyzed for suitability for hillslope treatments, with results showing that the slopes exceeded the steepness threshold for effective mulching. Scientific studies also show that certainty of success of mulch as effective erosion control is greatly reduced during high intensity rain events, which are the type of events expected to trigger a debris flow.

Hillslope treatments were ruled out by the FS BAER team based on the following factors: likelihood of short duration, high intensity rain events in the Blue Cut Fire area, lack of suitable slopes for effective hillslope treatment on National Forest lands, and the uncertainty of effectiveness of hillslope treatments.

4. Water Quality and Environmental Effects of Hazmat

a) Threats to Water Quality and Beneficial Uses of Water

Peak flow increases from the fire will also be bulked by ash, debris and other floatable and transportable material within stream channel areas of the fire. Temporary episodes of water quality degradation and fine siltation is likely during the first year after the fire to Cajon Canyon Creek and major tributaries. Less severe and localized water quality impacts to North Fork Lytle Creek below burned tributaries upstream and adjacent to the Lytle Creek residential area and downstream could occur. Beyond the first year, post-fire water quality impacts will be lessened as the burned watersheds recover. Beneficial uses listed in Tables 1 and 2 could experience temporary impacts post-fire.

b) Hazmat Release Potential from Burned Residential Refuse

The California Integrated Waste Management Board (CIWMB) has stated that ash and debris from residential structures consumed by wildfires may contain concentrated amounts of heavy metals, such as arsenic, barium, beryllium, copper, chromium, cadmium, lead and zinc (CIWMB, 2007). Further, according to the CIWMB, the occurrence of these metals in burned residential debris has been demonstrated in the "Assessment of Burned Debris Report for the Cedar and Paradise Fires, San Diego County, CA" dated December 2003. It is also known that asbestos remains are found in burned debris and poses a threat when disturbed and airborne. Common household products found in burned structures are usually present such as pesticides, fertilizers, paints and thinner, automobile products and other petroleum based products.

Up to 104 residences and outbuilding burned during the Blue Cut Fire. It is known that the fine debris of burned residential refuse contains toxic materials such as lead, mercury, arsenic and other metals, along with pesticides, petroleum products and other hazardous substances Without containment or removal of the refuse, there is a potential for off-site migration of hazardous materials to drainages caused by storm runoff, and soil and water contamination could result. Many of the ephemeral channels in the fire area could be impacted by residential refuse if not contained or removed before large storm events mobilize the waste. Several burned residences are located near drainages or in floodplains in braided channel systems. Forest lands downstream may be impacted. Reaches of surface water in Lower Cajon Creek may be contaminated if refuse is not contained or disposed from nearby burned buildings and from tributary sources upstream.

Figure 11: Photo of burned items and infrastructure that could pose risks to water quality if washed off site and into streams.

III. SUMMARY OF TREATMENTS AND MANAGEMENT RECOMMENDATIONS

A. EMERGENCY STABILIZATION TREATMENTS AND MANAGEMENT RECOMMENDATIONS

Watershed specialists identified and surveyed areas of concern containing values at risk (life and safety, property, and resources). Following field evaluations and modeling results, watershed specialists recommended the following treatments and actions to address risks from post-fire flooding, sedimentation, rockfall, and debris flows. See Table 5 for site specific treatment recommendations.

1. National Forest Jurisdiction Facilities, Roads and Trails

Applewhite Campground - Closure

The Applewhite Campground is positioned in a very hazardous area with high rockfall, sedimentation and debris flow potential. The campground is located within the deposition zone of an alluvial fan below steep, moderately burned slopes, with loose rock and sediment likely to be delivered into the campground. Although there is a chain link fence near the base of the alluvial fan bordering the campground, this fence is not expected to provide adequate protection to campground users. The campground should be closed to protect life and safety during the vegetation recovery period after the fire. A 1 to 2-year closure is recommended with follow-up evaluation prior to re-opening.

Applewhite Picnic Area – Closure of Lower Half

The lower, southeast portion of the Applewhite Picnic Area should be closed during the first 1-2 years of the vegetation recovery period after the fire, due to risk of flooding of Sheep Creek into the lower picnic area. There is high potential for a cascading effect of upstream culvert failure to cause flooding in the picnic area. The Applewhite Picnic Area should be closed east of the Sheep Creek Culvert, to both vehicle and pedestrian access.

Implement BAER Roads Treatments specified by Engineering

The road drainage improvements and maintenance specified for roads are critical to protecting life and safety, property, and resources from the effects of increased runoff, sedimentation, and erosion as a result of the fire. Several roads have inadequate drainage control structures to handle the increased post-fire runoff and erosion. There is potential for loss of drainage control on several roads to contribute to cascading failures downslope and catastrophic gully formation. Additionally, several low-water crossings are expected to be at risk of debris flows, and increased sediment and discharge during storm events, increasing life and safety risks for road users. Other roads have increased potential for rockfall, especially in areas with steep cutslopes, bedrock outcrops, and scree slopes. Vegetation in these areas previously helped stabilize hillsides and outcrops; however, with the lack of vegetation, occurrence of rockfall is expected to increase and could result in catastrophic effects for road users.

Close and decommission unauthorized OHV routes

Non-system OHV routes concentrate runoff, and this condition is exacerbated by the fire. Decommissioning unauthorized OHV routes will reduce the risk of flooding, erosion and sedimentation.

Recap burned well at Keenbrook dam

Well near Keenbrook dam was burned, removing the cap and posing a safety hazard. Well needs to be re-capped or decommissioned.

Mormon Rocks – Enhance Erosion and Drainage Control Structures

Mormon Rocks Fire Station main building and storage shed behind the main building (to the north) are positioned adjacent to a moderately steep, moderately burned slope. Increased runoff and sedimentation is expected to affect these structures that may cause moderate damage. The existing berm that surrounds the Fire Station at Mormon Rocks needs to be enlarged, the ditch capacity enhanced, and culvert cleaned out. Sandbags need to be placed around outbuilding for erosion control of nuisance sediment. These measures are intended to deflect runoff around these structures, and to prevent sediment from damaging these structures. The drainage ditch that directs slope runoff away from the facility is not expected to be adequately sized to handle post-fire runoff and sediment. Culvert that drains ditches and adjacent slopes is plugged. See Appendix E for treatment specs and site specific information.

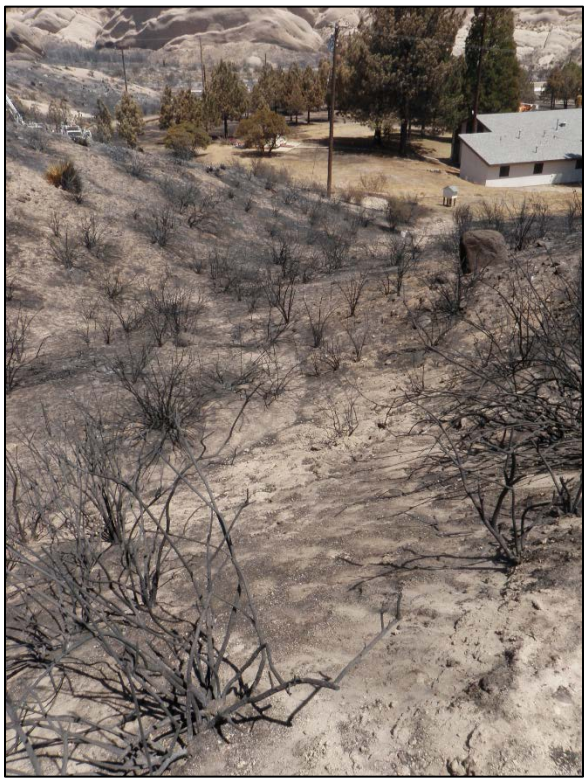

Figure 11: Mormon Rocks Fire Station Engine Bay. Site is at risk of increased sediment delivery from steep, burned, sediment charged swales and drainages. Current erosion and drainage control measures are insufficient.

2. Non-National Forest Jurisdiction Facilities, Roads, Infrastructure, Private Property

Watershed specialists evaluated the issues of concern to determine values at risk (VARs), both on and off National Forest Lands,that may be affected by the change in watershed conditions as a result of the Blue Cut Fire. In addition to values at risk on National Forest lands, other values at risk as a result of the fire were identified on other jurisdictions beyond the National Forest, and recommendations for those values at risk made by watershed specialists are listed below (and Table 5):

Utilities, railroads, counties, CalTrans evaluate in detail the integrity of their infrastructure with consideration of predicted change in conditions identified in BAER Assessment

Infrastructure and resources associated with the following entities were identified to be at risk from the effects of flooding, debris flows, rockfall, sedimentation and erosion. The BAER team was not able to conduct a detailed analysis of all the locations at risk of these post-fire effects. Additionally, not all of the information about some of the infrastructure was available to the team.

It is strongly recommended that these entities closely consider debris flows, peak stream flows, erosion and sedimentation predictions made in the rapid BAER assessment and conduct a more detailed analysis of potential risks to their infrastructure:

Southern California Edison (SCE), Los Angeles Department of Water and Power (LADWP), Union Pacific Railroad (UP), Burlington Northern Santa Fe Railroad (BNSF), San Bernadino, County – departments: Roads, Flood Control, Health, Los Angeles County- Roads department, Kinder Morgan petroleum lines, Southern California Gas, AT&T, CalTrans, State of California Department of Water Resources, California Regional Water Quality Control Board, Communities of Lytle Creek and West Cajon.

Railroads are particularly at risk from rockfall, debris flows, and peak stream flows, in the Cajon Canyon area, where high and moderate burn severity occurred.

Maintenance and/or improvement is recommended for stream crossings of roads and railroads in watersheds affected by high and moderate soil burn severity that show increased flows in the peak flow and sedimentation modeling as well as any roads located near, within, or downstream of the burn area. Examples of these roads include county roads, Highway 2 and Highway 138, and Interstate 15.

It is recommended that gas and petroleum pipeline entities evaluate the areas of high and moderate debris flow and erosion hazard rating, as well as the crossing of Cajon Wash. The crossing of Cajon Wash by the Kinder Morgan pipeline is in a segment of the stream channel where increased channel incision is predicted. The Kinder Morgan and Southern California Gas pipelines cross areas of very high erosion and debris flow hazard. Buried lines should be evaluated for risk from damage by erosion.

LADWP and SCE power infrastructure, including towers, poles and roads, was identified to be in areas of high and very high erosion, debris flow, sedimentation, and flooding hazards, and should be evaluated by these utilities for strategies to protect from damage.

<u>Coordination of NRCS and other community entities to inform the affected private lands and public, and address private lands and structures at risk.</u>

Homes and other properties were observed to be at risk from flooding, sedimentation, erosion, and impact from debris flows. At extreme risk are properties adjacent to the burned area and steep slopes in the Lytle Creek area, properties adjacent to steep slopes in the West Cajon area as well as those located throughout the West Cajon vicinity, and on the west side of Cajon Wash in the Blue Cut area.

<u>Installation of warning signs about flood and rock fall hazard on roads of their jurisdictions</u>

Risk of flash flooding and increased rockfall affecting the safety of main roads is a result of loss of vegetation from fire, particularly in watersheds that experienced high and moderate soil burn severity. Roads that should have warning signs about flash flood hazard are the Lytle Creek Road swale (near FS boundary) and stream crossings, and the Lone Pine and Swarthout Canyon Road at each point where the road crosses the main Lone Pine Canyon channel. Rock fall warning signs are also recommended were applicable.

<u>Coordination of emergency warning system for flash floods</u>

The likelihood of flash flooding has increased as a result of the fire, and coordination of an emergency warning system is recommended to protect life and safety of residents and occupants of the Lytle Creek, West Cajon, and Lone Pine areas and any private residence located within the burn area on alluvial fans or in floodplains.

Removal of hazardous material from all runoff areas: especially stream channels, floodplains

Debris remaining from burned structures in runoff areas presents risk of contamination of surface and groundwater, as hazardous materials are mobilized. It is recommended that coordination of the San Bernardino County Department of Health be conducted to address the threat of hazardous materials to be mobilized in runoff areas. Of particular concern are remnants of burned structures located in stream channels and floodplains.

Domestic, commercial, and municipal uses of water should anticipate a potential effect to water quality

Increased sedimentation and ash may affect quality of water utilized by homes, business, and communities in the Lytle Creek watershed. The greatest effect will be in the Lytle Creek community, and minor effect is expected for the City of Fontana's water intake in Lytle Creek. Runoff from burned infrastructure that may contain hazmat should also be considered for affects to water quality.

IV. REFERENCES

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Consultations

Alex Tardy, National Weather Service, Warning Coordination Meteorologist, San Diego, CA

Jayme Laber, National Weather Service, Senior Service Hydrologist, Oxnard, CA

V. APPENDICES

A. MAPS OF POUR POINTS FOR EROSION AND DISCHARGE MODELING
   1) Map of Pour Points for Erosion and Discharge Modeling: Overview
   2) Map of Pour Points for Erosion and Discharge Modeling: Railroad Area
   3) Map of Pour Points for Erosion and Discharge Modeling: Lytle Creek Area
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B. PRECIPITATION DATA USED FOR DESIGN STORM
C. COMPARISON CHARTS OF PRE AND POST-FIRE DISCHARGE.
D. MAPS OF POUR POINTS AND EROSION HAZARD RATINGS
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   2) Map of Pour Points and Erosion Hazard Ratings: Railroad Area
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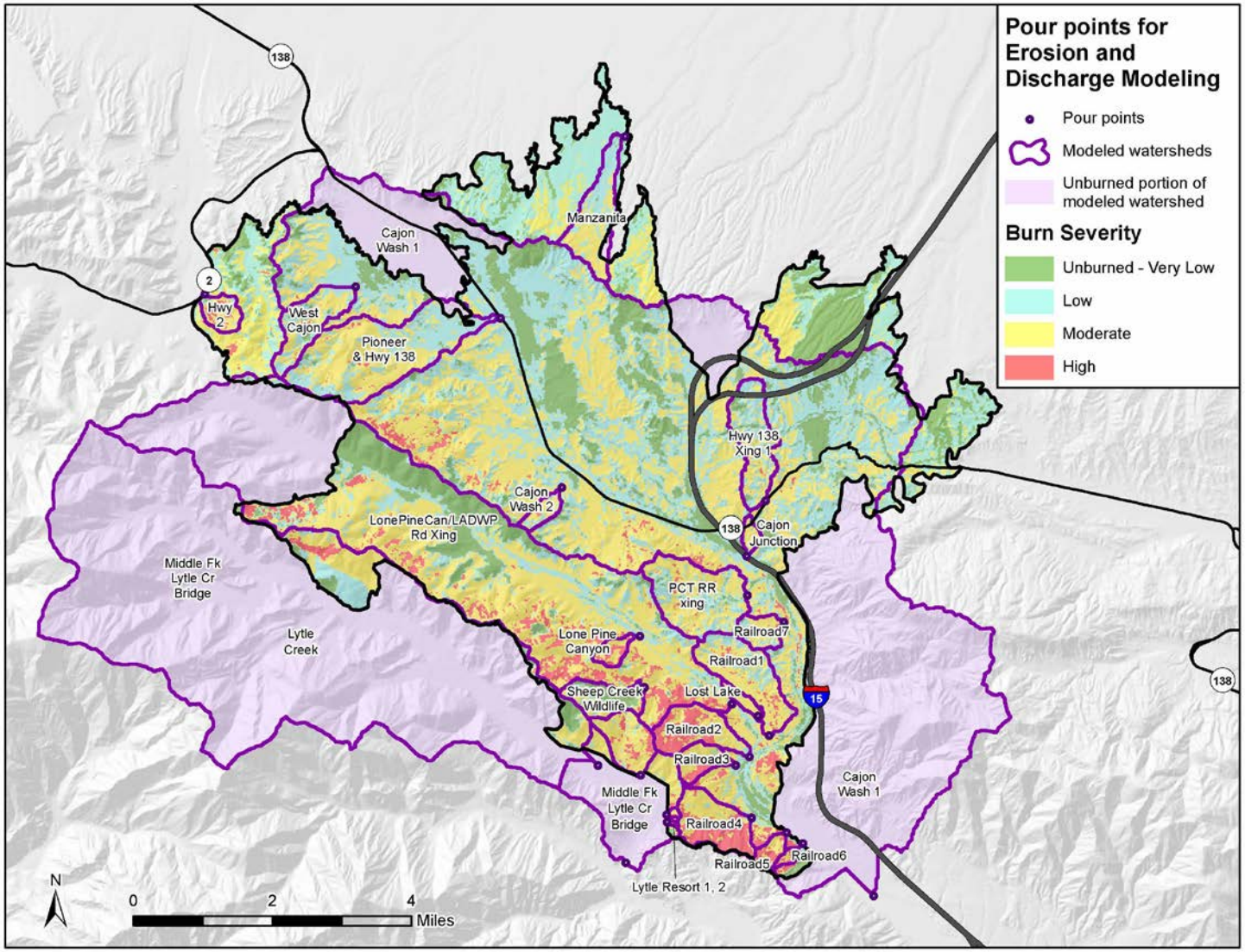
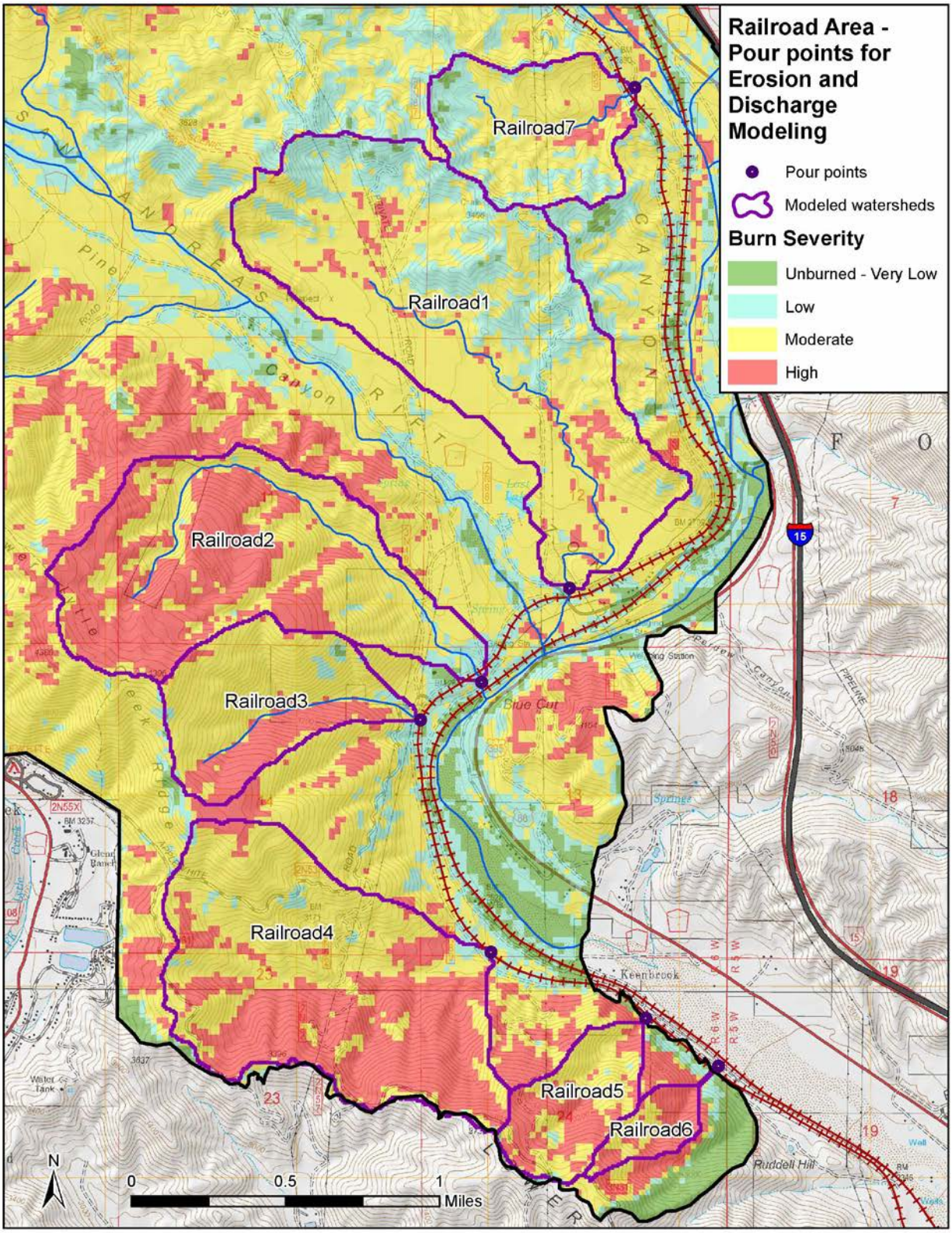
E. TREATMENT SPECS FOR MORMON ROCKS FIRE STATION

APPENDIX A: MAPS OF POUR POINTS FOR EROSION AND DISCHARGE MODELING

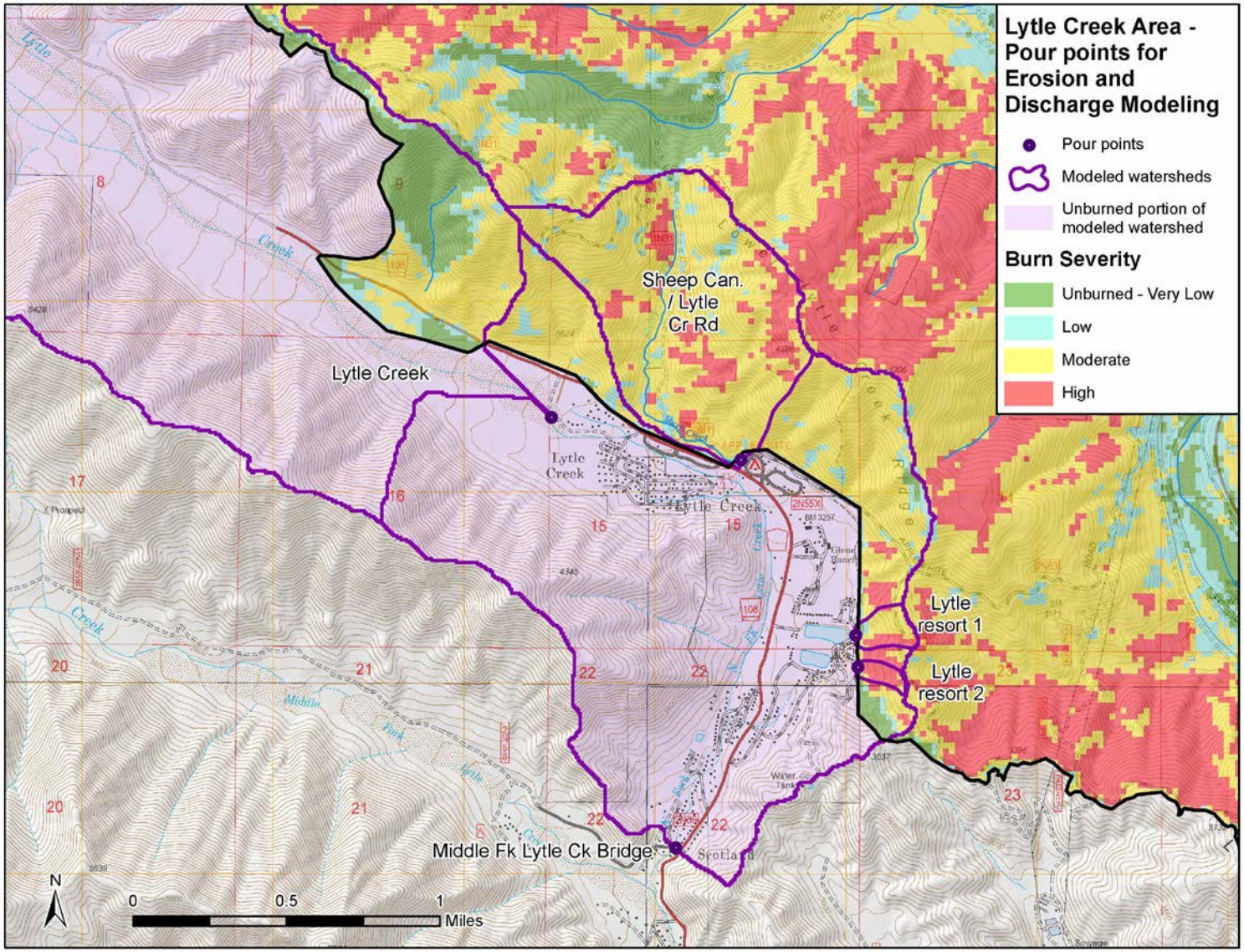
MAP 1: OVERVIEW



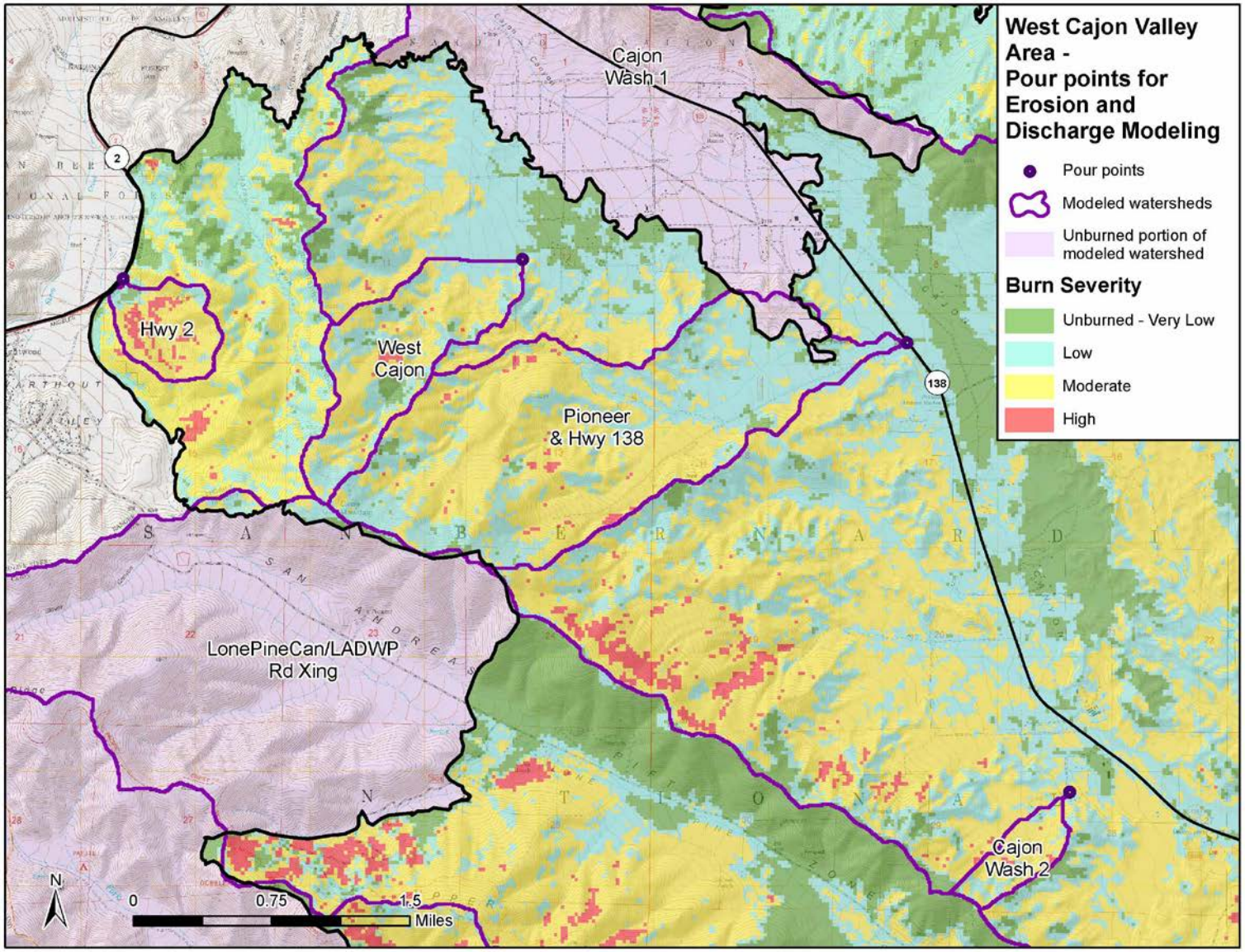
MAP 2: RAILROAD AREA



MAP 3: LYTLE CREEK AREA



MAP 4: WEST CAJON VALLEY



APPENDIX B: PRECIPITATION DATA USED FOR DESIGN STORM

Blue Cut Fire 2016: Selection of storms for hydrologic modeling

hdsc.nws.noaa.gov/hdsc/pfds/pfds_printpage.html?lat=34.2725&lon=-117.5107&data=depth&units=english&series=pds

Apps | Headlines | G start | Headlines | LNKs | Qwest | HMail | Pan | FFx | G | Aec Careers | http://www.pandora.co | Windows Media | Gateway Drivers MT 64 | Other bookmarks

NOAA Atlas 14, Volume 6, Version 2
Location name: Lytle Creek, California, US*
Latitude: 34.2725°, Longitude: -117.5107°
Elevation: 4532 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.145 (0.121-0.177)	0.194 (0.161-0.236)	0.259 (0.214-0.316)	0.314 (0.257-0.386)	0.390 (0.309-0.497)	0.450 (0.349-0.586)	0.513 (0.388-0.685)	0.580 (0.426-0.796)	0.673 (0.474-0.964)	0.747 (0.509-1.11)
10-min	0.208 (0.173-0.253)	0.278 (0.230-0.338)	0.371 (0.307-0.453)	0.450 (0.369-0.554)	0.559 (0.443-0.712)	0.645 (0.501-0.840)	0.736 (0.557-0.982)	0.831 (0.611-1.14)	0.964 (0.680-1.38)	1.07 (0.729-1.59)
15-min	0.252 (0.209-0.306)	0.336 (0.279-0.409)	0.449 (0.371-0.548)	0.544 (0.446-0.670)	0.676 (0.536-0.861)	0.781 (0.606-1.02)	0.890 (0.673-1.19)	1.00 (0.739-1.38)	1.17 (0.822-1.67)	1.30 (0.882-1.92)
30-min	0.404 (0.336-0.492)	0.540 (0.448-0.657)	0.721 (0.597-0.881)	0.874 (0.717-1.08)	1.09 (0.861-1.38)	1.25 (0.973-1.63)	1.43 (1.08-1.91)	1.61 (1.19-2.22)	1.87 (1.32-2.69)	2.08 (1.42-3.09)
60-min	0.690 (0.573-0.839)	0.921 (0.764-1.12)	1.23 (1.02-1.50)	1.49 (1.22-1.84)	1.85 (1.47-2.36)	2.14 (1.66-2.79)	2.44 (1.85-3.26)	2.76 (2.03-3.79)	3.20 (2.26-4.58)	3.55 (2.42-5.28)
2-hr	1.17 (0.969-1.42)	1.54 (1.28-1.88)	2.05 (1.69-2.50)	2.48 (2.03-3.05)	3.09 (2.45-3.93)	3.58 (2.77-4.65)	4.09 (3.10-5.46)	4.64 (3.42-6.38)	5.43 (3.83-7.78)	6.07 (4.13-9.00)
3-hr	1.54 (1.28-1.87)	2.02 (1.67-2.46)	2.67 (2.21-3.26)	3.22 (2.64-3.97)	4.01 (3.18-5.11)	4.65 (3.61-6.05)	5.33 (4.03-7.11)	6.05 (4.45-8.31)	7.09 (5.00-10.2)	7.95 (5.41-11.8)
6-hr	2.38 (1.98-2.90)	3.09 (2.56-3.76)	4.05 (3.35-4.95)	4.88 (4.00-6.01)	6.06 (4.81-7.73)	7.02 (5.45-9.14)	8.04 (6.09-10.7)	9.15 (6.73-12.6)	10.7 (7.57-15.4)	12.0 (8.19-17.9)
12-hr	3.37 (2.80-4.10)	4.37 (3.63-5.32)	5.74 (4.74-7.00)	6.89 (5.65-8.49)	8.54 (6.77-10.9)	9.87 (7.66-12.8)	11.3 (8.53-15.0)	12.8 (9.40-17.6)	14.9 (10.5-21.4)	16.7 (11.4-24.8)

hdsc.nws.noaa.gov/hdsc/pfds/pfds_printpage.html?lat=34.2725&lon=-117.5107&data=depth&units=english&series=pds

Apps | Headlines | G start | Headlines | LNKs | Qwest | HMail | Pan | FFx | G | Aec Careers | http://www.pandora.co | Windows Media | Gateway Drivers MT 64 | Other bookmarks

	(0.573-0.839)	(0.764-1.12)	(1.02-1.50)	(1.22-1.84)	(1.47-2.36)	(1.66-2.79)	(1.85-3.26)	(2.03-3.79)	(2.26-4.58)	(2.42-5.28)
2-hr	**1.17** (0.969-1.42)	**1.54** (1.28-1.88)	**2.05** (1.69-2.50)	**2.48** (2.03-3.05)	**3.09** (2.45-3.93)	**3.58** (2.77-4.65)	**4.09** (3.10-5.46)	**4.64** (3.42-6.38)	**5.43** (3.83-7.78)	**6.07** (4.13-9.00)
3-hr	**1.54** (1.28-1.87)	**2.02** (1.67-2.46)	**2.67** (2.21-3.26)	**3.22** (2.64-3.97)	**4.01** (3.18-5.11)	**4.65** (3.61-6.05)	**5.33** (4.03-7.11)	**6.05** (4.45-8.31)	**7.09** (5.00-10.2)	**7.95** (5.41-11.8)
6-hr	**2.38** (1.98-2.90)	**3.09** (2.56-3.76)	**4.05** (3.35-4.95)	**4.88** (4.00-6.01)	**6.06** (4.81-7.73)	**7.02** (5.45-9.14)	**8.04** (6.09-10.7)	**9.15** (6.73-12.6)	**10.7** (7.57-15.4)	**12.0** (8.19-17.9)
12-hr	**3.37** (2.80-4.10)	**4.37** (3.63-5.32)	**5.74** (4.74-7.00)	**6.89** (5.65-8.49)	**8.54** (6.77-10.9)	**9.87** (7.66-12.8)	**11.3** (8.53-15.0)	**12.8** (9.40-17.6)	**14.9** (10.5-21.4)	**16.7** (11.4-24.8)
24-hr	**4.61** (4.08-5.31)	**6.03** (5.34-6.96)	**7.97** (7.03-9.21)	**9.61** (8.41-11.2)	**11.9** (10.1-14.4)	**13.8** (11.5-17.0)	**15.8** (12.8-19.9)	**17.9** (14.1-23.2)	**20.9** (15.8-28.2)	**23.4** (17.1-32.6)
2-day	**5.52** (4.89-6.36)	**7.32** (6.48-8.44)	**9.84** (8.68-11.4)	**12.0** (10.5-14.0)	**15.2** (12.9-18.3)	**17.8** (14.8-21.9)	**20.6** (16.7-26.0)	**23.7** (18.6-30.7)	**28.1** (21.3-38.0)	**31.8** (23.3-44.5)
3-day	**5.85** (5.18-6.74)	**7.86** (6.95-9.06)	**10.7** (9.44-12.4)	**13.2** (11.6-15.4)	**16.9** (14.3-20.3)	**20.0** (16.6-24.6)	**23.3** (18.9-29.4)	**27.1** (21.3-35.1)	**32.6** (24.6-44.0)	**37.2** (27.2-52.0)
4-day	**6.26** (5.54-7.21)	**8.49** (7.51-9.79)	**11.7** (10.3-13.5)	**14.5** (12.7-16.9)	**18.7** (15.8-22.5)	**22.2** (18.4-27.3)	**26.0** (21.0-32.7)	**30.2** (23.8-39.2)	**36.5** (27.6-49.3)	**41.8** (30.6-58.4)
7-day	**7.09** (6.29-8.17)	**9.88** (8.74-11.4)	**13.8** (12.2-16.0)	**17.2** (15.1-20.1)	**22.3** (18.9-26.8)	**26.5** (22.0-32.5)	**31.0** (25.1-39.1)	**36.0** (28.4-46.6)	**43.3** (32.8-58.5)	**49.5** (36.1-69.1)
10-day	**7.42** (6.57-8.54)	**10.5** (9.27-12.1)	**14.8** (13.0-17.1)	**18.5** (16.2-21.6)	**23.9** (20.3-28.8)	**28.4** (23.6-35.0)	**33.3** (26.9-41.9)	**38.6** (30.4-49.9)	**46.3** (35.0-62.4)	**52.7** (38.5-73.5)
20-day	**8.60** (7.62-9.90)	**12.4** (11.0-14.3)	**17.7** (15.6-20.5)	**22.3** (19.5-25.9)	**28.8** (24.4-34.7)	**34.2** (28.4-42.1)	**40.0** (32.4-50.4)	**46.3** (36.5-59.9)	**55.4** (41.9-74.7)	**62.9** (45.9-87.8)
30-day	**10.1** (8.98-11.7)	**14.6** (13.0-16.9)	**20.9** (18.4-24.1)	**26.2** (23.0-30.6)	**33.9** (28.8-40.9)	**40.2** (33.4-49.5)	**47.0** (38.0-59.2)	**54.3** (42.8-70.3)	**64.8** (49.0-87.4)	**73.5** (53.7-103)
45-day	**12.3** (10.9-14.2)	**17.6** (15.6-20.3)	**24.8** (21.9-28.7)	**31.0** (27.2-36.2)	**39.9** (33.8-48.1)	**47.2** (39.1-58.0)	**54.9** (44.5-69.2)	**63.3** (49.9-82.0)	**75.4** (57.0-102)	**85.4** (62.4-119)
60-day	**14.1** (12.5-16.3)	**19.7** (17.4-22.7)	**27.3** (24.1-31.6)	**33.9** (29.7-39.5)	**43.4** (36.7-52.2)	**51.0** (42.4-62.8)	**59.2** (48.0-74.6)	**68.2** (53.7-88.3)	**81.0** (61.2-109)	**91.5** (66.9-128)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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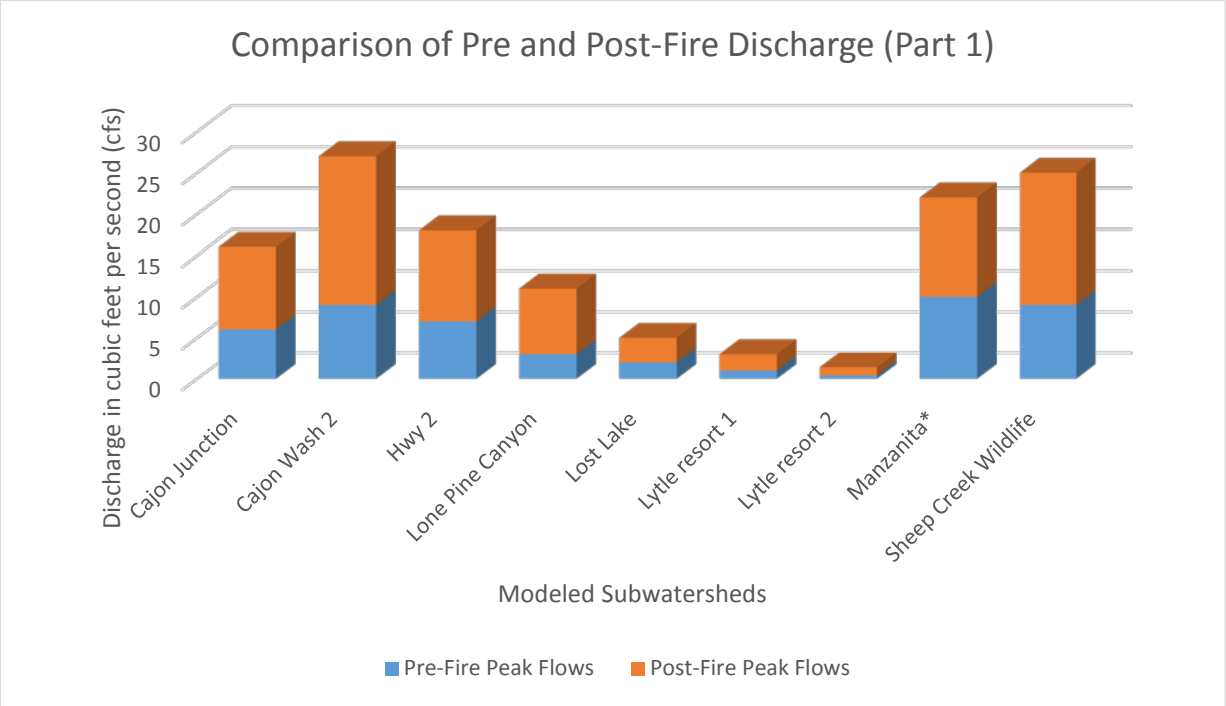
PF graphical

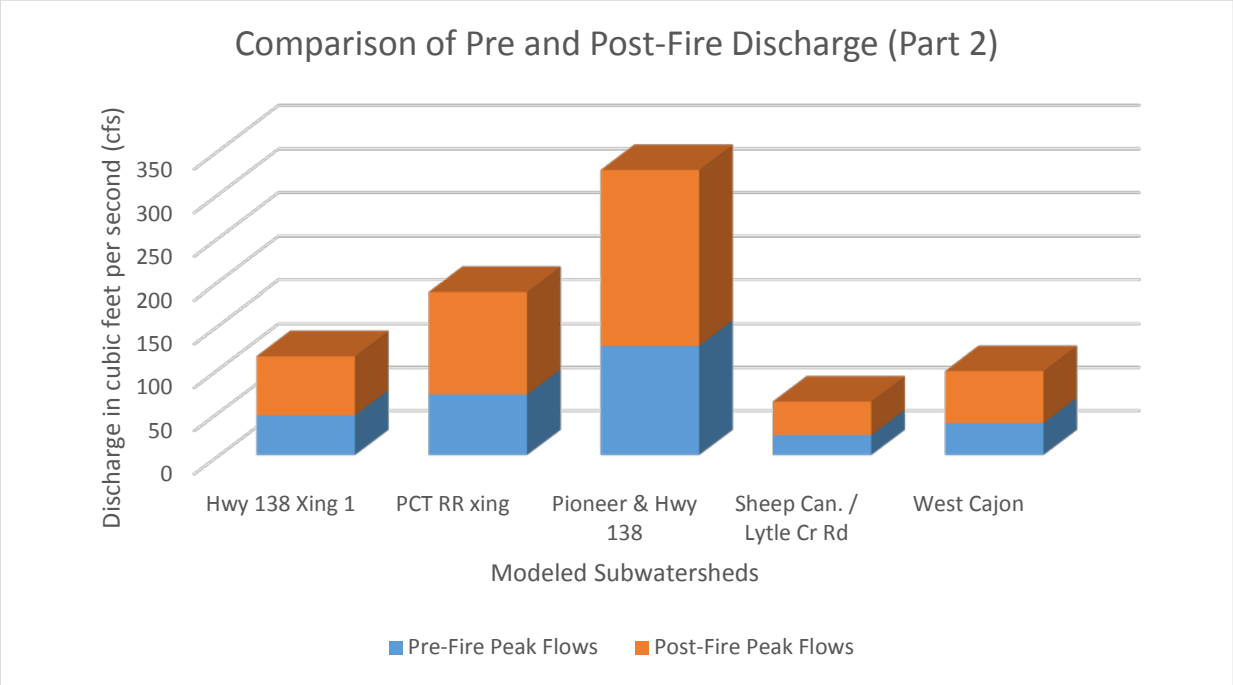
APPENDIX C: COMPARISON CHARTS OF PRE AND POST-FIRE DISCHARGE

Charts have been divided into groupings based on basin size (large vs small) or by area of concern (example: Railroad pour points).

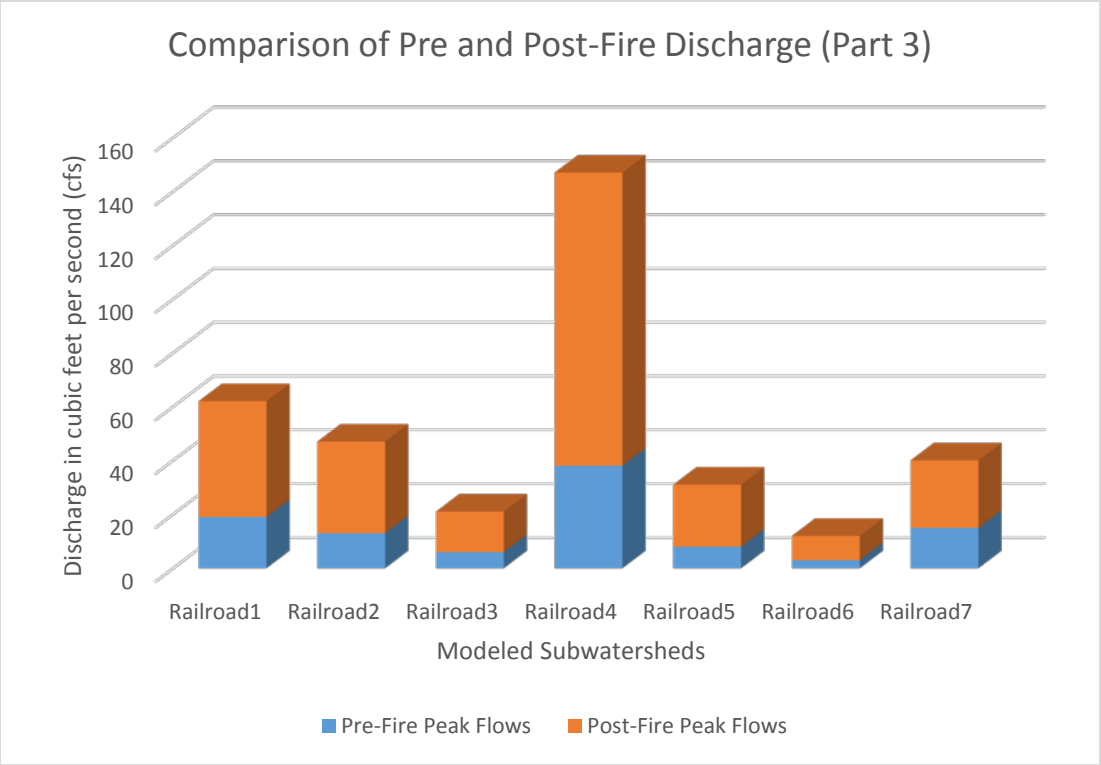
Smaller sized basins



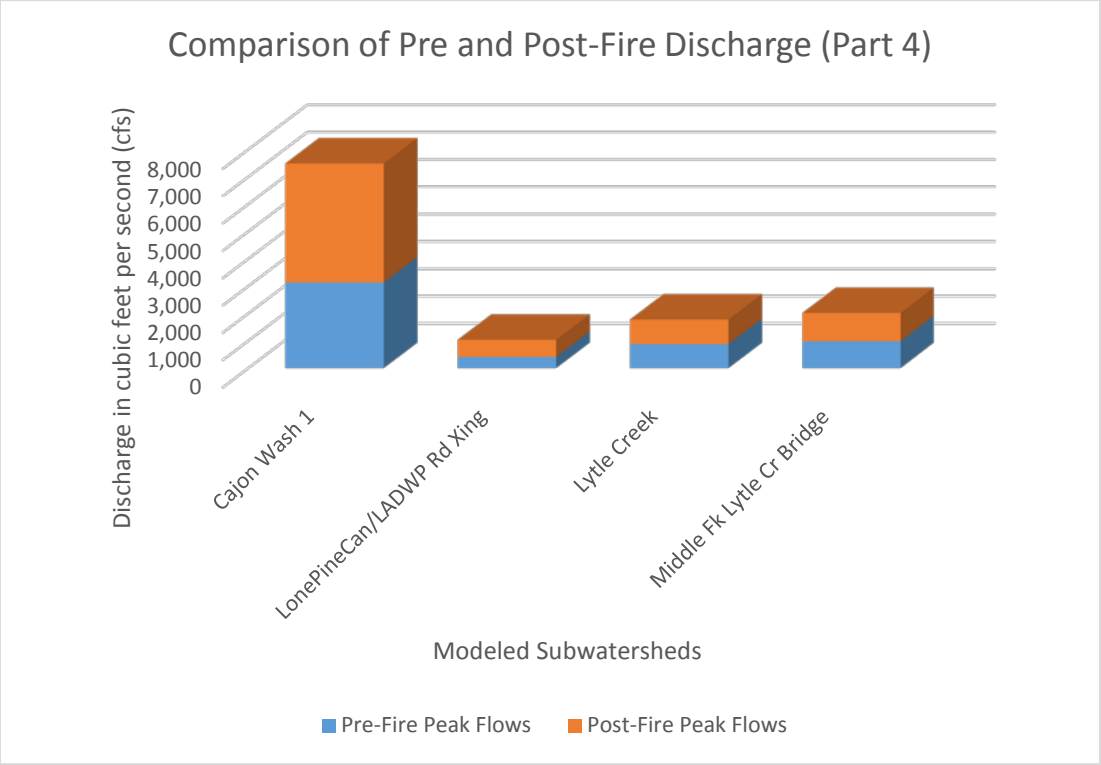
Moderately sized basins



Area of Special Interest

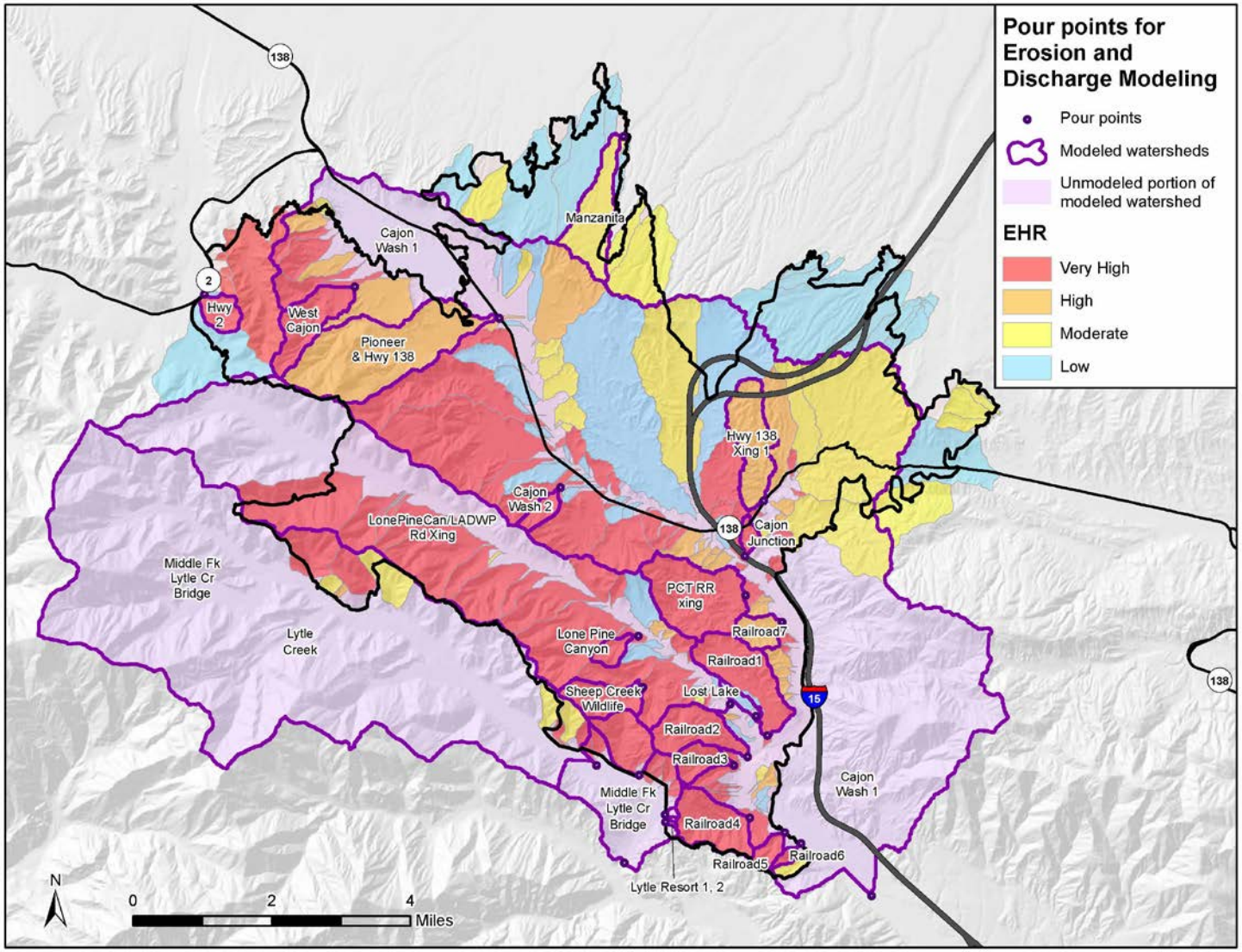


Larger sized basins

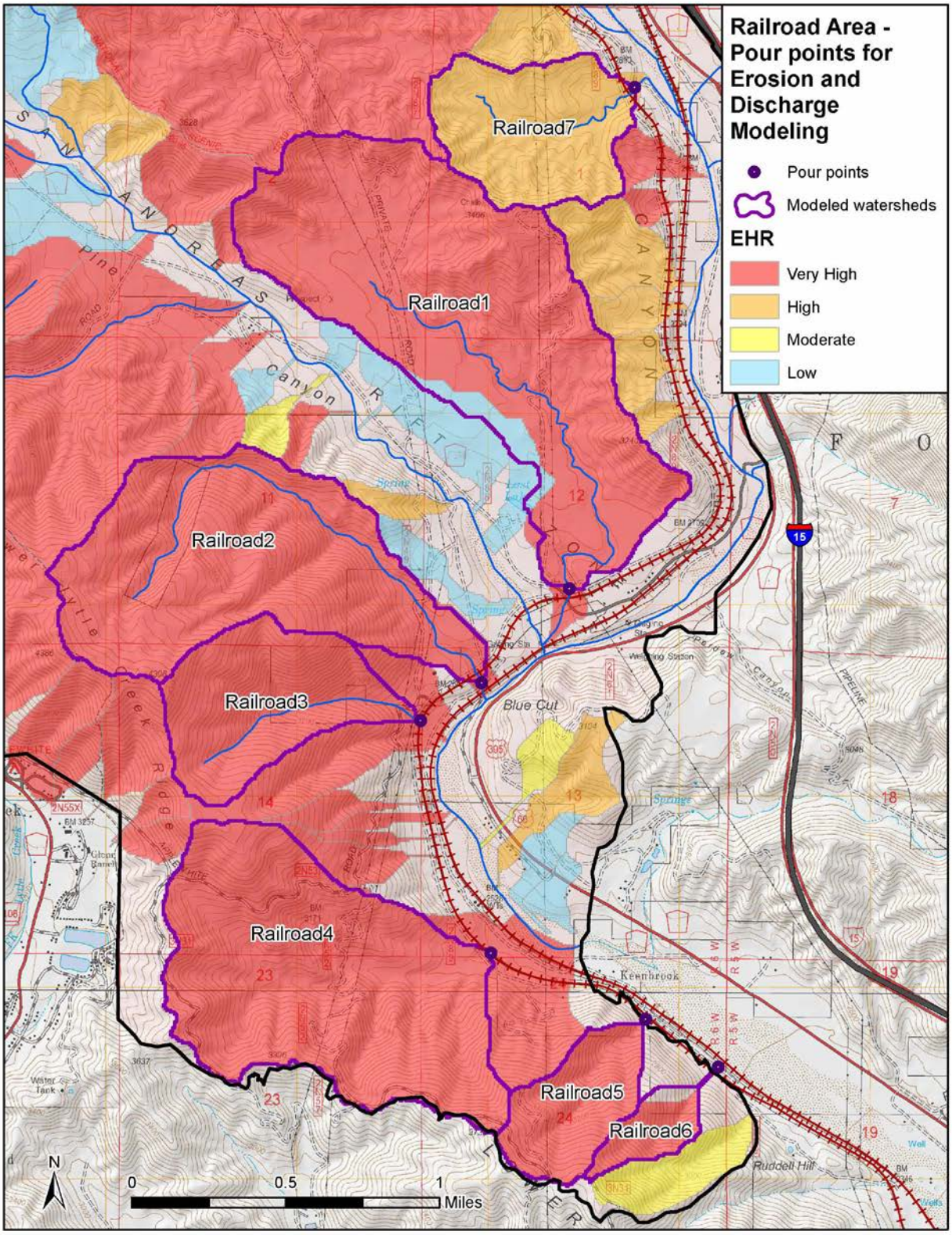


APPENDIX D: MAPS OF POUR POINTS AND EROSION HAZARD RATINGS

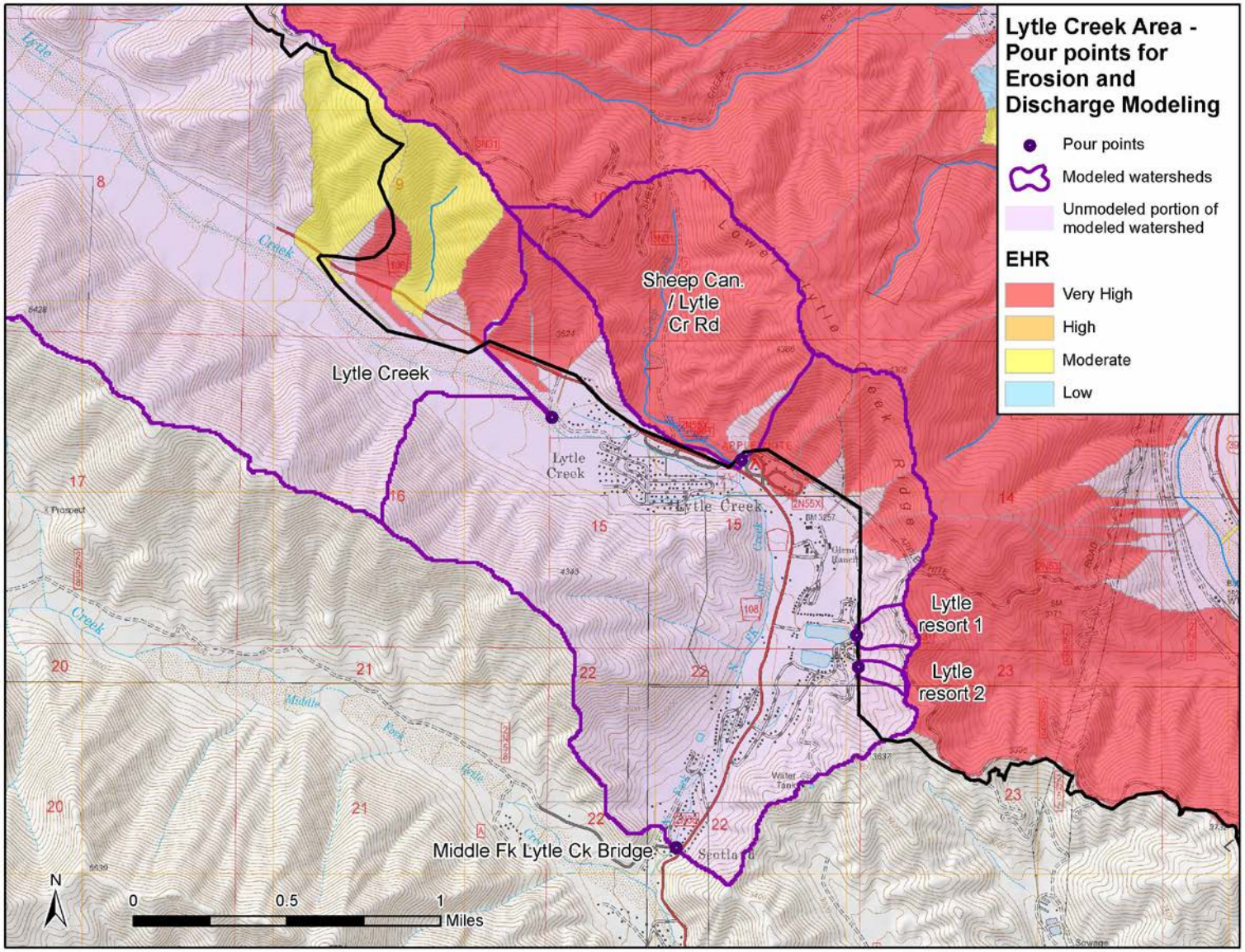
MAP 1: OVERVIEW



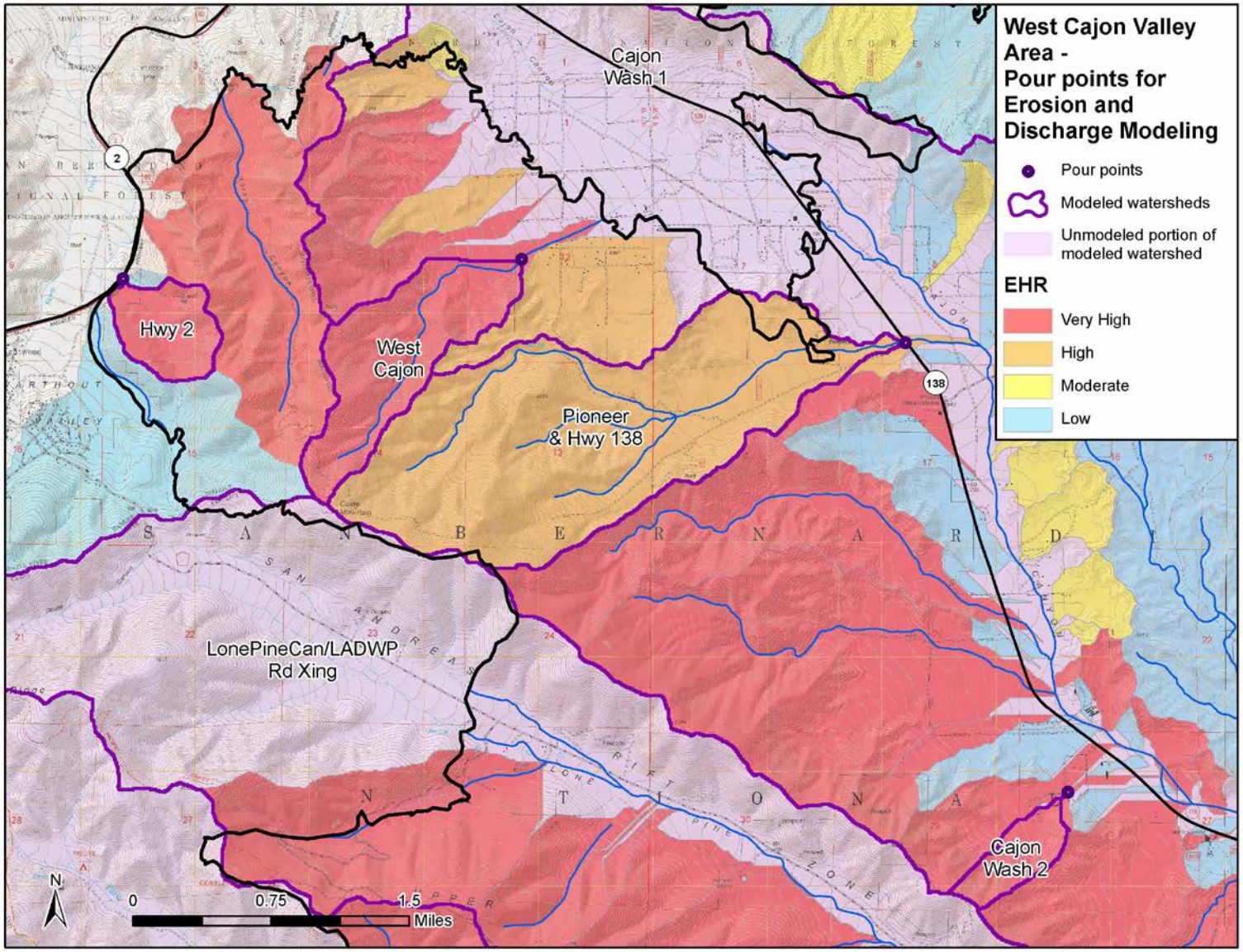
MAP 2: RAILROAD AREA



MAP 3: LYTLE CREEK AREA



MAP 4: WEST CAJON VALLEY



APPENDIX E: TREATMENT SPECS FOR MORMON ROCKS FIRE STATION

TREATMENT/ACTIVITY NAME	Mormon Rocks Fire Station Structure Protection	**PART E Spec-#**	
NFPORS SPEC TREATMENT CATEGORY*	Facility & Infrastructure	**FISCAL YEAR(S) (list each year):**	2016, 2017
NFPORS SPEC TREATMENT TYPE *	Protect Structures	**WUI? Y / N**	Y
IMPACTED COMMUNITIES AT RISK	Yes	**IMPACTED T&E SPECIES**	No

* See NFPORS Restoration & Rehabilitation module - Edit Treatment screen for applicable entries.

WORK TO BE DONE (describe or attach exact specifications of work to be done):

A. General Description: Mormon Rocks Fire Station main building and storage shed behind the main building (to the north) are positioned adjacent to a moderately steep, moderately burned slope. Increased runoff and sedimentation is expected to affect these structures that may cause moderate damage.

Enhancement of an existing flood control berm is specified for the main building of the Mormon Rock Fire Station, and sandbags are specified to be placed on the upslope side of the storage shed located behind the main building. These measures are intended to deflect runoff around these structures, and to prevent sediment from damaging these structures.

B. Location/(Suitable) Sites: Mormon Rocks Fire Station

1. Berm: Enhancement of existing berm on the west side of the main fire station building

2. Sandbags: Placing sandbags upslope on the west side of the storage shed behind the main fire station building

C. Design/Construction Specifications:
1. Berm: Build up existing berm by 2 vertical feet and extend length by 30 feet around upslope side of building.
Berm construction/enhancement should be done to achieve compaction of the soil material. Berm should be constructed in 2-inch deep lifts of material and slightly wetting lifts of material, then compacting with equipment to obtain optimal compaction.

2. Sandbags: Filled sandbags should be placed in an L-shape alignment on the back side (north and west sides) of the storage shed behind the main fire station building, sufficient to deflect runoff around the structure and prevent sediment from being deposited against structure. The sandbag barrier should be at least 2-3 sandbags high.

D. Purpose of Treatment Specifications (relate to damage/change caused by fire): To protect structures from flooding and sedimentation as a result of the Blue Cut Fire

E. Treatment consistent with Agency Land Management Plan (identify which plan): San Bernardino National Forest Plan

F. Treatment Effectiveness Monitoring Proposed: Inspect berm and sandbags after every significant rain event and areas behind structures affected by runoff upslope.