Tea Fire

CA-SBC-009981 (also CA-MT0-001023)

Burn Area Response Team (BART)
Report

DRAFT

Affecting Watersheds in Santa Barbara County
California

December 16, 2008

Tea Fire BART Team Report

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BURN AREA RESPONSE TEAM (BART) REPORT

The Burn Area Response Team (BART) objectives are to promote and recommend appropriate action to ensure the protection of life, property, environment, natural, and cultural resources within the State Responsible Areas (SRA) and Local Responsibility Areas (LRA) of California. Through maintaining communication and partnering with multiple State agencies across California and the Federal Emergency Management Agency (FEMA), the Tea Fire BART developed mitigations and recommendations to address the needs of communities, local cooperators, homeowner associations, city and county municipalities. This BART report was developed to help communicate the values at risk (VARs) in the aftermath of the 2008 Tea wildfire.

BART specialists conducted rapid surveys on burned areas to determine if immediate emergency rehabilitation treatment is needed to minimize the risk of threats to human life, safety, or property. These surveys may be used in conjunction with other relevant reliable sources of information to further assess if emergency rehabilitation treatment is indeed needed to minimize or prevent deterioration of water quality; minimize loss of soil productivity due to erosion; minimize or prevent degradation of wildlife and botanical habitat; and minimize or prevent degradation of cultural and natural resources. These rapid surveys also facilitated identification of other potential VARs, and determine if emergency rehabilitation treatment is needed and its urgency.

The recommendations presented in this report are to be used as a guideline for possible mitigation to decrease potential damages to life and property. It is a rapid initial assessment to disclose VARs. The treatments fall into one of two broad categories. Those treatments which can be considered temporary (short-term) measures are designed to be implemented quickly and be relatively inexpensively. Long-term treatments are designed to facilitate the recovery of the watershed at an accelerated pace, while concurrently minimizing the exposure of the VARs to the threats identified.

The scope of the assessment and the information contained in this report should not be construed to be either comprehensive or conclusive, nor to address all possible impacts that might be ascribed to the fire effect. Post fire effects in each area are unique and are subject to a variety of physical and climatic factors, which cannot be accurately predicted. The information in this report was developed from cursory field examination by licensed resource professionals and should be viewed in conjunction with other relevant sources of information. Neither the State of California nor any other Agency or Department employee or officer participating as a member of the Burn Area Response Team (BART) thereof makes any warranty, express or implied, nor assumes any damage or legal liability occurring by reason of any information disclosed or omitted to be disclosed under this Report.

EXECUTIVE SUMMARY

TEA FIRE
CA-SBC-009981 (also CA-MTO-001023)

Watersheds affected by the Tea Fire in Santa Barbara County, California were: Sycamore Canyon (3315.320002 [1]), Mission Canyon (3315.320001), and San Ysidro Canyon (3315.330002).

Introduction

The Tea Fire was reported at approximately 6:30 pm on November 13, 2008 and was declared contained at 6:00 pm on November 17, 2008. The fire encompassed 1,940 acres with 55% on private land, 35 % on U.S.D.A., Forest Service land, and 10% on County Park lands. Some 88% of the fire occurred in the headwaters of Sycamore Creek and covered the entire drainage basin of that creek into Sycamore Canyon. Sycamore Creek basin is a pear-shaped basin with rapid runoff concentration, which funnels into a single stream channel directly above a dense residential area of Santa Barbara City. This channel then traverses approximately 2 miles of the city, crossing the major coastal railroad route, and Highway 101, and finally empties in the Pacific Ocean. The remaining 12% of the burned area is in Rattlesnake Creek (Mission Canyon watershed), and Montecito Creek (San Ysidro Canyon watershed) and covers less than 2% and 1% of the two watersheds, respectively.

An initial Burn Area Response Team (BART) was deployed to Santa Barbara County on November 22, 2008, to evaluate VARs in the vicinity of the Tea Fire. The BART's primary objective is to convey their findings to local administrators (City and County of Santa Barbara, including County Fire and Flood Control, and the Montecito Fire District) to assist them in developing appropriate response mitigation to protect lives, property and the environment.

The BART has three key objectives:

Post-fire watershed assessment and recovery operations are conducted to:

- Identify on-site and downstream threats to public health or safety from landslides, mudslides, debris torrents, flooding, road hazards, and other public safety hazards from fire related effects.
- Identify threats to resources at risk, including: excessive erosion; impaired water quality; threats to wildlife, fisheries, botanical values; natural and cultural resources.
- Determine measures that may be used to prevent or mitigate identified threats.

[1] based upon CALWATER watershed map Version 2.2

An additional set of objectives was forwarded to the BART for consideration from the County of Santa Barbara. These issues have been addressed in the technical specialist reports embodied in this document.

- Santa Barbara County asked that the BART consider and develop:
  - Overall statement of the risk the fire now poses to fire area and downstream.
  - Hydraulic Modeling of the fire area to quantify pre vs post fire runoff volumes (similar to BAER analysis).
  - Sediment production estimates for each tributary (similar to USFS BAER analysis)
  - Evaluate geologic and topographic effects. Identify debris flow hazard areas.
  - Hydrophobic soils effects.
  - Transportation infrastructure risks (City, County, Caltrans).
  - Post Fire soil/debris inundation map (if key bridges are obstructed).
  - Risk assessment for homes that may be impacted by slides and debris flows.
  - Homeowner guidance document on erosion control treatments, methods, and applications.
  - List of inadequate city bridges that may require hazard mitigation.

Existing Reference Documentation

Many documents are available from both the County and City of Santa Barbara on flood awareness and erosion control including:

[City of Santa Barbara]

http://www.santabarbaraca.gov/Resident/Safety/PIO/Flood_Preparation.htm

http://www.santabarbaraca.gov/Resident/Safety/PIO/Tea_Fire_Residents.htm

http://www.santabarbaraca.gov/Resident/Community/Creeks/Storm_Water_Management_Program.htm

http://www.santabarbaraca.gov/Government/Departments/PW/

[County of Santa Barbara]

http://www.countyofsb.org/pwd/water/Fire_Flood_Prep.htm

http://www.countyofsb.org/pwd/water/flood_control.htm

http://www.countyofsb.org/pwd/Administration/SandBagInfo.htm

http://www.countyofsb.org/pwd/roads/closure.htm

The Natural Resource Conservation Service (NRCS) is available for consultation to private landowners who need site specific advice on controlling erosion in the burn area. The NRCS can be locally contacted at:

John Bechtold, District Conservationist
USDA-Santa Maria Service Center
920 E. Stowell Road
Santa Maria, CA 93454
(805) 928-9269
john.bechtold@ca.usda.gov

General Findings

The following brief summarizes key findings contained in the initial Tea Fire BART assessment.

Loss of Human Life and Property

The principal concern with the Tea Fire is loss of human life and property due to an increase in the potential for in-channel floods, hyperconcentrated floods, debris torrents, mudsliding and debris flows. Residences near the channel and below Sycamore Creek Canyon have been specifically identified at risk for damage from possible significant in-channel floods, hyperconcentrated floods, debris torrents, mudsliding rockfall and debris flows. Individual homes have been identified at risk in the event of debris slides, debris flows, and sediment laden floods.

Engineering Geologist (Vickery) and BART Team Leader (Bacca) attended a meeting by the Santa Barbara County and City emergency response personnel and County and City elected officials on November 24, 2008, to discuss the results of their survey of the Sycamore Canyon area. The following information as relayed:

- Vickery presented a short presentation of his survey results and his finding that there is eminent danger to the structures in the Sycamore Canyon area from debris flows down the channel and in chutes on the steeper slopes above.
- While no recommendation for evacuation was forwarded to the county and city by the BART Team, the gravity of the potential for threats to life and property were conveyed to those in attendance.

One storm front has passed since this information was relayed to County and City Emergency Responders. The structures in the Sycamore Canyon area (and below) will remain at risk with the onset of additional rain producing storms with less risk evolving with the establishment of soil binding vegetation in the burned over areas.

The BART Team commends the County and City for their response to the eminent danger to the structures in the Sycamore Canyon area in response to the first post fire storm (voluntary evacuation as the storm front approached, and mandatory evacuation when high rainfall was predicted by the National Weather Service)

Watershed Evaluation

At the request of the Santa Barbara County Office of Emergency Services, the BART Team Engineering Geologists performed a cursory mapping of geomorphic features concerning landsliding within the burnt area of the Tea Fire. The attached map titled, "Geomorphic Features of Potential Landsliding – Tea Incident, Santa Barbara County, California," (shown on page 10) provided general locations of existing mass wasting features including existing large-scale landslides, moderate to minor shallow landslides, existing recognizable debris flow channels, potential or incipient debris flow channels, materials on slopes which may mobilize into debris flow channels, and general potential rockfall sites, which may produce a mass wasting event.

The Tea Fire burned through the headwaters of one CALWATER ver. 2.2 watershed Sycamore Canyon (3315.320002) and encroached into two additional watersheds: Mission Canyon (3315.320001) to the west, and San Ysidro Canyon (3315.330002) to the east, burning across approximately 1,940 acres. Where the fire burned hot in upper portions of the Sycamore Canyon watershed, channel flows will be affected by the reduction in vegetative interception of rainfall and evapotranspiration, and will additionally be affected by the development of hydrophobic soils within the fire perimeter. Waxy substances released by volatized plant materials during hot fires follow thermal gradients into the soil and congeal as continuous surfaces in areas of moderate to high soil burn severity. Various levels of hydrophobic solids were found in the high and moderate soil burn severity areas with expected frequency and distribution relative to the moderate and high ratings.

Values at Risk (VARs)

The principal concern with the Tea Fire is an increase in the potential for in-channel floods, hyperconcentrated floods, debris torrents, mudsliding and debris flows. The primary mechanisms for this are the loss of mechanical support of hillslope materials that was provided by vegetation and vegetative litter and the development of hydrophobic soils. The increase in runoff resulting from reductions in interception and infiltration, from the simplification of surficial runoff patterns, and from the loss of mechanical support along stream channels where riparian vegetation was burned will increase the hydrologic response of the watershed contributing to the increase in the potential for in-channel floods, hyperconcentrated floods, debris torrents, mudsliding and debris flows.

A. Threats to Human Life, Property, and Infrastructure

As a result of the burn severity, reduction in vegetation, and development of hydrophobic soils, the impact to houses and the associated human occupancy, other outbuilding and infrastructure (e.g. roads, bridges, culverts) located within or adjacent to the fire perimeter are at an increased risk to the threat of flooding, mudsliding, debris torrents, rockfall, and debris flows. This threat includes the loss of life and property. This risk is greatest within the Sycamore Creek Canyon area identified.

Additional risks to those using road during and after large storm events, from falling rocks, mud and debris flow onto roads, is also identified as a major concern:

- Potential for isolated individual, multiple and avalanche type rockfall events may occur in the steep Mountain-County areas.
- Observations indicate that some debris flows may initiate in the upper mountains and cascade down into the foothill areas. At breaks in slope (for example, drainages flowing onto upper alluvial terraces, a potential for debris dam formation may develop. If a natural dam develops, sudden failure may occur sending a debris torrent down gradient.
- During strong sustained storm events additional materials may slough into the drainage channel, adding debris and increasing flow volume
- As tributaries merge, debris flow pulses may merge

B. Threats to Water Quality

Rainfall runoff is the most immediate impact to water quality to urban and rural streams. Three watersheds and nine drainages are affected by the fire. From east to west the three watersheds are: Cold Springs Canyon Creek, which flows to Montecito Creek, Sycamore Creek, and Rattlesnake Canyon Creek. The Sycamore Creek watershed is most affected with complete burn of the land around five tributaries. The Cold Springs Canyon/Montecito Creek watershed burn area and the Rattlesnake Canyon Creek watershed burn area are estimated at less than one and five percent respectively. As such, the water quality assessment focuses on the Sycamore Creek watershed given the severity and percentage of the burned area

C. Threats to Wildlife, Botanical Values, and Fisheries

Suppression activities (e.g. “dozer lines”) have also contributed to the current risk to biological, botanical, and fisheries habitat. The risk is greatest for those areas of the Tea Fire which contain habitat for state and federally listed rare, endangered, or threatened species, state species of special concern, and “covered species” identified by the Technical Specialist Report. Southern California steelhead, federally listed as endangered, are known to occur in Cold Springs Creek. Populations that constitute Southern Califonria steelhead are the most endangered populations in California. Sycamore Creek, Cold Springs Creek, and Rattlesnake Creek are all designated as critical steelhead habitat by NOAA Fisheries National Marine Fisheries Service (NMFS).

D. Threats to Cultural Resources

There is an increased risk of the exposure of cultural sites as a result of the fire or the associated suppression activities removing protective vegetative cover. Prior to conducting land disturbing activities, private landowners and public agencies should consult a qualified archaeologist.

Area Burned

The Tea Fire started as the result of an unattended warming fire, in Santa Barbara County on November 13, 2008, and was declared 100% contained on November 17, 2008. The fire burn 1,940 acres destroying 210 structures and damaging an additional 9 structures.

Landowners affected by the fire complex include: Private lands, land managed by the US Forest Service and County Park/open space.

Soil Burn Severity

Soil burn severity is a measurement of the amount of heat that is released by a fire and how it affects soil resources. Soil Burn Severity on the Tea Fire is shown on the Fire Severity Map on page 9 and has been determined to be as follows:

Burn Severity	% of Burn	Acres Burned
High:	20%	391 ac
Moderate:	51%	993 ac
Low to unburned:	29%	556 ac

DEFINITIONS

BURN SEVERITY CLASSES (FRAZIER 1989). (See Parsons (2003) for more detailed descriptions.)

High Severity

a. Hydrophobicity—soils are strongly water repellant; they will repel water for greater than 40 seconds. Very strongly hydrophobic soils may repel water for several minutes or longer. Hydrophobicity may be from the soil surface downward, from about 1/8 of an inch in depth to many inches, or it may begin below surface.
b. Organic Ground Cover Density—less than 20% cover of litter, duff, or woody debris remains. Often fully consumed in very high severity burns.
c. Vegetation—Trees: crowns fully burned, no needles or leaves remaining. Some or many branches may be consumed. Brush: crowns partially or fully volatilized; no leaves remaining. Herbaceous plants: usually fully consumed, often including roots and sometimes, residual seed.

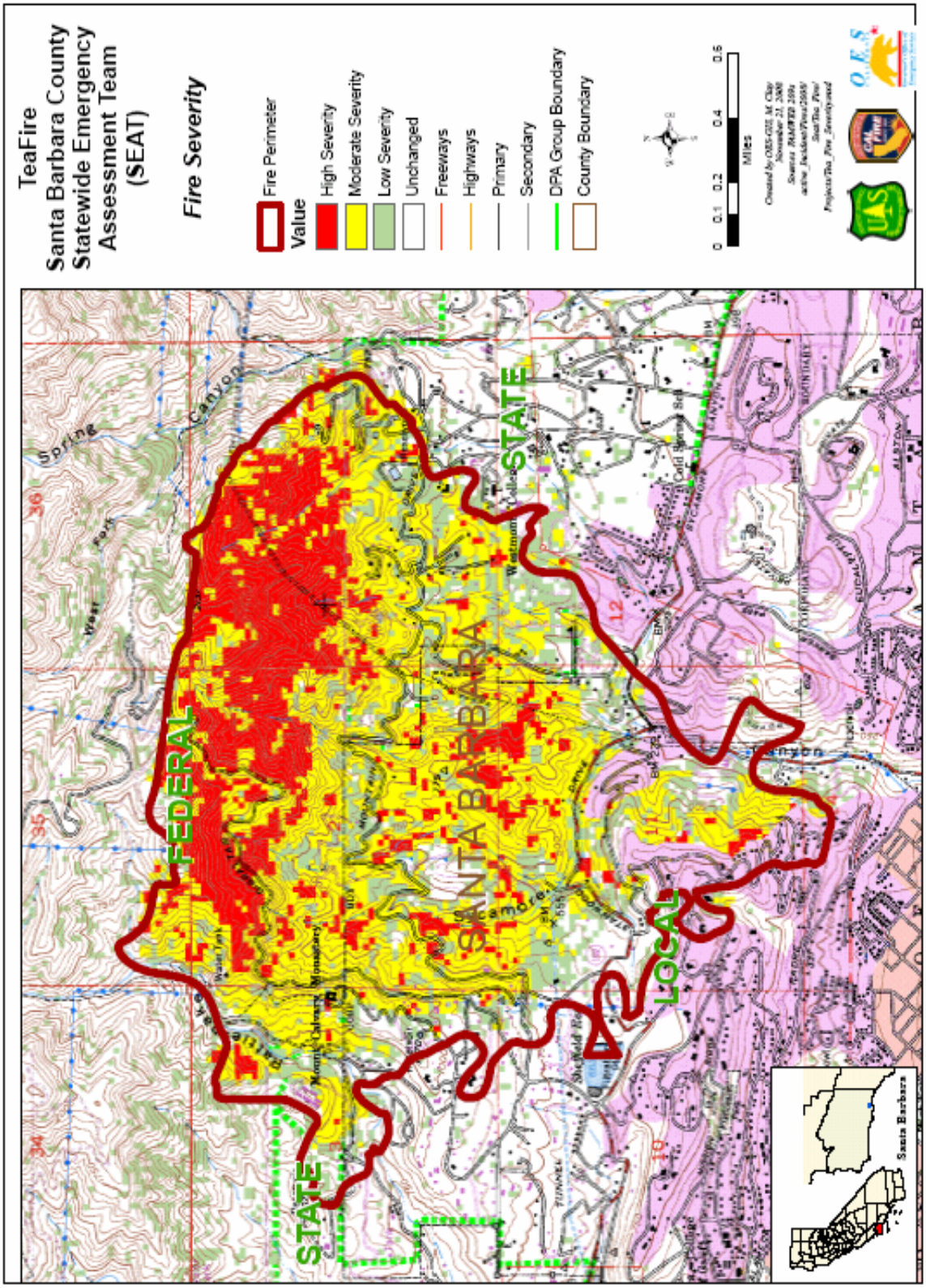
Moderate Severity

a. Hydrophobicity—soil will repel water for 10-40 seconds. Longer than that is strong hydrophobicity; less than that is weakly hydrophobic.
b. Organic Ground Cover Density—Approximately 20-50% density.

c. Vegetation—Trees: crowns remain but needles/leaves are singed to the extent that more than 50% of the crown is discolored (i.e., the crown of a pine tree has more than half to all the needles browned by fire). Brush: crowns remaining but leaves mostly discolored by burn. Herbaceous plants: mostly consumed, but patches remain.

Low Severity

a. Hydrophobicity—soil will repel water for less than 10 seconds. Often water will infiltrate within a second or two.
b. Organic Ground Cover Density—greater than 50% density. Often the fire will consume only fine woody debris and scorch the surface of a duff layer.
c. Vegetation—Trees: crowns remain. Fire will often only scorch the tree bole and perhaps a few lower branches on smaller trees. All or nearly all the crown will remain green. Shrubs: mostly unburned, but some scorching may be present on lower parts. Herbaceous plants: usually singed or partially burned, but will recover.


TeaFire
Santa Barbara County
Statewide Emergency
Assessment Team
(SEAT)
Fire Severity
Fire Perimeter
Value
High Severity
Moderate Severity
Low Severity
Unchanged
Freeways
Highways
Primary
Secondary
DPA Group Boundary
County Boundary
0 0.1 0.2 0.4 0.6
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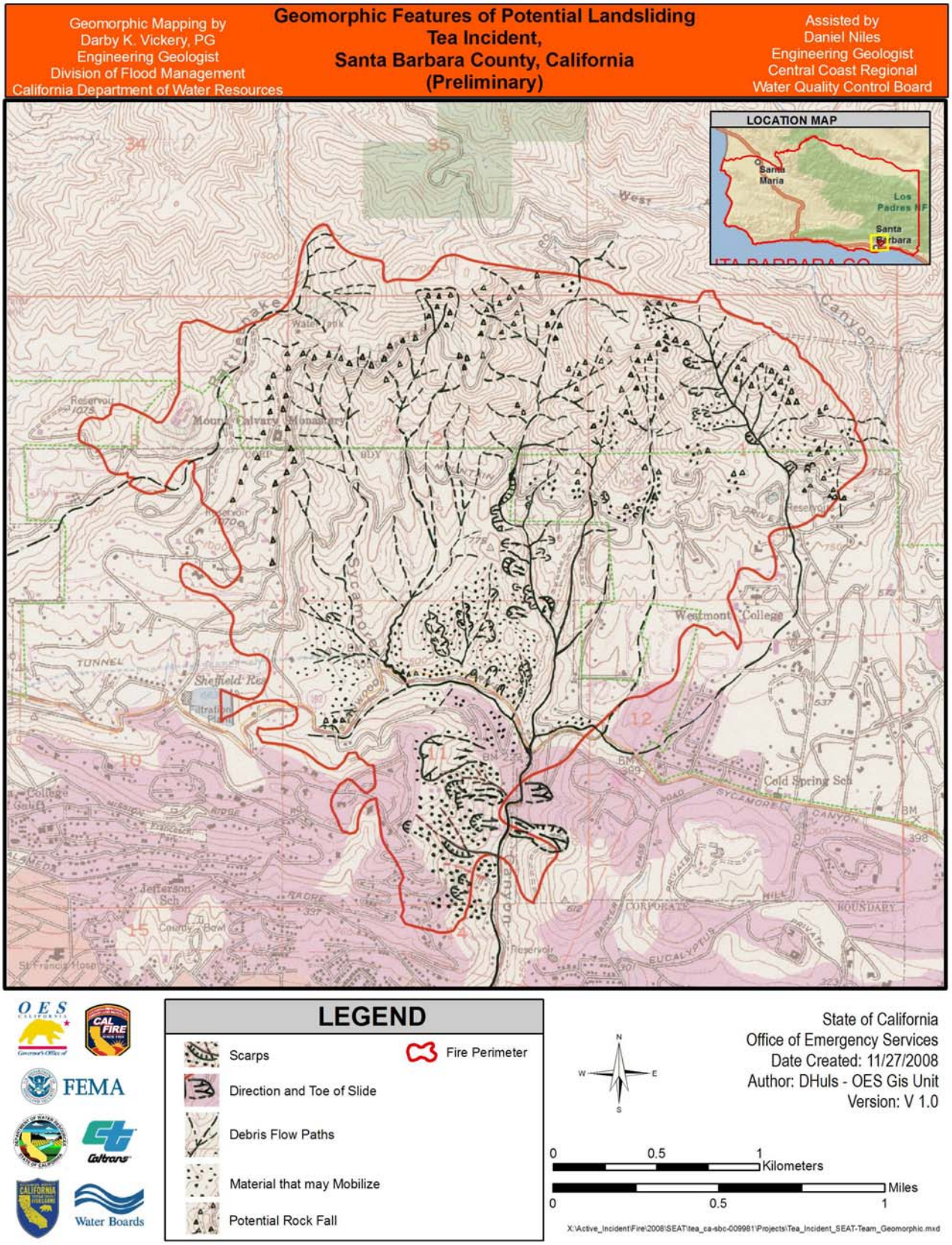
FEDERAL
STATE
SANTA BARBARA
STATE
LOCAL
Sycamore
Spring
Canyon
West
Fork
Santa Barbara


Geomorphic Mapping by
Darby K. Vickery, PG
Engineering Geologist
Division of Flood Management
California Department of Water Resources
Geomorphic Features of Potential Landsliding
Tea Incident,
Santa Barbara County, California
(Preliminary)
Assisted by
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Water Quality Control Board
LOCATION MAP
Santa Maria
Los Padres NF
Santa Barbara
Mount Calvary Monastery
Westmont College
Cold Spring Sch
Sycamore Canyon
Sheffield Res
Jefferson Sch
LEGEND
Scarps
Direction and Toe of Slide
Debris Flow Paths
Material that may Mobilize
Potential Rock Fall
Fire Perimeter
State of California
Office of Emergency Services
Date Created: 11/27/2008
Author: DHuls - OES Gis Unit
Version: V 1.0
0 0.5 1 Kilometers
0 0.5 1 Miles
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DRAFT TECHNICAL SPECIALIST'S REPORT
BURN AREA RESPONSE TEAM (BART)

Resource: Geology

Fire Name: Tea Fire, Santa Barbara County **Month/Year:** November 2008

Fire Designation: CA-SBC-009981(also CA-MTO-001023)

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A. Introduction

This BART (Burn Area Response Team) effort is meant to compliment and extend existing assessment and mitigation efforts that have already been undertaken, are presently occurring, or are planned as upcoming work with the Tea Fire Response. **Agencies and personnel involved in their perspective jurisdictions as well as local homeowners and public volunteers should be commended for recognizing and addressing this emergency and urgent need for preparation as the rain season commences.** A preliminary post fire hazard assessment has been conducted in the Santa Barbara City and County area to evaluate the general degree of risk associated with the Tea Fire burn area. The assessment was also conducted to evaluate the Values at Risk in and downstream from the affected burn area of the Tea Fire. Values at risk are defined as:

- On-site and downstream threats to public health or safety from landsliding, mud sliding, debris torrents, flooding, road hazards, and other fire related problems.
- Threats to watershed resources, including: excessive erosion; impaired water quality; threats to wildlife, fisheries, and botanical values; and cultural resources.

B. Background

The reader is directed to the beginning pages of the overall report to determine the particulars of the size, shape, origin, and duration of the Tea Fire.

C. Information Received, Resource Setting, Geology, Structural Geology, and Landslide Review

The principal concern with the Tea Fire is an increase in the potential for in-channel floods, concentrated floods/flows, rock falls, rock avalanches, and loss of burned vegetation resulting in the formation of debris flows and debris torrents. The primary mechanisms for this are:

- Increases in runoff resulting from the loss of live vegetation, their root systems, and resultant evapotranspiration,
- Reductions in infiltration due to the removal of duff, the dehydration of the soil, and crustal formation of soils after a burn,
- Development of hydrophobic soils whereby heated organic gases are driven into the soil column during intense fire temperatures and congeal at depths
- The simplification of surficial runoff patterns, and
- The loss of mechanical support of hill slope materials that was provided by vegetation and vegetative litter along stream channels.
-

Maps generated for the Tea Fire in Santa Barbara County for the BART by the U.S. Forest Service, CalFire, and Governor's Office of Emergency Services includes:

- Fire Severity
- Critical Infrastructure and Hydrology Overview
- Vegetation Overview
- Government Ownership Overview
- Sensitive Species Overview
- Direct Protection Overview

The base map available for location is the Santa Barbara 7.5-Minute Series Topographic Map by the U.S. Geological Survey.

Additional geological information for the burn area is derived from:

- Geologic Map of the Santa Barbara Quadrangle 1986, by Thomas W. Dibblee Jr.

The Thomas W. Dibblee Jr. geologic map is published by the Thomas W. Dibblee Jr. Geological Foundation, P.O. Box 60560, Santa Barbara, California 93160. The map can be acquired at the Santa Barbara Museum of Natural History.

Additional Documents found on the Santa Barbara City website include:

- Wildland Fire Plan, by the City of Santa Barbara Fire Department, January 21, 2004,
- Existing Conditions Study of the Arroyo Burro, Mission, Sycamore, and Laguna Creek Watersheds; for the City of Santa Barbara, Creeks Restoration/Water Quality Improvement Division, by Questa Engineering Corporation, August 4, 2005, and

- Creek Inventory and Assessment Study; prepared for the City of Santa Barbara, Parks and Recreation District by URS Corporation, September, 2000.

Maps generated during deployment include:

- Tea Incident Post-Fire Hazard Awareness Map (main BART report)
- Geomorphic Features of Potential Landsliding, Tea Incident, Santa Barbara County, California – Preliminary (this report)

General Geology and Geomorphology

The Tea fire area is located in the Santa Ynez Mountains within the Transverse Range geomorphic province. This burn area is situated above the town of Montecito and city of Santa Barbara. The Transverse Range is a series of tectonic blocks of the earth's crust which have been tilted as a result of seismic uplift. Rock formations in the burn area hill sides and mountains vary from Recent (Holocene) to Late Eocene in age. Table 1 consists of rock and formation names, and locations within the burn area.

In the Tea burn area the geologic formations are characterized by a folded stratigraphic sequence which, from oldest rock units (located higher in the drainage), includes the Coldwater Sandstone, a marine formation of Late Eocene age, the Sespe, a non-marine formation of Oligocene (?) age, the Vaqueros Sandstone, a shallow marine formation of Early Miocene age, the Rincon Shale, an Early Miocene age marine formation. Pleistocene sediments are located and deposited unconformably upon and above the previously mentioned formations.

"Quaternary alluvial fan and debris flow deposits are common along the steep lower flanks and foothills of the Santa Ynez Mountains, evidence of the active geology of the area. These deposits are typically coarse grained, ranging in size from sand and gravel size to cobble and boulder size. Toward the distal or seaward margins of these fans finer grained deposits of silt and sand may be found. More recent alluvium eroded from these deposits is concentrated in stream valleys." (Questa Engineering Corp., 2005, pg. 4.1.1.2). A chart of Formation names, descriptions and general locations within the Tea Fire burn area is provided in Table 1.

Six tributaries flow into one canyon drainage

Six main tributaries along with two to three additional minor watersheds divert and coalesce into the area commonly known as Sycamore Canyon. When studying the geologic map, it is noted that the Mission Ridge fault passes through the area from East to West. In the area of the head of Sycamore Canyon, two strands of the fault system exist. In each strand, the up thrown block is located on the downstream side of the fault. It may be that during successive seismic events, (each having this similar type of fault kinematics or movement) has caused a number of tributaries to become diverted laterally. Drainage was generally reestablished until a single common drainage (Sycamore Canyon) currently dominates the drainage landscape.

Geologic Period	Geologic Epoch	Symbol	Formation Name	Formation Description	Location
Quaternary	Holocene	Qs	Surfacial Sediments	Beach sands	
	Holocene	Qg		Stream channel deposits	Mapped along Stanwood Drive and Lower Sycamore Canyon Road
	Holocene	Qa		Alluvium, flood plain deposits	
	Holo-Pleistocene	Qls	Landslide debris		Mapped in Sycamore Canyon
	Pleistocene	Qoa / Qog		Older desiccated surfacial sediments	Generally in the Westmont College area
Early Miocene		Tr	Rincon Shale	Gray clay shale or claystone dipping 30° to 60° South	Mid-hills, Lower Burn Area
Early Miocene		Tvq	Vaqueros Sandstone	Thick bedded sandstone dipping 40° South	Stanwood Drive, Entrance to Parma Park
Oligocene		Tsp	Sespe Formation	Maroon, red, gray shale and sandstone 25° to 50° S.	Mid-Hills, Mid Burn area, Mountain City
Late Eocene		Tcw	Coldwater Sandstone	Hard bedded sandstone, dipping 8° to 57° South	Upper canyons and burn area Mountain County

Table 1. Rock types, formation names and ages with their relation to the Tea Fire.

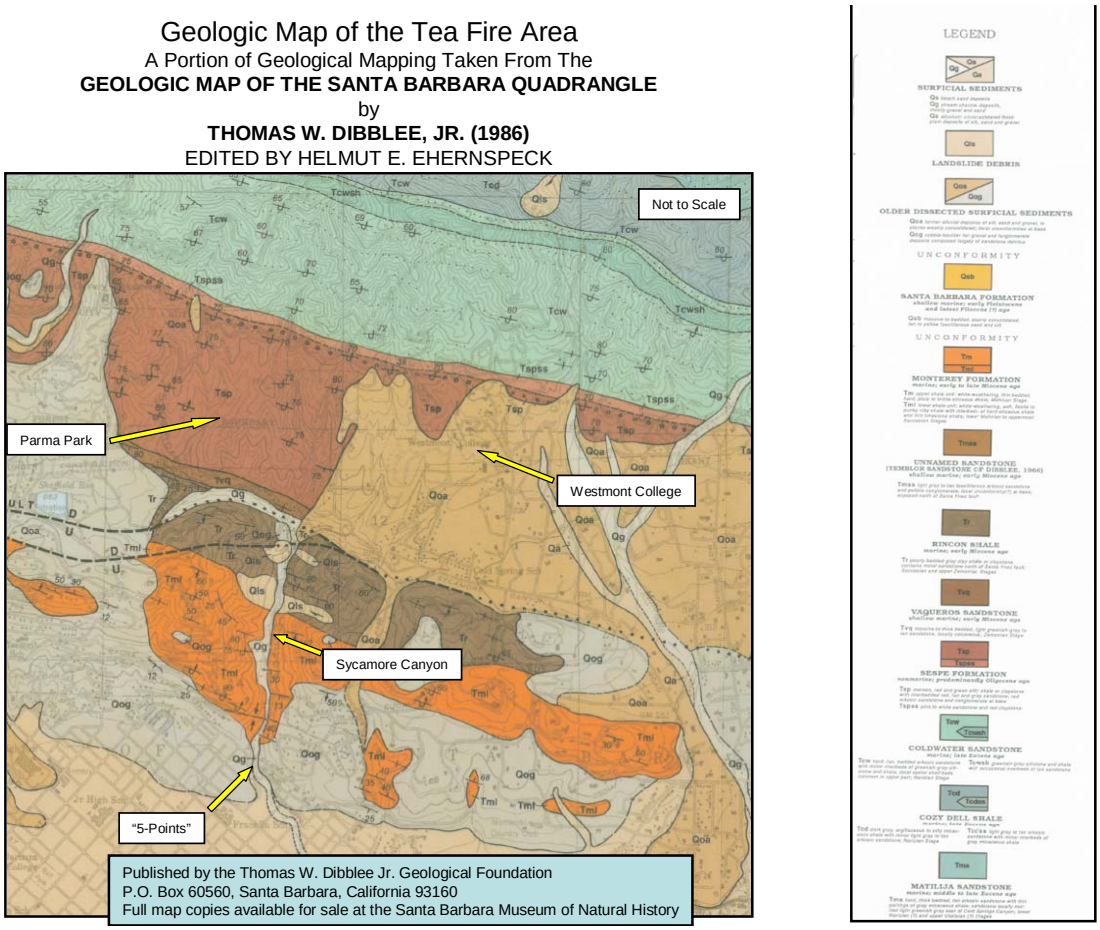


Figure No. 1. Geologic map of the Tea Burn area

The steep hills above Montecito and Santa Barbara form a barrier to the Pacific storm belt and as a result, orographic rainfall (rising of water-laden clouds over the mountains) is common. During wet years, weak rocks and unconsolidated surfacial deposits become saturated and may fail as rock falls, debris slides, and landslides. Debris flows generated during rain storms on recently burned areas have destroyed lives and property throughout the Western U.S. (Cannon, et al, 2007).

Faults and Local Seismicity

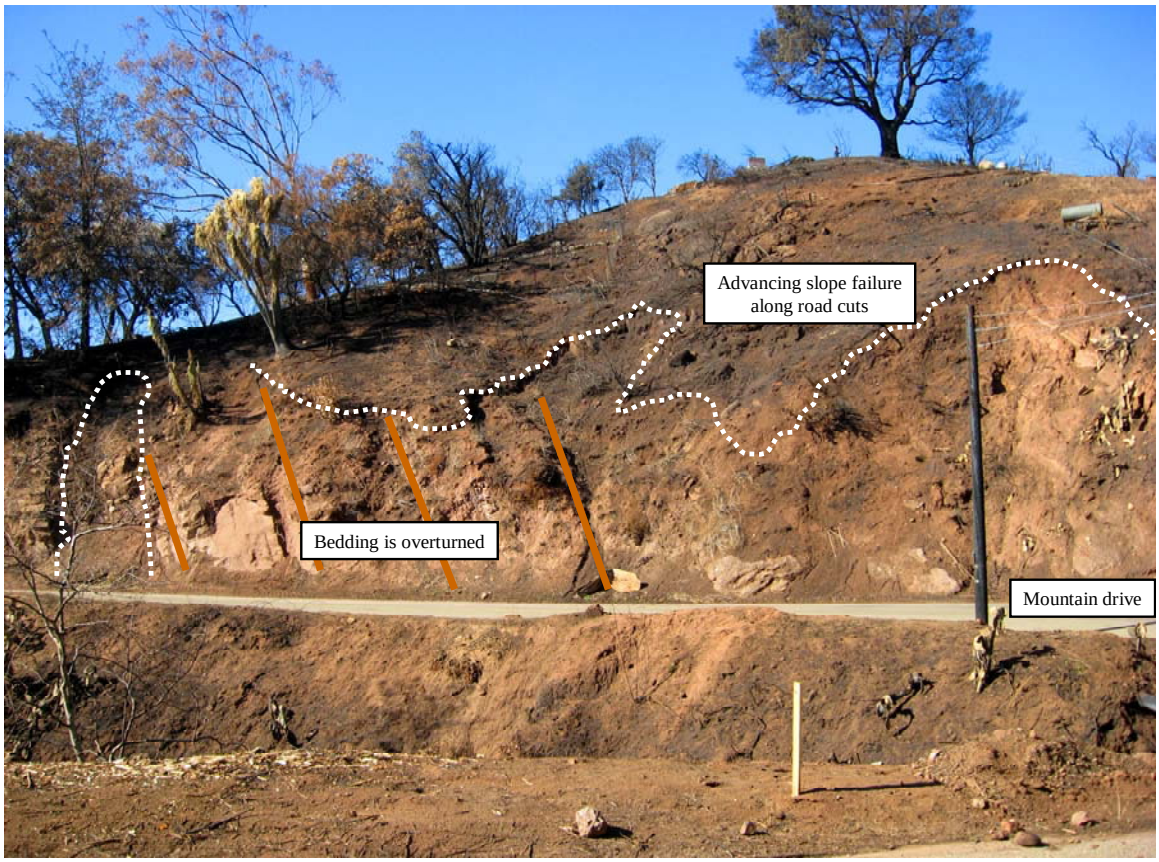
The predominate fault located near the Tea burn area which is partially mapped as having Holocene (<11,000 yrs bp) age movement is the Santa Ynez Fault (Jennings, 1994). Other faults in and near the Tea burn area indicating movement during late Quaternary time (<700,000 yrs bp) include the Santa Ynez Fault, Mesa-Rincon Fault, Mission Ridge Fault, and the Arroyo-Parida Fault. The offshore Pitas Point Fault is indicated to show evidence of displacement during the past 1.6 million years (Quaternary movement). There may be new information concerning local faulting. The burn area is located in a relatively active seismic area of recurring earthquakes. Loose rock located on steep

slopes is subject to falling, rolling, and bouncing during earthquakes. Saturated fine-grained sediments are also subject to liquefaction and slope failure during seismic events.

Local Structural Geology within the Tea-burn area – potential implications

Tom Dibblee's map shows the Mission Ridge Fault splitting into two sections in the lower burn area along Stanwood Drive, across the upper entrance to Sycamore Canyon and along the eastern portion of Sycamore Canyon Road. Conspicuously mapped, the older rock formations are indicated as being "overturned" (i.e., the formation beds have been tilted so steeply through faulting and tectonic uplift that they are actually upside down!).

This has implications for weathering and erosional characteristics. Steeply-dipping beds of more resistant materials will tend to channel rain water runoff along less resistant bedding materials such as siltstones and shales. As the interbedded shales erode more quickly (differential erosion), the more resistant beds lose their bearing capacity and collapse along clast contacts or weak joints. This may be the case of some rockfall found along Mountain Drive, as seen in photograph 1 below.



Photograph No. 1. Overturned formation bedding and landsliding features along Mountain Drive.

Landslides

The term landslide is used for "The movement of a mass of rock, debris, or earth down a slope" (Cruden, 1991). The criteria used in the classification of landslides follow Varnes (1978). In emphasizing landslide types, various criteria include:
Type of materials:

- Rock, debris, earth

Types of movement:
- Falls, topples, slides, spreads, and flows,

Activity:

- Active, reactivated, suspended, and
- Inactive (dormant, abandoned, stabilized, relict)

Distribution:

- Advancing, retrogressive, widening, enlarging, confined, diminishing, moving

Water content:

- Dry, moist, wet, very wet

And description of first and second movements:

- Extremely rapid, very rapid, rapid, moderate, slow, very slow, and extremely slow

Landslide definitions are then classified in this manner (e.g., Debris flows, Earth spreads, Rock falls, etc.). Activity of landsliding can be extremely slow to extremely rapid. Table 2 depicts a velocity classification related to probable destructive significance.

Table 2. Velocity classification related to Probable Destructive Significance.

Minimum Typical Velocity	Description	Velocity Class	Definition of Probable Destructive Significance of Landslides of Different Velocity Classes (in Turner and Schuster, 1996, Table 3-5, pg. 51).
>10 feet per second	Extremely rapid	7	Catastrophe of major violence; buildings destroyed by impact of displaced material; many deaths; escape unlikely
1 foot per minute	Very rapid	6	Some lives lost; velocity too great to permit all persons to escape
5 feet per day	Rapid	5	Escape evacuation possible; structures, possessions, and equipment destroyed
5 feet per month	Moderate	4	Some temporary and insensitive structures can be temporarily maintained

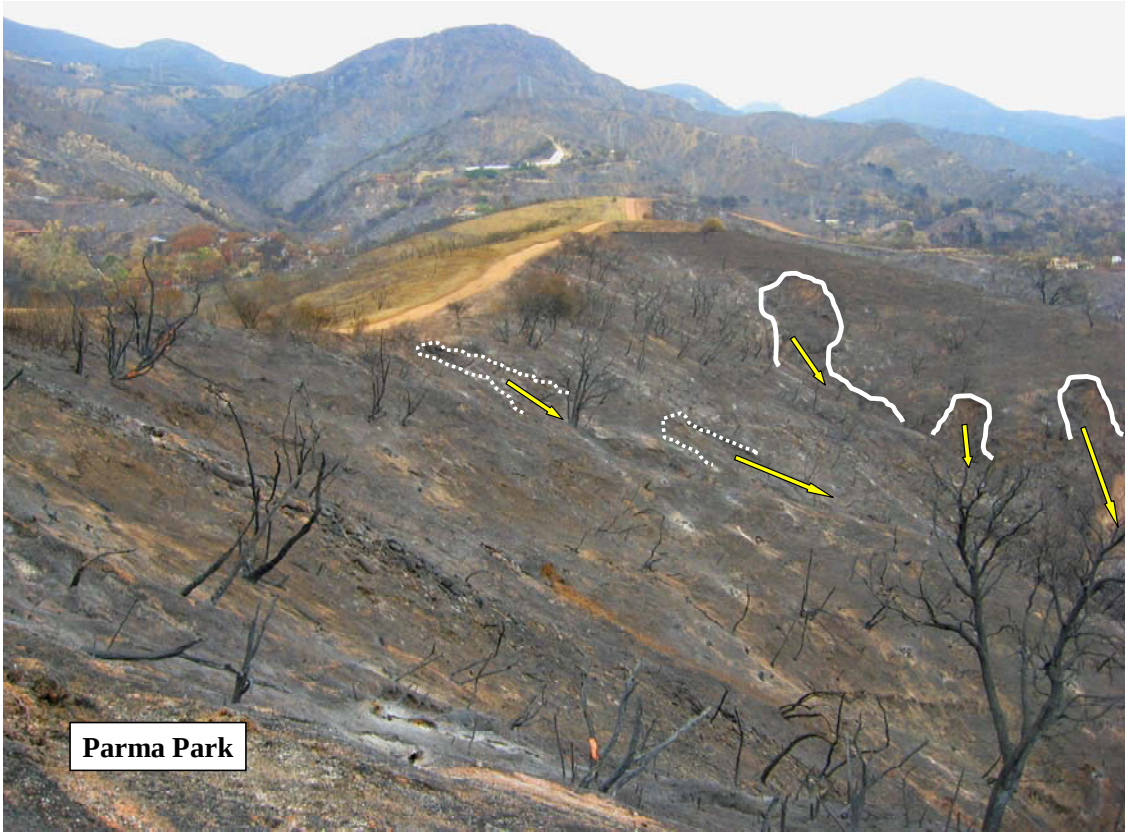
5 feet per year	Slow	3	Remedial construction can be undertaken during movement; insensitive structures can be maintained with frequent maintenance work if total movement is not large during a particular acceleration phase
1 foot per year	Very slow	2	Some permanent structures undamaged by movement
< 1 foot per year	Extremely slow	1	Imperceptible without instruments; construction possible with precautions

When considering rainfall intensity, duration, and location, combined with elevation change, proximity to populated areas and risk of seismic event, Velocity-Class events up to and including Class 7 can not be ruled out.

Existing and previous landslides, debris chutes, flooding courses and other mass wasting features are found within and down gradient from the Tea Fire burn area.

The Landslide Inventory Map of Southeastern Santa Barbara County, California (Bezore and Wills, 2000) indicates that a number of landslide and debris slide sites of multiple types exist within the Tea Fire burn area. Active or historic movements, and dormant slides of young to mature and old landforms are mapped.

During initial field work, the BART geologist made trips into accessible portions of the burn area to ground truth burn severity and locate current landslide features. Pictures of commonly seen landslide types are provided for review in Photograph 2.



Landslide Mapping

At the request of the Santa Barbara County Office of Emergency Services, the author performed a quick cursory mapping of geomorphic features related to landsliding within the Tea Burn area. The attached map titled "Geomorphic Features of Potential Landsliding – Tea Incident, Santa Barbara County, California" provides general locations of existing mass wasting features as seen during a one-day field examination prior to the onset of rains. The mapping included existing large-scale landslides, moderate to minor shallow landslides, existing recognizable debris flow channels, potential or incipient debris flow channels, materials on slopes which may mobilize into debris flow channels, and general potential rockfall sites which may produce a mass wasting event. There also may be other preexisting slope stability conditions which may or may not be exacerbated by this fire event which were not seen or mapped.

The scope of the preliminary landslide assessment as well as information contained within this report should not be construed to be either comprehensive or conclusive, or to address all possible impacts that might be ascribed to the fire effect. This cursory field examination and mapping is intended for emergency response prior to the full onset of winter rains. Neither the State of California nor any Agency or Department participating as a member of the BART team makes any warranty, express or implied, nor assume any legal liability for the information disclosed herein.

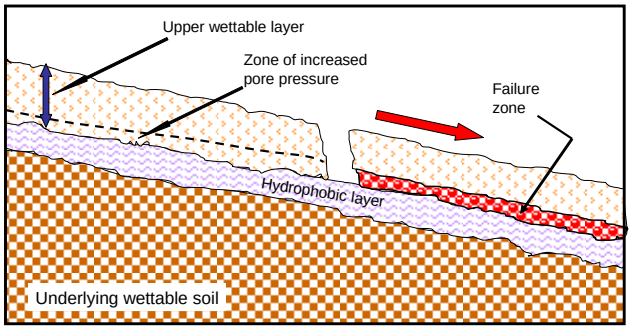
Mapping of existing landslides within a burn area has not been generally within the prevue of a rapid assessment team's directive. Multiple benefits for performing this function in the wildland/urban burn interface setting may exist:

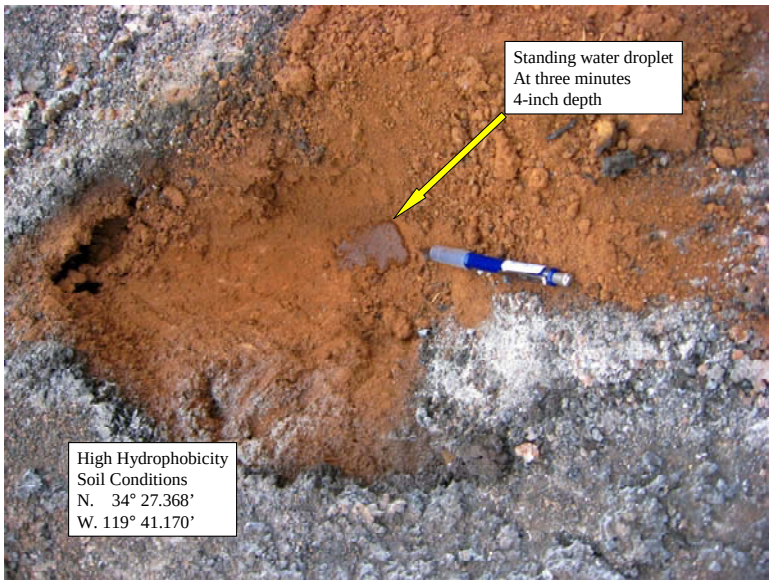
- Burned areas reveal geology which had hitherto been covered by dense vegetation,
- *The author contends that when a burn severity map is overlain by a post-burn map of potential landslide features, That overlapping areas of moderate to high burn-intensity (related to developed hydrophobic conditions) combined with existing soil surface weaknesses such as landslide features, may indicate potential "hot spots" for near-future additional mass wasting events or "trigger sites" for debris flow initiation. Recognition of such sites early may provide agencies with directions in mitigation types, methods, and resource distribution,*
- By mapping potential landslide and mass-wasting features early after a burn, a "Base-map" is created for the area. Generally speaking, availability of widespread landslide maps are not as common in California literature as other earth science maps (Geologic, groundwater basins etc.) but their numbers are on the increase.
- After the first winter season, the baseline landslide map should be re-evaluated to determine where mass-wasting damage occurred during the previous winter and to assess base map accuracy.
- During the following dry season, a more detailed and in-depth mapping of landslide features would be done. This may potentially assist local agencies in determining slope failure hazard sites as well as future land use planning.

Hydrophobicity

Many soils exhibit water-repellent properties after burning. On a typical burned slope, the surficial soil is loosely compacted and easily wettable (Turner and Schuster, 1996). During moderate to high burn intensities, waxy organic molecules generated by the burning of vegetative matter on and in the soil, are driven down into the soil where a hydrophobic barrier forms resisting penetration by water. During a rain event, increased pore pressure above the hydrophobic zone can cause the surface soils to slip. A steep slope is not necessary to start the process of slide movement. As momentum increases with the inclusion of pebbles, cobbles, dead vegetation, and boulders, a rapid pulse of debris flow is formed. The results can be devastating.

Schematic diagram of post-fire colluvial soil slope, showing effects of hydrophobic soil layer (after Turner and Schuster, 1996)





Photograph No. 3. Example of hydrophobic conditions found in the Tea burn

D.) Scope of Work and Deliverable Goals

A Burn Area Response Team (BART) assembled at Santa Barbara on short notice on Saturday, November 22, 2008. An introductory informational session between BART members and local authorities and agencies was conducted to a) describe the condition of the wildland/urban interface nature of this particular fire b) determine the scope of work, and c) elucidate the urgency of response due to the coming storm event.

After the meeting, The BART was provided a tour of the burn area by Fire Marshall Jim Langhorne of the Montecito Fire Protection District. This tour enabled the BART to navigate mountain roads and avoided various closures to expedite field time. Additional assistance was provided by Captain Mike Lee of Montecito Fire Station Number 2 in accessing certain properties and roads during power line re-establishment. The provision

by the local fire departments was most appreciated and enabled the BART to conduct field surveys in rapid measure.

Public Outreach

On Sunday, November 23, BART members began to move into the field in teams to perform assessments. Due to the impending onset of inclement weather, many affected homeowners and volunteers were seen working diligently to prepare ahead. The author saw many people filling, transporting and setting sandbags in place to control potential slope erosion. Other people were placing straw wattles across slopes, laying out hemp netting, and/or setting up silt curtains. On a number of occasions, the Team would stop and assist residents, neighbors, or volunteers. The assistance made included providing general erosion control suggestions, sandbag-layout techniques, and general encouragement to those working intently.

At the request of Deputy Public Works Director Thomas Fayram, a list of 11 deliverable goals was provided as guides where the BART might provide assistance. The following goals are listed along with the accomplishments realized:

1) Overall statement of the risk the fire now poses to fire area and downstream.

Response: During the morning of the second field day, the BART engineering geologist made a field call to Incident Command stating concerns for residential properties located within Sycamore Canyon. The concerns raised were the potential of

- A building storm front which was to move into the area the next day. Weather forecasting was changing and the potential for a stalled system in the mountains was becoming a possibility,
- Residential homes and outbuildings are present in narrow Sycamore Canyon and adjacent to Sycamore Creek – which at this point alone drains six watersheds,
- Steep hillsides abut up and close to the rear of a number of residences. The vegetation on these hillsides were denuded by fire and tests for Hydrophobicity of the soils indicated moderate to high hydrophobic conditions
- Existing landslides were observed on the hillsides of Sycamore canyon.

With the above concerns in mind, the engineering geologist relayed that potential entrapment of residents might occur if the storm event was sufficient to mobilize substantial flooding, debris flows and slope failures on the hillsides.

After consult, the field engineering geologist was requested to map the observed landslides and produce said map for review by County and City authorities.

- A meeting was arranged for later that day. The BART Incident Commander and engineering geologist appeared in the Santa Barbara Supervisoral council chambers. Approximately 26 attendees were present including Santa Barbara

County Supervisors, Santa Barbara City Council members, Deputy Directors from the County Office of Emergency Services, County Flood Control District and other entities to listen and question as the BART engineering geologist related observations made that morning. Information provided by the BART enabled the group to move forward in the emergency declaration process concerning the first substantial post-burn rain event of the season.

Post-burn storm events have now begun. A very brief post-storm cursory review of areas viewed (pre-storm) by the engineering geologist found evidence of initiating mass wasting features along Mountain Drive on Saturday, November 29th. Among the features seen were:

- A number of new small sediment cones (5-feet wide, 8-feet tall) which had formed along road cuts
- A fresh slump feature downslope of the road. Burned plants appeared to have rotated in position as the slump progressed
- A number of silt curtains had sediment buildup
- Fresh rockfall was apparent on roadways and catchment areas
- Sediment trails down driveways were diverted into drainages by sandbag wings
- Fresh blackened debris was abundant in the thalweg of a few incised stream channels. This suggests that localized heavier rains may have mobilized some burned materials.

Very apparent along Mountain Drive is the manifestation of ongoing erosion control placement by local homeowners. Numerous types of erosion control practices were seen including minor to major sandbagging of culverts, road edges and slopes, use of hemp netting and wattles on hillsides, placement of silt curtains for stream channel protection, applications of plastic sheeting to protect structures, and ongoing hydromulching operations. Agencies and private concerns are in a very pro-active mode to ensure erosion control methodologies are in place before the next storm event.

2) Hydraulic Modeling of the Fire Area to quantify pre and post fire runoff volumes (like BAER).

Response: Please refer to the overall BART report for discussion on hydraulic modeling.

3) Sediment production estimates for each Tributary (like BAER).

Response: Please refer to the overall BART report for discussion on sediment production estimates for each tributary. From the Geology point of view, field observations suggest that increases in sediment production may come from high erosion geologic units such as the shale sections within the Sespe Formation and the Rincon Shale. Potential higher sediment-production drainages may include Sycamore Creek and its upper tributaries as well as the Coyote Creek drainages. Higher sediment production may also occur from existing landslides and steep hillsides in Sycamore Canyon.

4) Looking at Geology and Topography, identify Debris Flow hazard areas.

Response: Multiple types of potential mass wasting events and occurrences may exist within and below the Tea Fire burn-area. They include but are not limited to:

- Potential for isolated individual, multiple and avalanche type rockfall events may occur in the steep Mountain-County areas.
- Observations indicate that some debris flows may initiate in the upper mountains and cascade down into the foothill areas. At breaks in slope (for example, drainages flowing onto upper alluvial terraces, a potential for debris dam formation may develop. If a natural dam develops, sudden failure may occur sending a debris torrent down gradient.
- During strong sustained storm events additional materials may slough into the drainage channel, adding debris and increasing flow volume
- As tributaries merge, debris flow pulses may merge

The Tea Incident Post-Fire Hazard Awareness Map was created to depict potential debris slide areas.

5) Review hydrophobic soils potential.

Response: Numerous sites and soils throughout the Tea-Fire burn area were assessed for hydrophobic potential. Standard methodology was used at each site. This was performed in part to assess the quality of information depicted on the OES/USFS/CalFire Burn Severity Map as well as to document soil drainage conditions.

Many sites exhibited a natural Hydrophobicity to some degree or another. For example, in a burn area within Parma Park, the burn severity map indicated a moderate burn. Some duff was apparent on the surface and unburned plant roots were seen within the upper two inches of soil, yet the underlying materials (claystones) exhibited moderate to high Hydrophobicity.

6) Identify likely Transportation Infrastructure risk areas (City, County, and CalTrans).

Response: Please refer to main BART report.

7) Post Fire inundation map, assume likely bridges plugged.

Response: Please refer to the Tea Incident Post-Fire Hazard Awareness Map. This map, when overlain in GIS by bridge locations may indicate which bridges may be constricted by debris and the resulting flooding which may occur.

"There is a long history of flooding in the Santa Barbara area, with floods recurring about every 5 to 15 years. The exception is the period of the 1940s and 1950s. Damaging floods have occurred in 1862, 1909, 1914, 1927, 1938, 1962, 1964, 1967, 1973, 1978, 1980, 1983, 1991, 1993, 1995, and 1998. Even so, relatively few structural flood control

projects have been implemented." (Questa Engineering Corporation, 2005, Section 4.2.2.1, pg. 123.)

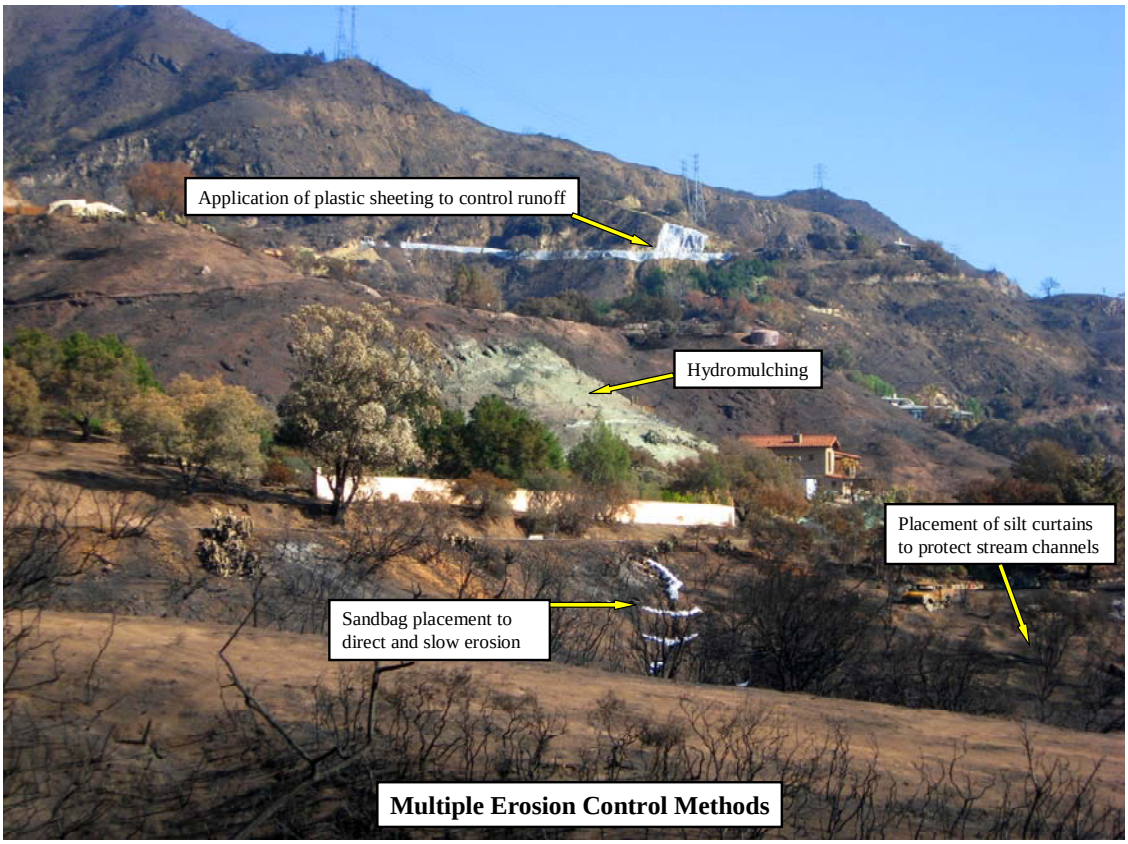
During the brief reconnaissance time, the author recognized that at least two city bridges, both located very close to the Five-Points round about appear to have constricted channels and low clearance between the channel bottom and the bottom of the bridge deck. That said, the potential for inundation and flooding of streets/homes is increased.

8) Identify homes not burned that are a risk to slides, and debris flows.

Response: A GIS layer depicting unburned homes combined with the Tea Incident Post-Fire Hazard Awareness Map may indicate those homes in the burn area and below the burn area which may be at risk to slides and debris flows. General inspection during field reconnaissance indicates that homes located within the Sycamore Canyon are at most risk for both landslides and debris flows. Homes along hilltops where post-burn landsliding may encroach upon the structure's foundations may also be at risk. Additionally, homes located along stream banks where active channel and bank erosion may take place during flooding events may also be at risk.

9) Prepare homeowner guidance document on erosion control treatments, methods, and applications.

Response: One of the aspects of erosion control methodology that the author is most impressed with is the number of agencies and private entities who have taken pro-active approaches to mitigate potential erosion problems. One such aspect is a Santa Barbara government website which provides a printable/downloadable copy of flood/debris flow mitigation methods. It features a number of different ways and means to prevent flooding or impact to structures from debris flows and provides a "how to" method for the public. Another observation made in the field is the number of homeowners who have engaged their landscape engineers, erosion control specialists, and gardeners. A photograph is provided to demonstrate the activity undertaken by many private homeowners:



Photograph No. 4. Showing multiple uses of erosion control methods being employed.

During a recent meeting, the author presented a recently acquired text titled:

BAER: Burned Area Emergency Response Treatments Catalog, published by the United States Department of Agriculture, Forest Service; National Technology & Development Program
Watershed, Soil, Air Management, Number 0625 1801-SDTDC-December 2006.

In response, Tom Fayram indicated that he possessed a copy of the treatments catalog also. This is advantageous due to time constraints of the BART that such a copy exists within the Santa Barbara Flood Control District. Numerous erosion control methods with simplified diagrams for construction are supplied within the catalogue.

10) Identify City Bridges that are inadequate, and candidates for hazard Mitigation.

Response: Please refer to number 7 above.

11) Immediate Delivery of Erosion Control Supplies.

Response: Prior to the Thanksgiving Holiday, three containers of erosion control supplies were being supplied and sent from the California Department of Water Resources to Santa Barbara.

E.) General Observations

1.) Tea Fire Post-Fire Hazard Awareness Map

The map titled "Tea Fire Post-Fire Hazard Awareness Map – Draft", prepared and compiled by GIS specialist Doug Huls of the Governor's Office of Emergency Service, graphically depicts the potential aerial extent of areas at risk for flooding and potential debris flows within the burn perimeter. This map may be used with other GIS maps, such as parcel identification, to determine the number of potential residences, properties or structures at risk as well as determine escape corridors and safe havens in the event of a strong sustained storm event. There may be locations or areas of potential danger that are at risk for possible loss of life and/or property which may be on the fringe or out side of the mapped areas at risk.

2.) City and County Road System, Interstate Highway 101, Amtrak Corridor, Power, Water, and Wastewater Infrastructure

Water courses, stream channels and drainages descending from the Tea burn area may impact much infrastructure in the Montecito/Santa Barbara urban areas as well as many private lands. A number of bridges, culverts, pipelines and other watercourse crossings are located along City, County, State, and Interstate government roads, highways, alternative transportation (bicycles, pedestrian traffic) in and downstream from the burn area. Numerous privately owned and maintained bridges, private roads, and additional structures are also within the drainage areas affected by or located below the burn area.

Additionally, major infrastructure such as the Interstate Highway 101, the Amtrak rail corridor, power, water, and waste water conveyance facilities may all be impacted due to in and out-of-channel flooding, concentrated floods, sudden debris flows, and/or debris torrents. The town of Montecito, city of Santa Barbara, and the Santa Barbara County Department of Public Works recognize the severity and are proactively moving forward with emergency response plans.

3.) Surface Water and Groundwater Quality Concerns

Concerns are raised for surface water quality degradation during the initial first pulses of flooding, debris flows and/or debris torrents which may originate in the Tea Fire burn area. Depending upon severity, duration, and location of rainfall or storm tracks, high-intensity flooding and/or debris flows or debris torrents may initiate and proceed down the Sycamore Canyon area. Unprotected surface items such as natural gas tanks or bottles, agricultural, domestic, and/or municipal chemical storage containers, homes or outbuildings may become entrained within the flooding or debris flow waters. Accidental discharge of combustible and/or toxic materials or liquids may occur. Additional items

that may be entrained in the flood waters including but are not limited to: fertilizers, pesticides, petroleum products, outhouses, excavation or entrainment of dead animals, equipment, buildings, and vehicles.

Groundwater quantity and quality may become affected. Development of hydrophobic layers in the burn area may contribute to increased runoff but may also inhibit recharge of groundwater supplies. Domestic wells located down gradient from recharge areas may notice a drop in groundwater levels over time as well a change in groundwater quality. Domestic groundwater wells, wellheads and pumping equipment, agricultural wells, wellheads, pumping and storage equipment which are located within the flow paths of flooding, concentrated flooding, debris flows, and/or debris torrents may be subject to damage and loss. Unprotected, damaged, or opened wellheads may become conduits for groundwater contamination by previously listed concerns.

4.) Areas Not Assessed.

Numerous homes, ranches, agricultural buildings and structures exist in the interior of or below some of the burn areas. Accessibility and time was limited for field observations and in some areas not at all due to locked gates, or postings of No Entry and/or No Trespassing signs. It should be noted that it is beyond the scope of this preliminary evaluation to gain access to every residential structure and/or outbuilding that may be at risk. Areas with low, moderate, and high potential risks to life and property from slope instability may exist in the vicinity of and down slopes below burned areas. Evaluation of all properties within the all the burn areas is beyond the scope of this review. The evaluation of all sites not directly affected by the fire is likewise beyond the scope of this evaluation.

F.) Emergency Determination

An Emergency Determination is made for Values at Risk graphically portrayed in the Tea Fire Post-Fire Hazard Awareness Map. Values at Risk considered in this evaluation include the possible loss of life and property due to landsliding, debris flow, debris torrents, and concentrated flooding from increased surface water runoff. In general, the risk from landslides, debris flows and floods are possible where roads, residences or other developments are located within and/or adjacent to canyon stream channels, in narrow valleys whose valley floors have previously been sites for flooding, debris flow or debris torrent runout or on alluvial fans, urban streets located along stream channels, infrastructure which crosses natural and existing stream discharge areas, colluvial slopes and debris flow deposits.

It should be noted that these hazards are part of the natural processes in this environment, and that these risks were present to a degree under pre-fire conditions. Existing structures in the burn area and downstream of the burn area have been and will continue to be at risk from post-burn hazards. The potential for these processes to be exacerbated by fire is primarily dependent upon burn severity and slope steepness, both of which are highly variable in the Tea Fire area. In general, where the burn severity is moderate to

high and the slopes are steep. Stream courses passing through populated and urban areas the potential for increased hazard is greatest.

Areas with low, moderate, and high potential risks to life and property from flooding, concentrated floods, sudden debris flows and/or debris torrents likely exist in the vicinity of narrow valley constriction points such at culverts, sharp changes in drainage direction, lower natural levees or graded lands, or places along stream reaches where debris dams may form and break are not included in this assessment. Assessment of all properties within or adjacent to or below all the burn areas is beyond the scope of this review. The assessment of sites not directly affected by the fire is likewise beyond the scope of this evaluation.

G.) Need for further evaluation

Threats to life, public health or safety, infrastructure, and structures have been or are being assessed on an ongoing basis by authorities and local agencies involved with implementing the Tea Fire emergency response recommendations.

A series of stakeholder meetings with coordination by all parties including local, county, and State emergency response personnel, news media and public broadcasting, as well as parties from all services which might be impacted (Amtrak, CalTrans, water, power, Red Cross etc.) should commence and continue throughout the upcoming rain season.

Potential deficiencies that may come to light in flood mitigation, evacuation routes, and rescue and emergency shelter locations should be addressed prior to the onset of any forecasted heavy rains or as the deficiency comes to light.

H.) General Recommendations – Near Term (next three to five months)

1) Remain Vigilant, although the first rains have arrived and passed, the danger to life and property within and downstream of the Tea Fire burn-area is still a substantial threat
2) Continue to promote and where possible assist private home owners with erosion control activities. Conditions during preparation and erosion control activities may actually be more dangerous because of a false sense of security after the initial storm has passed. Hill slope creep may only be just beginning.
3) When working near steep slopes or during rain events:
    a. A minimum of two people should work together
        i. One is a Spotter – always looking around and especially uphill, the other person concentrates on the work being performed
    b. Wear protective footing – boots
        i. Everything is now slick
        ii. Roof tiles are especially slick

iii. Claystones and clays become wet, smear and make travel slick

4) Roadways may have mud – a thin layer, combined with oil buildup from the summer may become very slick, Reduce Speed, especially around blind corners.
5) Continue slope protection efforts where safe to do
6) Continue public notification of potential and planned optional to mandatory evacuations when sizable rain events are projected to impact either the Tea or the Gap fire watersheds.
7) If a potential long rain event is projected, authorities may suggest to home owners within Sycamore Canyon to temporarily move personal belongs of value to safe havens such as a storage shed. During this time, home owners whose properties may be adjacent to a potentially flooding creek, should move sources of contamination away from the potential flood course.

I.) General Recommendations – Mid-Term (next six months to 1+ years)

1) Assess runoff conditions and characteristics for the burn areas. Begin to plan, budget, and schedule for more in-depth erosion and flood control measures which may be accomplished in the mid-term and long term (2 to 5 years out)
2) Design, perform and complete an in-depth landslide mapping project for all fires within an agency's jurisdiction (for example, the Zaca, Gap, and Tea Fires). Build GIS layer data bases for each fire area. This may assist County and local planning agencies on future land use options within and downstream from the burn areas.

J.) General Recommendations – Long-Term (2-5 years)

1) Begin to accomplish mid- and long-term goals for flood control, especially in Sycamore Canyon

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DRAFT TECHNICAL SPECIALIST'S REPORT
BURNED AREA RESPONSE TEAM (BART) Report

Resource: Hydrology

Fire Name: Tea Fire, Santa Barbara County **Month/Year:** November, 2008

Fire Designation: CA-SBC-009981(also CA-MTO-001023)

Author Name: Derick Louie, Water Resource Engineer
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Introduction

This assessment focuses on watershed hydrology for the three sub-watersheds affected by the Tea Fire. It addresses general hydrology of the area, the potential for additional runoff and sediment load in response to precipitation over the burned area, and estimates of treatment efficacy. It does not identify or analyze specific features at risk from debris flows; mudslides and flooding.

I. Resource Condition Assessment

A. Resource Setting

The Tea Fire burned steep, heavily vegetated hills in three small canyon watersheds on the coast range above an urbanized shoreline. The three watersheds drain about 34 square miles, and each are less than fifteen square miles each. The basin rims range from about 1800 to 3200 ft above mean sea level (MSL), and the stream courses are generally less than ten miles in length. The following figures represent the longest reaches and extent of the watercourses in or near the burn perimeter.

The Sycamore Canyon watershed was extensively burned in its upper forks where 1705 acres of the 5616 acre watershed burned. Five tributaries of Sycamore Creek that drain the burn area, join the main stem of the creek near the junction of Highways 192 and 144. This area is locally known as Sycamore Creek Canyon. This concentration of runoff channels may be due to geologic controls of drainage of the area; the topography may have implications for soils and sedimentation characteristics too (see geology report). The Sycamore Canyon rim rises to about 1800 ft in elevation and is bounded on the west by San Rouque Canyon, on the north by Mission Canyon and to the east by San Ysidro Canyon. The Pacific Ocean is to the south.

The Mission Canyon basin drains 8233 acres, and is about nine miles long from it's rim at 3200 ft elevation to the Pacific Ocean. 216 acres of its north eastern rim in the Rattlesnake Creek area was burned in the Tea Fire.

San Ysidro Canyon had only 22 acres burned of its 8056 acre area. The longest reach of Cold Spring Canyon Creek (in San Ysidro Cyn) is almost six miles from the basin rim at 2900 ft elevation to the Pacific Ocean.

Precipitation within the county varies greatly from season to season and with each location. Average annual precipitation ranges from a minimum of about 8 inches in the Cuyama Valley to over 36 inches at the apex of the Santa Ynez Mountains. Snow is common at the county's highest elevations that are in excess of 6,600 feet above sea level. Climate studies have determined that drought periods occur regularly and may last as long as a decade or more. The most recent drought lasted from 1986 to 1991, during which water storage in the county's major reservoirs was nearly depleted. Only 4.49 inches of rain were recorded in downtown Santa Barbara in 1877, the driest year of record.

Although rainfall within the County is moderate on average, some winters yield well over twice the average. The maximum annual rainfall of 47.07 was recorded in downtown Santa Barbara in 1998. In addition, Santa Barbara County is occasionally subject to short duration rainfall of very high intensity (see table below). Due to it's pronounced topography and variable rainfall, Santa Barbara County has been subject to numerous periods of flooding. Significant floods were reported by Spanish Missionaries as long ago as the late 18th Century. 20th Century flood years include 1914, 1941, 1948, 1969, 1978, 1983, 1992, 1995, and 1998.

Duration (hours)	Location	Year	Rain (inches)
0.5	Santa Barbara Foothills	1984	1.80
1	San Marcos Pass	1998	2.51
2	Montecito Foothills	1973	4.50
3	Montecito Foothills	1973	5.99
6	Jameson Lake	1969	8.78
8	Jameson Lake	1969	10.98
12	Jameson Lake	1969	13.38
24	Jameson Lake	1969	16.31

Table 1. Observed storm duration and depth (*from IDF curves developed at Santa Barbara county fire stations; Stanwood #228 and downtown #234)

The above precipitation discussion and table are from the Santa Barbara County Public Works Hydrology: website http://www.countyofsb.org/pwd/water/hydro.htm and Santa Barbara County Climatology website: http://www.countyofsb.org/pwd/water/climatology.htm

Precipitation events that cause historical rainfall can be correlated to flood peaks in the streams that drain a watershed. There was only one streamflow gage located on Sycamore Creek; USGS station 11119700. It recorded stream flow data from 12/21/1970 to 2/16/1980; the major peak flow in that period occurred February 9, 1978 with a river stage of 4.65 ft flowing at 1,120 cfs. This correlated with a daily rainfall total of 2.5 inches at the downtown Santa Barbara County Flood Control District office station #234 and was followed by a daily rainfall of 3.6 inches February 10, 1978.

Only one USGS gage (11119745 Mission Cr at Rocky Nook Park) and three DWR CDEC gages (MTC Montecito fire climate station, SBR Santa Barbara Sanitation monthly precipitation, GBL Gibraltar reservoir monthly storage) currently operate near the Tea Fire area.

The County of Santa Barbara has many monitoring and response plans and procedures. Together with NWS the County operates a network of ALERT gages to monitor precipitation and meteorological conditions. As early as 1948 a cloud seeding operation has been ongoing in Santa Barbara County and is said to have generated precipitation increases of 20% which equates to 20,000 acre feet of water in a year like 1992-1993 when 31.71 inches of rain fell on the downtown Santa Barbara Flood Control District office gage #234. During large storms, cloud seeding operations are suspended to avoid increasing the flood hazard.

Large water facilities in the fire perimeter include a historic diversion tunnel and scenic trail from the west branch of Sycamore Creek westward towards Mission Creek and downtown Santa Barbara and an underground reservoir named Sheffield reservoir near Highway 192. Gibraltar Reservoir is outside of the Tea Fire affected watersheds, but does have a tunnel diversion which carries about 1,000 cfs to the City of Santa Barbara via Mission Creek, this located to the west of Sycamore Canyon.

Near the ocean, at the end of the stream channel, nearly a mile and a half from the Highway 192 crossing, the Clark bird refuge pond is located east of the outlet of Sycamore Creek. The flat topography and geology of this area seem to provide some protection of this section of the channel from burned area runoff.

B. Evaluation Methods

Published regression equations, standard flood flow frequency analysis, and an erosion risk management model were used with watershed geometry and characteristics to generate flood flows for various return periods, estimate potential increases in runoff and sediment loading, and characterize emergency treatment efficacy for the burned area.

The USGS program PEAKFQ was run for stations near the burned area to assess the magnitude and frequency of historical storm runoff events. From the USGS Santa Barbara Coastal region 18060013 the following stations were evaluated in PEAKFQ:

USGS #	USGS Site Name	Begin Date	End Date	Peaks
11119660	SAN YSIDRO CANYON MONTECITO CA	12/27/1971	1/24/1983	12
11119700	SYCAMORE CANYON SANTA BARBARA CA	12/21/1970	2/16/1980	10
11119740	MISSION CANYON SANTA BARBARA CA	12/27/1971	2/16/1980	9
11119745	MISSION CANYON ROCKY NOOK PARK SANTA BARBARA CA	12/25/1983	1/30/2007	13
11119750	MISSION CANYON NR MISSION ST NR SANTA BARBARA CA	11/29/1970	1/30/2007	36
11119760	VICTORIA ST DRAIN A OUTLET NR SANTA BARBARA CA	1/25/1969	2/9/1978	8

Table 2. USGS peak flow stations in Tea Fire area

Wanaanan and Crippen (WRI 77-21, USGS 1977) regression models for the Central Coast and the BARC (Burned Area Reflectance Classification) map information was used in a spreadsheet to estimate peak flows and potential sediment load increase for each canyon watershed. The proportion of soil burn severities applied to the burned acreage within each watershed is 15% high, 60% moderate, and 25% low/no soil burn.

Rowe et. al (USDA, 1949) was used to generate post-fire peak flows for the return interval classes and the cumulative probability estimates were scaled up proportionately to match the Wanaanan and Crippen flows for peak flow sedimentation rates given in table 4.

The web based ERMiT model (Erosion Risk Management Tool) was used to evaluate sedimentation rates between untreated and select erosion mitigation measures. A Santa Barbara, CA climate regime was used along with some basic assumptions about hillslope geometry and soil character in the ERMiT model to compare moderate and high soil burn model results. Details are included in Appendix 2 and results are interpreted in the following sections.

The methods applied are commonly used and do not incorporate a great deal of specific detail for areas (detailed history inherent in the regressions notwithstanding) within the watersheds and are based primarily on percentages of burned area within the watersheds.

C. Resource Condition after Fire

Burn Area Reflectance Classification (BARC) maps provided by Cal Fire indicated the level of soil burn severity within the fire boundaries as low to no burn, moderate and high soil burn severity. Moderate and high burn soil severity can reduce water infiltration into the soil and lead to an increase in soil erosion. Rainfall and runoff carry the eroded soil downhill into water channels increasing the potential for debris flows, sediment transport, mudslides, flooding and rock fall risks. The severity of erosion is influenced by duration, intensity and amount of rainfall, slope steepness and length. The type of soil influences erosion potential from a burn area. The Maymen soils in the upper parts of the watershed are erodible, rocky, and extend across the upper watershed rim and northern fire perimeter.

Towards the coastal plain and urbanized areas the soils are more diverse and include rocky clay and sandy loams. Two types, the Zaca and Diablo clays are identified in the SSURGO 2003 soils database as being farmland of statewide importance, but only a small areas of these soils were within the Tea Fire perimeter.

The following tables relate the pre- and post- fire peak flows for various exceedence probabilities and expected sedimentation rate increases due to the burned acreage.

Pre- and Post-Fire peak flood flows, Q, cfs, for various recurrence intervals in. years						
Pre-Fire Q, cfs	2	5	10	25	50	100
Mission Cyn	*249*	*688*	*1095*	*1706*	*2274*	*2870*
Sycamore Cyn	**175**	**485**	**776**	**1214**	**1618**	**2050**
San Ysidro Cyn	*244*	*674*	*1074*	*1673*	*2231*	*2816*
Post-Fire Q, cfs	2	5	10	25	50	100
Mission Cyn	*253*	*696*	*1107*	*1721*	*2292*	*2890*
Sycamore Cyn	**277**	**699**	**1060**	**1573**	**2046**	**2543**
San Ysidro Cyn	*244*	*675*	*1074*	*1671*	*2226*	*2809*
Increase ratio	2	5	10	25	50	100
Mission Cyn	*1.017*	*1.013*	*1.011*	*1.009*	*1.008*	*1.007*
Sycamore Cyn	**1.58**	**1.44**	**1.37**	**1.30**	**1.26**	**1.24**
San Ysidro Cyn	*1.003*	*1.001*	*1.000*	*0.998*	*0.998*	*0.998*

Table 3. Pre- and Post-Tea Fire design flows in cubic feet per second

From the table, about a fifty percent increase in first year peak flows can be expected, depending on the scale of the storm event, with a higher increase for smaller storms as higher flows mute fire induced increases above normal flows.

Other sources for storm peak design flows are intensity-duration-frequency curves from the County of Santa Barbara's rational method spreadsheet calculator, statistically derived IDF charts for stations such as the Stanwood or Flood Control District office stations operated by the County, and model output from PEAKFQ and ERMiT. Both the County station IDF charts and the USGS PEAKFQ estimates of peak flow magnitudes by return period frequency differ from the Wanaanan and Crippen regression results; the local station records show drier climate with lower peak flows while the USGS station results are markedly higher at the lower flows. All estimates should be considered as indicative of potential rainfall as the return period frequency aspect relates only event magnitude. There is no substitute for preparation, monitoring, and protection of life and safety.

	Pre-Fire Sediment (tons)	Pre-Fire Sediment (t/ac)	Post-Fire Sediment (tons)	Post-Fire Sediment (t/ac)	Sediment Increase X Normal
Watersheds					
Mission Cyn	7,492	0.91	8,104	1.0	**1.08**
Sycamore Cyn	**5,111**	**0.91**	**19,582**	**3.5**	**3.83**
San Ysidro Cyn	7,331	0.91	7,480	0.9	**1.02**

Table 4. Pre- and Post-Tea Fire sedimentation rate increase estimate

The (pre-fire) background sedimentation rate from ERMiT is 0.91 ton/acre and the lower end of sedimentation rate increase is found to be almost 4 times the background rate. The exceedence probability of observing various sedimentation rates from ERMiT is given as percent chance of exceeding some number of tons per acre. The burned acreages can be used to generate rough volume estimates or can be taken as a general expected increase ratio. The results above suggest a potential sediment load increase of up to 4 times normal rates. Figure 1 is an example of determining the percent chance the base rate will be exceeded.

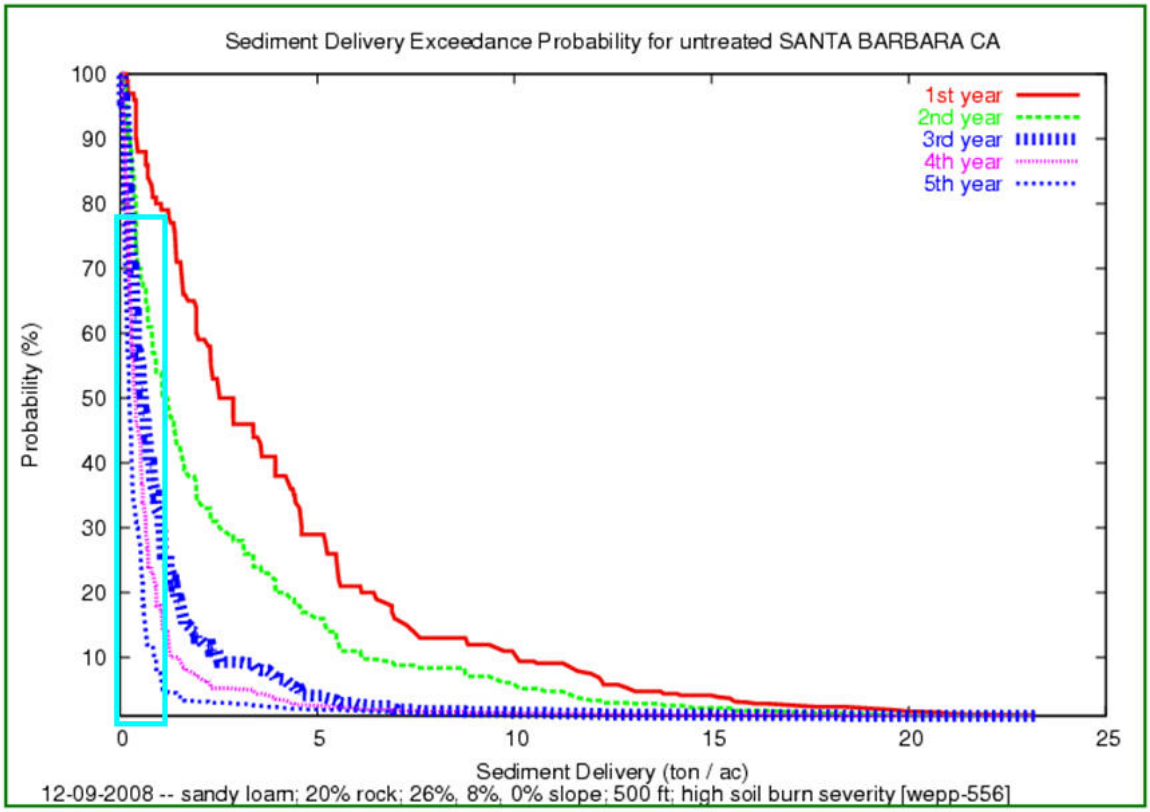


Figure 1. Estimate probability that the base rate of 1.5 ton/acre is exceeded (~78%, moderate burn is about 65%)

ERMiT exceedence probability	Moderate burn ton/ac	High/severe burn ton/ac
50%	2	3
25%	4	6
10%	9	10

Table 5. ERMiT chart results comparison between first year base sedimentation rate exceedence probability

The basic result of the ERMiT treatment efficacy tables in Appendix 2 is that within a few years the sedimentation rate should tend toward background rates. The figures can be used to estimate the loading of specific locations from upstream drainage areas or to generate cost benefit figures for installed land treatments.

ERMiT sediment delivery over time (untreated), ton/ac

From ERMiT output table and plot

	ton/acre expected for some years after fire				
	1	2	3	4	5
50% hi	2.6	1.7	1	0.6	0.3
50% mod	2.3	1	0.5	0.3	0.2
50% low	1.9	0.8	0.4	0.2	0.1

10% hi	10.22	6.27	2.64	1.49	0.91
10% mod	9.04	5.23	1.81	1.07	0.91
10% low	7.22	4.64	1.81	1.07	0.91

Table 6. Fifty percent and ten percent exceedence sedimentation rates for soil burn severity classes

Table 6 shows the number of tons per acre that can be expected from Sycamore Canyon based only on climate, hillslope geometry, vegetation type, soil texture, and soil burn severity. For treatment design and event scale estimation the acreage burned of each type can be multiplied by the table factor desired. The resulting mass estimate can then be located within the acreage so things like travel time and accumulation volumes can be computed.

The danger to specific areas within and around the burned area due to precipitation runoff, erosion, sedimentation, and landslides is dependent on site specific conditions and intensity/duration of storm events within sub-watersheds. More specific evaluations of localized hazards should be used to detail the use of the model output for planning and mitigation activity.

USGS and NOAA produced USGS Circular 1283 report in 2005. It relates localized precipitation intensity to flooding and debris flow hazards. It suggests that the two to three day forecast products for forecasted precipitation events exceeding 0.25 in/hr be used to develop a 24 hour notice to local Public Works and Roads Divisions, Sheriff's Communication offices, EOC, and Flood Control officials. Affected communities could then be forewarned about potentially moderate to severe flooding and associated debris flow events based on these weather predictions.

II. Determination

A. Emergency Determination - The potential for increased runoff and sediment/debris load due to the Tea Fire qualify as immediate threat if storm events of high intensity were to occur. In and around the burned areas, an emergency to human life, property, and water quality could occur due to the natural flow of increased precipitation runoff, burned debris, ash, and sediment. Road cut areas, developed land/property, natural drainages, and drainage control structures in the burned area are likely to experience additional sediment, debris, and potentially land movement that could plug culverts and overcome storm drains during winter storms. Places where streams come together such as the area where the five tributaries of Sycamore Creek join at the head of Sycamore Creek Canyon, near the intersection of Highways 192 and 144 are likely to be impacted most by accumulated and bulked stormwater.

B. Treatment to Mitigate the Emergency – Due to the nature of the threat to lives and property in the Tea Fire area, some preparation and structural actions such as installation of trash racks may be feasible, however most risk is related to winter

storm events and rainfall mobilizing ash and debris from the newly denuded hillsides. Therefore close monitoring and preparation by residents, commercial/industrial interests, municipalities, and jurisdictional agencies is recommended.

DWR's Flood Center has delivered flood fighting supplies to burned area emergency response teams over the course of recent months and local agencies have been coordinating response teams and disseminating information to the public. Monitoring of weather forecasts for the near term (five day) period could serve as a maximum mobilization timeframe for any mitigation to be placed prior to a storm event for the areas in and around the Tea Fire.

General recommendations:

- Daily rainfall and streamflow can be monitored using existing climatological and hydro-meteorological gauging stations.
- Develop a correlation between the Mission Creek gauge and Sycamore Creek flow could help get river flow estimates for Sycamore Creek.
- Locations where the Tea Fire has produced risk to life or property, or where fire effects were severe, or accumulated flow/debris are expected to concentrate, should be visited/observed with increased frequency as large precipitation events occur, to the extent they can be accessed safely.
- It may be possible to quickly quantify precipitation and even streamflow forecasts using radar, gridded precipitation forecast models, and river hydraulics software if a standard platform and protocol is developed.

Some references are provided below to help accommodate situational surveillance.

City of Santa Barbara
http://www.santabarbaraca.gov/Resident/Safety/PIO/Flood_Preparation.htm
http://www.santabarbaraca.gov/Resident/Safety/PIO/Tea_Fire_Residents.htm
http://www.santabarbaraca.gov/Resident/Community/Creeks/Storm_Water_Management_Program.htm
http://www.santabarbaraca.gov/Government/Departments/PW/

County of Santa Barbara
http://www.countyofsb.org/pwd/water/Fire_Flood_Prep.htm
http://www.countyofsb.org/pwd/water/flood_control.htm
http://www.countyofsb.org/pwd/Administration/SandBagInfo.htm
http://www.countyofsb.org/pwd/roads/closure.htm

From http://www.countyofsb.org/pwd/water/flood_control.htm:
Here are a few ways to obtain weather information from the National Weather Service – Los Angeles/Oxnard Weather Forecast Office:
On the internet: www.wrh.noaa.gov/lox/, By phone: (805) 988-6610
For the automated weather phone service select menu option 1 and then menu option 3 for Santa Barbara County. To speak to a weather specialist between the hours of 9:30

a.m. and 3:00 p.m. select menu option 1 and then menu option 6. Local television & radio stations also serve as a major distributor of information provided by the National Weather Service.

The National Weather Service also operates six radio transmitters which broadcast information daily. A receiver can be purchased at most local electronic stores. For the frequency that covers your area please visit the National Weather Service website at: www.wrh.noaa.gov/lox/

DWR CDEC stations
http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=MTC (Montecito fire weather, Lat 34.4600°N Lon 119.6430°W, USFS operator)
http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=SBR (Santa Barbara Sanitation, Lat 34.4170°N Lon 119.7500°W, accumulated monthly precip)
http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=GBL (Gibraltar dam, Lat 34.5260°N Lon 119.6860°W, monthly reservoir storage)

NOAA debris flow early warning system
http://www.wrh.noaa.gov/lox/main.php?suite=hydrology&page=debris-flow_project

USGS peak streamflow stations in California
http://nwis.waterdata.usgs.gov/nwis/peak?state_cd=06&format=station_list&sort_key=site_no&group_key=huc_cd&sitefile_output_format=html_table&column_name=agency_cd&column_name=site_no&column_name=station_nm&begin_date=&end_date=&TZoutput=0&set_logscale_y=1&date_format=YYYY-MM-DD&rdb_compression=file&hn2_compression=file&list_of_search_criteria=state_cd
USGS 11119745, the only streamflow gage on Mission Cr at Rocky Nook Park,
http://waterdata.usgs.gov/nwis/uv/?site_no=11119745&

REFERENCES:

City of Santa Barbara website
http://www.santabarbaraca.gov/Government/Departments/PW/
County of Santa Barbara website
http://www.countyofsb.org/pwd/
State of California Data Exchange Center
http://cdec.water.ca.gov/
USGS surface water peak flow and real-time data
http://nwis.waterdata.usgs.gov/nwis/peak/
http://waterdata.usgs.gov/nwis/current
USDA Rocky Mountain Research Station, Moscow Forestry Sciences Laboratory
http://forest.moscowfsl.wsu.edu/
http://forest.moscowfsl.wsu.edu/engr/software.html
http://forest.moscowfsl.wsu.edu/fswepp/
http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/ermit/ermit.pl
http://forest.moscowfsl.wsu.edu/fswepp/docs/ermit/

NOAA-USGS Debris Flow Task Force, 2005, NOAA-USGS debris-flow warning system—Final report: U.S. Geological Survey Circular 1283, 47 p.46

Robichaud, P.R., J.L. Beyers, and D.G. Neary. 2000. Evaluating the effectiveness of postfire rehabilitation treatments. Gen. Tech. Rep. RMRS-GTR-63. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 85 p. http://www.fs.fed.us/rm/pubs/rmrs_gtr63.html

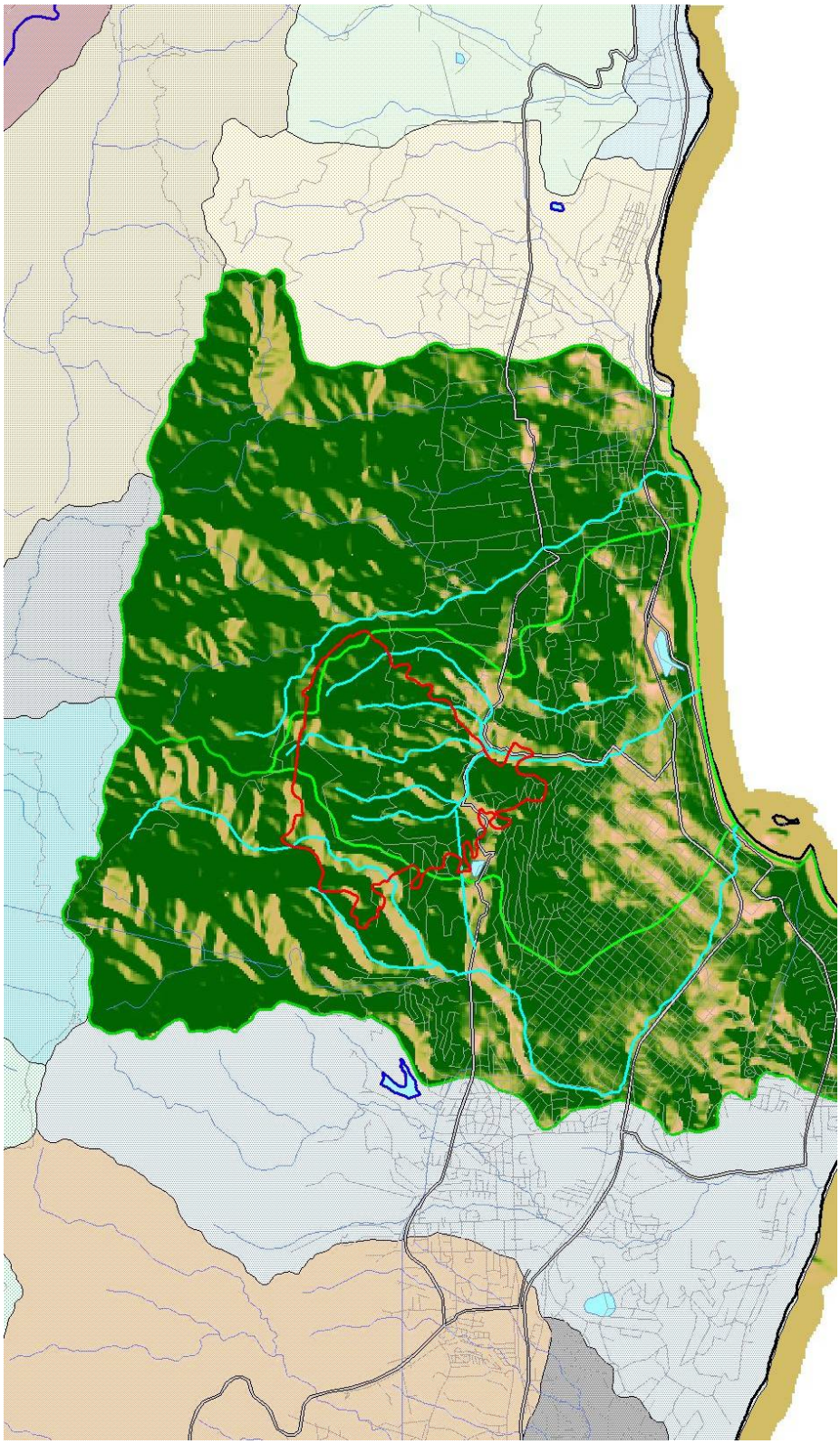
Robichaud, P.R.; Elliot, W.J.; Pierson, F.B.; Hall, D.E.; Moffet, C.A. 2006. Erosion Risk Management Tool (ERMiT) Ver. 2006.01.18. [Online at <http://forest.moscowfsl.wsu.edu/fswepp/>.] Moscow, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Robichaud, P.R.; Elliot, W.J.; Pierson, F.B.; Hall, D.E.; Moffet, C.A.; Ashmun, L.E. 2007. Erosion Risk Management Tool (ERMiT) user manual (version 2006.01.18). Gen. Tech. Rep. RMRS-GTR-188. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 24 p.

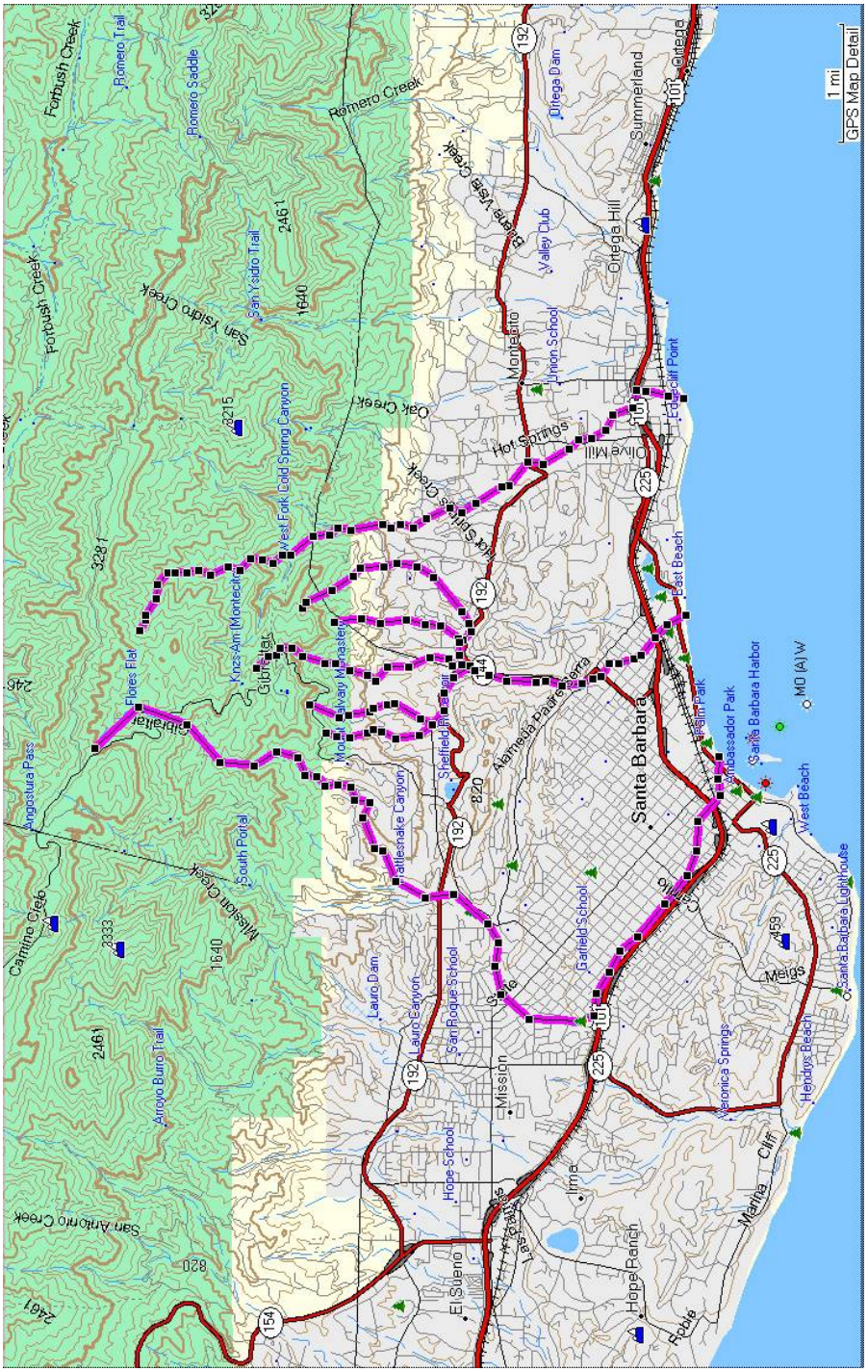
Rowe, P.B., C.M. Countryman, and H.C. Storey. 1949. Probable peak discharges and erosion rates from southern California watersheds as influenced by fire. USDA Forest Service. California Forest and Range Experiment Station, Berkeley, California. 305 p.

Waananen, A.O., and J.R. Crippen. 1977, Magnitude and frequency of floods in California: U.S. Geological Survey Water-Resources Investigations Report 77-21, 96 p.

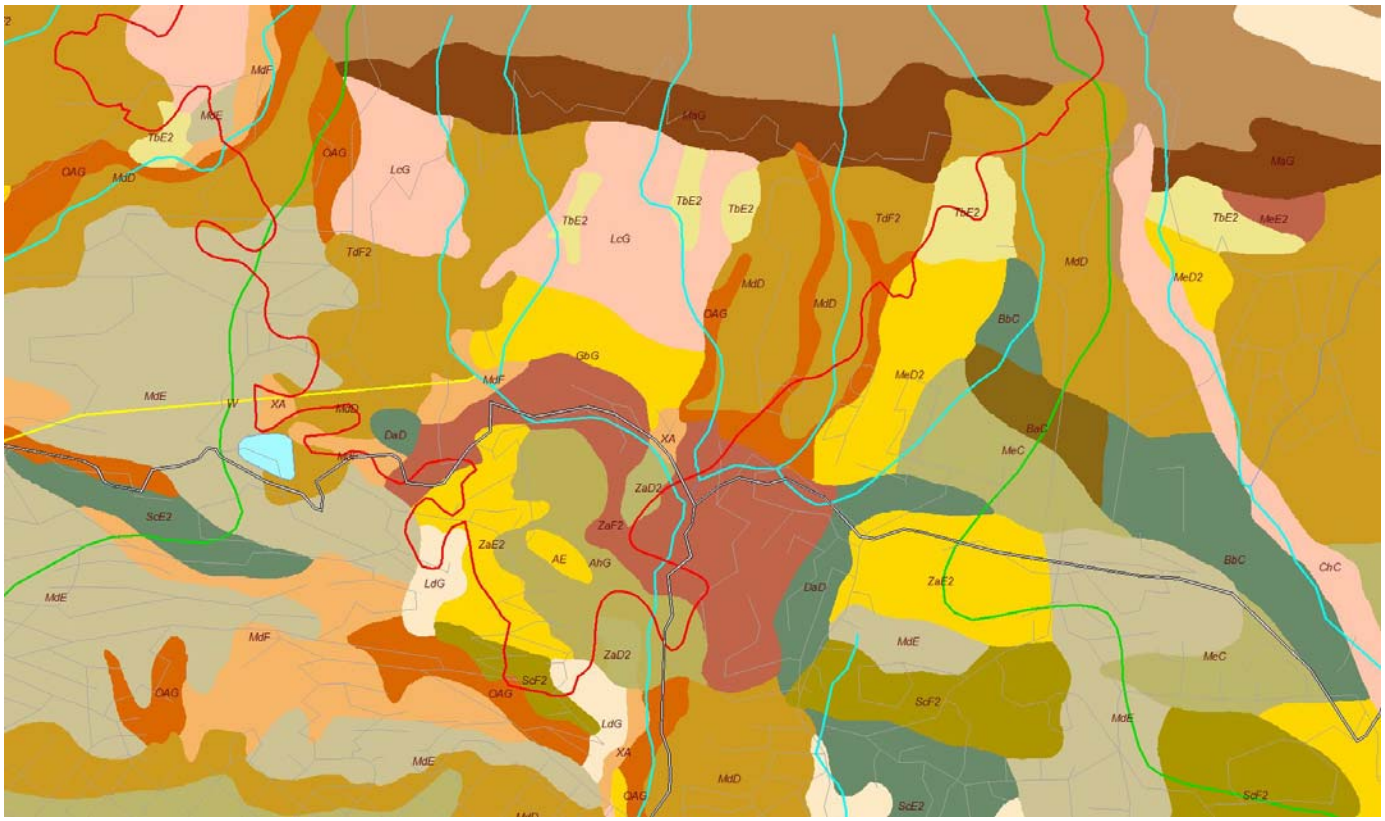
Appendix 1. Maps and Tables



Tea Fire perimeter and selected watersheds and streams



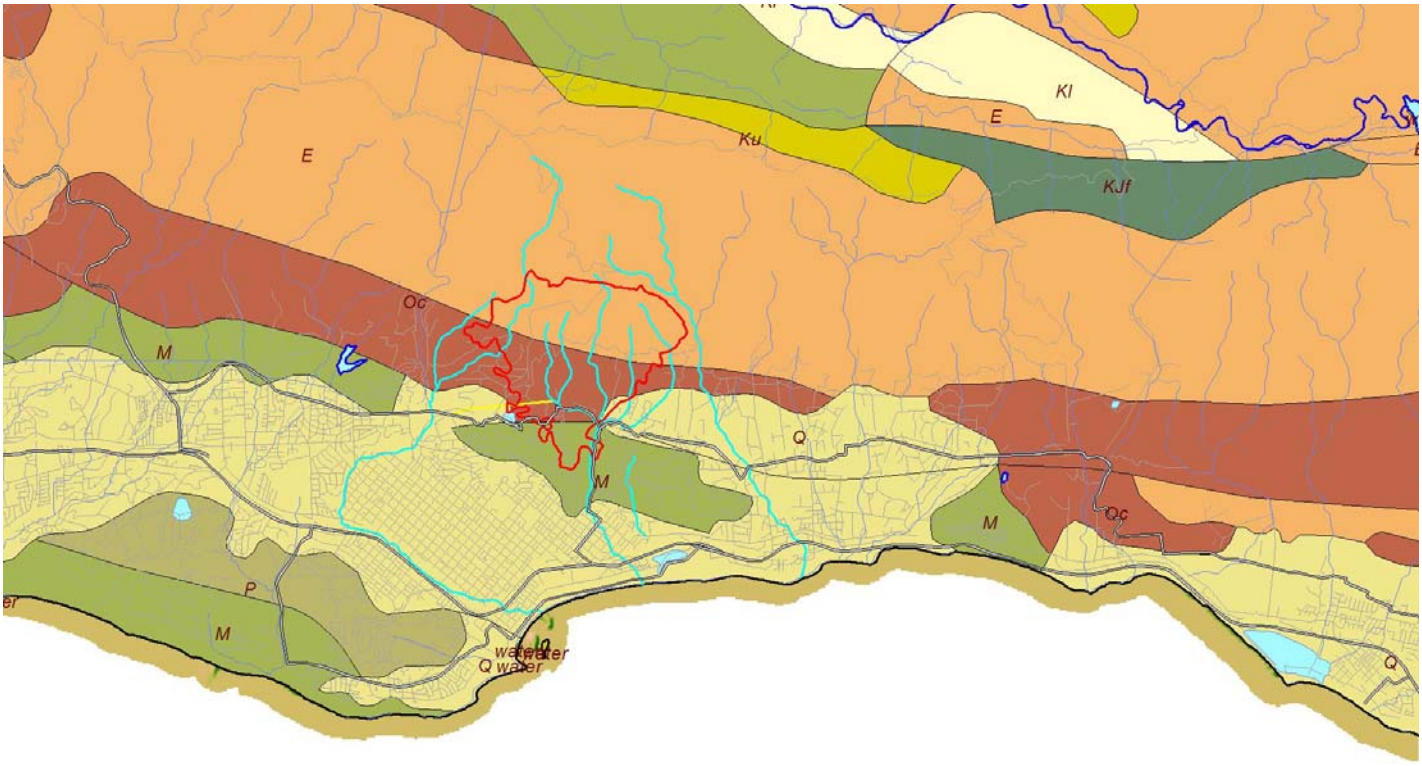
City of Santa Barbara 1:100,000 scale USGS topography with primary stream channels which drain the Tea Fire area



Tea Fire perimeter and SSURGO soil map unit symbols, USDA, NRCS, 2003

Mapunit Symbol	Mapunit Name	Kind	Total Acres	farm class	Legend key	Mapunit key
DaD	DIABLO CLAY, 9 TO 15 PERCENT SLOPES	Consociation	1077	Farmland of statewide importance	14131	457590
MdD	MILPITAS STONY FINE SANDY LOAM, 9 TO 15 PERCENT SLOPES	Consociation	2047	Not prime farmland	14131	457622
MeD2	MILPITAS-POSITAS FINE SANDY LOAM, 9 TO 15 PERCENT SLOPES, ERODED	Complex	4860	Not prime farmland	14131	457626
ZaD2	ZACA CLAY, 9 TO 15 PERCENT SLOPES, ERODED	Consociation	327	Farmland of statewide importance	14131	457648
MdE	MILPITAS STONY FINE SANDY LOAM, 15 TO 30 PERCENT SLOPES	Consociation	1247	Not prime farmland	14131	457623
ScE2	SANTA LUCIA SHALY CLAY LOAM, 15 TO 30 PERCENT SLOPES, ERODED	Consociation	2467	Not prime farmland	14131	457641
TbE2	TODOS CLAY LOAM, 15 TO 30 PERCENT SLOPES, ERODED	Consociation	1469	Not prime farmland	14131	457644
ZaE2	ZACA CLAY, 15 TO 30 PERCENT SLOPES, ERODED	Consociation	970	Not prime farmland	14131	457649
MdF	MILPITAS STONY FINE SANDY LOAM, 30 TO 50 PERCENT SLOPES	Consociation	687	Not prime farmland	14131	457624
ScF2	SANTA LUCIA SHALY CLAY LOAM, 30 TO 50 PERCENT SLOPES, ERODED	Consociation	2974	Not prime farmland	14131	457642
TdF2	TODOS-LODO COMPLEX, 30 TO 50 PERCENT SLOPES, ERODED	Complex	5058	Not prime farmland	14131	457645
ZaF2	ZACA CLAY, 30 TO 50 PERCENT SLOPES, ERODED	Consociation	664	Not prime farmland	14131	457650
MaG	MAYMEN STONY FINE SANDY LOAM, 30 TO 75 PERCENT SLOPES	Consociation	6407	Not prime farmland	14131	457618
AhG	AYAR CLAY, 50 TO 75 PERCENT SLOPES	Consociation	1357	Not prime farmland	14131	457561
GbG	GAVIOTA-ROCK OUTCROP COMPLEX, 50 TO 75 PERCENT SLOPES	Complex	3257	Not prime farmland	14131	457601
LcG	LODO-SESPE COMPLEX, 50 TO 75 PERCENT SLOPES	Complex	13470	Not prime farmland	14131	457609
MbH	MAYMEN-ROCK OUTCROP COMPLEX, 50 TO 75 PERCENT SLOPES	Complex	39202	Not prime farmland	14131	457656
OAG	ORTHENTS, 50 TO 75 PERCENT SLOPES	Consociation	1039	Not prime farmland	14131	457632
Rb	ROCK OUTCROP-MAYMEN COMPLEX, 75 TO 100 PERCENT SLOPES	Complex	26148	Not prime farmland	14131	457635
W	WATER	Consociation	322	Not prime farmland	14131	457651
XA	XERORTHENTS, CUT AND FILL AREAS	Consociation	811	Not prime farmland	14131	457646

Tea Fire area soil types and map unit classifications

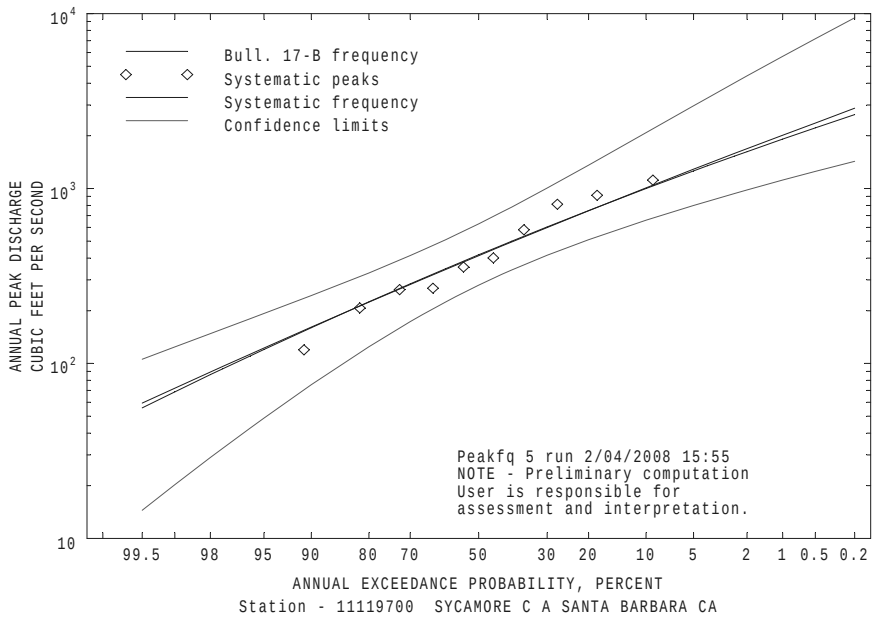


Tea Fire perimeter and regional geology (Jennings 1977 1:750,000 scale fault and geology, Bulletin 201, CDC, DMG)

Unit on 1:750,000 map	CENOZOIC SEDIMENTARY ROCKS
Q	Alluvium (mostly Holocene, some Pleistocene),Quaternary nonmarine, Quaternary marine
P	Pliocene marine
M	Miocene marine
Oc	Oligocene nonmarine
Unit on 1:750,000 map	MESOZOIC - PALEOZOIC – PRECAMBRIAN SEDIMENTARY AND METASEDIMENTARY ROCKS
Ku	Upper Cretaceous marine
Kl	Lower Cretaceous marine
KJf	Franciscan Complex
Unit on 1:750,000 map	CENOZOIC-PRECAMBRIAN PLUTONIC, METAVOLCANIC, AND MIXED ROCKS
M	Undivided pre-Cenozoic metasedimentary and metavolcanic rocks

APPENDIX 2. ANALYSIS DETAIL, ASSUMPTIONS AND OUTPUT.

A.2.1.a PEAKFQ output for 1119700 Sycamore Canyon Creek 1970 to 1980



Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.001
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 12/04/2008 15:55

Station - 11119700 SYCAMORE C A SANTA BARBARA CA

I N P U T D A T A S U M M A R Y

Number of peaks in record	=	10
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	10
Historic peaks in analysis	=	0
Years of historic record	=	0
Generalized skew	=	-0.279
Standard error	=	0.550
Mean Square error	=	0.303
Skew option	=	WEIGHTED
Gage base discharge	=	0.0
User supplied high outlier threshold	=	--
User supplied low outlier criterion	=	--

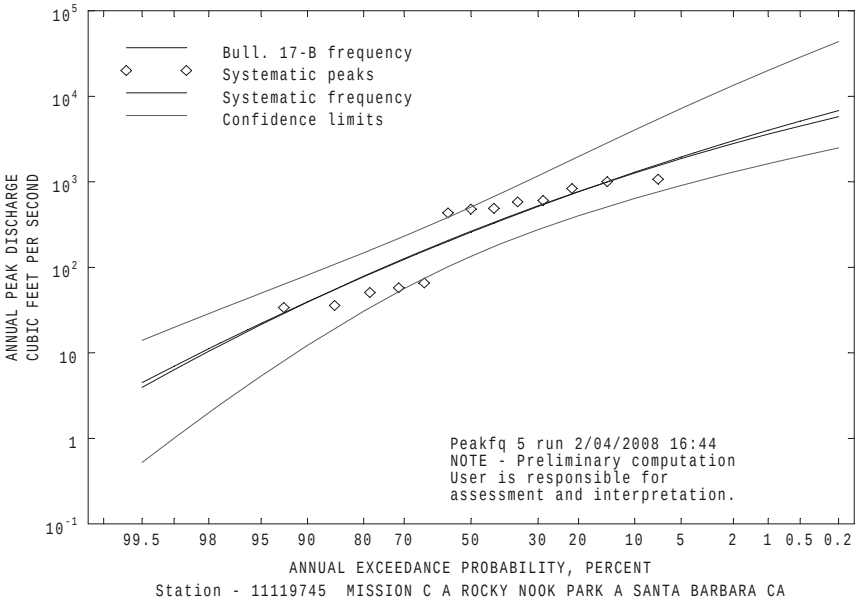
Plotting position parameter = 0.00

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXPECTED 95-PCT CONFIDENCE LIMITS

EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	PROBABILITY FOR BULL. 17B ESTIMATES ESTIMATE	LOWER	UPPER
0.9950	55.7	59.4	26.8	14.5	105.8
0.9900	68.8	72.3	40.0	20.3	124.3
0.9500	120.2	122.5	96.0	48.7	192.7
0.9000	160.3	161.3	140.3	75.6	244.3
0.8000	224.9	223.9	210.9	124.5	329.3
0.6667	305.7	302.7	297.7	190.1	444.3
0.5000	417.8	413.1	417.8	280.2	628.7
0.4292	474.2	469.0	478.8	323.4	733.9
0.2000	748.2	746.3	791.7	510.4	1360.0
0.1000	1000.0	1009.0	1115.0	659.3	2085.0
0.0400	1348.0	1382.0	1641.0	844.6	3288.0
0.0200	1626.0	1688.0	2144.0	981.1	4397.0
0.0100	1916.0	2017.0	2770.0	1117.0	5691.0
0.0050	2221.0	2369.0	3556.0	1252.0	7180.0
0.0020	2644.0	2873.0	4925.0	1432.0	9471.0

A.2.1.a PEAKFQ output for 1119745 Mission Creek at Rocky Nook Park 1983 to 2007



Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.001
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 12/04/2008 16:44

Station - 11119745 MISSION C A ROCKY NOOK PARK A SANTA BARBARA CA

I N P U T D A T A S U M M A R Y

Number of peaks in record	=	13
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	13
Historic peaks in analysis	=	0
Years of historic record	=	0
Generalized skew	=	-0.281
Standard error	=	0.550
Mean Square error	=	0.303
Skew option	=	WEIGHTED
Gage base discharge	=	0.0
User supplied high outlier threshold	=	--
User supplied low outlier criterion	=	--
Plotting position parameter	=	0.00

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXPECTED 95-PCT CONFIDENCE LIMITS

EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	PROBABILITY FOR BULL. 17B ESTIMATES ESTIMATE	LOWER	UPPER
0.9950	4.5	3.9	1.5	0.5	14.0
0.9900	7.0	6.3	3.1	1.0	19.8
0.9500	22.1	21.4	15.8	5.4	50.0
0.9000	39.6	39.2	32.4	12.2	81.4
0.8000	77.8	78.6	70.7	30.7	148.1
0.6667	141.9	44.9	136.5	66.6	265.0
0.5000	258.6	264.6	258.6	134.7	507.0
0.4292	328.7	335.7	333.3	174.6	671.2
0.2000	766.7	768.6	828.7	401.2	1972.0
0.1000	1295.0	1269.0	1496.0	639.1	4033.0
0.0400	2192.0	2080.0	2816.0	997.5	8465.0
0.0200	3027.0	2801.0	4264.0	1301.0	13440.0
0.0100	4000.0	3609.0	6231.0	1630.0	20100.0
0.0050	5115.0	4499.0	8874.0	1986.0	28730.0
0.0020	6810.0	5794.0	13740.0	2493.0	43620.0

A.2.2 Spreadsheet tables and regression coefficients

Waananan and Crippen regression 1977

$Q_{ri}=K\ A^a\ P^b\ H^c$

South Coast Region

Equations are defined only for basins of 25 mi^2 or less

A, Drain Area, mi^2

P, Mean Ann Precip, inches

H, Altitude Index, 1000's ft Use minimum altitude index value of 1.0

Central Coast Region eqns 19 to 24 in WanaananCrippen 1977

		K Coeff	a Area Coeff	b MAP Coeff	c Altitude Coeff	SE Std Err	N Number of Stations used
recurrence interval, ri	2	0.0061	0.9200	2.5400	-1.1000	0.47	98
	5	0.118	0.910	1.950	-0.790	0.39	91
	10	0.583	0.900	1.610	-0.640	0.35	91
	25	2.91	0.89	1.26	-0.50	0.35	91
	50	8.20	0.89	1.03	-0.41	0.38	91
	100	19.70	0.88	0.84	-0.33	0.41	91

	A	P	H
Mission Cyn	12.9	16	1
Sycamore Cyn	8.8	16	1
San Ysidro Cyn	12.6	16	1

A.2.3 ERMiT input assumptions and output detail

Input climate *SANTA BARBARA CA
Climate parameters for SANTA BARBARA CA

34.42°N 119.72°W; 120 feet elevation
66 years of record

Month	Mean Maximum Temperature (°F)	Mean Minimum Temperature (°F)	Mean Precipitation (in)	Number of wet days
January	65.2	41.8	3.05	5.3
February	65.9	43.8	3.45	5.4
March	67.2	45.5	2.52	5.3
April	69.4	48.3	1.10	3.1
May	70.7	51.2	0.26	1.2
June	72.8	54.1	0.09	0.7
July	76.7	57.2	0.02	0.4
August	77.8	58.0	0.04	0.4
September	77.2	56.4	0.18	1.2
October	75.1	52.2	0.35	1.6
November	71.3	46.2	1.48	3.0
December	66.6	42.7	2.89	5.2
Annual			15.42	32.7

Show map | Show PAR | Return to input screen

INTERPOLATED DATA

Station	Weighting	Station	Weighting
Wind Stations		**Solar Radiation and Max .5 P Stations**	
SANTA BARBARA CA	76 %	BAKERSFIELD, CALIF	67.3 %
OXNARD CA	14.4 %	FRESNO, CALIFORNIA	32.7 %
SANTA MARIA CA	9.5 %		0 %
Dewpoint Stations		**Time-to-Peak Stations**	
SANTA MARIA CA	60.9 %	SANTA BARBARA CA	100 %
LOS ANGELES CA	39.1 %	GIBRALTAR DAM 2 CA	0 %
	0 %	SAN MARCOS PASS CA	0 %

Rock:Clime 'descpar.pl' version 2005.06.07
USDA Forest Service, Rocky Mountain Research Station

ERMiT reference URLs and output screenshot

http://forest.moscowfsl.wsu.edu/engr/software.html

http://forest.moscowfsl.wsu.edu/fswepp/

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

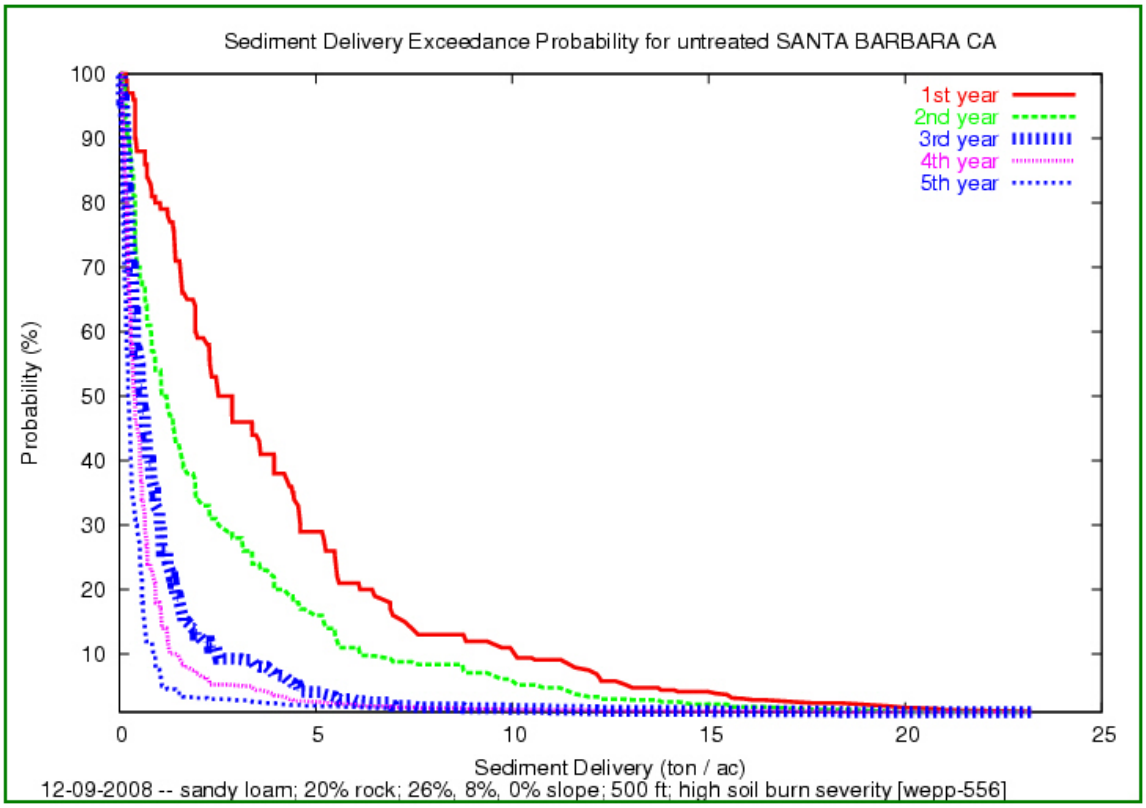
R2: *Santa Barbara, high severity soil burn, Second run using climate above and assumptions below with full output text from links. All figures through the rainfall ranking table are identical for the moderate burn results.

SANTA BARBARA CA
sandy loam soil texture, **20%** rock fragment
26% top, 8% average, 0% toe hillslope gradient
500 ft hillslope horizontal length
high soil burn severity on **chaparral**
Prefire community **80% shrub, 0% grass, 20% bare**

100 - YEAR MEAN ANNUAL AVERAGES				
16	**in**	annual precipitation from	3289	storms
3.4	**in**	annual runoff from rainfall from	713	events
0.01	**in**	annual runoff from snowmelt or winter rainstorm from	4	events

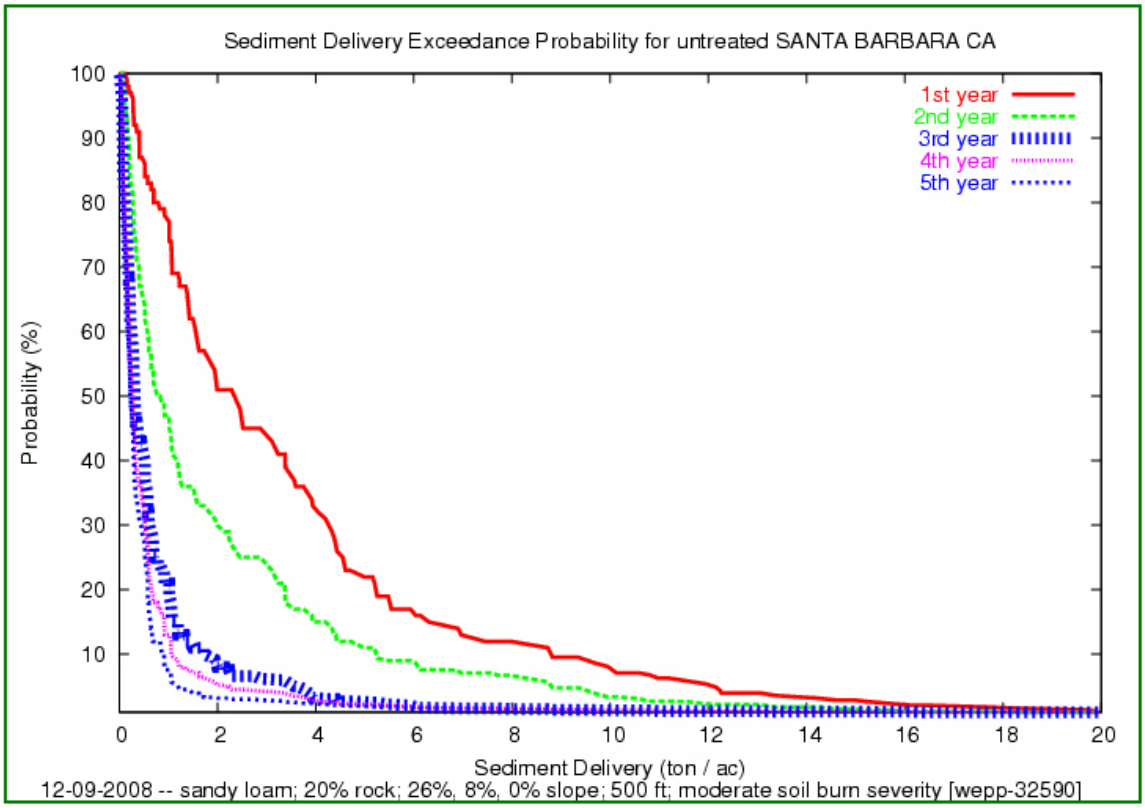
Rainfall Event Rankings and Characteristics from the Selected Storms

Storm Rank based on runoff (return interval)	Storm Runoff (in)	Storm Precipitation (in)	Storm Duration (h)	10-min Peak Rainfall Intensity (in h^{-1})	30-min Peak Rainfall Intensity (in h^{-1})	Storm Date
1	4.77	6.81	15.82	4.32	3.88	March 21 year 75
5 (20-year)	3.48	5.26	5.96	4.58	3.95	December 28 year 92
10 (10-year)	2.65	4.37	5.63	4.53	3.79	December 24 year 44
20 (5-year)	2.08	3.43	9.80	3.49	2.93	January 11 year 57
50 (2-year)	1.16	2.01	4.24	3.83	2.74	February 26 year 65
75 ($1^1/3$-year)	0.72	1.88	5.81	4.02	2.76	November 13 year 53



Mitigation Treatment Comparisons					
Probability that sediment yield will be exceeded 10 % go	Event sediment delivery (ton ac^{-1})				
	Year following fire				
	1st year	2nd year	3rd year	4th year	5th year
Untreated	10.22	6.27	2.64	1.49	0.91
Seeding	10.22	2.98	1.61	1.06	0.91
Mulch (0.5 ton ac^{-1})	1.99	2.42	2.64	1.49	0.91
Mulch (1 ton ac^{-1})	1.34	1.91	2.64	1.49	0.91
Mulch (1.5 ton ac^{-1})	1.31	1.57	2.64	1.49	0.91
Mulch (2 ton ac^{-1})	1.29	1.48	2.64	1.49	0.91
Erosion Barriers: Diameter 0 ft Spacing 50 ft go ?					
Logs & Wattles	10.22	6.27	2.64	1.49	0.91

Figures 6 and 7: high soil burn severity ERMiT results



Mitigation Treatment Comparisons					
Probability that sediment yield will be exceeded 10 % go	Event sediment delivery (ton ac^{-1})				
	Year following fire				
	1st year	2nd year	3rd year	4th year	5th year
Untreated	9.04	5.23	1.81	1.07	0.91
Seeding	9.04	2.26	1.07	0.91	0.91
Mulch (0.5 ton ac^{-1})	1.56	1.9	1.81	1.07	0.91
Mulch (1 ton ac^{-1})	0.99	1.39	1.81	1.07	0.91
Mulch (1.5 ton ac^{-1})	0.95	1.23	1.81	1.07	0.91
Mulch (2 ton ac^{-1})	0.91	1.08	1.81	1.07	0.91
Erosion Barriers: Diameter 0 ft Spacing 50 ft go ?					
Logs & Wattles	9.04	5.23	1.81	1.07	0.91

Figures 8 and 9: Moderate soil burn ERMiT results