Alluvial Fan Task Force

California Department of Water Resources Project

DRAFT AFTF Implementation Manual

For Flood Managers, Local Governments, Developers and Public Stakeholders

9/17/08

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Introduction to Implementation Report

The drafters of the AFTF Design Guidelines and Model Ordinance realized that there would be different levels of interest and expertise among those interested in our endeavor. For some, a general reading of what we did and how would suffice. Others would want a more detailed explanation of our process, but wouldn't need the detail that the planner drafting a site specific ordinance might require. So to address the needs of the various audiences, we design an Executive Summary to give the highlights, the Toolkit to give a bit more detail, and the Implementation Report to provide the fine detail and step-by-step instructions and guidance for applying the tools.

Phase One—Pre-Design
(To be inserted)
Step One Intro language
(To be inserted)

AF1: **Preliminary inspection of DFIRM data mapped by 10-county study area**

Summary of Protocol

Objectives
1. To determine whether a study area resides in a region of known or suspected alluvial fans
2. To assess the first-order degree of flood risk for a particular study area

Data Resources
1. Alluvial Fan Task Force 10-County map showing areas potentially containing alluvial fans
(a GIS data base created by the Water Resources Institute from various data sources including USGS, DWR, CGS, and PBS&J)
2. Individual county maps showing 2007 preliminary DFIRM flood zones (a GIS data set compiled by the Alluvial Fan Task force to display relationships between flood hazard zones and areas of known or suspected alluvial fans)

Procedures
1. Inspect the 10–County map to determine whether alluvial fans are geographically associated with the study area

2. Inspect the DFIRM map specific for the county containing study area
A. Relate to the legend for DFIRM flood hazard classification **(note that the terms A, AE, AO, AH, VE are not well explained in this legend)**
B. Determine the type of DFIRM Flood zone(s), if any encompassed by study area
C. Determine % probability of flooding to be expected in a given year

AF2: Research and acquisition of pertinent data resources

Summary of Protocol

Objective

To acquire pertinent data resources (Internet downloads or hard copies) necessary to accomplish tasks of the various planning tools and mapping protocols in a particular alluvial fan study area

Data Resources Available from Internet (compiled by Dr. Jon Nourse, August, 2008)

GIS data bases

PDF versions of the following maps are available at http://wri.csusb.edu/aftf/aftfweb.htm
The complete data base is available upon request from The Water Resources Institute (909) 537-7681 or the Alluvial Fan Task Force coordinator: email slongvil@csusb.edu

1. Alluvial Fan Task Force 10-County map showing areas potentially containing alluvial fans (a GIS data base created by the Water Resources Institute from various data sources including USGS, DWR, CGS, and PBS&J)

2. Individual county maps showing 2007 preliminary DFIRM flood zones (a GIS data set compiled by the Alluvial Fan Task force to display relationships between flood hazard zones and areas of known or suspected alluvial fans)

FEMA Guidance for Alluvial Fan Flooding Analysis and Mapping

In April of 2003, the Federal Emergency Management Agency (FEMA) published "Guidelines and Specifications for Flood Hazard Mapping Partners." Detailed information pertaining to alluvial fans and flood hazards is presented in Appendix G of this document: http://wri.csusb.edu/aftf/documents/FEMAAppendixG_GuidanceAlluvialFanFloodingAnalysesMapping.pdf . Of particular interest are specifications for recognizing and characterizing alluvial fan landforms and guidelines for mapping flood-prone areas or characterizing sediment transport.

1:24,000 scale topographic maps

1. Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/

2. hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

3. Digital Elevation Models: For those with GIS analytical capabilities, digital topography may be obtained from the USGS at http://rockyweb.cr.usgs.gov/elevation/dpi_dem.html
Digital elevation models with 30m x 30m sample spacing are available for most 7.5 minute quadrangles in the conterminous United States

Aerial Photographs and Satellite Imagery

1. Digital ortho photographs (DOQs) that cover quarter portions of each 7.5 minute quadrangle in California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/remote_sensing/doq/

2. Aerial photographs and satellite imagery of various scales and vintages may be purchased from the USGS at:

http://erg.usgs.gov/isb/pubs/booklets/aerial/aerial.html
3. A complete index of aerial products from EROS (Earth Resources Observation and Science) is available at:
http://edc.usgs.gov/products/aerial.html
4. Satellite imagery is viewable on screen through Google Earth software available free of charge at: www.googleearth.com
5. High resolution satellite Google Earth images may be printed by purchasing the Professional version of Google Earth software for about $400
6. CSU San Bernardino's Water Resources Institute (WRI) maintains an archive of historical aerial photographs from parts of most watersheds in San Bernardino County at:
http://wri.csusb.edu/web-pages/archives/hist-aerial-photos/index.asp
7. An atlas of panoramic aerial photographs of many parts of California is maintained by Dr. William Bowen of the CSU Northridge Geography Department. The index map with links to specific areas is available at: http://130.166.124.2/ca_panorama_atlas/index.html. These images are copyrighted and their use without the expressed approval of the owner is strictly forbidden. Please contact Dr. Bowen for additional information concerning copyright issues and the development of commercial projects (drwilliambowen@hotmail.com)

Geologic Maps

1. Maps displaying bedrock geology, soil units and faults at 1:24,000 scale are available for many of the 7.5 minute quadrangles of southern California. These may be obtained in digital and /or hard copy format through links to the USGS Western Earth Surface Processes team website: http://geomaps.wr.usgs.gov/socal/
2. Geologic maps displaying earthquake faults and other seismic hazards may be obtained in digital and /or hard copy format through the California Geological Survey website:
http://www.consrv.ca.gov/cgs/rghm/ap/Pages/Index.aspx
3. Additional geologic maps displaying known localities of hazardous soils containing as asbestos, mercury, or radon may be obtained in digital and /or hard copy format through the California Geological Survey website:
http://www.consrv.ca.gov/cgs/geologic_hazards/hazardous_minerals/Pages/Index.aspx
4. Geologic maps of 7.5 minute quadrangles not covered by the USGS or CGS may be purchased from the Thomas W. Dibblee Foundation at:
http://www.sbnature.org/estore/sbnature_web/CTGY/mp/list.htm

Surface Fault Rupture Hazards (Alquist Priolo Earthquake Fault Zones)

1. A general description of California's Alquist Priolo Earthquake Fault Zoning Act (1972) is accessible through the California Geological Survey website:
http://www.consrv.ca.gov/cgs/rghm/ap/Pages/Index.aspx
2. A detailed powerpoint presentation explaining the Alquist Priolo Act and methodologies used by CGS geologists to create Alquist Priolo Fault Zonation maps may be downloaded at:
http://www.1906eqconf.org/tutorials/EQHazMapGrndShaking_Bryant.pdf
3. Special Publication 42, "Fault-rupture Hazard Zones in California, is available for $6.00 per copy plus shipping and handling at any California Geological Survey public information office or it may be ordered by mail from CGS, P.O. Box 2980, Sacramento, California 95812.
4. An index to official 7.5 minute Alquist Priolo Earthquake Fault Zonation maps published by the California Geological Survey through 1999, included in Special Publication 42, is also available at: http://www.consrv.ca.gov/cgs/rghm/ap/map_index/Pages/index.aspx

5. Official Alquist Priolo maps may be ordered by name as shown on the index map in Special Publication 42. there is a $7.00 minimum charge per order. Each order will be charged $4.09 for handling regardless of the number and type of maps ordered. Sales tax and shipping charges will be added. The first copy of each map will cost $1.90. Additional copies of the same map are $1.32. Prices are subject to change.
6. A few official Alquist Priolo maps in southern California, released in 2003, are available online in PDF various GIS formats. An index of these maps may be viewed at:
http://www.consrv.ca.gov/cgs/rghm/ap/official_release/Pages/index.aspx
Clicking on the index map brings up 7.5 specific quadrangles from which data may be downloaded. Available GIS formats include MapInfo tab files, ArcInfo .e00 export files, and dxf export files.
7. California Geological Survey CDs 2002-01, 2002-02 and 2002-03: Fault Evaluation Reports Prepared Under the Alquist-Priolo Earthquake Fault Zoning Act These Fault Evaluation Reports (FERs) are unpublished manuscripts prepared since 1976 by the California Geological Survey staff to summarize evidence for Holocene faulting on various faults in California. These reports are divided into three regions of California, and may be purchased on CD from: http://www.consrv.ca.gov/cgs/rghm/ap/ap_fer_cd/Pages/index.aspx
8. Technical Guidelines for Evaluating Surface Fault Rupture Hazard (CGS Note 49):
http://www.consrv.ca.gov/cgs/information/publications/cgs_notes/note_49/Documents/note_49.pdf
9. Technical Guidelines for Reviewing Geologic Reports (CGS Note 41):
http://www.consrv.ca.gov/cgs/information/publications/cgs_notes/note_41/Pages/index.aspx

Earthquake-Triggered Ground Failure Hazards

1. Guidelines for protecting the public safety from the effects of earthquake-triggered ground failure:
--Provisions of California's Seismic Hazards Mapping Act (1990):
http://www.consrv.ca.gov/cgs/shzp/Pages/SHMPAct.aspx
--California Division of Mines and Geology Special Publication 118: *Recommended Criteria for Delineating Seismic Hazard Zone in California:*
http://www.consrv.ca.gov/cgs/shzp/webdocs/Documents/SP118_Revised.pdf
-- California Division of Mines and Geology Special Publication 117: *Guidelines for Evaluating and Mitigating Seismic Hazards in California*:
http://www.consrv.ca.gov/cgs/shzp/webdocs/Documents/sp117.pdf
2. Seismic Hazards Zone maps, created by the California Division of Mines and Geology, display liquefaction zones and earthquake-induced landslide zones.
--The index below provides access to individual 7.5 minute quadrangles in southern California and the San Francisco Bay area for which digital data may be downloaded in the formats of pdf, MapInfo .tab files, ArcView shape files, microdstation .dgn files, and AutoCad .dxf files. Also available for download are evaluation reports in pdf format:
http://gmw.consrv.ca.gov/shmp/MapProcessor.asp?Action=SHMP&Location=All&Version=7&Browser=IE&Platform=Win

Landslide Inventory Maps

--California Geological Survey is compiling a 7.5 minute map series to provide information on landslides in mountainous or hilly terrain adjacent to urbanized areas. Several southern California quadrangles may currently be downloaded from:
http://redirect.conservation.ca.gov/CGS/information/publications/LSIM_SOCAL.htm
Three northern California quadrangles may currently be downloaded from:

http://redirect.conservation.ca.gov/CGS/information/publications/LSIM_NORCAL.htm

Hazardous Materials Reports and Maps

--an overview of the primary hazardous minerals identified in California is posted on the California Geological Survey website at:
http://www.conservation.ca.gov/cgs/geologic_hazards/hazardous_minerals/Pages/Index.aspx
This site provides links to published reports, maps, and other information related to
Asbestos:
http://www.conservation.ca.gov/cgs/minerals/hazardous_minerals/asbestos/Pages/Index.aspx
Mercury:
http://www.conservation.ca.gov/cgs/minerals/hazardous_minerals/mercury/Pages/Index.aspx
and Radon:
http://www.conservation.ca.gov/cgs/minerals/hazardous_minerals/radon/Pages/Index.aspx

Precipitation Data

Real-time precipitation data from automated rain gauges, daily or monthly precipitation records from other active gauges, and/or historical archives of precipitation data are available from several sources, depending on the geographic region:

1. California Data Exchange Center, operated by California Department of Water Resources (DWR): http://cdec.water.ca.gov/snow_rain.html

2. National Water Information System, operated by the USGS real-time precipitation data): http://waterdata.usgs.gov/ca/nwis/current/?type=precip&group_key=basin_cd

3. Los Angeles County Department of Public Works (DPW) posts real-time and daily precipitation data from various rain gauges, as well as some historical rainfall records at http://dpw.lacounty.gov/wrd/precip/index.cfm

4. San Bernardino County Department of Public Works maintains a network of real-time rain gauge information. Specific rain gauge locations are displayed on a Google Earth overlay: http://www.sbcounty.gov/trnsprtn/pwg/ALERT_Data/ALERT_Menu.htm

5. An index map of current and discontinued rain gauges in San Bernardino County with links to data archives is available from San Bernardino County Flood Control district at: http://www.sbcounty.gov/trnsprtn/pwg/Precip_Data/Zone_5_Precip_Stations.htm

6. NOAA's National Weather Service forecast office for the Los Angeles-Oxnard area posts a real-time observation map of rainfall data from numerous gauges in southern California at http://www.wrh.noaa.gov/mesowest/mwmap.php?map=la. A similar clickable observation map is posted for the San Diego service area and areas east at http://www.wrh.noaa.gov/mesowest/mwmap.php?wfo=&map=sgx&sort=name&list=1

Stream Flow Data

Real-time stream-flow data from automated rain gauges, daily or monthly runoff records from other active gauges, and/or historical archives of runoff data are available from several sources, depending on the geographic region:

1. California Data Exchange Center, operated by California Department of Water Resources (DWR): http://cdec.water.ca.gov/riv_flows.html

2. National Water Information System, operated by the USGS provides real-time stream-flow data at http://waterdata.usgs.gov/ca/nwis/current/?type=flow and historical runoff data at http://waterdata.usgs.gov/ca/nwis/sw. A user-friendly clickable map showing daily stream flow measurements compared to historical daily averages from selected streams of California is may be accessed at http://water.usgs.gov/waterwatch/?m=pa01d&w=map&r=ca

3. Los Angeles County Department of Public Works (DPW) maintains an archive of daily stream flow records from various rivers for variable periods of record at http://dpw.lacounty.gov/wrd/runoff/index.cfm
4. An index map of current and discontinued stream gauges in San Bernardino County with links to historical data archives is posted by San Bernardino County Flood Control district at: http://www.sbcounty.gov/trnsprtn/pwg/Streamflow_Data/Average_Flow/Zone_Boundry_Map.htm

Groundwater Data

1. Metropolitan Water District (MWP) published a report in 2007 assessing the status of mapping, usage and management of groundwater resources in its southern California service area: http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/GWAS.html Included in this report is a regional map showing locations and names of groundwater basins: http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/ES-1.pdf and an index map showing basins that are described in the 2007 report: http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/GARCh4PlateIV-1Map.pdf
2. California Department of Water Resources (southern district) posts a wide variety of groundwater information at http://wwwdpla.water.ca.gov/sd/groundwater/groundwater.html Various publications and reports pertaining to groundwater resources and development are posted at: http://wwwdpla.water.ca.gov/sd/groundwater/groundwater_pubs.html. One very useful publication is Bulletin 118, which contains detailed descriptions of individual groundwater basins throughout California: http://www.groundwater.water.ca.gov/bulletin118/basin_desc/index.cfm, and a map of individual groundwater basins and subbasins in California: http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/maps/correct_statewide_basin_map_V3_subbas.pdf, part of which is available in shape file format through the link at: http://www.groundwater.water.ca.gov/bulletin118/basin_maps/index.cfm
3. California Department of Water Resources (DWR) posts groundwater level data, compiled from sources at Orange County water District, the USGS, and Ventura County Public Works Agency, at http://wdl.water.ca.gov/gw/
4. The USGS Water Resources Division provides links to groundwater data for parts of California at: http://ca.water.usgs.gov/. Included at this site are recent publications. Current real-time groundwater data may be accessed at http://waterdata.usgs.gov/ca/nwis/current/?type=gw&group_key=county_cd. Historical daily or periodic field measurements of water well levels are accessed through http://waterdata.usgs.gov/ca/nwis/gw/. A user-friendly clickable map showing real-time measurements of water levels in selected wells of California is may be accessed at http://groundwaterwatch.usgs.gov/StateMaps/CA.html
5. Los Angeles County Department of Public Works (DPW) posts information about its groundwater spreading facilities at http://dpw.lacounty.gov/wrd/spreadingground/index.cfm
6. CSU San Bernardino's Water Resources Institute maintains an archive of water well records at http://wrigis.csusb.edu/WellRecordsProject/Default.aspx
7. San Diego County Water Authority has posted limited information on groundwater at http://www.sdcwa.org/manage/sources-groundwater.phtml

Dams and Reservoirs

1. Los Angeles County Department of Public Works (DPW) posts information about recent and ongoing dam rehabilitations at http://dpw.lacounty.gov/wrd/reservoir/index.cfm

2. San Diego County Water Authority has posted a map of the region's reservoirs at http://www.sdcwa.org/manage/reservoirs-map.phtml
3. California Department of Water Resources (DWR) posts information about reservoirs throughout California at http://cdec.water.ca.gov/reservoir.html. DWR has also compiled records of reservoir storage for the time period of August, 1999 through February, 2005 at http://wwwdpla.water.ca.gov/sd/hydrologic_data/hydrologic_data.html#reservoir

Statistical Methods for 100-Year Flood Determination

1. A graphical approach to determining probability of flooding is outlined in *Pipkin, Bernard W. and Cummings, David, 1983, Environmental Geology Practical Exercises, Star Publishing Co., p. 130-132.*
2. Appendix G of 2003 FEMA report "*Guidelines and Specifications for Flood Hazard Mapping Partners*." contains various definitions of the 100-year flood in **Section 2.3:** http://wri.csusb.edu/aftf/documents/FEMAAppendixG_GuidanceAlluvialFanFloodingAnalysesMapping.pdf
(need more references here—one report I found describes the statistical methodology): http://www.sinotechcc.co.za/Software/UPFLOOD/SDF1.pdf
Background information is summarized at: http://www.wvdhsem.gov/WV_Disaster_Library/Library/FLOODS/USGS-hydrology%20of%20floods.htm

Mineral Resource Classification and Designated Zones

1. California Surface Mining and Reclamation Act (SMARA) **Mineral Land Classification Reports and Updates** by the California Geological Survey (CGS) are available at: http://www.conservation.ca.gov/cgs/minerals/mlc/Pages/index.aspx
2. California State Mining and Geology Board (SMGB) **Designation Reports** are available at: http://www.conservation.ca.gov/smgb/reports/Pages/reports.aspx
3. SMGB Guidelines for Classification and Designation of Mineral Lands are available at: http://www.conservation.ca.gov/smgb/Guidelines/Pages/guidelines.aspx

Historical Climate Data

1. Site specific climate data may be accessed from National Climatic Data Center: http://www.ncdc.noaa.gov/oa/ncdc.html
This will require some searching, but probably is the best source of data from obscure locations. For example, find monthly climate data from specific weather stations at: http://www.ncdc.noaa.gov/oa/climate/climatedata.html#monthly
Historical drought severity index maps of the United States for each month since 1900 are at: http://www.ncdc.noaa.gov/oa/climate/research/drought/palmer-maps/
2. Average high and low temperatures per month are tabulated at http://www.weather.com/
Simply enter the zip code or name of the closest city, then select the button for "averages"
3. Average relative humidity per month is compiled in various websites:
http://www.met.utah.edu/jhorel/html/wx/climate/rh.html
http://www.climatesource.com/us/fact_sheets/fact_rh_us.html

Rare, Threatened, or Endangered Species

California Department of Fish and Game (CDFG) manages the California Natural Diversity Database (CNDDB): An inventory of the status and locations of rare, threatened, and endangered plants and animals in California. This database provides riparian vegetation data. http://www.dfg.ca.gov/biogeodata/cnddb/

California Drinking Water Standards

--USEPA Region 9 Drinking Water Standards and Health Advisories Table:
http://www.epa.gov/region09/water/drinking/files/dwsha_0607.pdf
This is a compendium of standards, health advisories and related information for chemicals and other contaminants which may be found in ground and surface waters. It provides a comprehensive listing of all current and proposed National Primary Drinking Water Regulations (NPDWRs), additional Maximum Contaminant Levels (MCLs) specific for California, Arizona and Hawaii, and California Drinking Water Action Levels.

California Environmental Impact Assessment Reports

A good place to begin online research is the Humboldt State University's index library at http://library.humboldt.edu/infoservices/FEIRsandEISs.htm#calif

Need More Ecology and Biology References

Other Important Data Resources that are not Web-Accessible

Much data relevant to alluvial fan analysis has been compiled by scientists or municipal agencies but is not posted on websites. This is commonly the case for remote areas with low population density. Diligent research (email requests, phone calls, regular mail, etc.) may yield valuable information that could negate the need for future expensive studies. Many agencies compile archives and obscure publications in libraries or private collections that may be accessed by special request. Types of data sets to search for include, but are not limited to:

1. rainfall records from discontinued or remote, non-automated gauges
2. historical stream flow records from discontinued gauges
3. water well data from municipal or private wells
4. city planning reports
5. published scientific articles or abstracts
6. unpublished theses available from universities
7. Environmental Impact Reports
8. internal reports from the DWR, USGS, CGS, MWD, DPW, U.S. Forest Service
9. data archives from the DWR, USGS, CGS, MWD, DPW, U.S. Forest Service
10. maps of burned areas compiled by the US Forest Service or involved fire-suppression agencies
11. geotechnical reports (produced by industry consultants) that focus on geology, soils, seismic hazards, and slope stability)

Procedures

1. Peruse the web resources listed above and bookmark pertinent sites

2. Download site-specific maps, images, hydrologic or groundwater data sets, and reports applicable to the planning tools for a study area

3. Research the availability of other data sets that are not web accessible.

4. Acquire hard copies of this additional data through telephone or email inquiry or regular mail.

AF3: Identify the presence of an alluvial fan
(Originally called FM1)

Summary of Protocol

Objectives
1. To identify areas associated with study site that displays the requisite geomorphic and geologic characteristics of an alluvial fan
2. To map the lateral boundaries and aerial extent of individual alluvial fans

Procedures
1. Acquire pertinent data resources and FEMA guidelines.

A. Appendix G of 2003 FEMA report "*Guidelines and Specifications for Flood Hazard Mapping Partners*."
http://wri.csusb.edu/aftf/documents/FEMAAppendixG_GuidanceAlluvialFanFloodingAnalysesMapping.pdf .
Pertinent definitions of alluvial fan landforms are explained in **Section G2.1**

B. 1:24,000 scale topographic maps
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

C. Aerial Photographs and Satellite Imagery
--Digital ortho photographs (DOQs) that cover quarter portions of each 7.5 minute quadrangle in California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/remote_sensing/doq/
--Aerial photographs and satellite imagery of various scales and vintages may be purchased from the USGS at:
http://erg.usgs.gov/isb/pubs/booklets/aerial/aerial.html
--A complete index of aerial products from EROS (Earth Resources Observation and Science) is available at:
http://edc.usgs.gov/products/aerial.html
--Satellite imagery is viewable on screen through Google Earth software available free of charge at: www.googleearth.com
--High resolution satellite Google Earth images may be printed by purchasing the Professional version of Google Earth software for about $400
--CSU San Bernardino's Water Resources Institute (WRI) maintains an archive of historical aerial photographs from parts of most watersheds in San Bernardino County at: http://wri.csusb.edu/web-pages/archives/hist-aerial-photos/index.asp
--An atlas of panoramic aerial photographs of many parts of California is maintained by Dr. William Bowen of the CSU Northridge Geography Department. The index map with links to specific areas is available at:
http://130.166.124.2/ca_panorama_atlas/index.html. These images are

copyrighted and their use without the expressed approval of the owner is strictly forbidden. Please contact Dr. Bowen for additional information concerning copyright issues and the development of commercial projects (drwilliambowen@hotmail.com)

D. Geologic Maps
--Maps displaying bedrock geology, soil units and faults at 1:24,000 scale are available for many of the 7.5 minute quadrangles of southern California. These may be obtained in digital and /or hard copy format through links to the USGS Western Earth Surface Processes team website: http://geomaps.wr.usgs.gov/socal/
--Additional geologic maps displaying earthquake faults and other seismic hazards may be obtained in digital and /or hard copy format through the California Geological Survey website:
http://www.consrv.ca.gov/cgs/rghm/ap/Pages/Index.aspx
--Geologic maps of 7.5 minute quadrangles not covered by the USGS or CGS may be purchased from the Thomas W. Dibblee Foundation at:
http://www.sbnature.org/estore/sbnature_web/CTGY/mp/list.htm

2. Analyze topography.
Alluvial fans are landforms that are fan shaped in plan view and approximate a portion of a cone in three-dimensions. The landform is created by deposition of sediments along a drainage network that fans out from a trunk stream at the edge of mountainous or hilly terrain.

A. Focus on areas where streams flow across with sharp topographic breaks**.** Typically this will occur where a stream exits mountainous or hilly terrain and flows into a valley. The topographic break occurs where closely-spaced contours abruptly change to contours with wider spacing. **(Refer to illustration)**

B. Identify a fan-shaped drainage network (commonly referred to as "distributary channels"). In general, active drainages will be demarcated by a dashed line-three dot symbol representing intermittent stream. Axes of these stream channels correspond to "v" shaped patterns in topographic contours in which the "v" points uphill. The linear traces of individual stream channels will connect multiple apexes of "v's" on adjacent contours. Distributary channels typically radiate outward from the apex of the fan, located at the topographic break where a single stream exits mountainous or hilly terrain. The gross effect is a reverse dendritic drainage pattern in that the main trunk stream at higher elevations bifurcates and feeds progressively more stream channels at lower elevations. Some of the drainages may appear to be braided or sinuous. **(Refer to illustration)**

C. Confirm that the topographic contours encompassing the drainage network form a system of concentric arcs that mimic a fan shape. These arcuate contours will be shortest at the fan apex and longest at the toe of the fan, while their elevation values decrease systematically. The angle of arc swept out by the concentric contours may be as little as 30 degrees or as great as 180 degrees. **(Refer to illustration)**

D. Define the distal terminus (toe) of the fan. Commonly, this will be where the concentric contours terminate against contours with wider spacing that represent

flatter ground of the valley floor. Sometimes the toe is marked by the edge of a playa lake or alluvial plain. Or it may correspond to the trace of a stream that crosscuts older fan deposits or distributary channels and transports deposits away from the fan.

E. Define the lateral boundaries of the fan. Such boundaries can often be identified on topographic maps by changes in contour lines. Generally, this will be where the uniform, concentric arrangement of contours is abruptly terminated by contours with different orientation and spacing. Some lateral boundaries coincide with the edges of adjacent fans. These may be marked by a topographic trough or ridge. Other lateral boundaries are delimited by the trace of a younger, incised stream channel whose associated contour patterns truncate those of the alluvial fan.

3. Analyze aerial photographs and/or satellite imagery.

Many of the topographic features described in 2 above will be evident in aerial or satellite photographs, which illuminate differences between various types of sediments or soils and may display contrasting types or density of vegetation

A. The trunk stream and distributary channel network may be the most obvious feature. Streams will stand out as narrow, linear features filled with gravel and sand. Active alluvial channels may be have large bushes or trees at their edges but will be generally devoid of dense, small-scale vegetation. **(Refer to illustration)**

B. The overall fan-shaped morphology of the sediment pile may be well expressed, particularly if one analyzes stereo pairs of aerial photos. In three dimensions, the fan will appear as a cone-shaped sediment pile projecting onto a flat valley floor from the mouth of a mountain canyon.

C. The fan shape may be enhanced by the presence of vegetation that differs from that of surrounding lowlands or highlands. **(Refer to illustration)**

D. The topographic break at the range front may appear as a sharp linear feature, especially if this corresponds to a fault.

E. Playa lakes or flat portions of the valley floor near the toe of the fan will stand out as areas of smoother texture due to their fine-grained sediment content.

F. Lateral boundaries of single alluvial fans can often be identified as a contact of distinct differences between light-colored, freshly abraded, alluvial deposits and darker-colored, weathered deposits with well-developed soils on piedmont plains. Care should be taken to ensure that the contact is not simply a divide between older and more recent deposits of the alluvial fan.

4. Analyze available geologic maps.

Alluvial fans are composed of alluvial sediments ("alluvium") deposited during flooding of a trunk stream and its distributary channels. These alluvial deposits may rework debris flows that are locally derived from a steep mountain front or escarpment that is commonly fault-bounded.

A. On most geologic maps, the main portion of the alluvial fan will be shown as "Quaternary fan deposits" or "Quaternary alluvium." Commonly, sediments or soils of different age may be distinguished on a given alluvial fan.

B. Many geologic maps distinguish active stream channels (also called "distributary channels") on the alluvial fan. These geologically young, poorly consolidated sands and gravels are typically mapped as "Holocene alluvium", "young Quaternary alluvium," or "Quaternary wash deposits." Commonly, only the major active channels may be mapped. Other alluvial channels that help define the fan-shaped network will be evident in satellite imagery. **(Refer to illustration)**
C. The topographic break at the apex of many alluvial fans commonly coincides with a fault that records vertical displacement. Such faults are indicated with bold solid or dashed lines on geologic maps. Highlands will be situated on the up side of the fault (indicated by **U**), while the alluvial fan will be on the down side (indicated by **D**). **(Refer to illustration)**

5. Map the extent of alluvial fans identified in 2, 3, and 4 above onto a standard topographic base with a minimum of four geo-registration points.
--Draft or digitize polygons denoting boundaries of each identified alluvial fan.
--Determine the size in square footage of each alluvial fan
--Distinguish and label features of interest such as fan toe, lateral boundaries, apex, trunk stream, major distributary channels
--Add colors, patterns, and text labels to distinguish each alluvial fan according to a pre-specified catalog system. For example, alluvial fans might be classified by geographic region and size.

6. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. Differentiation of the alluvial fans and associated features should be explained in the map legend, and may further be distinguished by GIS line types, patterns, shading and text labels.

FH1: Identify hazardous upstream catchment areas

(Proposed new mapping protocol)

Summary of Protocol

Objectives

1. To analyze important physical aspects of upstream catchment areas that may influence flooding or debris flows on an alluvial fan
2. To rank the degree of risk for flooding and debris flows on alluvial fan based on upstream catchment parameters

Rationale (to be developed in narrative that follows the Summary Protocol)

The severity of flooding on an alluvial fan will be depend largely on characteristics of the upstream drainage basin (catchment area) that supplies stream runoff to the apex of the fan. Important factors include size of catchment area, presence of land denuded by wildfires, magnitude and intensity of rainfall, and historical nature of runoff. Utilizing historical precipitation and stream-flow data, it is possible to estimate the magnitude of maximum expected flood in two ways.

A preliminary assumption is that alluvial fan flood risk is greatly minimized by dams that regulate flow from the upstream drainage basin. Flood control dams are usually situated on the trunk stream near the fan apex or farther upstream in a mountain canyon. Smaller debris basins or check dams may be constructed below drainages of less extensive area. Therefore, the risk analysis process should evaluate the capability of existing flood-control structures to handle maximum expected flood events.

Consideration of weather patterns and climate factors that control the frequency and magnitude of storm events in a particular geographic area may also be important. For example, storms derived from the Pacific Ocean will have more severe impact on upslope areas that face the storms, particularly those at high elevations. Summer thunderstorms with high precipitation tend are much more common in Imperial County and the eastern portions of San Bernardino and Riverside Counties than in San Diego, Orange, Los Angeles, and Ventura Counties.

Procedures

1. Acquire pertinent data resources.

A. 1:24,000 scale topographic maps
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

B. Aerial Photographs and Satellite Imagery
--Digital ortho photographs (DOQs) that cover quarter portions of each 7.5 minute quadrangle in California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/remote_sensing/doq/
--Aerial photographs and satellite imagery of various scales and vintages may be purchased from the USGS at:
http://erg.usgs.gov/isb/pubs/booklets/aerial/aerial.html
--A complete index of aerial products from EROS (Earth Resources Observation and Science) is available at:
http://edc.usgs.gov/products/aerial.html
--Satellite imagery is viewable on screen through Google Earth software available free of charge at: www.googleearth.com
--High resolution satellite Google Earth images may be printed by purchasing the Professional version of Google Earth software for about $400
--CSU San Bernardino's Water Resources Institute (WRI) maintains an archive of historical aerial photographs from parts of most watersheds in San Bernardino County at:
http://wri.csusb.edu/web-pages/archives/hist-aerial-photos/index.asp

C. Precipitation data
Real-time precipitation data from automated rain gauges, daily or monthly precipitation records from other active gauges, and/or historical archives of precipitation data are available from several sources, depending on the geographic region:
--California Data Exchange Center, operated by California Department of Water Resources (DWR): http://cdec.water.ca.gov/snow_rain.html
--National Water Information System, operated by the USGS real-time precipitation data):
http://waterdata.usgs.gov/ca/nwis/current/?type=precip&group_key=basin_cd

--Los Angeles County Department of Public Works (DPW) posts real-time and daily precipitation data from various rain gauges, as well as some historical rainfall records at http://dpw.lacounty.gov/wrd/precip/index.cfm
--San Bernardino County Department of Public Works maintains a network of real-time rain gauge information. Specific rain gauge locations are displayed on a Google Earth overlay: http://www.sbcounty.gov/trnsprtn/pwg/ALERT_Data/ALERT_Menu.htm
--An index map of current and discontinued rain gauges in San Bernardino County with links to data archives is available from San Bernardino County Flood Control district at: http://www.sbcounty.gov/trnsprtn/pwg/Precip_Data/Zone_5_Precip_Stations.htm
--NOAA's National Weather Service forecast office for the Los Angeles-Oxnard area posts a real-time observation map of rainfall data from numerous gauges in southern California at http://www.wrh.noaa.gov/mesowest/mwmap.php?map=la. A similar clickable observation map is posted for the San Diego service area and areas east at http://www.wrh.noaa.gov/mesowest/mwmap.php?wfo=&map=sgx&sort=name&list=1

D. Stream Flow data
Real-time stream-flow data from automated rain gauges, daily or monthly runoff records from other active gauges, and/or historical archives of runoff data are available from several sources, depending on the geographic region:
--California Data Exchange Center, operated by California Department of Water Resources (DWR): http://cdec.water.ca.gov/riv_flows.html
--National Water Information System, operated by the USGS provides real-time stream-flow data at http://waterdata.usgs.gov/ca/nwis/current/?type=flow and historical runoff data at http://waterdata.usgs.gov/ca/nwis/sw. A user-friendly clickable map showing daily stream flow measurements compared to historical daily averages from selected streams of California is may be accessed at http://water.usgs.gov/waterwatch/?m=pa01d&w=map&r=ca
--Los Angeles County Department of Public Works (DPW) maintains an archive of daily stream flow records from various rivers for variable periods of record at http://dpw.lacounty.gov/wrd/runoff/index.cfm
--An index map of current and discontinued stream gauges in San Bernardino County with links to historical data archives is posted by San Bernardino County Flood Control district at: http://www.sbcounty.gov/trnsprtn/pwg/Streamflow_Data/Average_Flow/Zone_Boundry_Map.htm

E. Flood-control dam and reservoir parameters
--Los Angeles County Department of Public Works (DPW) posts information about recent and ongoing dam rehabilitations at http://dpw.lacounty.gov/wrd/reservoir/index.cfm
--San Diego County Water Authority has posted a map of the region's reservoirs at http://www.sdcwa.org/manage/reservoirs-map.phtml
--California Department of Water Resources (DWR) posts information about reservoirs throughout California at http://cdec.water.ca.gov/reservoir.html. DWR has also compiled records of reservoir storage for the time period of August, 1999 through February, 2005 at http://wwwdpla.water.ca.gov/sd/hydrologic_data/hydrologic_data.html#reservoir

F. Wildfire Records
These are most likely obtainable from the US Forest Service or local fire protection agencies that who been involved in past fire suppression efforts

G. Statistical Methods for 100-Year Flood Determination

-- A graphical approach to determining probability of flooding is outlined in *Pipkin, Bernard W. and Cummings, David, 1983, Environmental Geology Practical Exercises, Star Publishing Co., p. 130-132.*
--Appendix G of 2003 FEMA report "*Guidelines and Specifications for Flood Hazard Mapping Partners*." contains various definitions of the 100-year flood in **Section 2.3**
http://wri.csusb.edu/aftf/documents/FEMAAppendixG_GuidanceAlluvialFanFloodingAnalysesMapping.pdf .
(need more references here—one report I found describes the statistical methodology):
http://www.sinotechcc.co.za/Software/UPFLOOD/SDF1.pdf
Background information is summarized at:
http://www.wvdhsem.gov/WV_Disaster_Library/Library/FLOODS/USGS-hydrology%20of%20floods.htm

2. Identify trunk streams with non-existent or inadequate flood-control dams or debris basins

A. Map the existing flood-control structures and debris basins associated with the trunk stream.
B. Determine the carrying capacity (in cubic feet) of each flood-control structure.
C. If available, investigate historical maintenance records to determine the dates and frequency of debris or silt removal. Other important data to retrieve is the volume of removed debris. This may be correlated with specific historical flood events.
D. Evaluate the adequacy of the flood-control structure to handle the maximum expected flood or debris-flow event, considering results of 2B and 2C above, and 7 below.

3. Measure area of upstream drainage basin

A. Utilize topographic map to outline the drainage divides in that bound the perimeter of the upstream catchment area.
B. Determine the catchment area in square feet.

4. Map upstream burned areas subject to accelerated erosion

A. Consult historical fire records to determine dates of last wildfire event in the upstream drainage basin.
B. Map the extent of each burned area on a map of the drainage basin, and note year of each event.
C. Determine proportion of drainage basin area affected by wildfire; note this on map.
D. Rank risk or degree of future downstream debris flows. Ranking system should account for size of burned area, its proportion of aerial coverage, and time elapsed since burn event

5. Analyze historical precipitation data to determine maximum expected rainstorm that might affect upstream catchment area

A. Plot locations of all rain gauges on a map of the drainage basin (catchment area) that feeds the trunk stream of the alluvial fan.
B. Tabulate historical daily precipitation data recorded at each rain gauge, creating separate columns for *inches of precipitation* and *date*.
C. If available, tabulate historical precipitation intensity associated with each significant storm event on record. Create separate columns for *intensity* in inches/hr and *time*.
D. For each gauge, note precipitation totals and peak precipitation intensities (if available) associated with the five largest storm events on record**.**

E. For each of the storms noted in 5D, use available rain gauge data to calculate weighted mean values for *total precipitation* and *precipitation intensity* that could be applied to the entire catchment area.

6. Analyze historical stream flow records to determine magnitude and frequency of upstream floods

A. Tabulate historical runoff data from the flow gauge(s) on the trunk stream, creating separate columns for *discharge* (in cfs) and *date* (or time).

B. Note peak discharge (flow rate) in cfs associated with the three greatest runoff events for each year on record.

C. Graph peak discharge for the events of 6B vs. year. This will yield an effective visual overview of the magnitude and frequency of major floods.

7. Estimate stream discharge and volume of maximum expected flood event

A. Perform flood frequency analysis to estimate the discharge (in cfs) associated with the theoretical 100-year flood event (see *Bernard and Cummings* reference above for detailed procedures).

In essence, this graphical procedure entails plotting peak discharge associated with specific flood events vs. flood recurrence interval on semi-log graph paper. Then one simply picks the discharge value off the graph that corresponds to a recurrence interval of 100 years.

B. Estimate the volume of runoff associated with a maximum expected storm event focused on the upstream catchment area. Utilizing parameters determined in 3B and 5E above, the applicable formula is:

Volume = Maximum Precipitation Total x Catchment Area x Runoff Factor

The Runoff Factor is the proportion of rainfall that runs off rather than infiltrating the ground. This would typically range from 40% to 100% depending on degree of previous ground saturation.

C. Estimate the stream discharge associated with a maximum expected storm event focused on the upstream catchment area. Utilizing parameters determined in 3B and 5E above, the applicable formula is:

Discharge = Peak Precipitation Intensity x Catchment Area x Runoff Factor.

In this case, the runoff factor may be close to 100% because intense rainfall rate will overwhelm the rate at which the ground absorbs precipitation

8. Rank the probability or potential for flash-flooding and/or debris flows

(Many interrelated factors are involved here; their relative importance needs discussion. Below is a suggested ranking system):

Zone 1—Low risk

Alluvial fans protected by adequate flood-control structures

Zone 2—Moderate Risk

Alluvial fans protected by marginal or inadequate flood-control structures

Zone 3—Significant Risk

Alluvial fans not protected by flood-control structures. Degree of risk is controlled by multiple factors. A suggested ranking of lowest risk to highest risk follows:

--small, unburned catchment areas

--small catchment areas with significant proportion of area burned

--large, unburned catchment areas

--large catchment areas with significant proportion of area burned

--small, burned catchment areas subject to unusually large or intense rainstorms

--small, unburned catchment areas subject to unusually large or intense rainstorms

Risk assessment may also involve consideration of weather and climate patterns

9. Compile results of flood and debris flow hazard analysis onto a 1:24,000 or larger scale topographic base map with a minimum of four geo-registration points. The map area should encompass the alluvial fan of interest and its upstream drainage basin. Various features may be hand-drafted onto a hard copy of the topographic base or digitized into a GIS data base.

10. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. Separate layers should be created for topography, boundaries of catchment area, burned areas, flood control structures, rain gauges, and stream gauges. Spreadsheets and graphs of precipitation and stream flow data may be directly linked to the corresponding measurement gauge. All mapped features should be explained in the map legend, and may further be distinguished by GIS line types, patterns, and shading.

FH2: Map areas demarked by active stream channels
(originally the first part of WS3)

Summary of Protocol

Objectives
1. To map active stream channels on an alluvial fan
2. To distinguish primary active channels prone to significant flooding from less hazardous secondary channels

Procedures
1. Acquire pertinent data resources.

A. Appendix G of 2003 FEMA report "*Guidelines and Specifications for Flood Hazard Mapping Partners*."
http://wri.csusb.edu/aftf/documents/FEMAAppendixG_GuidanceAlluvialFanFloodingAnalysesMapping.pdf .
Pertinent description of active vs. inactive alluvial fan surfaces are explained in **Section G2.2**

B. 1:24,000 scale topographic maps
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

C. Aerial Photographs and Satellite Imagery
--Digital ortho photographs (DOQs) that cover quarter portions of each 7.5 minute quadrangle in California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/remote_sensing/doq/
--Aerial photographs and satellite imagery of various scales and vintages may be purchased from the USGS at:

http://erg.usgs.gov/isb/pubs/booklets/aerial/aerial.html
--A complete index of aerial products from EROS (Earth Resources Observation and Science) is available at:
http://edc.usgs.gov/products/aerial.html
--Satellite imagery is viewable on screen through Google Earth software available free of charge at: www.googleearth.com
--High resolution satellite Google Earth images may be printed by purchasing the Professional version of Google Earth software for about $400
--CSU San Bernardino's Water Resources Institute (WRI) maintains an archive of historical aerial photographs from parts of most watersheds in San Bernardino County at: http://wri.csusb.edu/web-pages/archives/hist-aerial-photos/index.asp
--An atlas of panoramic aerial photographs of many parts of California is maintained by Dr. William Bowen of the CSU Northridge Geography Department. The index map with links to specific areas is available at:
http://130.166.124.2/ca_panorama_atlas/index.html. These images are copyrighted and their use without the expressed approval of the owner is strictly forbidden. Please contact Dr. Bowen for additional information concerning copyright issues and the development of commercial projects (drwilliambowen@hotmail.com)

D. Geologic Maps
--Maps displaying bedrock geology and soil units at 1:24,000 scale are available for many of the 7.5 minute quadrangles of southern California. These may be obtained in digital and /or hard copy format through links to the USGS Western Earth Surface Processes team website:
http://geomaps.wr.usgs.gov/socal/
--Geologic maps of 7.5 minute quadrangles not covered by the USGS may be purchased from the Thomas W. Dibblee Foundation at:
http://www.sbnature.org/estore/sbnature_web/CTGY/mp/list.htm

2. Identify fan-shaped drainage network on the topographic map.

A. On USGS topographic maps, the most significant active drainages are generally demarcated by a blue dashed line-three dot symbol representing intermittent stream. Alluvial fan drainages typically radiate from the apex of the fan located at the topographic break where a single stream exits mountainous or hilly terrain. **(Refer to illustration)**

B. Axes of primary and secondary stream channels correspond to "v" shaped patterns in topographic contours in which the "v" points uphill. The linear traces of individual stream channels will connect multiple apexes of "v's" on adjacent contours.

C. Traces of certain secondary channels may be braided or somewhat sinuous.

3. Utilize aerial photographs and/or satellite imagery to deduce truly active segments of the alluvial fan drainage network.

A. Active alluvial channels will stand out as narrow, linear features filled with gravel and sand. These channels tend to appear brighter and smoother textured than older fan surfaces into which they are incised. **(Refer to illustration)**
B. Active channels that overlie a relatively shallow water table may be have large bushes or trees at their edges but will be generally devoid of dense, small-scale vegetation.
C. Density and type of vegetation can provide useful clues to the age of an alluvial fan surface area. Fresh alluvial deposits contain little organic carbon or clay and, as a result, do not promote vegetation growth. Vegetation is limited on older surfaces because they receive only direct rain, and can be less fertile due to development of calcium carbonate cement that may impede infiltration. Intermediate-age surfaces (middle to late Holocene) are less consolidated or cemented and commonly contain the most dense and diverse vegetation. **(Refer to illustration)**
D. Examination of the historical record of flooding and deposition can enhance the information gained from the soils map. Comparison of aerial photographs from different years can be used to identify sites of new deposition.

4. Analyze geologic maps of the area (if available).
A. Confirm that the active alluvial channels identified in 2 and 3 above are mapped as such. Poorly consolidated sands and gravels in active alluvial fan channels are usually mapped by geologists as "Holocene alluvium", "young Quaternary alluvium," or "Quaternary wash deposits."
B. Commonly, only the major active channels may be distinguished on published geologic maps. Other alluvial channels will be evident in satellite imagery and aerial photographs.

5. Delineate segments of active channels that have been channelized or otherwise modified by human activity.
A. Such flood-control channels will be evident in satellite images as relative straight linear features lined with concrete or asphalt.
B. The existence of a flood control channel is a good clue that the channel is active and has experienced significant historical flooding.

6. Conduct detailed field check of features identified above
A. All flow paths identified by maps and aerial photographs should be walked to verify the active and inactive areas that have been delineated.
B. Field check is complete when the analyst has defined and delineated all active and inactive areas of deposition, erosion, and unstable flow path flooding, as well as adjacent inactive fan areas. All active areas should be considered flood prone. Inactive secondary channels characterized by apparently stable, vegetated flow paths are expected to have a lesser but somewhat uncertain degree of flood risk.

7. Map the active channels identified in 2, 3, 4, 5, and 6 above onto a standard topographic base with a minimum of four geo-registration points.
--Draft or digitize line segments to locate axial traces of various types of active stream channels.

--Where stream channels have significant widths, map edges of the channel (stream banks) with separate line segments. These will be represented as distinct polygons on the GIS map.
--Distinguish primary (major) channels from secondary (minor) channels.
--Denote presently channelized segments of the drainage network.

8. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. Differentiation of channel types and related features should be explained in the map legend, and may further be distinguished by GIS line styles, line weights or polygon fill patterns of different color.

FH3: Identify Disturbed area
(Proposed new mapping protocol)

Placeholder

Step Two Intro language
(To be inserted)

MH1: Map zones prone to surface rupture
Of active faults
(Originally GIS 4)

Summary of Protocol

Objectives
1. To identify surface fault rupture hazard zones near alluvial fans as defined by the Alquist Priolo Act
2. To distinguish the 100 ft-wide "no-build" zone from the encompassing 1000 ft-wide "Earthquake Fault Zone" in which further earthquake fault investigations are required before building structures for human occupancy

Rationale
The Alquist Priolo Earthquake Fault Zoning Act of 1972 was designed to mitigate surface fault rupture hazard by avoiding the placement of human-occupied structures across traces of hazardous faults. The law requires establishment of "Earthquake Fault Zones" encompassing hazardous faults, which are specified as those faults that are "sufficiently active" and "well-defined." A sufficiently active fault exhibits evidence of Holocene displacement (i.e., movement during the last 11,000 yrs). A well defined fault has a surface trace detectable by a trained geologist.

The Alquist Priolo Act bears on alluvial fan development because many alluvial fans owe their existence to uplift of the adjacent highlands by incremental displacement on an active fault (or faults). Most commonly, such active faults occur at the topographic break and thus transect the upper reaches of a fan near its apex. However, it is not unusual for active fault traces to transect the mid-fan or toe region.

The basic rule is one cannot build within 50 ft of an active fault (structures built prior to 1972 are exempt from this, however). There is a straightforward procedure for identifying active fault traces and locating the 1000 ft-wide "Earthquake Fault Zones" that require further investigation for potentially hidden active fault traces. Simply consult the appropriate 7.5 minute Alquist Priolo Earthquake Fault Zonation map produced by the California Geological Survey.

Procedures

1. Acquire pertinent data resources and guidelines.

A. A general description of California's Alquist Priolo Earthquake Fault Zoning Act (1972) is accessible through the California Geological Survey website: http://www.consrv.ca.gov/cgs/rghm/ap/Pages/Index.aspx

B. A detailed powerpoint presentation explaining the Alquist Priolo Act and methodologies used by CGS geologists to create Alquist Priolo Fault Zonation maps may be downloaded at: http://www.1906eqconf.org/tutorials/EQHazMapGrndShaking_Bryant.pdf

C. Special Publication 42, "Fault-rupture Hazard Zones in California, is available for $6.00 per copy plus shipping and handling at any California Geological Survey public information office or it may be ordered by mail from CGS, P.O. Box 2980, Sacramento, California 95812.

D. An index to official 7.5 minute Alquist Priolo Earthquake Fault Zonation maps published by the California Geological Survey through 1999, included in Special Publication 42, is also available at: http://www.consrv.ca.gov/cgs/rghm/ap/map_index/Pages/index.aspx

E. Official Alquist Priolo maps may be ordered by name as shown on the index map in Special Publication 42. there is a $7.00 minimum charge per order. Each order will be charged $4.09 for handling regardless of the number and type of maps ordered. Sales tax and shipping charges will be added. The first copy of each map will cost $1.90. Additional copies of the same map are $1.32. Prices are subject to change.

F. A few official Alquist Priolo maps in southern California, released in 2003, are available online in PDF various GIS formats. An index of these maps may be viewed at: http://www.consrv.ca.gov/cgs/rghm/ap/official_release/Pages/index.aspx Clicking on the index map brings up 7.5 specific quadrangles from which data may be downloaded. Available GIS formats include MapInfo tab files, ArcInfo .e00 export files, and dxf export files.

G. California Geological Survey CDs 2002-01, 2002-02 and 2002-03: Fault Evaluation Reports Prepared Under the Alquist-Priolo Earthquake Fault Zoning Act These Fault Evaluation Reports (FERs) are unpublished manuscripts prepared since 1976 by the California Geological Survey staff to summarize evidence for Holocene faulting on various faults in California. These reports are divided into three regions

of California, and may be purchased on CD from:
http://www.consrv.ca.gov/cgs/rghm/ap/ap_fer_cd/Pages/index.aspx

H. Technical Guidelines for Evaluating Surface Fault Rupture Hazard (CGS Note 49):
http://www.consrv.ca.gov/cgs/information/publications/cgs_notes/note_49/Documents/note_49.pdf

I. Technical Guidelines for Reviewing Geologic Reports (CGS Note 41):
http://www.consrv.ca.gov/cgs/information/publications/cgs_notes/note_41/Pages/index.aspx

J. A description of the Seismic Hazards Mapping Act (1990) is available at:
http://www.consrv.ca.gov/cgs/shzp/Pages/shmpact.aspx

K. 1:24,000 scale topographic maps (standard base maps for plotting Alquist-Priolo fault zones)
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

2. Locate study area on the index of official 7.5 minute Alquist Priolo Earthquake Fault Zonation maps (see 1E above)

A. If no active faults are indicated for the area of your alluvial fan of interest, your analysis is finished.
B. If your study area encompasses a mapped trace of an active fault, obtain the appropriate Alquist Priolo Earthquake Fault Zonation map and proceed to Step 3.

3. Zone all active faults located in study area

A. Establish a "no build" zone extending 50 ft in from the trace of all mapped active faults. State law specified that no structures intended for human occupation may be built within this zone. Boundaries of this "no build zone" coincide with a 50 ft "setback," represented by two lines parallel to but 50 ft from the active fault trace.
B. Establish boundaries of the "Earthquake Fault Zone" associated with the active fault(s). This will generally be an area extending 500 feet from the mapped trace of an active fault. Within this zone, detailed fault investigations (fault trenching, borings, etc.) are required prior to new building construction. This is to ensure that no additional, previously unidentified active faults strands occur within the Earthquake Fault Zone.

4. Map the features identified in step 3, above onto a standard topographic base with a minimum of four geo-registration points.

--Draft or digitize line segments coinciding with known active fault traces, using different line styles to indicate location precision or data quality.

--Draft or digitize line segments coinciding boundaries of the "no build" zone and "Earthquake Fault Zone."
--Note other seismic features deemed important by the state geologist.

5. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. Differentiation of the active e fault traces, hazard zones and related features should be explained in the map legend, and may further be distinguished by GIS line styles, line weights or polygon fill patterns of different color.

MH2: Identify unstable soils or sediment prone to amplified seismic shaking, liquefaction, differential settling, or swelling

Summary of Protocol

Objectives

1. To identify those alluvial fans whose bedrock source areas are likely to yield concentrations of fine-grained sediment (clay, mica, or silt).
2. To map areas of alluvial fans underlain by fine grained soil or sediment prone to amplified seismic shaking, liquefaction, differential settling, or swelling.

Rationale

The natural flooding process that drives alluvial fan sedimentation tends to produce thick deposits of sand and gravel with relatively minor proportions of fine-grained particles. This is because a natural sorting or winnowing action associated with high-energy stream flow transports fine-grained clay and silt out to the valley floor, while gravel and sand are deposited closer to the mountain front within the apron of sediment that forms the alluvial fan. Typically, particle size ranges from boulder size at the fan apex to fine gravel and course sand in the mid-fan region to fine sand at the fan toe. Such gravel-sand sediments intrinsically have significant porosity and permeability and therefore drain well. Finer-grained sediments and soils that drain poorly tend to accumulate beyond the toe of the fan in playa lake beds. These localities are notorious for seismic shaking hazards and differential swelling or settling.

However, certain alluvial fans may contain significant accumulations of clay or mica minerals and silt-sized particles. These fans correspond to geologic settings where an upstream bedrock source is composed of shale, siltstone, or mica schist. Alluvial fan sediments eroded from these rock types will contain a higher proportion of fine-grained minerals. Soils developed on undisturbed surfaces of the fan between active stream channels may be very rich in unstable clay minerals.

Subsurface layers of clay and silt are most likely to be encountered in the toe region of the fan. Here, inter-stratification of fine-grained playa lake beds with distal fan sediments may result from climate induced lake–level changes and periodic influx of higher-energy fan deposits. Thus apparently stable sandy soils on the fan surface may be underlain weak clay layers of significant thickness. Such relationships are poorly exposed and but may be revealed by shallow geotechnical drill holes.

Poorly consolidated, fine-grained sediments and soils typically contain major void space (porosity values in excess of 50%), but have very low permeability. They have the capacity to

absorb large quantities of water but drain poorly. Such soils pose foundation hazards because of their inherent weakness and instability when water-saturated. When one considers that a unit volume of this material commonly contains more than half water, it is easy to visualize foundation failure by shear or liquefaction during an earthquake event. Furthermore, seismic waves tend to slow down when passing through fine-grained, water-saturated sediments; this requires an increase in wave amplitude to transmit the seismic energy. Hence, wet mud is well known for experiencing stronger ground shaking than nearby sand-gravel deposits or bedrock.

An additional hazard is posed by soils containing significant proportions of bentonite or montmorillinite (a.k.a. "smecktite") clay. These clays are known for their capacity to expand when wet (they also have very low shear strength). In general, soils with significant but variable clay content may experience seasonal effects of differential settling or compaction that alternate with swelling.

Unfortunately, most published geologic maps do not distinguish soil types on alluvial fans to level of detail needed for sophisticated soil hazard analysis. The best information on soil or sediment properties may be obtained from geotechnical reports associated with recent nearby construction sites. Generally, detailed field check of the property of interest will be needed to make a reasonable judgment of risk. The up side is that thick deposits of unstable, fine-grained soils and sediments are not common on most alluvial fans.

Procedures

1. Acquire pertinent data resources.

A. Guidelines for protecting the public safety from the effects of earthquake-triggered ground failure:
--Provisions of California's Seismic Hazards Mapping Act (1990):
http://www.consrv.ca.gov/cgs/shzp/Pages/SHMPAct.aspx
--California Division of Mines and Geology Special Publication 118: *Recommended Criteria for Delineating Seismic Hazard Zone in California:*
http://www.consrv.ca.gov/cgs/shzp/webdocs/Documents/SP118_Revised.pdf
-- California Division of Mines and Geology Special Publication 117: *Guidelines for Evaluating and Mitigating Seismic Hazards in California*:
http://www.consrv.ca.gov/cgs/shzp/webdocs/Documents/sp117.pdf

B. Seismic Hazards Zone maps, created by the California Division of Mines and Geology, display liquefaction zones and earthquake-induced landslide zones.
--The index below provides access to individual 7.5 minute quadrangles in southern California and the San Francisco Bay area for which digital data may be downloaded in the formats of pdf, MapInfo .tab files, ArcView shape files, microstation .dgn files, and AutoCad .dxf files. Also available for download are evaluation reports in pdf format:
http://gmw.consrv.ca.gov/shmp/MapProcessor.asp?Action=SHMP&Location=All&Version=7&Browser=IE&Platform=Win

C. Geologic Maps:
--Maps displaying bedrock geology, soil units and faults at 1:24,000 scale are available for many of the 7.5 minute quadrangles of southern California. These may be obtained in digital and /or hard copy format through links to the USGS Western Earth Surface Processes team website: http://geomaps.wr.usgs.gov/socal/
--Additional geologic maps of unstable soils and associated seismic hazards may be obtained in digital and /or hard copy format through the California Geological Survey website:
http://www.consrv.ca.gov/cgs/rghm/ap/Pages/Index.aspx

--Geologic maps of 7.5 minute quadrangles not covered by the USGS or CGS may be purchased from the Thomas W. Dibblee Foundation at:
http://www.sbnature.org/estore/sbnature_web/CTGY/mp/list.htm

D. Local Geotechnical Reports:
--Recently developed areas of alluvial fans very likely have gone through a permitting process that involved subsurface geotechnical study. Associated geotechnical reports, where available, offer valuable sources of information about soil characteristics of the natural foundation materials. These data may be in the form of well borings, soil particle size analyses, soil strength tests or cross sections.

2. Read CDMG Special Publications 117 and 118.

3. Note all zones of potential liquefaction displayed on the appropriate Seismic Hazards Zone map (if this is available for study area)

4. Analyze available geologic maps and seismic hazards zone maps

A. Note specific occurrences of clay-rich soil, silt, or lake beds on the alluvial fan mapped by professional geologists. Most commonly, none will be shown on the fan proper, but the adjacent valley floor or playa lake may be mapped as a clay or silt unit.
B. Study the mapped bedrock geology in the upstream catchment area. Note any occurrences of shale, siltstone, or mica schist. These rock types are the main sources of flake-shaped or "platy" minerals that yield clays as a product of chemical weathering
C. Any alluvial fan associated with significant *(>25%) upstream occurrence of shale, siltstone, and/or mica schist bedrock should be flagged for further field investigation.
*this value is a rough estimate—I'm not sure what the experts would consider significant

5. Analyze available geotechnical reports for significant subsurface clay occurrences

A. Study logs of any drilling operations (core drilling, reverse-circulation drilling, auger holes, other types of borings) reported from developed sites on the fan
B. Analyze results of soils tests, focusing on measurements of porosity, permeability, and shear strength. Also note any mention of bentonite or montmorillinite clay.
C. Peruse the geotechnical reports for verbal descriptions of any soils or sediments containing clay or silt. Of paramount importance is whether or not these soils form continuous horizons at depth. Some reports will display the different soil types in cross section view.
D. Note significant occurrences of fine grained soils or sediment on the topographic base map.
E. If sufficient surface and drill hole data exist, construct cross sections at various orientations to determine extent and continuity of subsurface clay or silt horizons.

6. Conduct a detailed field check of potentially hazardous soils identified in 3, 4, and 5

A. The main areas to focus on are older portions of the fan surface situated between active stream channels. These will have the best-developed soils, and clay content generally increases with the age of soil. The proportion of clay and silt-sized particles is generally highest near the toe of the fan.
B. Pay close attention to areas where residual cobbles and pebbles on the fan surface are predominantly shale or mica schist.

C. Search for 3-dimensional exposures of the alluvial fan sediments that may reveal fine-grained horizons. Suitable exposures are most likely to occur in deeply incised portions of active stream channels

D. Note precise GPS coordinates of significant silt or clay occurrences. Collect soil samples for laboratory analysis.

7. Compile results of soil hazard analysis onto a 1:24,000 or larger scale topographic base map with a minimum of four geo-registration points. The map area should encompass the alluvial fan of interest and the bedrock geology of its upstream drainage basin. Various features identified in Steps 3, 4, 5 and 6 may be hand-drafted onto a hard copy of the topographic base or digitized into a GIS data base.

8. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. Separate layers should be created for topography, upstream bedrock geology, mapped occurrences of clay, silt, or lake beds, and sites of previous geotechnical investigation. All mapped features should be explained in the map legend, and may further be distinguished by GIS line types, patterns, and shading.

MH3: Identify potential landslide or slope stability hazards

Summary of Protocol

Objective

To delineate areas of alluvial fans with steep topography prone to slope failure or erosional undercutting.

Rationale

Alluvial fans by definition are gently sloping land forms composed predominantly of gravel and sand. Landslide risk will only be significant in rare areas where the ground slope exceeds ~15 to 20 degrees (or 4:1 to 3:1). The rationale here is that completely unconsolidated (zero-cohesion) sand and gravel will maintain stable slope angles up to the value of their "internal angle of friction" which is generally in the range of 30-45 degrees. Stability of such slopes increases over time due to natural cement bonding (a.k.a "cohesion") between the particles. However, the presence of fine-grained clay or silt under water saturated conditions may significantly reduce the effective friction angle, posing a potential hazard. The 15 degree cutoff is chosen to provide a reasonable factor of safety for most slope stability hazards, with the exception of long-term creep of topsoil layers.

The focus of landslide/slope stability assessment can generally be restricted to embankments of active flood channels because slope angles of most of the fan surfaces are typically less than 15 degrees. The most hazardous areas are flood channels that have incised >10 ft into the fan surface. Such incisions most commonly occur on the outside bends of stream channels, where unstable, sub-vertical banks are created. Due to the focusing of stream velocity along these bends, erosional undercutting of the embankment is likely to occur during future flood events. Any development near the embankments will require retaining walls for stabilization, as well as flood-control structures. Depending on proximity to the incised channel, building may be prohibited due to the general flood hazard.

An uncommon landslide hazard on alluvial fans is posed by subsurface layers of clay or silt adversely inclined at angles exceeding their wet friction angle. These may provide slip surfaces to focus large soil movements. The risk of this type of failure is generally low because: a) continuous clay and silt layers are rare in the alluvial fans, and b) such layers are typically deposited at very low angles. Procedures for identifying and mapping subsurface clay and silt layers are outlined in MH2

The upper reaches of a few fans may present excessively steep slopes. These should be investigated for occurrences of weak soils or precariously perched boulders. In rare cases, the mountain front bounding the alluvial fan may pose a landslide hazard, but such potential slope failures will only affect the immediately adjacent apex area of the fan surface.

Unfortunately, most published geologic maps do not distinguish landslide hazards on alluvial fans. California Geological Survey is beginning to produce a series of "Landslide Inventory Maps," but these focus mainly on hilly or mountainous regions with steep topography. USGS topographic maps are also of limited use for precise determination of ground slope in small areas because contour interval may be 20 ft or 40 ft. More detailed topographic maps (with contour intervals <10 ft) may be obtained from geotechnical reports associated with recent nearby construction sites. Generally, detailed field check of the property of interest is necessary to make a reasonable judgment of risk. The up side is that slope stability hazards are rare on stable

portions of the fan surface away from active flood channels. Most of the areas prone to landslides will already be flagged as flood hazard zones.

Procedures

1. Acquire pertinent data resources.

A. 1:24,000 scale topographic maps
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

B. Digital Elevation Models
--For those with GIS analytical capabilities, digital topography may be obtained from the USGS at http://rockyweb.cr.usgs.gov/elevation/dpi_dem.html
Digital elevation models with 30m x 30m sample spacing are available for most 7.5 minute quadrangles in the conterminous United States

C. Aerial Photographs and Satellite Imagery
--Digital ortho photographs (DOQs) that cover quarter portions of each 7.5 minute quadrangle in California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/remote_sensing/doq/
--Aerial photographs and satellite imagery of various scales and vintages may be purchased from the USGS at:
http://erg.usgs.gov/isb/pubs/booklets/aerial/aerial.html
--A complete index of aerial products from EROS (Earth Resources Observation and Science) is available at:
http://edc.usgs.gov/products/aerial.html
--Satellite imagery is viewable on screen through Google Earth software available free of charge at: www.googleearth.com
--High resolution satellite Google Earth images may be printed by purchasing the Professional version of Google Earth software for about $400
--CSU San Bernardino's Water Resources Institute (WRI) maintains an archive of historical aerial photographs from parts of most watersheds in San Bernardino County at:
http://wri.csusb.edu/web-pages/archives/hist-aerial-photos/index.asp
--An atlas of panoramic aerial photographs of many parts of California is maintained by Dr. William Bowen of the CSU Northridge Geography Department. The index map with links to specific areas is available at: http://130.166.124.2/ca_panorama_atlas/index.html. These images are copyrighted and their use without the expressed approval of the owner is strictly forbidden. Please contact Dr. Bowen for additional information concerning copyright issues and the development of commercial projects (drwilliambowen@hotmail.com)

D. Local Geotechnical Reports:
--Recently developed areas of alluvial fans very likely have gone through a geotechnical permitting process that involved topographic survey. Associated geotechnical reports, where available, offer valuable sources of detailed information about ground slope and soil characteristics of the natural foundation materials. These data may be in the form of maps, well borings, soil particle size analyses, or soil strength tests.

E. Landslide Inventory Maps
--California Geological Survey is compiling a 7.5 minute map series to provide information on landslides in mountainous or hilly terrain adjacent to urbanized areas. Several southern California quadrangles may currently be downloaded from:
http://redirect.conservation.ca.gov/CGS/information/publications/LSIM_SOCAL.htm
Three northern California quadrangles may currently be downloaded from:
http://redirect.conservation.ca.gov/CGS/information/publications/LSIM_NORCAL.htm

2. Begin analysis with focus on the distributary channel network. (see also FH2)

A. The primary flood channels will be evident on the topographic maps. Aerial photographs and satellite imagery will help define minor secondary channels**.**

B. Identify segments of active flood channels that have incised the fan surface. The steepest ground slopes are likely to coincide with embankments at the channel edge.

C. Look for other places on the fan surface where contours are noticeably close-spaced. These areas are most likely to occur in the upper reaches of the fan.

3. Identify areas with ground slopes exceeding 15 degrees or ~4:1 slope.

A. Analyze topographic contours near the areas noted in Step 2 above. Ground slope is given by the equation:

$$\tan\Psi = \text{change in elevation / horizontal distance}$$

where Ψ = slope angle in degrees. Differences in elevation may be determined by noting the contour values of two points located up-slope and down-slope. Utilize the map scale to determine horizontal distance between the two points.

B. If you have GIS analytical capabilities, import the DEM for this area and use the program to highlight any areas with ground slope exceeding 15 degrees.

C. Study images of existing development and flag man-made cuts or excavations likely to exceed the specified 15 degree slope. Gravel pits or gravel quarries are common large-scale examples.

4. Analyze available geotechnical reports for occurrences of steep slopes and subsurface clay or silt horizons. (see also MH2)

A. Utilize detailed topographic maps to carry out site-specific contour analysis per Step 3A.

B. Study logs of any drilling operations (core drilling, reverse-circulation drilling, auger holes, other types of borings) reported from developed sites on the fan

C. Analyze results of soils tests, noting any mention of bentonite or montmorillinite clay.

D. Peruse the geotechnical reports for verbal descriptions of any soils or sediments containing clay or silt. Of paramount importance is whether or not these soils form continuous, inclined horizons at depth. Some reports will display the different soil types in cross section view.

E. If sufficient surface and drill-hole data exist, construct cross sections at various orientations to determine extent and continuity of subsurface clay or silt horizons.

5. Conduct detailed field check of potentially hazardous ground slopes identified in Steps 2, 3, and 4.

A. The key focus areas are active distributary channels. These are likely to have steep embankments not distinguished at the scale of the topographic map. Brunton compasses or other inclinometers provide a simple mechanism for measuring slope angle at any given location

B. Pay close attention to areas where flood channels have incised deeply into the fan surface. These exposures may reveal layers of fine grained clay or silt that pose additional slope stability or soil hazards (see also MH2)
C. Of particular importance are the outside reaches of bends in incised stream channels. These represent areas most susceptible to undercutting by erosion.
D. Use a GPS receiver to map precise boundaries of steep slopes. Also note coordinates of significant silt or clay occurrences. Collect soil samples for laboratory analysis.
E. Investigate other areas of the fan surface with steep slopes. Note characteristics of the underlying soil or sediment (e.g. grain size distribution, degree of consolidation). Map occurrences of precariously positioned large boulders that might roll down slope during an earthquake.

6. Compile results of slope hazard analysis onto a 1:24,000 or larger scale topographic base map with a minimum of four geo-registration points. The map area should encompass the alluvial fan of interest. Various features identified in Steps 3, 4 and 5 may be hand-drafted onto a hard copy of the topographic base or digitized into a GIS data base.

7. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. Create separate layers for the topographic base, flagged areas with >15 degree ground slope, surface exposures of inclined clay or silt layers, and sites where inclined clay layers are known from previous geotechnical investigation. All mapped features should be explained in the map legend, and may further be distinguished by GIS line types, patterns, and shading.

MH4: Map areas underlain by hazardous materials

Summary of Protocol

Objectives

1. To delineate areas of alluvial fans with known occurrences of radon, asbestos, uranium, or mercury
2. To outline extent of current and historical landfills or industrial complexes capable of contributing toxins to local soils

Procedures

1. Acquire pertinent data resources.

A. 1:24,000 scale topographic maps
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

B. Hazardous Materials reports and maps
--an overview of the primary hazardous minerals identified in California is posted on the California Geological Survey website at:
http://www.conservation.ca.gov/cgs/geologic_hazards/hazardous_minerals/Pages/Index.aspx
This site provides links to published reports, maps, and other information related to
Asbestos:
http://www.conservation.ca.gov/cgs/minerals/hazardous_minerals/asbestos/Pages/Index.aspx
Mercury:
http://www.conservation.ca.gov/cgs/minerals/hazardous_minerals/mercury/Pages/Index.aspx
and Radon:
http://www.conservation.ca.gov/cgs/minerals/hazardous_minerals/radon/Pages/Index.aspx

C. Local Geotechnical Reports:
--Developed areas of alluvial fans very likely have gone through a geotechnical permitting process that involved topographic survey. Associated geotechnical reports, where available, offer valuable sources of detailed information about ground slope and soil characteristics of the natural foundation materials. These data may be in the form of maps, well borings, soil particle size analyses, or soil strength tests.

2. Consult published hazardous minerals maps and reports

A. Note specific occurrences of asbestos within the alluvial fan study area. These will generally be limited to areas that have serpentinite bedrock sources.
B. Note specific occurrences of mercury within the alluvial fan study area. These tend to be associated with old mining districts
C. Note specific occurrences of radon within the alluvial fan study area. These hazardous zones have been extensively documented in recent years, and may be widespread where trace quantities of uranium and thorium are naturally present in rocks or soils
D. Map the boundaries of hazardous mineral zones onto a topographic base map

3. Outline boundaries of other potential sources of soil contamination

A. Consult municipal or county zoning maps

B. Delineate portions of alluvial fan currently or previously occupied by solid waste landfills

C. Delineate portions of alluvial fan currently or previously occupied by industrial complexes

D. Research municipal or county records for descriptions of issues or studies regarding hazardous materials, toxic waste cleanup, other mitigation efforts

4. Compile results of hazardous materials analysis onto a 1:24,000 or larger scale topographic base map with a minimum of four geo-registration points. The map area should encompass the alluvial fan of interest. Various features identified in Steps 2 and 3 may be hand-drafted onto a hard copy of the topographic base or digitized into a GIS data base.

5. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. Create separate layers for the topographic base map and known occurrences of asbestos, mercury, or radon. If applicable, delineate the extent of landfills or industrial complexes. All mapped features should be explained in the map legend, and may further be distinguished by GIS line types, patterns, and shading.

MH5: Identify zones of alluvial fan aquifers with poor groundwater quality

(proposed new mapping protocol)

Summary of Protocol

Objectives

1. Utilize hydrochemical analyses from existing water wells to demarcate regions of poor groundwater quality

2. Identify down-gradient aquifer zones prone to future groundwater contamination

3. Estimate groundwater seepage velocity in areas down-gradient from existing contaminant plumes.

4. Predict future extent of groundwater contaminant plumes

Rationale

Alluvial fan aquifers generally provide very good quality groundwater because alluvial fan sediments are relatively young and the sand and gravel particles tend to have low solubility. Because of frequent fresh water recharge and flushing or dilution by the trunk stream and seasonal precipitation, the total dissolved solids (TDS) are maintained at levels below the drinking water standard. Unfortunately, the intrinsic properties of high porosity and high permeability that make alluvial fan sediments such ideal aquifers cause the same aquifers to be prone to surface contamination. Most regions of poor groundwater quality in alluvial fan aquifers may be directly tied to sources of industrial waste (these may include a wide variety of toxic metals or complex organic molecules) or agricultural waste products such as fertilizer or sewage.

The basic approach is to determine the extent of a contaminant plume in an alluvial fan aquifer, then use basic hydrologic principles to predict the direction and velocity that the plume will migrate in the future. This information is deduced from analysis of water well data; e.g.,

hydrochemical analyses and water levels. GIS techniques that analyze spatial distribution of water chemistry will facilitate mapping of present-day contaminated regions or identification of individual contaminated wells. Likewise, water table contour maps (derived from water well levels) provide a direct measure of the hydrologic gradient throughout the study area. Contaminated groundwater will seep down-gradient in a direction perpendicular to the water table contours. The seepage velocity will be proportional to the hydrologic gradient and hydraulic conductivity, and inversely proportional to aquifer porosity. Typical seepage velocities in alluvial fan aquifers range from a few feet per year to hundreds of feet per year.

Additional areas of with poor groundwater quality (high TDS) should be expected in the toe region of the fan where fine sand aquifers are commonly interstratified with playa lake deposits. Minor occurrences of highly soluble evaporate minerals (gypsum and halite) typically elevate the levels calcium, sodium, sulfate, and chloride to the point where the groundwater is non potable, or even unsuitable for irrigation purposes.

Procedures

1. Acquire pertinent data resources.

A. 1:24,000 scale topographic maps (standard base maps useful for plotting water well locations):
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

B. General information on specific groundwater basins:
--Metropolitan Water District (MWP) published a report in 2007 assessing the status of mapping, usage and management of groundwater resources in its southern California service area: http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/GWAS.html
Included in this report is a regional map showing locations and names of groundwater basins:
http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/ES-1.pdf
and an index map showing basins that are described in the 2007 report:
http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/GARCh4PlateIV-1Map.pdf
--California Department of Water Resources (southern district) posts a wide variety of groundwater information at http://wwwdpla.water.ca.gov/sd/groundwater/groundwater.html
Various publications and reports pertaining to groundwater resources and development are posted at: http://wwwdpla.water.ca.gov/sd/groundwater/groundwater_pubs.html. One very useful publication is Bulletin 118, which contains detailed descriptions of individual groundwater basins throughout California:
http://www.groundwater.water.ca.gov/bulletin118/basin_desc/index.cfm, and a map of individual groundwater basins and subbasins in California:
http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/maps/correct_statewide_basin_map_V3_subbas.pdf, part of which is available in shape file format through the link at: http://www.groundwater.water.ca.gov/bulletin118/basin_maps/index.cfm
--Los Angeles County Department of Public Works (DPW) posts information about its groundwater spreading facilities at http://dpw.lacounty.gov/wrd/spreadingground/index.cfm
--San Diego County Water Authority has posted limited information on groundwater at
http://www.sdcwa.org/manage/sources-groundwater.phtml

C. Water well data, including groundwater levels, drilling logs, well completion reports, pump test, and hydrochemical analyses:
--California Department of Water Resources (DWR) posts groundwater level data, compiled from sources at Orange County water District, the USGS, and Ventura County Public Works Agency, at http://wdl.water.ca.gov/gw/
--The USGS Water Resources Division provides links to groundwater data for parts of California at: http://ca.water.usgs.gov/. Included at this site are recent publications. Current real-time groundwater data may be accessed at http://waterdata.usgs.gov/ca/nwis/current/?type=gw&group_key=county_cd. Historical daily or periodic field measurements of water well levels are accessed through http://waterdata.usgs.gov/ca/nwis/gw/. A user-friendly clickable map showing real-time measurements of water levels in selected wells of California is may be accessed at http://groundwaterwatch.usgs.gov/StateMaps/CA.html
--CSU San Bernardino's Water Resources Institute maintains an archive of water well records at http://wrigis.csusb.edu/WellRecordsProject/Default.aspx

D. Additional information on groundwater levels, drilling logs, and hydrochemical analyses may be available from local municipal water agencies and the geotechnical industry. Although significant research and legwork may be required, this data can be very valuable as it may provide infill constraints on incomplete or widely scattered well logs available from the DWR and USGS data bases.

E. California drinking water standards:
--USEPA Region 9 Drinking Water Standards and Health Advisories Table:
http://www.epa.gov/region09/water/drinking/files/dwsha_0607.pdf
This is a compendium of standards, health advisories and related information for chemicals and other contaminants which may be found in ground and surface waters. It provides a comprehensive listing of current and proposed National Primary Drinking Water Regulations (NPDWRs), additional Maximum Contaminant Levels (MCLs) specific for California, Arizona and Hawaii, and California Drinking Water Action Levels.

2. Review existing water well data bases

A. Access data sets associated with specific wells. These may include drilling logs, well completion reports, pump test reports, water well levels, and water quality analyses. The DWR and USGS online data bases are a good place to begin, but sometimes more valuable data and historical records may be obtained through diligent research of municipal water agencies and landowners who operate private wells. Geotechnical reports
B. Peruse groundwater quality reports specific for the region encompassing the study area.
C. Note any geotechnical studies related to investigations of groundwater contamination or industrial waste mitigation. Nearby Superfund sites may provide abundant data

3. Extract pertinent values from water well data base and existing water quality reports.

A. Compile an Excel spreadsheet of water well data. Create separate columns for:
-well ID number
-well name
-latitude and longitude coordinates in degrees or UTM coordinates
-ground elevation (at the top of well)
-total depth drilled
-water table elevation

-values of total dissolved solids (in ppm) reported in hydrochemical analyses
-measured concentrations of specific chemical constituents

B. Red-flag any wells reporting levels of total dissolved solids (TDS) that exceed federal drinking water standards

C. Yellow-flag those wells whose present-day quality is not potable but suitable for irrigation.

D. Green-flag those wells whose present-day quality is potable (suitable for drinking).

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4. Create color-coded maps that display spatial variation of water quality

A. Plot key water quality data (e.g., TDS and concentrations of specific chemical constituents) next to individual wells on the map. Note any patterns apparent in their spatial distribution**.**

B. Generate color-coded point maps or contour maps of TDS

C. Generate color-coded point maps or contour maps of individual chemical constituents that exceed federal drinking water standards.

D. Highlight and differentiate those map areas underlain by groundwater that exceeds federal drinking standards or irrigation standards

5. Create a water table contour map as a base for depicting the regional groundwater flow direction (see also procedures in MB1)

A. Construct a contour map of water table elevation (in feet above sea level), using available wells as control points. This is most easily accomplished by utilizing GIS computer programs to contour the Z component of an X, Y, Z data set, where X and Y represent well coordinates and Z is elevation.

B. Construct sufficient flow lines to describe the groundwater flow field. Flow will be directed form high elevation of the eater table toward lower elevations. Each flow line should be perpendicular to any water table contour it crosses.

6. Estimate groundwater seepage velocity for regions located down gradient of contaminant plumes identified in Step 4. e

A. Calculate the *Hydrologic Gradient*, **dh/dl**, at multiple locations of interest. The applicable formula is:

dh/dl = (difference in water table elevation between two points) / (length of flow path between the points)

B. Estimate values of *Hydraulic Conductivity*, **K**, and *Porosity*, **n**, for the aquifer. These values may be previously quantified studies that accompany drilling and pump testing. In alluvial fans, typical values of Hydraulic Conductivity range from 1 ft/day to 100 ft/day, whereas porosity may range from 15% to 40%

C. Calculate seepage velocity in **ft/day** at multiple locations. The applicable formula is:

$$v_{seepage} = K(dh/dl)(1/n)$$

where porosity, n, is expressed as a decimal, and the remaining terms are defined above

D. Plot values of seepage velocity on the groundwater flow map at each point calculated

7. Map present-day boundaries and predicted future extent of contaminated groundwater

A. Define the limits of separate "contaminant plumes" by drawing polygons enclosing wells that exceed federal drinking water standards.

B. Utilize the groundwater flow map with seepage velocity values to calculate and locate the down-gradient positions of plume boundaries at specific future times of 10 yrs, 25 yrs, 50 yrs, and 100 yrs.

8. Map the various features and patterns identified in Steps 4, 5, 6 and 7 above onto a standard topographic base with at least four geo-registration points.
--Draft or digitize line segments representing contours of water table elevation, total dissolved solids (TDS), or values of specific chemical constituents. Label these with appropriate values.
--Draft or digitize polygons outlining the extent of significant contaminant plumes.
--Draft or digitize arrows to depict groundwater flow direction. Annotate these arrows with calculated values of seepage velocity in feet/year
--Add point features corresponding to water well locations, seepage velocity values and other specific features of interest; e.g. geographic reference points, man-made structures. Color-code the wells according to water quality parameters.

9. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. This mapping exercise is ideally suited for GIS presentation. Multiple features such as water well locations, water levels, water table contours, groundwater flow lines and seepage velocities, contaminant plumes, and concentrations of chemical constituents may be displayed in different layers. Each well should be linked to an attribute table containing water elevation and hydrochemical data. Differentiation of map features should be explained in the map legend, and may further be distinguished by GIS line types, patterns, colors, and shading.

MH6: Delineate existing wildfire hazards

Summary of Protocol

Objectives

1. To analyze risk factors contributing to wildfire hazard on an alluvial fan
2. To rank the propensity for wildfire on an alluvial fan using GIS tools and matrices that consider statistical analysis of multiple risk factors

Rationale

Property losses due to wildfires are an unfortunate consequence of residential development in southern California. In recent years, occurrences of wildfires in mountainous or hilly terrain have accelerated, as have costs to affected homeowners and the financial drain on state and federal resources for fire suppression. Many California wildfires are propelled by dry "Santa Ana type" offshore winds that are funneled down mountain canyons. Others are associated with dry "Chinook type" winds. Because alluvial fans by definition are situated at the mouth of canyons, they may be prone to wind-driven wildfire if their trunk stream is oriented in an unfavorable direction. Specifically, those upstream drainages that flow south or west are most susceptible to offshore "Santa Ana" winds, while those that flow east are likely to focus prevailing westerly "Chinook" winds. In addition to funneling effects, down slope adiabatic heating is a common feature of both wind types.

Wildfire hazard on a given alluvial fan may be quantified through GIS analysis tools that consider multiple risk factors, each of which should be weighted according to pre-determined guidelines. Significant factors contributing to wildfire risk include: 1) density of vegetation (fuel), 2) type of vegetation and its moisture content), 3) orientation of upstream drainage basin, 4) wind velocity, 5) humidity, 6) temperature, 7) time since last significant fire, and 8) response time for fire suppression efforts. Most of these risk factors will vary with location or time. Thus GIS methodologies are ideally suited for analyzing their spatial distribution through multiple time slices.

Because the majority of California wildfires originate upstream from the alluvial fan environment, risk analysis and associated wildfire hazard maps should encompass not just the fan surface, but the drainage basin of the trunk stream that feeds the fan.

Procedures

1. Acquire pertinent data resources.

A. 1:24,000 scale topographic maps (standard base maps useful for plotting water well locations):
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/
-- Digital Elevation Models: For those with GIS analytical capabilities, digital topography may be obtained from the USGS at http://rockyweb.cr.usgs.gov/elevation/dpi_dem.html
Digital elevation models with 30m x 30m sample spacing are available for most 7.5 minute quadrangles in the conterminous United States

B. Historical records of previous wildfires in the region are generally archived by the US Forest Service. Consult personnel at the closest Ranger District office. Other records may be accessible through state or local fire-suppression agencies

C. Historical climate data
--Site specific climate data may be accessed from National Climatic Data Center:
http://www.ncdc.noaa.gov/oa/ncdc.html
This will require some searching, but probably is the best source of data from obscure locations. For example, find monthly climate data from specific weather stations at:
http://www.ncdc.noaa.gov/oa/climate/climatedata.html#monthly
Historical drought severity index maps of the United States for each month since 1900 are at:
http://www.ncdc.noaa.gov/oa/climate/research/drought/palmer-maps/
--average high and low temperatures per month are tabulated at http://www.weather.com/
Simply enter the zip code or name of the closest city, then select the button for "averages"
--average relative humidity per month is compiled in various websites:
http://www.met.utah.edu/jhorel/html/wx/climate/rh.html
http://www.climatesource.com/us/fact_sheets/fact_rh_us.html

D. Maps of water supply infrastructure and fire-suppression response time.
--in developed areas this type of information should be available from applicable municipal agencies

2. Consult historical records to determine extent and frequency of past fires affecting the alluvial fan and its upstream drainage basin

A. Map outlines of historical burn events on the topographic base. Note date of each fire.
B. Assign separate values to the fan surface and the upstream drainage basin to denote number of fires in the past 100 years. This will quantify fire frequency.
C. Red-flag those upstream drainages that have not burned in historical time.
D. Yellow-flag those upstream drainages that have not burned in 50 years.

3. Map density and type of vegetation

A. Analyze recent satellite images and/or aerial photographs to assess the density of vegetative cover on the fan surface and its upstream drainage basin
B. Map boundaries between zones with different vegetation density. For each mapped zone, assign values or ranges of values to differentiate the percent of land covered by vegetation.
C. Field-check the heavily vegetated areas with a trained botanist. Distinguish various plant species with emphasis on ranking their fuel potential and moisture content. Also note those species whose fuel potential is adversely affected by short periods of drought.
D. Devise a "fuel index" to rank the degree of risk posed by various types of vegetation.

4. Analyze the orientation of upstream drainage network in terms of potential for focusing offshore "Santa Ana type" winds

A. Measure azimuths of discrete segments of the trunk stream. Use values between 0 and 360 degrees, as measured from upstream to downstream. Plot azimuth values on the topographic base map next to the corresponding stream segment
B. Measure azimuths of the main tributaries. Use values between 0 and 360 degrees, as measured from upstream to downstream. Plot azimuth values on the topographic base map next to the corresponding stream segment

C. Analyze the slope aspect of the upstream drainage basin, using a GIS tools applied to a Digital Elevation Model. Record the variation in slope aspect as azimuth in the downhill direction that the slope faces.

D. Rank the likelihood of offshore "Santa Ana type" wind as high, medium, or low. Because these winds most commonly blow **from** the northeast **to** the southwest, canyons and slopes that face between south and west are slopes most prone to offshore winds. Below is a suggested ranking system:

3=High—Azimuths between 180 and 270

2=Medium-- Azimuths between 150 and 180 or between 270 and 300

1=Low-- Azimuths between 300 and 150

5. Analyze the orientation of upstream drainage network in terms of potential for focusing "Chinook type" prevailing westerly winds

A. Alluvial fans situated along the east side of steep mountain escarpments are commonly affected by prevailing westerly winds that experience adiabatic heating.

B. Follow a similar azimuth measurement procedure to Step 4, but focus on east-facing drainages

C. Rank the likelihood of prevailing westerly or "Chinook type" winds, assigning the highest values for azimuths between 60 and 120 degrees

6. Analyze historical climate data

A. Graph Average Relative Humidity vs. Month. Note values for the six highest months

B. Where data are available, graph Average Sustained Wind Velocity vs. Month. Note values for the six highest months; also note prevailing wind direction

C. Graph Average High Temperature vs. Month. Note values for the six highest months

D. Devise separate numerical systems to rank the degree of risk associated with Humidity, Peak Wind Speed, and High Temperature. This will require comparison with other alluvial fan regions in the state.

E. Access maps of the Palmer Drought Severity Index (available for each month since 1900). Note the dates of each severe drought affecting the alluvial fan study site. Analyze these data to determine the frequency and extent of severe drought

F. Apply a numerical system to rank the

7. Analyze fire risk to structure as mapped by 10-county Alluvial Fan Study Area (originally GIS2)

A. Assess response time for fire-suppression agencies

B. Assess local fire-suppression capabilities; e.g., existing water supply infrastructure and distance/access to external water reservoirs.

C. Devise a numerical system to rank the degree of risk relative to other areas in the 10-county Alluvial Fan Study Area

8. Devise a matrix that incorporates the degree of risk contributed by factors outlined in Steps 2, 3, 4, 5 and 6 (much of the following needs review and will require decision making beyond my expertise)

A. Assign a numerical weighting system to rank the relative importance of each subcategory or zone distinguished for a specific risk factor. For example, average humidity, wind velocity, and temperature each could be subdivided into categories of low, medium, and high risk). Percent vegetation cover needs to categorized, etc.

B. Decide which individual risk factors carry more weight

C. Incorporate the variations with time or season exhibited by some risk factors (or only consider data from high risk seasons)
D. The overall matrix needs to be carefully assessed for internal consistency—the composite fire hazard will be strongly influenced by the weighting assigned to different factors.

9. Map the various risk components and patterns identified in, Steps 2, 3, 4, 5, 6 and 7 above onto a standard topographic base with at least four geo-registration points.
--Draft or digitize line segments representing boundaries between fire hazard zones with different degrees of risk.
--Draft or digitize polygons encompassing the various risk zones. Label these appropriately.
--Add point features to denote mapped occurrences of specific vegetation types or other features of interest; e.g. geographic reference points, man-made structures.

10. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. This mapping exercise is ideally suited for GIS presentation. Each risk factor may be mapped into separate zones that different levels of risk. Variations in specific risk factors can then be displayed in a different map layers. Every line or polygon should be linked to an attribute table containing source data. Differentiation of map features should be explained in the map legend, and may further be distinguished by GIS line types, patterns, colors, and shading.

MB1: Determine geometry, quantity, and quality of existing groundwater resource

(proposed new mapping protocol)

Summary of Protocol

Objectives

1. To determine the subsurface geometry of water-saturated gravel and sand aquifers associated with an alluvial fan
2. To determine present-day water well levels that demarcate elevation of the water table
3. To quantify volume of recoverable groundwater stored in alluvial fan aquifers
4. To obtain quantitative aquifer parameters useful for future management of the groundwater resource
5. To survey groundwater quality of existing wells, and develop a sense for its special variation

Rationale

Alluvial fans are preferred environments for groundwater development because their thick gravel and sand deposits are porous and very permeable, hence they are capable of storing large quantities of pore water and transmitting it efficiently to wells. Thicknesses of water-saturated sand and gravel aquifer systems typically range from tens to hundreds of meters. High-energy floods associated with alluvial fan deposition tend to winnow out fine-grained clay and silt particles that generally inhibit the groundwater transmission in unconsolidated sediments. The cumulative effect of this natural fluvial process is to produce a systematic particle size gradation from boulders and cobbles near the fan apex to medium gravel and coarse sand in the mid-fan region to fine sand near the toe **(see illustration)**. All of these sediments provide good aquifers when water-saturated.

Gravel-sand aquifers in alluvial fans are bounded at the top by a gently sloping water table extending from the apex region to the playa lake or valley floor that bounds the toe of the fan

(see illustration). The highest point on the water table usually occurs where the trunk stream exits the mouth of the mountain canyon at the fan apex. The water table level is maintained by recharge from surface water, the primary source of which is periodic flooding focused in the primary active channel and its distributary channels. A secondary (but generally minor) source of groundwater recharge is infiltration of rainwater into the surface area of the fan (see also MB2). In areas of long term, extensive groundwater development, the water table may be dramatically lowered due to "drawdown" effects associated with pumping wells (see case study of Borrego Valley, cited below).

Evaluation of groundwater resource in an alluvial fan requires three-dimensional analysis of subsurface data acquired during the drilling and subsequent monitoring of water wells. Available information may be quite limited, with sparse geographic coverage, but it is worth pursuing all potential sources of well data (see below) because each well provides crucial information needed to constrain the subsurface geology and location of the water table. An ideal data set will allow one to generate contour maps showing elevation of the water table and elevation of the bedrock surface that forms the basement of an alluvial fan. From these maps it is straightforward to derive an estimate of the total volume of water saturated sediment. Another important procedure is to construct cross sections (if possible) that display the configuration of gravel and sand deposits. It is not unusual to encounter layers of clay and silt interstratified with sand and gravel. This is most common in the region between the mid fan and toe, where water table tends to occur at the shallowest depths

Of crucial importance for future management of the groundwater resource is the determination of a representative average value for Specific Yield. This aquifer parameter, usually obtained through pump tests of individual water wells, is the best measure of water volume that one could expect an aquifer to yield. Effectively, one multiplies the total volume of water-saturated aquifer material by the percent value of Specific Yield to obtain the theoretical recoverable groundwater volume. Specific Yield is also a key parameter for predicting the amount of "drawdown" (water table lowering) caused by pumping an individual well or multiple wells at a known discharge rate.

Water quality is another important parameter for assessment of the alluvial fan groundwater resource. Typically, total dissolved solids (TDS) and sodium, chloride, and sulfate will be elevated closer to the toe of the fan because these areas are more strongly influenced by groundwater associated with soluble evaporate minerals formed in playa lake beds. The best groundwater quality commonly occurs in areas near active flood channels where the highest rates of fresh-water recharge occur. However, any well subject to surface contamination may display marginal water quality. Groundwater contaminant plumes associated with industrial or agricultural waste are a particularly common problem in alluvial fan areas of southern California that were developed in the years following World War II (see also MH5).

Procedures

1. Acquire pertinent data resources.

A. 1:24,000 scale topographic maps (standard base maps needed for plotting water well data and constructing cross sections):

--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:

http://casil.ucdavis.edu/casil/maps/drg/

--hard copies of these same USGS quadrangle maps may be purchased at:

http://topomaps.usgs.gov/

B. Information on specific groundwater basins:

--Metropolitan Water District (MWP) published a report in 2007 assessing the status of mapping, usage and management of groundwater resources in its southern California service area: http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/GWAS.html Included in this report is a regional map showing locations and names of groundwater basins: http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/ES-1.pdf and an index map showing basins that are described in the 2007 report: http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/GARCh4PlateIV-1Map.pdf
--California Department of Water Resources (southern district) posts a wide variety of groundwater information at http://wwwdpla.water.ca.gov/sd/groundwater/groundwater.html Various publications and reports pertaining to groundwater resources and development are posted at: http://wwwdpla.water.ca.gov/sd/groundwater/groundwater_pubs.html. One very useful publication is Bulletin 118, which contains detailed descriptions of individual groundwater basins throughout California: http://www.groundwater.water.ca.gov/bulletin118/basin_desc/index.cfm, and a map of individual groundwater basins and subbasins in California: http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/maps/correct_statewide_basin_map_V3_subbas.pdf, part of which is available in shape file format through the link at: http://www.groundwater.water.ca.gov/bulletin118/basin_maps/index.cfm
--Los Angeles County Department of Public Works (DPW) posts information about its groundwater spreading facilities at http://dpw.lacounty.gov/wrd/spreadingground/index.cfm
--San Diego County Water Authority has posted limited information on groundwater at http://www.sdcwa.org/manage/sources-groundwater.phtml

C. Water well data, including groundwater levels, drilling logs, well completion reports, and pump tests:
--California Department of Water Resources (DWR) posts groundwater level data, compiled from sources at Orange County water District, the USGS, and Ventura County Public Works Agency, at http://wdl.water.ca.gov/gw/
--The USGS Water Resources Division provides links to groundwater data for parts of California at: http://ca.water.usgs.gov/. Included at this site are recent publications. Current real-time groundwater data may be accessed at http://waterdata.usgs.gov/ca/nwis/current/?type=gw&group_key=county_cd. Historical daily or periodic field measurements of water well levels are accessed through http://waterdata.usgs.gov/ca/nwis/gw/. A user-friendly clickable map showing real-time measurements of water levels in selected wells of California is may be accessed at http://groundwaterwatch.usgs.gov/StateMaps/CA.html
--CSU San Bernardino's Water Resources Institute maintains an archive of water well records at http://wrigis.csusb.edu/WellRecordsProject/Default.aspx

D. Additional information on groundwater levels, drilling logs, well completion reports, and pump tests may be available from local municipal water agencies and the geotechnical industry. Although significant research and legwork may be required, this data can be very valuable as it may provide infill constraints on incomplete or widely scattered well logs available from the DWR and USGS data bases.

E. A recent DWR groundwater study of Borrego Valley provides examples of groundwater elevation maps and the variation of water table elevation over a 50 year period: http://wwwdpla.water.ca.gov/sd/groundwater/basin_assessment/basin_assessment.html

F. Examples of the types of geologic information from drilling logs and well completion studies are available in reports on three recent wells drilled by DWR in Borrego Valley: http://wwwdpla.water.ca.gov/sd/groundwater/groundwater_pubs.html

G. California drinking water standards:
--USEPA Region 9 Drinking Water Standards and Health Advisories Table:
http://www.epa.gov/region09/water/drinking/files/dwsha_0607.pdf
This is a compendium of standards, health advisories and related information for chemicals and other contaminants which may be found in ground and surface waters. It provides a comprehensive listing of current and proposed National Primary Drinking Water Regulations (NPDWRs), additional Maximum Contaminant Levels (MCLs) specific for California, Arizona and Hawaii, and California Drinking Water Action Levels.

2. Determine location of study area relative to regional designated groundwater basins

A. Find the nearest basin on the MWD index map (if located in southwestern California).
B. For other regions of California, access the DWR index map. These provide digitized outlines of some groundwater basins or subbasins in shape file format
C. Note the name of the groundwater basin for future reference.

3. Analyze existing groundwater reports and data sets.

A. Peruse groundwater reports specific for the region encompassing the study area
B. Access data sets associated with specific wells. These may include drilling logs, well completion reports, pump test reports, water well levels, and water quality analyses. The DWR and USGS online data bases are a good place to begin, but sometimes more valuable data and historical records may be obtained through diligent research of municipal water agencies and landowners who operate private wells.
C. Compile Excel spreadsheets of water well data. Create separate columns for:
-well ID number
-well name
-latitude and longitude coordinates in degrees or UTM coordinates
-ground elevation (at the top of well)
-total depth drilled
-water table elevation
-elevation of bedrock basement
-specific information about geology encountered during drilling (drilling logs commonly indicate thicknesses of different sediment or soil horizons, depths of contacts or boundaries between different units, and notation of mean grain size or grain size distribution at specific depths
-values of total dissolved solids (in ppm) reported in water quality analyses
-measured concentrations of specific chemical constituents
D. In areas of significant previous groundwater development it is useful to acquire historical water level data, because water table elevation may fluctuate seasonally and commonly the water table has experienced drawdown (lowering) during long periods of pumping. Rate of water table drawdown is important for the analysis of Step 7.

4. U**tilize contouring methods to map water well data onto topographic base map**

A. Generate a contour map of water table elevation (in feet above sea level), using available wells as control points.

B. Generate a contour map of depth to water table. The applicable formula is

Depth to Water Table = Ground Elevation – Water Table Elevation

C. Generate a contour map of depth to bedrock basement.

D. Generate a "structure contour" map showing elevation of the top of the bedrock surface. The applicable formula is:

Elevation of Bedrock Surface = Ground Elevation – Depth to Bedrock

5. Construct hydrogeologic cross sections to illustrate aquifer geometry

A. Select several wells from your map to use for data control. Ideally it is useful to generate a longitudinal section (oriented from the apex region to the alluvial fan toe) and a transverse section oriented roughly perpendicular to this. Plot the locations of chosen cross section lines on the topographic base map, labeling end points uniquely

B. Construct a topographic profile, utilizing an exaggerated vertical scale of 5x or 10x, depending on maximum slope conditions. Vertical and horizontal scales should be in units of feet.

C. Locate traces of all water wells intersected by the profile line. Scale these appropriately to indicate total depth drilled. Project additional traces for those wells located near the line of profile (note these wells as "projected."

D. Plot sediment or soil units intersected by each well. Distinguish these units with conventional patterns for coarse gravel, fine gravel, coarse sand, medium sand, fine sand, silt, clay, and bedrock. Mixtures of two units may also be distinguished.

E. Extrapolate contacts (layer boundaries) between adjacent wells. Use solid lines for well constrained contacts, dashed lines for approximately located contacts, and queried lines for uncertain location.

F. Note values of porosity at specific levels of well traces where known

G. Measure dimensions from each hydrogeologic cross section to quantify the thickness and geometry of water-saturated zone. This will be the region between the water table and the bedrock basement.

H. Estimate the proportion of total water-saturated zone on each section that is occupied by gravel and sand (these are the aquifers of interest). Express this information as an area in units of square ft.

I. Considering the gross surface area of the alluvial fan and the proportion of water-saturated gravel and sand aquifers evident in the hydrogeologic cross sections, calculate the total volume of aquifer associated with the alluvial fan, in units of cubic ft.

6. Estimate volume of existing recoverable groundwater resource

A. Peruse drilling logs for information about Porosity and Permeability. Plot well-constrained values on the cross sections of Step 5 and incorporate into spreadsheet of Step 3C.

B. Peruse water well completion reports, pump tests, or local groundwater reports for information about Specific Yield and Transmissivity. Plot well-constrained values on the cross sections of Step 5 and incorporate into spreadsheet of Step 3C.

C. Analyze the spatial distribution of data from Step 6A and B to calculate a representative average values for Porosity and Specific Yield that may be applied to the entire aquifer. Typically, Porosity may range from 15% to 35%, while Specific Yield may range from 5% to 20%

D. A crude estimate of the total volume of recoverable groundwater is given by the formula:

Volume of Recoverable Groundwater = Total Aquifer Volume x Specific Yield

7. Estimate the effects of future pumping on lowering of the water table

A. Drawdown effects associated with pumping from individual wells will vary nonlinearly. In general, the following proportionality relationships apply simultaneously:

$\mathbf{s} \sim \log \mathbf{t}$ $\quad$ $\mathbf{s} \sim 1/\log \mathbf{r}^2$ $\quad$ $\mathbf{s} \sim \mathbf{Q_p}$ $\quad$ $\mathbf{s} \sim 1/\mathbf{S}$

where ~ means "proportional to"

s = drawdown or drop in water table induced by pumping
t = time since initiation of pumping
r = radial distance from pumping well
$\mathbf{Q_p}$ = pumping rate in gpm or cfs
S = Specific Yield

B. When multiple wells are pumping groundwater simultaneously, the amount of drawdown induced in the water table beneath the pumped area may be predicted from the following formula:

$$s = (\mathbf{Q_p} \times \mathbf{t}) / (\mathbf{A_p} \times \mathbf{S})$$

where A_p = area pumped and remaining variables are defined above

C. Conversely, the volume of groundwater yielded by an aquifer for a specific drawdown of the water table is given by the aquifer yield equation:

Volume pumped = Volume yielded by pores

and **Volume pumped =** $\mathbf{Q_p} \times \mathbf{t} = \mathbf{s} \times \mathbf{A_p} \times \mathbf{S}$

in other words, **Volume Yielded** = $\mathbf{s} \times \mathbf{A_p} \times \mathbf{S}$

8. Estimate existing groundwater quality

A. Peruse water quality reports from existing water wells and compare with California drinking water standards. Note values of total dissolved solids (TDS). Flag those wells containing groundwater constituents exceeding the maximum contaminant levels (MCLs)

B. Note those wells whose present-day quality is suitable for drinking

C. Note other wells whose present-day quality is suitable for irrigation

D. Plot key water quality data (e.g., TDS and concentration of specific chemical constituents) next to individual wells on the map. Note any patterns apparent in their spatial distribution**.** For rapid visual assessment of groundwater quality, these patterns may be contoured and/or color-coded with GIS computer programs that analyze X, Y, Z relationships.

9. Map the various features and patterns identified in, Steps 3, 4, 5, and 8 above onto a standard topographic base with at least four geo-registration points.

--Draft or digitize line segments representing contours of water table elevation, depth to water table, depth to bedrock, total dissolved solids (TDS), or values of specific chemical constituents. Label these with appropriate values.

--Draft locations of cross section lines. Label the endpoints uniquely

--Add point features corresponding to water well locations and other specific features of interest; e.g. geographic reference points, man-made structures. Color-code the wells according to water quality parameters.

10. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. This mapping exercise is ideally suited for GIS presentation. Multiple features such as contours, water well locations, and values of parameters derived from water well data may be displayed in different layers. Each well should be linked to an attribute table containing various types of elevation and hydrochemical data and well logs. Specific cross section lines should be linked to corresponding hydrogeologic cross sections drafted in Step 5. Differentiation of map

features should be explained in the map legend, and may further be distinguished by GIS line types, patterns, and shading.

MB2: Map Areas Critical to Water Supply
(originally WS5)
Summary of Protocol

Objectives

1. To identify areas of alluvial fans with greatest groundwater recharge capacity
2. To map and rank zones of variable recharge capability on an alluvial fan

Procedures

1. Acquire pertinent data resources.

A. 1:24,000 scale topographic maps
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

B. Aerial Photographs and Satellite Imagery
--Digital ortho photographs (DOQs) that cover quarter portions of each 7.5 minute quadrangle in California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/remote_sensing/doq/
--Aerial photographs and satellite imagery of various scales and vintages may be purchased from the USGS at:
http://erg.usgs.gov/isb/pubs/booklets/aerial/aerial.html
--A complete index of aerial products from EROS (Earth Resources Observation and Science) is available at:
http://edc.usgs.gov/products/aerial.html
--Satellite imagery is viewable on screen through Google Earth software available free of charge at: www.googleearth.com
--High resolution satellite Google Earth images may be printed by purchasing the Professional version of Google Earth software for about $400

C. Geologic Maps
--Maps displaying bedrock geology and soil units at 1:24,000 scale are available for many of the 7.5 minute quadrangles of southern California. These may be obtained in digital and /or hard copy format through links to the USGS Western Earth Surface Processes team website:
http://geomaps.wr.usgs.gov/socal/
--Additional geologic maps displaying seismic and landslide hazards information may be obtained in digital and /or hard copy format through the California Geological Survey website:
http://www.consrv.ca.gov/cgs/maps/Pages/Maps.aspx

--Geologic maps of 7.5 minute quadrangles not covered by the USGS or CGS may be purchased from the Thomas W. Dibblee Foundation at: http://www.sbnature.org/estore/sbnature_web/CTGY/mp/list.htm

2. Identify areas of enhanced groundwater recharge. Groundwater recharge will be highest in active stream channels floored by unconsolidated porous and permeable gravel and sand. Stream runoff during storm events provides the primary water source for groundwater infiltration.

A. Analyze the topographic map to identify a fan-shaped drainage network. In general, active drainages will be demarcated by a dashed line-three dot symbol representing intermittent stream. Axes of these and other stream channels correspond to "v" shaped patterns in topographic contours in which the "v" points uphill. Primary drainages typically radiate from the apex of the fan located at the topographic break where a single stream exits mountainous or hilly terrain. **(Refer to illustration)**

B. Utilize aerial photographs and/or satellite imagery to deduce which segments of the fan-shaped drainage network are truly active. These will stand out as narrow, linear features filled with gravel and sand. Active alluvial channels may be contain large bushes or trees at their edges but will be generally devoid of dense, small-scale vegetation. **(Refer to illustration)**

C. Study geologic maps of the area (if available) to confirm that the active alluvial channels identified in 2A and 2B are mapped as such. Poorly consolidated sands and gravels in active alluvial fan channels are usually mapped by geologists as "Holocene alluvium", "young Quaternary alluvium," or "Quaternary wash deposits." Commonly, only the major active channels may be distinguished. Other alluvial channels will be evident in satellite imagery.

3. Delineate areas of lesser or zero recharge capability. Moderate to minor recharge will occur via infiltration of rainwater into older portions of alluvial fans that may be variably consolidated or vegetated. Zero recharge can be expected in areas with impervious cover.

A. Identify areas of the fan covered by moderately to well-consolidated old alluvial fan deposits. These are areas of slightly higher elevation situated between the active alluvial channels that generally compose >95% of a given alluvial fan. On geologic maps such areas are distinguished as "old Quaternary alluvium" or "Quaternary alluvial fan deposits." Some geologic maps subdivide alluvial fan deposits into different relative age categories. Infiltration capacity of sediments and soils generally decreases with age.

B. Utilize aerial photos or satellite imagery to subdivide the old alluvial fan deposits into:

a. areas of sparse vegetation **(Refer to illustration)**

b. areas of moderate or dense vegetation. **(Refer to illustration)**

C. Delineate areas of the fan that have been modified by human activities. Use the most recent available satellite imagery or aerial photos to subdivide these into:

a. graded portions of residential lots or other properties not covered by man-made structures

b. impervious cover occupied by roads, houses, or other man-made structures

4. Carry out field checks of map units delineated in 2 and 3 above. Modify the mapped subdivisions as needed

5. Rank the Recharge Capability of the mapped zones and apply specific zoning values.

Zone 4: Highest Recharge Capability--Active Holocene alluvial or stream wash deposits

Zone 3: Medium Recharge Capability--Old alluvial fan deposits with sparse vegetation

Zone 2: Low Recharge Capability—moderately to densely vegetated portions of old alluvial fan deposits

Zone 1: Very Low Recharge Capability—graded portions of residential lots or other properties not covered by man-made structures

Zone 0: Zero Recharge Capability—impervious zones covered by paved roads and man-made structures

6. Map the various units identified in 2, 3, 4, and 5 above onto a standard topographic base with at least four geo-registration points.

--Draft or digitize line segments and/or polygons denoting boundaries of each map unit.

--Combine individual lines to form polygons that can be tied to attributes of distinct map units.

--Add point data corresponding to other specific features of interest; e.g. geographic reference points, man-made structures

7. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. Differentiation of map units and the degree of anticipated recharge should be explained in the map legend, and may further be distinguished by GIS line types, patterns, and shading.

MB3: Map Areas with Risk Reduction potential
(Placeholder)

MB4: Map Areas Ecologically Valuable areas
(originally WS1+ WS2+ WS3 +WS8+WS4)
Placeholder

A. Map areas of discrete transition from one ecological setting to another

These areas can be particularly important to overall ecological functions. These zones can be dynamic and change in character and location over time. Development should anticipate changes and provide for maintenance of the transition areas. The transition from the upper watershed canyon area to the alluvial fan is an example of this zone.

B. Map Areas of known habitat for state or federally listed threatened or endangered species.

Alluvial fans provide important ecological functions to the immediate and larger regions of southern California, including sand delivery, aquifer recharge, flood control, and nutrient and sediment transport for riparian habitats. They offer critical connectivity between lowlands and uplands, provide habitat for sensitive species, while still providing economic and recreational benefits to local and regional communities (AFTF 2007).

Habitat for state or federally listed threatened or endangered (T&E) species are valuable for the protection of sensitive species and to maintain biological diversity. In general, the principal reason an individual taxon (species, subspecies, or variety) is given a state or federal threatened or endangered listing is the documented or expected decline or limitation of its population size or geographical extent and/or distribution that results, in most cases, from habitat loss. From this perspective, Watershed Subcommittee Local Planning Tool Number Two (WS#2) is designed to provide a method for evaluating the relative capability of alluvial fan surfaces for habitat conservation needs.

I. INTRODUCTION

Proposed herein, is a general mapping methodology that may assist in identifying habitat potential on alluvial fans for state or federally listed T&E species. The purpose of this methodology is to describe a protocol for mapping habitat for T&E species on an alluvial fan, while giving appropriate attention to the hierarchy of regulations and issues that pose restrictions on land use as related to development on alluvial fans. The focus of this methodology is on mapping of natural communities and conservation areas for T&E species, such that the methodology is generally applicable to all regions in southern California.

This mapping is intended to be part of an integrated watershed management approach that combines all resources defined in the Watershed Section. This zonation of watershed resource values may then be included with flood, debris flow, and other

hazard data to aid in evaluating sites being considered for development on alluvial fans.

II. DEFINITIONS

Areas of known habitat for state or federally listed T&E species include habitat and buffer areas identified by United States Fish and Wildlife Service (USFWS) or California Department of Fish and Game (CDFG). Any construction in these zones must have specific provisions for avoidance of impacts on the species of concern or mitigation approved by state and federal resource agencies.
Known habitat includes habitat identified in any biological opinion or recovery strategy by USFWS or CDFG; habitat areas identified in a regional federal Habitat Conservation Plan (HCP) and/or state Natural Community Conservation Plan (NCCP); or habitat identified in an Environmental Impact Report (EIR) or Environmental Impact Statement (EIS), or a reconnaissance study conducted under the auspicious of a state or federal agency or University.

III. THREATENED AND ENDANGERED SPECIES REGULATIONS

The following list presents current federal and state regulations related to threatened or endangered species. Local agencies, districts, jurisdictions, and ordinances govern its usage.

Federal

Federal Endangered Species Act of 1973
The Endangered Species Act (FESA) and implementing regulations, Title 16 United States Code (USC) §1531 et seq. (16 USC 1531 et seq.), Title 50 Code of Federal Regulations (CFR) §17.1 et seq. (50 CFR §17.1 et seq.), includes provisions for the protection and management of federally listed threatened or endangered plants and animals and their designated critical habitats. Section 7 of the FESA requires a permit to take threatened or endangered species during lawful project activities. The administering agency for the above authority is the USFWS for terrestrial, avian, and most aquatic species. The NMFS is responsible for administering the FESA as it applies to marine species and anadromous fish.

Fish and Wildlife Coordination Act
Section 7 of the Fish and Wildlife Coordination Act, 16 USC 742 et seq., 16 USC 1531 et seq., and 50 CFR 17 requires consultation if any project facilities could jeopardize the continued existence of an endangered species. Applicability depends on federal jurisdiction over some aspect of the project. The administering agency for these authorities is expected to be the Corps in coordination with the USFWS.

Migratory Bird Treaty Act
The Migratory Bird Treaty Act (MBTA) (16 USC §§703–711) includes provisions for protection of migratory birds, including the non-permitted take of migratory birds, under the authority of the USFWS and CDFG. The MBTA protects over 800 species

including geese, ducks, shorebirds, raptors, songbirds, and many relatively common species.

State

California Endangered Species Act of 1984

The California Endangered Species Act (CESA) and implementing regulations in the Fish and Game Code, §2050 through §2089, includes provisions for the protection and management of plant and animals species listed as endangered or threatened, or designated as candidates for such listing. Incidental take of an endangered species is permitted by CDFG only under certain conditions and provided that the proper federal permits have been obtained and notifications made to the CDFG as described in Fish and Game Code §2080.1. Plants of California declared to be endangered, threatened, or rare are listed at 14 CCR §670.2. Animals of California declared to be endangered or threatened are listed at 14 CCR §670.5.14. CCR §15000 et seq. describes the types and extent of information required to evaluate the effects of a proposed project on biological resources of a project site.

California Environmental Quality Act – Treatment of Listed Plant and Animal Species

Although threatened and endangered species are protected by specific federal and state statutes, Section 15380(b), (c) and (d) of the CEQA Guidelines provides that a species not listed on the federal or state list of protected species may be considered rare or endangered if the species can be shown to meet certain specified criteria.

Two other sources for sensitive species are the California Species of Special Concern and Fully Protected Species lists; and the CNPS "RARE" listings. The status "State Species of Special Concern" and "Fully Protected Species" apply to animals not listed under the FESA and CESA, but which nonetheless either (1) are declining at a rate that could result in listing or (2) historically occurred in low numbers and known threats to their persistence currently exist. The CNPS Inventory of Rare and Endangered Vascular Plants of California is sanctioned by CDFG, and serves as a Species of Special Concern list for plants. For purposes of CEQA review, observed plant and wildlife Species of Special Concern, and plants with a CNPS designation of 1a, 1b, and 2 that could potentially occur in an area, are considered sensitive species, as well as any others that meet the requirements under the CEQA Guidelines Section 15380 (b), (c), or (d).

The significance of impacts to a species under CEQA must be based on analyzing actual rarity and threat of extinction despite legal status or lack thereof.

Fish and Game Code of California

The Fish and Game Code provides specific protection and listing for several types of biological resources.

Section 2081(b) and (c) of the CESA allows CDFG to issue an incidental take permit for a state-listed threatened and endangered species only if specific criteria are met. These criteria can be found in Title 14 CCR, Sections 783.4(a) and (b). No Section 2081(b) permit may authorize the take of "fully protected" species and "specified birds." If a project is planned in an area where a species or specified bird occurs, an Applicant must

design the project to avoid all take; the CDFG cannot provide take authorization under CESA.

Native Plant Protection Act of 1977
The Native Plant Protection Act of 1977 and implementing regulations in Section 1900 et seq. of the Fish and Game Code designates rare and endangered plants, and provides specific protection measures for identified populations. It is administered by the CDFG.

Wetlands Conservation Policy of 1993
This policy provides for the protection, preservation, restoration, enhancement, and expansion of wetland habitats in California. It primarily acts to ensure no overall net loss of wetlands within the state and achieve a long-term net gain in the quantity, quality, and permanence of wetlands acreage and values in California in a manner that fosters creativity, stewardship, and respect for private property. The administering agencies for this authority are the CDFG, the California Environmental Protection Agency (Cal-EPA), and the RWQCB.

Local
Ordinances, policies, or habitat conservation plans adopted by local jurisdictions that protect locally recognized threatened and endangered species and their habitat are applicable.

IV. MAPPING METHODOLOGY

Mapping of habitat and buffer areas for state or federally listed T&E species on alluvial fans should account for both existing and potential plant and wildlife regulations; and should also include the use of existing published and unpublished maps by federal and state resource agencies, private conservation organizations, and others. Potential habitat conservation areas may be identified based on flora and fauna mapping; regional and local conservation plans; biological opinion, reports, and studies; and areas identified in existing regulations. Specific attention should also be given to studies, either ongoing or completed, that identify habitat areas.

Data Collection
Habitat conservation plans, general plans, CDFG, USFWS, and other local and regional resources can be used as a general guide in delineating known habitat areas for T&E species. In addition to areas that have been identified and mapped as habitat for T&E species, active stream channels and wetlands should be considered as potential habitat areas for such species, and further investigations and surveys should be done to determine species presence and absence. Resources that can be used for habitat data collection include the following:

Local Sources
- A local biologist/expert in the study area
- Regional HCPs, including MSHCPs (provide conservation areas with a species list)

- State NCCP
- City and County General Plans
- Local biological studies/reports
- EIR prepared in the area
- Reconnaissance studies conducted by state or federal agencies, or universities
- Resource management plans (i.e., forest plans)

Databases and GIS Data

- CDFG regional office
- CDFG's California Natural Diversity Database (CNDDB) – The CNDDB is a program that inventories the status and locations of rare, threatened, and endangered plants and animals in California. CNDDB staff work with partners to maintain current lists of rare, threatened, and endangered species as well as maintain an ever-growing database of GIS-mapped locations for these species.

- USFWS regional office
- USFWS's Critical Habitat Portal – The Critical Habitat Portal provides a list of species with final, published critical habitat, including access to critical habitat spatial data, critical habitat meta data, Federal Register Documents, and USFWS species profile information.
- Water Resources Institute (WRI) [MAP SOURCE-- WAITING TO HEAR FROM LISA PIERCE]
- California Spatial Information Library (CASIL) [MAP SOURCE—WAITING TO HEAR FROM LISA PIERCE]
- Department of Water Resources (DWR) [MAP SOURCE—WAITING TO HEAR FROM LISA PIERCE]

Irrespective of the availability of habitat data and maps for T&E species from the sources listed above, a biological survey should be conducted for the site-specific study area by a qualified biologist to determine potential habitat for T&E species.

Areas Identified in Existing Regulations

Known habitat (either specific occurrences or designated Critical Habitat) for T&E species that are either mapped by regulatory entities or implied in local agency or other plant and wildlife regulations can be mapped as flora and fauna groups as shown in the figure titled "Known and Potential Habitat for Threatened and Endangered Species."

Potential Areas Identified in Existing Regulations

As previously discussed, in addition to the known habitat areas for T&E species, active stream channels, riparian vegetation, and wetlands should be considered as potential habitat areas for such species. These areas are regulated by jurisdictional agencies; however, further investigations and surveys should be done to determine species presence and absence as shown in the figure titled "Known and Potential Habitat for Threatened and Endangered Species."

Map Exhibits
The mapped habitat areas for T&E species should be differentiated in the explanation on the map and explained in the map legend. The maps should be developed at a scale of 1:24,000 (1 inch = 2000 feet) or larger to be useful in assessing impacts at both the project and watershed levels. For full utility, the maps should be prepared using a Geographical Information Systems (GIS) that is compatible with one used by the lead permitting agency.

GIS Protocols (Placeholder to be Defined Later)
Delineation of the habitat areas on the final map using GIS, shall be conducted using the following information:
Data Quality Information
Spatial Data Organization Information
Spatial Reference Information
Entity and Attribute Information

VI. SUMMARY AND RECOMMENDATIONS

Identifying areas of known habitat on alluvial fans will help developers, regulatory agencies, and the public in protecting these valuable areas. Compiling and developing information on known and potential habitat for T&E species, as described above, is a possible first step. The maps will need to include supporting documentation for justification. In addition to the preliminary mapping, consideration should also be given to local and regional biological reports or studies, given the potential that development may impact local or regional habitat. The information on the potential for habitat can then be combined with other watershed eco zone maps in determining appropriate conservation and mitigation needs.

IV. REFERENCES CITED

Alluvial Fan Task Force. 2007. Minutes from Plenary Meeting #1. "An Ecological Perspective," by Cameron Barrows, Research Associate, UC Riverside Center for Conservation Biology, December 7.
CDFG. 2008. California Natural Diversity Database website. http://dfg.ca.gov/biogeodata/cnddb/. Accessed June 30, 2008.
_____. 2008. Natural Community Conservation Planning website. http://www.dfg.ca.gov/habcon/nccp/index.html. Accessed June 17, 2008.
USFWS. 2005. Habitat Conservation Plans. Endangered Species Program, December.
_____ . 2008. FWS Critical Habitat for Threatened & Endangered Species website. http://criticalhabitat.fws.gov/. Accessed June 30, 2008.

C. Map Areas of important ecological patterns not otherwise delineated

A given alluvial fan may not by itself be large enough to sustain a population of plants or animals that would be identified for protection through federal/state law or through regional conservation programs. That population may only be sustainable if it

is relatively close to another alluvial fan where the species is also found. In the case of birds (i.e. burrowing owls, cactus wrens) or flying insects (i.e. butterflies), these species may periodically move between these habitat patches in a manner that sustains populations on both alluvial fans; removing one may result in the collapse of both populations. The regional context of an alluvial fan must be considered from the standpoint of its role in supporting regional conservation goals and landscape-scale patterns of habitat distribution should be maintained. Areas of important ecological patterns may include gradients of soils, stream sediments, nutrients, vegetation, particular patches of plants, soils, or rocks, or other characteristics that are clearly tied to an important local ecosystem element, function, or process. Development in these areas should sustain the key pattern underlying the zone designation.

D. Map areas supporting important corridors of migration, transit or dispersal for native species of plants, animals and sediments that are critical to sustain their habitats

Development in these areas must take into account its impact on the corridor functions and ability for animals, plant or sediment materials to be moved within the corridor. Corridors can be defined either as connecting the alluvial fan habitats to other, nearby habitats, or the alluvial fan itself may be the corridor between lowland (valley bottom) and upland (mountain) habitats. The connected habitats would be significant if identified as part of a regional habitat conservation network. Climate change and the needs of species to move in order to remain within their preferred temperature-moisture envelope is an important consideration for maintaining these corridors.

Need protocol for former WS8

E. Map riparian adjacent areas

I. INTRODUCTION

Riparian ecosystems are linear corridors of variable width that occur along perennial, intermittent, and ephemeral streams. Two distinguishing features of riparian ecosystems are the hydrologic interaction that occurs between the stream channel and adjacent areas through the periodic exchange of surface and ground water, and the distinctive geomorphic features and vegetation communities that develop in response to this hydrologic interaction.

Riparian communities within California include wetlands, uplands, or some combination of these two, including riparian forest, woodland, and scrub habitats. In some instances (e.g., within waterways and drainages) these habitat types may also have wetlands characteristics, where an adequate supply of water (surface or ground) is present and appropriate soil conditions have developed.

The size and type of riparian vegetation varies depending on the type of stream channel. Along small stream channels, the extent of the riparian community may only be a thin band of shrub-like vegetation within or directly adjacent to the channel,

whereas along larger streams or rivers the riparian habitat can be in the form of dense woodlands that can be quite extensive.

Native riparian communities, although they typically make up only a tiny fraction of the landscape, perform many important ecological functions. These functions have direct economic and social value as well as environmental value. Proposed herein, is a general mapping methodology that may assist in classifying active stream channels and riparian plant communities on alluvial fans. The purpose of this methodology is to describe a protocol for mapping streams and riparian vegetation communities on an alluvial fan, while giving appropriate attention to the hierarchy of regulations and issues that pose restrictions on land use as related to development on alluvial fans. The focus of this methodology is on mapping of floodplains and plant communities as it relates to alluvial fans, such that the methodology is generally applicable to all regions in southern California.

This mapping is intended to be part of an integrated watershed management approach that combines all resources defined in the Watershed Section. This zonation of watershed resource values may then be included with flood, debris flow, and other hazard data to aid in evaluating sites being considered for development on alluvial fans.

II. DEFINITIONS

Areas demarked by active stream channels often, but not always, include adjacent riparian plants. On inactive fan surfaces, these areas include floodplains associated with ten percent annual chance flow floodplain. On active fan surfaces, these areas are characterized by plant community structure based on historical records (for the past 100 years, if available). Development in this zone should be minimal and restricted to paths and roads providing pedestrian access or traversing the zone. Additional terms used in this document are defined below and are depicted on Figure 1.

Stream Channel - The low-flow part of the streambed, or the part where water is flowing at some portion of the year. The channel may cover the entire bed or a portion of the bed. Many local streams have “braided channels” within the streambed.

Streambed (or Bed) - The bottom of a stream or channel bounded by banks.

Floodplains – Land areas adjacent to a river, stream, watercourse, ocean, bay or lake that is likely to be flooded.

Figure 1: Cross-section of Stream Channel, Riparian Community and Floodplain (Dunn and Leopold 1978)

Riparian Community - The stream corridor, including the hydrophilic vegetation along the bank, is known as a riparian community. Riparian communities serve as the transition between aquatic and upland, or dry, communities.

III. WATER RESOURCE PROTECTION REGULATIONS

The following list presents current federal and state regulations in California related to streambeds and riparian communities. Local agencies, districts, jurisdictions, and ordinances govern its usage.

Federal

Clean Water Act of 1977, Section 404

This section of the Act (33 USC 1251 et seq., 33 CFR §§320 and 323) gives the Corps authority to regulate discharges of dredge or fill material into waters of the U.S., including streams and wetlands. The corps jurisdiction is limited to areas of the channel that fall below the Ordinary High Water Mark, as designated by the Corps.

State

Fish and Game Code of California

Section 1602 of the Fish and Game Code requires a Streambed Alteration Agreement for any activity that may alter the bed and/or bank of a stream, river, or channel, including the adjacent riparian vegetation Typical activities that require a Streambed Alteration Agreement include excavation or fill placed within a channel, vegetation clearing, structures for diversion of water, installation of culverts and bridge supports, cofferdams for construction dewatering, and bank reinforcement.

Porter-Cologne Water Quality Control Act

The State of California's Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code) provides the basis for water quality regulation within California, including the California Toxics Rule (CTR), State Implementation Plan (SIP), Inland Surface Water Quality Standards, California Urban Water Management Act, and National Pollutant Discharge Elimination System (NPDES) permits. The State Water Resources Control Board (SWRCB) administers water rights, water pollution control, and water quality functions throughout the state, while the RWQCBs conduct planning, permitting, and enforcement activities. The Porter-Cologne Water Quality Control Act authorizes the SWRCB to adopt, review, and revise policies for all waters of the state (including both surface and groundwater) and directs the RWQCBs to develop regional Basin Plans. Section 13170 of the California Water Code also authorizes the SWRCB to adopt water quality control plans on its own initiative.

Clean Water Act of 1977, Section 401

This section of the Act requires a state-issued Water Quality Certification for all projects regulated under Section 404. In California, the Regional Water Quality Control Board (RWQCB) issues Water Quality Certifications for jurisdictional areas.

General Construction Activity Stormwater Permit
In accordance with NPDES Phase I regulations, to minimize the potential effects of construction runoff on receiving water quality, California requires that any construction activity affecting 5 acres or more must obtain coverage under the General Construction Storm Water Permit. Implementation of NPDES Phase II expanded this requirement to include construction activities disturbing 1 acre or more. The SWRCB permits all regulated construction activities under Order No. 98-08-DWQ (1999) (NPDES No. CAS000002).
The General Construction Permit requires the preparation and implementation of a storm water pollution prevention plan (SWPPP), which must be prepared before construction begins. Components of SWPPPs typically include specifications for BMPs to be implemented during project construction for the purpose of minimizing the discharge of pollutants in storm water from the construction area. In addition, a SWPPP includes measures to minimize the amount of pollutants in runoff after construction is completed, and identifies a plan to inspect and maintain project BMPs and facilities.

Local
Ordinances, policies, or water resource management plans adopted by local jurisdictions that protect local water resources are applicable. These include, but are not limited to steam ordinances watershed management plans, water quality control plans, or municipal NPDES permits.

IV. MAPPING METHODOLOGY

Mapping of streams and riparian habitat on alluvial fans should account for both existing and potential streambed and riparian community regulations; and should also include the use of existing published and unpublished maps by federal and state resource agencies, private conservation organizations, and others. Potential riparian communities may be identified based on vegetation community mapping; biological opinion, reports, and studies; and areas identified in existing regulations. Specific attention should also be given to studies, either ongoing or completed, that identify riparian areas, and further investigations and surveys should be conducted to determine the site-specific boundaries of these areas. Resources that can be used for water resource data collection include the following:

Data Collection
Local Sources
- Regional HCPs, including MSHCPs (provide a list of riparian plants)
- State NCCP
- City and County General Plans
- Local biological studies/reports
- EIR prepared in the area

- Reconnaissance studies conducted by state or federal agencies, or universities
- Resource management plans (i.e., water management plans)

Databases and GIS Data

- United States Geological Survey (USGS) National Hydrography Dataset (NHD) - The NHD is a comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells. Within the NHD, surface water features are combined to form "reaches," which provide the framework for linking water-related data to the NHD surface water drainage network. These linkages enable the analysis and display of these water-related data in upstream and downstream order.
- USGS Geologic Map Database – This database is a geoscience resource for maps and related data about geology, hazards, earth resources, geophysics, geochemistry, geochronology, paleontology, and marine geology.
- CDFG regional office
- CDFG's California Natural Diversity Database (CNDDB) – The CNDDB is a program that inventories the status and locations of rare, threatened, and endangered plants and animals in California. CNDDB staff work with partners to maintain current lists of rare, threatened, and endangered species as well as maintain an ever-growing database of GIS-mapped locations for these species. This database provides aquatic and riparian vegetation data.
- USFWS regional office
- Water Resources Institute (WRI) [MAP SOURCE-- WAITING TO HEAR FROM LISA PIERCE]
- California Spatial Information Library (CASIL) [MAP SOURCE—WAITING TO HEAR FROM LISA PIERCE]

Areas Identified in Existing Regulations

Active stream channels and adjacent riparian areas that are either mapped by regulatory entities or implied in local agency or other resource protection regulations can be mapped as streams, channels, and riparian vegetation, and then presented in a map exhibit as exemplified in "Active Stream Channels and Riparian Habitat."

Identification of Potential Areas

In addition to the known active stream channels and adjacent riparian areas, other potentially unidentified or unmapped areas, particularly aquatic and riparian habitat, should also be considered. While most of these areas are regulated by jurisdictional agencies, further investigations and surveys should be done to determine site-specific riparian boundaries.

Map Exhibits

The mapped active stream channels and riparian communities areas should be differentiated in the explanation on the map and explained in the map legend. The maps should be developed at a scale of 1:24,000 (1 inch = 2000 feet) or larger to be useful and ensure assessments at the watershed scale can be made. For full utility, the maps

should be prepared using a Geographical Information Systems (GIS) that is compatible with one used by the lead permitting agency.

GIS Protocols (Placeholder to be Defined Later)
Deliniation of the two recharge areas on the final map using GIS, shall be conducted using the following information:
Data Quality Information
Spatial Data Organization Information
Spatial Reference Information
Entity and Attribute Information

VI. SUMMARY AND RECOMMENDATIONS

Identifying areas of active streams and riparian communities on alluvial fans will help developers, regulatory agencies, and the public in protecting these valuable areas. Compiling and developing information on mapped active stream channels and riparian communities, as described above, is a possible first step. The maps will need to include supporting documentation for justification. In addition to the preliminary mapping, consideration should also be given to local and regional hydrologic/scientific reports or studies given that may provide greater detail of the potential development opportunities and constraints on local streams and riparian communities. The information on the potential for riparian communities can then be combined with other watershed eco zone maps in determining appropriate conservation and mitigation needs.

VII. REFERENCES CITED

California Natural Diversity Database (CNDDB). 2008. http://www.dfg.ca.gov/bdb/html/cnddb.html. Accessed July 1, 2008.
United States Geological Survey. 2008. National Hydrography Dataset website. http://nhd.usgs.gov/. Accessed July 1, 2008.
_____. 2008. Geological Map Database website. http://ngmdb.usgs.gov/. Accessed July 1, 2008.

MB5: Identify designated mineral resource zones and classified mineral resource zones
(originally WS9)

Summary of Protocol

Objectives
1. To map areas of alluvial fans containing economic mineral resources, usually sand/gravel aggregate
2. To rank the importance of sand/gravel mineral resources in terms of market accessibility and costs/benefits to local communities

Procedures
1. Acquire pertinent data resources and guidelines.

A. California Surface Mining and Reclamation Act (SMARA) **Mineral Land Classification Reports and Updates** by the California Geological Survey (CGS) are available at:
http://www.conservation.ca.gov/cgs/minerals/mlc/Pages/index.aspx
B. California State Mining and Geology Board (SMGB) **Designation Reports** are available at: http://www.conservation.ca.gov/smgb/reports/Pages/reports.aspx
C. SMGB Guidelines for Classification and Designation of Mineral Lands are available at:
http://www.conservation.ca.gov/smgb/Guidelines/Pages/guidelines.aspx
D. The California Mineral Land Classification System (Figure 1; below)
E. State Defined Mineral Resource Zone (MRZ) Categories and Nomenclature (see Item 2 below)
F. 1:24,000 scale topographic base maps for plotting mineral resource zones
--Digital raster graphics (DRGs) of all USGS 7.5 minute quadrangles in the state of California may be downloaded free of charge at:
http://casil.ucdavis.edu/casil/maps/drg/
--hard copies of these same USGS quadrangle maps may be purchased at:
http://topomaps.usgs.gov/

2. Determine classified mineral resource zone.
Areas of southern California classified under the California Surface Mining and Reclamation Act (SMARA) are subdivided into six Mineral Resource zones. Reports are available through the web link of 1A above.

MRZ-1: Areas where available geologic information indicates that little likelihood exists for the presence of significant mineral resources.
MRZ-2a: Areas underlain by mineral deposits where geologic data indicate that significant *measured or indicated* resources are present. Contains known economic mineral deposits.
MRZ-2b: Areas underlain by mineral deposits where geologic information indicates that significant *inferred* resources are present.
MRZ-3a: Areas containing *known* mineral occurrences of undetermined mineral resource significance.

MRZ-3b: Areas containing *inferred* mineral occurrences of undetermined mineral resource significance.
MRZ-4: Areas of no known mineral occurrences.

No SMARA land classification has occurred in the southern California's Imperial County and in the northern California counties of Alpine, Colusa, Del Norte, Humboldt, Kern, Kings, Lake, Lassen, Mariposa, Mendocino, Modoc, Plumas, Sierra, Siskiyou, Tehama, and Trinity.

3. Identify regionally significant designated mineral resource zones.
The areas of "Significant Identified Mineral Resources," MRZ-2a and MRZ-2b are the highest ranked zones. However, other areas designated as having a regional significance by the SMGB have received additional consideration, and will need to receive the higher ranking in this process. The objective of the "classification-designation" process is to provide local agency decision makers with information on the location, need and importance of mineral resources within their jurisdiction, and to assure that the information will be considered in local land-use planning decisions.

Designation reports authored by the State Mining and Geology Board (SMGB) draw on data from California Geological Survey (CGS) mineral classification reports. An index of designation reports published since 1980 is available at:
http://www.conservation.ca.gov/smgb/reports/Designation/Documents/Table%201.pdf

4. Process for mineral resources reclassification
Any individual or organization who wishes to reclassify a published mineral resource zone may submit a petition to the SMGB for such updates. This will generally require new geological mapping and field investigation by a State Geologist. Guidelines and forms for New Classification-Designation of Mineral Lands petitions may be downloaded at:
http://www.conservation.ca.gov/cgs/minerals/mlc/Pages/Index.aspx

5. Additional considerations for ranking importance or value of mineral resources might include the following factors. A numerical ranking system should be established to weigh the pros and cons of developing the resource.
--transport distance to nearest viable market
--impact of noise and dust on local community
--impact of truck traffic on local transportation infrastructure
--potential for developing new groundwater resources during mining
--potential for future reclamation of site as parkland
--economic benefits to the local community in terms of jobs and tax revenue

6. Map the various Mineral Resource Zones identified in 2, 3, and 4 above onto a standard topographic base with a minimum of four geo-registration points.
--Draft or digitize polygons of SMGB-designated sectors and classified mineral resource zones based on existing published data

--Link polygons to attributes, usually a specific mineral resource zone or designation
--If applicable, link the mineral resource zone or designation to a numerical rank based on the additional considerations of Item 5

7. Produce a standardized multi-layer GIS map with accompanying geo database, scale, and legend. Differentiation of the types of mineral resource zones should be explained in the map legend, and may further be distinguished by GIS line types, patterns, and shading.

MB6: Identify Culturally significant zones
(originally WS7)

Placeholder

MB7: Identify development potential
(new protocol)

MB7 RAW LAND CAPACITY

MB7 calls for using the following data source for development potential.

Citation:

CA Department of Housing and Community Development

Raising the Roof, California's Housing Development Projections and Constraints, 1997-2020

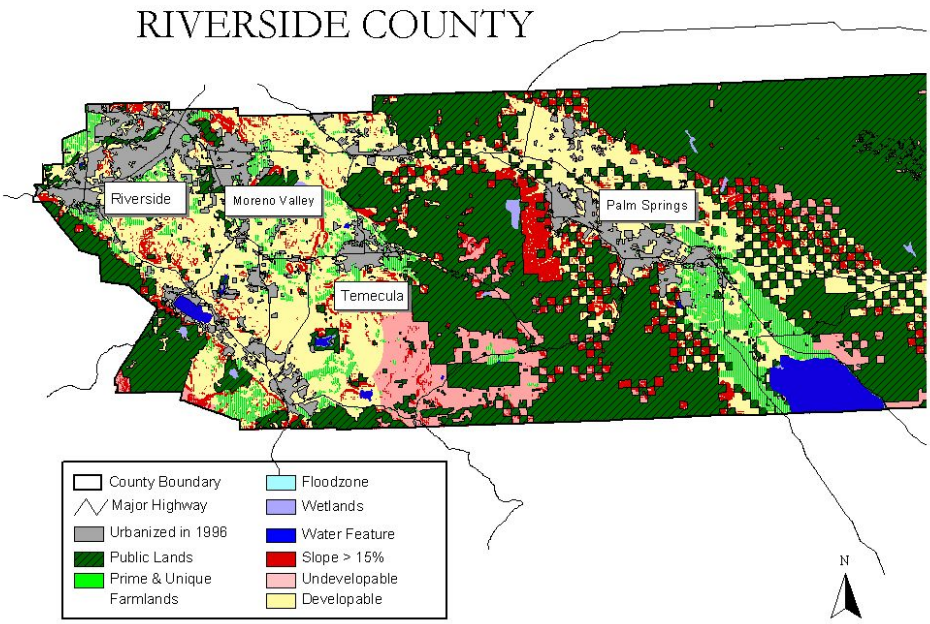
May 19 2000

Summary

Developers talk about land that is privately owned, lacks urban services, and has not been previously developed as "raw land." Raw land parcels located at the fringe of existing urban areas are commonly referred to as "greenfield" sites, to distinguish them from "infill sites," which are located within developed urban areas. In theory, California should have ample supplies of raw land. As of 1996, the 35 California counties for which detailed land supply data are available—including all of the state's urban counties (see Exhibit 12)—included approximately 3.5 million acres of urbanized land, 32 million acres of public or undevelopable land, and nearly 25 million acres of physically-developable raw land. [1]

To determine how much of this 25 million acres of physically developable land might *realistically* be considered developable, a geographical information system (GIS) and various digital map layers were used to identify and characterize potential development sites.[2] Detailed digital maps and data were obtained from many sources, including the U.S. Geological Survey, the California Farmland Mapping and Monitoring Project (FMMP), the State of California Teale Data Center, the National Wetlands Inventory, FEMA, the U.S. Census Bureau, the California Department of Fish and Game's Natural Heritage Program, and the Gap Analysis Project. (Appendix E includes a detailed listing of map and data sources.) The data were assembled for the entire state, "grided" into a common system of one-hectare cells, and then separated by county.[3] Because no federal or state agency collects comprehensive data on sites within urban areas, the comparable potential for infill development could not be established.

Sample Map


RIVERSIDE COUNTY
Riverside
Moreno Valley
Temecula
Palm Springs
County Boundary
Major Highway
Urbanized in 1996
Public Lands
Prime & Unique Farmlands
Floodzone
Wetlands
Water Feature
Slope > 15%
Undevelopable
Developable
N

Step Three Intro language
(To be inserted)

MA1 Placeholder
MA2 Placeholder
MA3 Placeholder
Orange County Case Study Placeholder

A. Case Study: Developed Watershed with Alluvial Fans Study (South Orange County)

Using historical records and aerial photographs of the geographical region known as South Orange County prior to urbanization in the early 1960's, data is being collected to create a GIS map layer of the ecosystem landscape before urbanization. Working with the County of Orange Flood Control Division—who designs and constructs flood channels, storm drains, dams, pump station, and other drainage facilities—data is being collected on the major facilities constructed in South Orange County during urbanization. This is to create a GIS map layer of major flood management channels to overlay on the GIS map layer of the ecosystem before urbanization.

Using reputable scientific data collected on the current biological landscape, Dr. Thomas Scott, a UC Riverside Natural Resources/Wildlife Specialist will present findings to the AFTF on the lessons learned from alluvial fan flood management facilities that were constructed when South Orange County was developed.

MA4 Placeholder
Sustainable Development Tool

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A. Use Web-based Sustainable Development Tool to identify local regulations, policies and Best Management Practices (BMP's)

Sustainable development practices attempt to link the built environment with the benefits derived from natural systems. The challenge when development occurs on alluvial fans lies between protecting people and structures from risks and protecting the beneficial floodplain functions necessary to sustain ecosystem values and recharge ground water basins.

The Sustainable Development tool is a database of local regulations, policies and Best Management Practices (BMP's) already in place across various jurisdictions. The tool is intended to put the extensive existing body of knowledge about sustainable development practices at the planner's fingertips.

The purpose of developing a **Sustainable Development Tool** for the AFTF was two-fold. First, there was no mechanism for the AFTF to examine the current regulations, policies and BMP's in the 10-county study area to ascertain commonalities

and differences. Second, there was a lack of information available to support the AFTF's goal of "seeking to achieve balance between development and the protection of environmental assets on alluvial fans."

Because development and construction regulations as well as alluvial fan systems vary widely by location in Southern California, the tool covers a variety of topics that may not be applicable to all alluvial fan areas. The **Sustainable Development Tool** helps identify obstacles to sustainable development or gaps in policies that may exist.

The database for the **Sustainable Development Tool** is temporarily housed in Google Doc format. Planning is underway for the AFTF to develop a custom program with a search engine as the final product.

To understand how the database is structured, review the Ordinance Evaluation Guide, Ordinance Evaluation Table and Data Dictionary on the following pages.

Then click on the following link to access the **Sustainable Development Tool** at http://spreadsheets.google.com/ccc?key=pbapiOJ35vM-2fL03ZEsTNw&inv=bwitherspoon@csupomona.edu&t=1310115371555918631&guest

When the Google Doc entitled AFTF **Sustainable Development Tool** opens, click on Sign in at the top right of the screen to access the function tools. (If prompted to log in while the database is served in Google docs, insert bwitherspoon@csupomona.edu as the User Name and XJ911bw3 as the Password.)

By placing the cursor below the column headings, a Sort icon will automatically appear with a drop down arrow. You can examine existing regulations, policies, and Best Management Practices (BMP's) in the ten counties in Southern California and review information from technical sources related to sustainable development practices that may be appropriate for a particular project.

Please let us know what you think about the general logic of the tool and what's missing and needs to be included so the Cal Poly team can continue to populate the database.

B. Use Ordinance Evaluation Guide to rank for its potential for meeting a specific sustainable development objective, as defined by the AFTF

The primary goal for the AFTF model ordinance is to reduce the loss of life and property caused by the unique risks associated with development on alluvial fans in Southern California. The secondary goal for the model ordinance is to promote ordinances that address multiple objectives. The following table presents the AFTF model ordinance objectives and the preliminary categories of ordinances/BMP's/guidelines that define development practices in alluvial fans. Each

practice is given a rank for its potential effectiveness at meeting a specific AFTF objective. The final column is an index representing the relative degree to which the guideline meets multiple objectives.

Practices as described in this table are the categories used to sort and discover the model ordinances in the Sustainable Development Tool (SDT). This table can be used to evaluate the over-all goals and objectives of a planning authority considering implementing a model ordinance using the SDT. The practices are presented in major categories, i.e. Avoidance, Programs. Each major category has sub categories that represent a more detailed type of guideline. The SDT will have multiple examples of specific ordinance language applicable to the sub category type. The definitions of the major and sub types of guidelines can be found in the SDT Data Dictionary (AFTF 07-03-08).

Definition of the Ranking Categories

Effective	The guideline is effective at promoting the general goals and conditions of the specific objective
Neutral	The guideline has no effect on the general goals and conditions of the specific objective
Not Effective	The guideline may have a negative effect on the goals and conditions of the specific objective

The following table presents the AFTF model ordinance objectives and the preliminary categories of ordinances/BMP's/guidelines that define development practices in alluvial fans. Each practice is given a rank for its potential effectiveness at meeting a specific AFTF objective. The final column is an index representing the relative degree to which the guideline meets multiple objectives.

- Placeholder for Criteria for Defining Effectiveness of Ranking Categories Objectives Table
- Placeholder for Evaluation Guide Table

C. Consult the Data Dictionary for definitions of the major and sub types of guidelines available.

- Placeholder for Data Dictionary

PHASE TWO

DC1: Asset Management of Flood Facilities (formerly DC2)

Local governments will be responsible for providing Public Works to new developments in alluvial fan areas. Among the greatest drawbacks of alluvial fan development is the potential for serious flooding, even from relatively minor isolated storms. Alluvial or high-velocity debris flows are unpredictable and can cause great damage from the amount of debris they carry. Other potential hazards of alluvial fans include: wildfires, debris flows, erosion, seismic issues, and liquefaction.
The process recommended by the AFTF to evaluate the potential local government impact from a substantial new development in an alluvial fan area is listed below. It is based on the U.S. Environmental Protection Agency's work in regards to Asset Management of water systems .

1. Identify and document the current and proposed state of the flood management system. This includes reviewing the proposed tract maps, hydrological studies and engineering reports for new developments. Key questions which need to be identified include who will own and be responsible for the facility, where will it be located, what is its projected useful life and what is its current dollar value. Key in this assessment is documenting the maintenance cycles for various storm events. In addition, identification of access routes for facility maintenance should also be considered.
2. Establish Appropriate Service Levels for the Facilities. This includes projecting the levels of service needed after each storm event necessary to maintain the facility in a ready-state. For example, based on the hydrology report and engineering studies, a calculation of the expected annual maintenance needs should be identified, using typical storm and debris flow scenarios. In a typical annual storm event, some debris loading is expected, but it is critical to understand at what loading level will the system requires debris removal. The Public Works Department confers with the local flood agency manager to determine a reasonably foreseeable level of risk for debris material to impact a new development. In alluvial fan areas where the risk of wildfire and post-fire debris flows is historically well documented, it is useful to compare the risk for debris material to impact a new development with other models. For example, the National Flood Insurance Program estimates a one percent chance of flooding each year for a structure located on a 100 year floodplain. This same risk calculated over a longer period of time, such as 30 years, is 26 percent meaning there is a one in four percent chance that structure would be flooded.
3. Determine Critical Levels of Facility Performance. This includes identifying the point in which an facility may exceed its capacity, and cease to be operational. The issues that should be considered include what is the likelihood and consequences of a failure of the facility, what will a failure of the facility look like, what will it cost to repair the facility if it does fail, and what are the associated costs with the facility failure.
4. Establish Minimum Life Cycle Activities and Associated Costs. This includes identifying the maintenance, repair and rehabilitation costs associated with the facility. For example, a facility has a life expectancy of 50 years, but may sustain moderate

damage from a significant event every 10 years, and will need to be cleaned out every two years under normal services. The costs for all these activities should be estimated prior to construction of the new development in order to properly allocate these costs over each unit of the development. These maintenance costs may include:

a. The Public Works department determines the round trip mileage of a haul-route to a local depository that is permitted and capable of accepting debris material.

b. The Public Works department determines the cubic foot volume of debris materials from the new development that may need to be moved to the depository in each of the scenarios.

c. The Public Works department estimates the personnel and equipment costs associated with removing and transporting the cubic foot volume of debris material from roads, driveways, storm drains and private properties in the new development and loading in the vehicle.

5. Establish Long Term Funding Strategy. Included in this is the determination of what the total costs for management of the facility are projected over the life of the facility, including future value of the costs. Based on this, an annualized cost number can then be developed and used in the various funding strategies available.

DC2: Establish Procedures and Protocols for Evaluating Evacuation Routes (formerly DC3)

Local governments will be responsible for providing Public Works to new developments in alluvial fan areas. Among the greatest drawbacks of alluvial fan development is the potential for serious flooding, even from relatively minor isolated storms. Alluvial or high-velocity debris flows are unpredictable and can cause great damage from the amount of debris they carry. Other potential hazards of alluvial fans include: wildfires, debris flows, erosion, seismic issues, and liquefaction. In some situations, debris flows may be more mud flows, consist primarily of soils suspended in water, as opposed to large debris such as rocks, boulders and vegetation.

The potential hazards of alluvial fans must translate into various response strategies and management approaches at the local level. Most evacuation plans focus on moving residents safely out of an affected area and moving emergency personnel in. This usually involved police, fire and paramedic personnel and vehicles, and are often developed by the public safety branches within a local agency. These plans often do not take into consideration the movement of public works personnel and equipment into the affected area to remove debris, clear roadways and to install temporary protection measures around threatened properties to prevent additional loss.

The process recommended by the AFTF to incorporate local debris management in master planned projects is listed below:

1. Identify and Assess all Proposed Roadways and Access Areas For Adequacy. Most development access is assessed on whether a fire truck has adequate street widths in order to turn around, or whether there are more than one access route into a project location. Public Works Departments should identify the facilities proposed, and establish minimum standards for access for their equipment at the time the development is in design review. The typical cul-de-sac turnaround radius for a fire

truck is approximately 37-feet. This may or may not be adequate for turning end- or side-dump trailers. If tracked equipment such as bulldozers may be needed to clear debris, roadway surfaces paved with asphalt may not be adequate to support the weight of the bulldozer or will experience severe pavement damage from the tracks. Access roads into debris basins should be reviewed for use by all public works equipment and weight usages to ensure that they will not fail under repetitive operations. Residential and Collector streets within a development that also are used to access service areas for flood and debris facilities should be review as to adequate width in order to stage and operate heavy equipment while allowing other emergency traffic to pass without interference.

2. Review Locations of Adjacent Facilities. Public Works should review the locations of adjacent facilities in order to determine if any potential conflicts may occur between departments or agencies. For example, are storm drain facilities located adjacent to areas where fire equipment may need to use hydrants or electrical power to support an effort?

3. Determine Conflict Points or Areas that May Need Special Attention. Access of emergency vehicles such as fire, police or paramedic services may be cut off by debris flows during storm events. Public Works Departments should, in conjunction with the fire departments, identify critical access needs in which assigned crews may need to be stationed during an event during development planning, and work towards minimizing these types of locations. For example, if a major roadway into a development could be bisected by a debris flow from an adjacent canyon, it may be necessary to position Public Works equipment there in order to be able to ferry emergency personnel into the isolated area or to maintain adequate roadway clearances on a repetitive basis.

4. Ensure Appropriate Traffic Flow Patterns for Debris Removal. New development should be required to provide separate ingress and egress to medium to large catch basins and other significant storm facilities. This is necessary to ensure that debris removal operations can proceed with minimum on-site conflicts between heavy equipment and dump trucks, as well as off-site on adjacent streets. Issues that must be considered include minimizing traffic conflicts, compliance with construction site NPDES Best Management Practices (as it relates to soil track-out from the job site), and operational standards.

5. Identify Potential Diversion Routes for Debris Flows. During a storm event, it may be advantageous to divert active debris flows by using deep curbing, sandbagging and temporary or engineered diversion walls. While under typical storm conditions, the engineered storm system would normally handle storm water flows, in the event of combined fire and storm events, excessive debris flows may exceed the engineered system. It may be useful to review the topography adjacent to the proposed development with a view towards being able to temporarily divert debris flows through streets or open spaces in order to minimize damage to property. Such techniques can be pre-planned and designed into developments and incorporated into emergency response plans. Placement of open space areas can be done in such a manner to facilitate emergency diversion of debris flows.

The EPA's Asset Management: A Best Practices Guide is available at http://www.epa.gov/safewater/smallsystems/pdfs/guide_smallsystems_assetmanagement_bestpractices.pdf

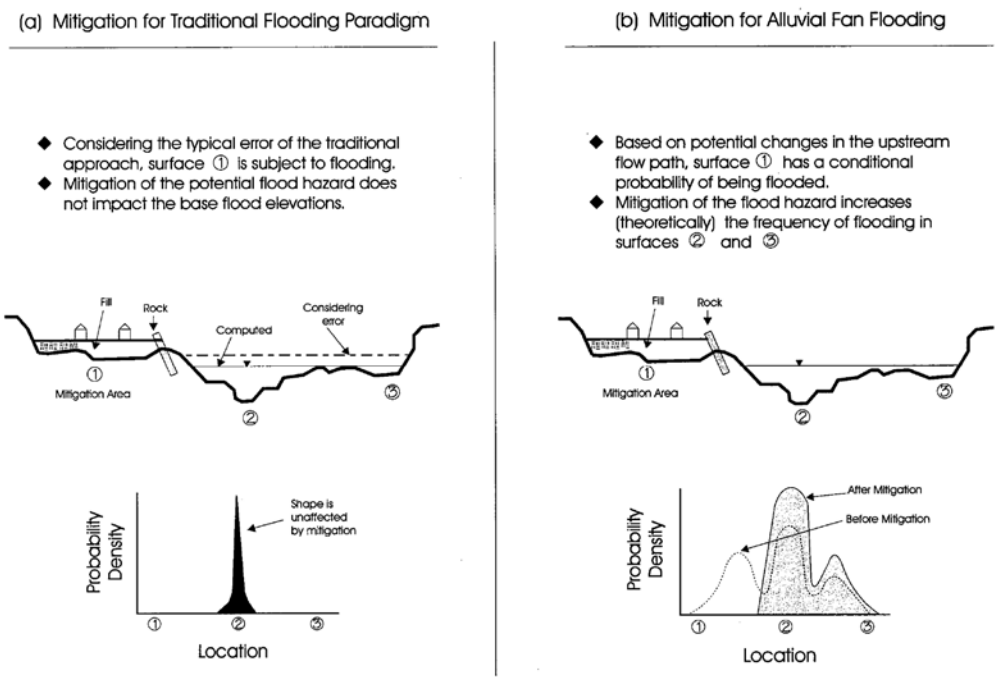
Econ1: Establish appropriate level of hazard protection (formerly FM4)

The 100-year peak flow (or the flood with a 1 percent probability of occurring in a given year) is the minimum flow that needs to be considered in developing flood protection measures. There are circumstances where flows greater than the 100-year peak flow may need to be considered. The NRC Alluvial Fan Flooding report states "…for regulatory purposes alluvial fan flooding is a flood hazard that on active parts of alluvial fans has a 1 percent chance of occurrence, and it is identified by flow path uncertainty and deposition and erosion below the hydrographic apex." In that light, the appropriate level of hazard protection would incorporate mechanisms that consider these elements. Establishing whether debris flows may occur on an alluvial fan is also a major consideration to formulate the appropriate level of hazard protection.

Depending on the magnitude and possibility of these additional hazards, there are different hazard protection measures that may be required. For example, areas subject to sediment-laden flows may necessitate the use of engineered channels to protect areas from inundation. The presence of sediments in the water would require careful evaluation to properly configure and size a conveyance structure. The possibility of debris flows that could occur on an alluvial fan during a flood may cause a need for the design of debris flow basins.

It is important to note that elevating the building surface above the base flood elevation is not a sufficient mitigation measure in areas subject to alluvial fan flooding according to FEMA regulations. Section 65.13 (c) of Chapter 44 of the CFR states, "In general, elevations of a parcel of land or a structure by fill or other means, will not serve as a basis for removing areas subject to alluvial fan flooding from an area of special flood hazard." The implication of this policy is that other mitigation measures are required to remove an area from a special flood hazard zone.

Also, the NRC report explains that elevating a surface subject to alluvial fan flooding can increase the frequency of flooding at adjacent areas because of flow path uncertainty on the active areas of alluvial fans. Figure 1-6 of the NRC report (provided below) compares the effect of adding fill on the probability of flooding occurring in a sample cross-section of the study area.



Comparison between mitigation for traditional flooding paradigm and alluvial fan flooding as shown in Figure 1-6 of the 1996 NRC Alluvial Fan Flooding report.

ECON2: Benefit analysis to weigh development benefits against public safety risks (formerly Econ1)

Econ3: Estimate long-term costs of alluvial fan development (formerly Econ2)

Budgets for current Geologic Hazard Abatement Districts (GHADs) provide us a good source of information about likely continuing operations and maintenance costs for flood control, geotechnical, habitat, and open space structures and practices because current GHADs are responsible for all of these functions. GHAD fees range from $130 per year per residential unit to $3,000 per year with typical communities in the $600 per residential unit. Commercial and other uses are assessed at rates that reflect their benefit from the public safety services provided by the GHAD. Small developments tend to have higher per-unit fees because they do not enjoy economies of scale.

We reviewed in detail four long-term GHAD budgets provided by ENGEO, Inc. Costs associated with stormwater and flood control were the largest part of the budget, averaging 47% of costs. These costs include the annual portion of anticipated major repairs to infrastructure. Other major categories are administrative and general technical services at 28% of costs and erosion control measures at 17% of costs. Management of trails, habitat, and open space and fire management measures are minor expenditures for these GHADs. For most developments, it appears that if communities assess likely stormwater and flood control operations and maintenance costs, general administrative costs, and erosion control measures, they should have a good estimate of continuing costs.

The GHAD costs are not directly related to the number of residential units in the development. The size of the public safety challenge for development area matters more than the size of the development. Even very small developments can have high operations and maintenance costs if there are significant public safety challenges.

Sediment and debris removal is a minor expense category for the GHADs we reviewed, but is likely to be a major factor in operations and maintenance expenses for developments on alluvial fans. Therefore, the amount of debris generated by the watershed should be a key factor in developing operations and maintenance costs. Los Angeles County operates a network of debris dams and basins with an annual maintenance cost of $9.5 million. Their costs of sediment removal in 2008 are $18/cubic yard and debris removal costs are $1,200/ton. These figures can be used (appropriately updated to current dollars) to estimate approximate debris removal cost for developments on alluvial fans based on the debris-generating characteristics of the watershed.

Other key considerations for maintenance costs include: the material type, right-of-way access, and environmental permits and restrictions. Stormwater managers believe that the more hardened the material type the less need there is for repair. Lack of appropriate right-of-way and access is likely to increase maintenance costs. Finally, environmental permitting and increased environmental regulation of operations and maintenance continues to increase operations and maintenance costs.

An unresolved area is the operations and maintenance costs for naturalized runoff channels on alluvial fans. Stormwater managers in the Southern California generally believe these approaches will result in higher operations and maintenance costs because of the lack of hardened material and access difficulties. However, there is little data on the issue.

Econ4

1. HAZUS information is available at http://www.fema.gov/plan/prevent/hazus/index.shtm Figure 1 provides an overview of the HAZUS flood model.

Figure 1: HAZUS Flood Model Overview PLACEHOLDER

2. Consult FEMA Mitigation BCA Toolkit (Version 3.0, July 2006). FEMA has developed software "modules" in a Microsoft Excel spreadsheet platform for preparing benefit-cost analyses for floods, hurricane winds, earthquakes, tornados, and wildland/urban interface fires. There are two basic types of software modules:

- The Full Data (Engineering Method) module uses engineering data concerning the probability and severity of hazards to estimate damages and losses (before-and after-mitigation) vs. a quantitative measure of the hazard severity (e.g., flood depth, wind speed, or level of earthquake ground shaking). When the necessary hazard data are available, these modules provide the more accurate benefit-cost analysis then the Limited Data module. There are five Full Data modules: Riverine Flood, Coastal A-Zone Flood, Coastal V-Zone Flood, Hurricane Wind, and Earthquake.
- The Limited Data (Frequency Damage Method) modules use historical data and engineering judgment to develop frequency damage relationships for both before- and after-mitigation site conditions. Although labeled as "riverine," the Riverine Limited Data module can actually be used for many types of hazard where a frequency-damage relationship has been established.

The BCA Toolkit should be adaptable for alluvial fan analyses. It is available at FEMA regional offices or by contacting the BC Helpline (bchelpline@dhs.gov or calling (866) 222-3580).

3. Flood Rapid Assessment Methodology (FloodRAM). Consultants to DWR are developing a spreadsheet model for DWR to quickly estimate direct flood damage. This model develops damage-frequency curves for without- and with-project conditions based upon hydrologic and hydraulics data, levee fragility curves, structural and crop inventories, depth-damage curves, etc. Damage categories include residential, commercial and industrial properties, crops and roads, but other categories can be added. An adjustment (for example, 25%) is added to damage estimates to account for other direct damage not specifically included in the model. The model is flexible in that many of the analysis assumptions and parameters can be changed

(for example, structural foundation heights, unit replacement values, and depreciation factors; depth-damage curves; discount rates; analysis period; other direct damage "adjustment factor"; etc.). FloodRAM should be available by the fall of 2008 and should be adaptable to alluvial fan analyses.

4. **HEC-FIA. The Corps' Hydrologic Engineering Center is developing HEC-Flood Impact Analysis (HEC-FIA) to estimate flood event damage and casualties.** Although expected annual damage estimates will not be developed by HEC-FIA, event damage estimates can be input into FloodRAM and other models to do the integration analyses required for the expected annual damage estimates. HEC-FIA is GIS-based and inputs include hydrology and hydraulic assumptions and structural inventories based upon HAZUS or county assessor data. HEC-FIA will accept a flood depth grid which increases its flexibility and may make it applicable for alluvial fan analyses if the fan depth grids can be developed.

5. Use GIS models. Although not specifically developed for flood risk applications, Geographic Information System models (GIS) are an invaluable tool for flood assessments because they are spatial analyses. For example, GIS can be used to overlay floodplain and parcel data shape files thereby identifying land uses and specific parcels affected by floods, thereby providing the basis for many types of analysis. The HAZUS-MH model is GIS-based. Although HEC-FDA is not currently GIS-based, GIS can be used to develop its data inputs (such as structural inventories). HEC-FIA will be GIS-based.

Econ5: Identify financial strategies for long-term maintenance of flood management facilities (formerly Econ4)

Continuing financial support for upkeep, maintenance, and evaluation of facilities and safety practices is critical for maintaining public safety on alluvial fans.
Development on alluvial fans should provide a vehicle for the long-term financing of upkeep and maintenance of the capital projects that ensure public safety. In addition, because of the uncertainties inherent in development on alluvial fans, it should be recognized that either new capital projects or significant changes to original projects may eventually be necessary. Financial and governmental structures should be set up at the time of original development to facilitate continuing evaluation of public safety concerns on the alluvial fan.

Fee levels should reflect the costs generated by particular parcel. Different areas of alluvial fans may generate differing levels of operations and maintenance costs. For example, developments on inactive portions of alluvial fans may need relatively low operations and maintenance expenditures to ensure their safety, while development on more active portions of the fan may need considerable expenditures. The fee levels should de differentiated so that developed parcels on areas of the fan that need significant infrastructure (and therefore have high O & M costs) are higher than parcels that need less O & M expenditures to ensure their safety.

The developer shall assist in setting up a local funding structure that covers the estimated future costs of maintenance on flood control and other public safety practices. Some funding structure alternatives are: Geologic Hazard Abatement Districts (GHADs), Assessment Districts and Mello-Roos Community Funding districts (CFDs). The preferred alternative is a GHAD because they can respond more flexibly to new or changed hazards and because their structure ensures periodic re-evaluation of flood and seismic hazards.

GHAD Timeline Flowchart Placeholder

Geologic Hazard Abatement Districts

GHADs are a potential planning tool for providing continuing financial support and technical oversight of alluvial fan developments. GHADs are a state level agency that are exempted from many local ordinances and so can provide a degree of flexibility and agility to respond to public safety concerns that other governmental entities may not possess. In addition, GHADs require a plan of control based on a professional assessment of geologic hazard and require continued oversight of geologic hazards.

GHAD Approval Process.

Once the local city or the county has authorized GHAD legislation, GHADs are formed by landowner petition and subject to Proposition 218 requirements for approval of an assessment. At the time of development there will typically only be one landowner (the developer) so approval will be automatic with the consent of the developer. However, the developer should also consider whether any other existing landowners on areas of the fan that will benefit from public safety improvements should be included in the GHAD. These landowners should be brought into the GHAD if possible. GHADs can also contain non-contiguous areas, so the developer should also explore joining an already-existing alluvial fan GHAD.

Another possibility is that a GHAD could be established on a county-wide level. The GHAD would cover the entire county, though fees would be minimal or zero for areas that do not directly benefit from the improvements. Fees for alluvial fans would be graduated based on the life-cycle cost of the infrastructure necessary to ensure public safety on the fan.

GHAD financial plan.

The GHAD financing plan will depend on the degree of geological risk and the maintenance needs of the public safety practices installed at the time of development. Professional engineering firms with expertise in GHAD management should be engaged to recommend funding levels. Some have developed formulas based on the degree and type of geological risk

and their past experience in managing GHADs. The assessment must establish a nexus between the benefit of the public safety improvements to the assessed parcels and the fee level.

The GHAD assessment level should include sufficient funds for the continual upkeep and maintenance costs for the flood control infrastructure. See Economics Planning Tool 2 for some considerations in planning for future maintenance costs.

GHAD operation and control.

We recommend that a local agency, such as a city council or county board of supervisors, be incorporated as the GHAD board. In addition, at the time of formation the GHAD should examine which key services (e.g., debris basin cleaning) should be contracted out to stormwater, public works, or other local agencies.

Bond Funding

A GHAD can issue bonds to fund capital projects.
Local Statutes

Some local land use regulations do not apply to GHADs, since they are a state level agency. One example is grading permits.

Land ownership

A GHAD may own land, such as open space set aside for flood control purposes.

Flood Control or Stormwater Assessment Districts

Assessment districts can provide a source of continuing funding for maintenance and upkeep. Generally, flood control or stormwater assessment districts whose funds are intended for maintenance would fall under the Benefit Assessment Act (1982). They do not have flexibility of a GHAD to manage a variety of public safety hazards. Funds for an assessment district can only be directed to the original purpose of the district. In addition, assessment districts do not include the ongoing technical component that is necessary to evaluate changing geologic hazards. However, in circumstances where the main public safety hazard is limited to one problem, such as flood control, assessment districts may be desirable because they can prove a funding stream without setting up a full-fledged agency like a GHAD.

Assessment District Approval Process.

Assessment districts are started via a petition from landowners in the geographic area. Engineering studies determine the cost of the improvements or services and allocates the costs to each parcel in proportion to the benefits received by the parcel. Final approval of the assessment is subject to Proposition 218 rules on voter approval of assessments. As with GHADs, setup is easiest where there is one developer.

Assessment operation and control.

An assessment district can be set up by any existing local agency or special district under the Benefit Assessment Act of 1982.

Bond Funding

Assessment districts set up under the Benefit Assessment District of 1982 cannot issue bonds. Therefore, a separate assessment district under another assessment act would have to be set up to finance large capital projects. There are several different assessment acts that could apply to flood control or other public safety oriented activities and local agencies should seek legal advice to determine which is best suited for the planned capital projects.

Mello-Roos Community Facilities District

Mello-Roos Districts are typically set up to finance public improvements such as roads, sewers, schools, flood control, etc that cannot be paid for through general revenue. They are normally used to pay off bonds issued for the public improvement. Mello-Roos Districts can also be set up to fund ongoing maintenance costs. Mello-Roos Districts, like assessment districts must restrict their expenditures to the specific purposes outlined in the original setup of the district. Thus, like assessment districts, they do not have the flexibility to respond to public safety hazards that were not anticipated at the time of alluvial fan development. An advantage to Mello-Roos Districts relative to assessment districts is that the special tax does not have to be tied directly to the benefits a parcel receives from the facilities financed by the tax.

Mello-Roos Approval Process.

The Mello-Roos formation process begins with a petition by landowners or voters in the area. A hearing is then set up where a majority protest vote stops the formation process. Then the responsible local agency prepares a plan with the budget for the capital projects and the taxes necessary to finance the projects. The District then must be approved by 2/3 of the voters in the area. With a single developer/landowner the process will only be subject to the agreement of the developer.

Mello-Roos operation and control.

A Mello-Roos CFD district can be set up by any existing local agency or special district.

Bond Funding

Mello-Roos Districts may issue bonds.

Local Statutes

Assessment Districts are part of local level agencies and all local statues apply.

Land ownership

Assessment districts may not own land.

Econ6: Identify local land use planning tools (formerly Econ5)

Many areas on alluvial plains have significant water, open space, ecological, or public safety uses. However, it may be prohibitively expensive to purchase these areas directly and downzoning these areas to prohibit or restrict development may unduly limit private ownership rights. In these cases, tools such as transferable development rights or purchase of development rights allow protection of the land at lower cost to public agencies and without curtailing private ownership rights. Markets in development rights may also enhance cooperation between public and private entities in the preservation of areas that provide a number of benefits in their undeveloped state.

Transferable Development Rights (TDRs) allow landowners sell the development rights in perpetuity to their property. These rights are purchased by other landowners to allow development above typical zoning development limits. A number of counties and cities have developed programs for transferable development rights that successfully protect open space, aquifers, and ecologically valuable areas. In California, the Lake Tahoe and Santa Monica areas have successfully implemented transferable development rights.

Purchase of Development Rights (PDRs) can be implemented on its own or in conjunction with TDR programs. In a PDR program public agencies (and occasionally private institutions) buy development rights from landowners in areas where development is to be limited. This can be less expensive than outright buying parcels, especially where other uses of the land, such as agriculture, are compatible with open space, water supply, or other values.

Transferable Development Rights Policy Choices. Transferable development rights create a market for development rights that is separate from the real estate market. In the case of

alluvial fans, the purpose of development rights would be to transfer development from areas with high values in non-developed uses to other areas that are designated for development. Markets work best where the market area supports many transactions and where there is sufficient demand and supply. There are a number of key issues in setting up a TDR program, including: the delineation of TDR sending and receiving areas, mandatory or voluntary program, allocation of TDRs, and market institutions.

Choice of sending and receiving areas. Other planning tools will help identify alluvial fan areas that are desirable to maintain undeveloped for open space, water supply, ecological, or fire protection reasons. These areas would be the sending areas and would be allowed to sell off development rights. Receiving areas are where extra development rights can be utilized to build more units than the area is zoned for. Often, receiving areas have a normal zoning limit without TDRs, and then more dense zoning limits with TDRs. The receiving areas and their zoning must generate sufficient demand to buy TDRs from sending areas. Without sufficient demand the price of TDRs will be low and few parcels will sell their development rights or they will receive little compensation. The larger the receiving area and the more desirable it is for development the greater the demand for TDRs. In addition, the area must have restrictive enough zoning so that landowners want to develop more than the usual zoning allows. If zoning in the receiving area already allows enough density for developers or variances are easy to obtain then demand for TDRs will be low (Johnston 1997). Some jurisdictions also waive certain permits or requirements in the receiving area with the purchase of TDRs.

For these reasons it is unlikely that a TDR program would work well within a single alluvial fan. It would be difficult to identify receiving areas that would generate enough demand for the TDRs, and there would be few transactions and preserved land. A TDR program to preserve alluvial fan land would work better if it encompassed a number of different fans, and even better if it included some other non-fan areas that are well-suited to receive TDRs because they have the infrastructure necessary to support additional density.

Some TDR programs work not by zoning, but an individual evaluation, usually by a public agency, of each parcel for its suitability to sell or buy development rights. The Santa Monica Mountains Coastal Zone TDR program uses this method. This is a more administratively complex method because it relies on individual lot assessment, but it is also more flexible than a broad based zoning approach that may not reflect the individual characteristics of each fan. The same market principles apply, though, in that the methodology to determine appropriate receiving areas must ensure that there is sufficient demand for TDRs.

Mandatory vs. Voluntary. Some TDR programs are completely voluntary, landowners are allowed to sell TDRs but can also develop according to current zoning rules. Other TDR programs are mandatory, the sending area is downzoned to limit development and landowners are allowed to sell the development rights they lose in the downzoning. The coupling of

downzoning and TDRs is suited for areas where it is critical that the area not be developed for public safety or other reasons. The TDRs can then serve as compensation for the landowners in these areas.
Allocation of development credits:

TDRs can be allocated based on the development potential of the parcel and its value in an undeveloped state (i.e. a combination of ecological, water supply/quality, public safety, and open space values.) The simplest scoring methods are based on acreage and zoning, i.e. if a 20 acre parcel is zoned for 1 du/5 acres, then, if the parcel is undeveloped, it could sell up to 4 TDRs. The Santa Monica Mountains Coastal Zone allocates one TDR for each buildable lot up to 20 acres and then another TDR for each additional 20 acres that is retired. A TDR program can also incentivize retirement by adding TDR credits for land that is particularly desirable in an undeveloped state. By giving these desirable parcels additional TDR credits the landowner has increased incentive to retire the land.

Market Institutions. Successful TDR programs have public agencies that actively work to ensure the smooth functioning of the TDR market. One function is to publicize and perform outreach to potential buyers and sellers to educate them on the TDR market. Frequently, TDR markets need to be started through an auction system where a public agency or non-profit either buys credits and sells them off to establish a market price, or sets up a market exchange to connect buyers and sellers of TDRs. Another market function is for a public agency to act as a buyer of last resort for TDRs. The Santa Monica Coastal Zone has taken this a step farther; under its program development is only allowed when the developer retires some land through the TDR program. However, developers are also allowed to pay an in-lieu fee that later is used to purchase TDRs.
A purchase of development rights program could be combined with, or operated independently of, a TDR program. Some of the decisions are similar, such as how to designate sending and receiving areas or parcels, and how to allocate development credits. A PDR program could operate in conjunction with a TDR program by negotiating to buy development rights from particularly desirable parcels while allowing the TDR market to function for other areas.

A PDR program could also stand alone, by buying development rights and retiring, rather than transferring them. As a stand alone program PDRs are similar to conservation easement purchase programs. This would be less expensive than outright land purchase where there are valuable non-development land uses. For example, agricultural land may retain significant value even after losing development rights.

Multiple-Benefit Valuation and TDR or PDR programs. A difficult element of land use decisions on alluvial fans is that some areas are likely to have their highest and best use as open space once a number of values are considered, but no single value (i.e. water supply) would justify keeping the land in open space. This poses a financing problem in that no single public

agency may have a financial incentive to purchase the land and it would be time-consuming and expensive to negotiate a multi-agency purchase for each parcel. However, a TDR or PDR program can facilitate the preservation of land in open space for multiple benefit uses by allowing agencies to contribute to a fund for the purchase of development rights for retirement or later transfer. For example, a water supply agency could set up a fund that would finance a percentage of the purchase of development rights for retirement or transfer in important recharge areas and the TDR market institutions could use this contribution to either subsidize the sale of these TDRs, or in conjunction with other contributions, to retire the development rights entirely. The Santa Monica Mountains conservancy has used the TDR program to target marginal parcels with high preservation values

Econ7: No Adverse Impact planning tools (formerly Econ 6)

As discussed in planning tool ECON 2, the key benefit of alluvial fan development is increased housing services and the attendant economic benefits. However, these benefits should be weighed against the costs that may be incurred not only on-site, but also on adjacent properties and others further downstream. Any development that is approved on alluvial fans should be done so with the objective of reducing adverse impacts upon other properties.

The Association of State Floodplain Managers (ASFPM) has proposed a series of No Adverse Impact (NAI) strategies of to reduce adverse consequences of floodplain development. The objectives of these strategies are to:

- Ensure that the actions of any community or property owner do not adversely impact others and
- Incorporate multi-objective and watershed planning principles.

NAI does not mean "no development" but rather that any adverse impact caused by a project must be mitigated, preferably based on a community or watershed-based plan.
The ASFPM has identified basic, better and NAI (i.e., the "best") strategies for these categories:

- Hazard identification,
- Education and outreach,
- Planning,
- Regulations and development standards,
- Mitigation,
- Infrastructure and
- Emergency services.

The benefits of adopting these strategies include:

- Reduce flood losses over time in your community,
- Reduce likelihood of your actions increasing flood damage to others,
- Reduce challenges and lawsuits,

- Receive recognition through the Community Rating System,
- Incorporate multiple objectives and
- Protect natural resources and values of floodplains.

For more information on the ASFPM NAI strategies, visit the ASFPM website at:
http://www.floods.org/home/default.asp

or the California Department of Water Resources Economics website (Comprehensive Floodplain Management Workshop) at:

http://www.economics.water.ca.gov/studies.cfm

Econ8: **Apply for bond funding for regional alluvial fan projects**
Editing note from Plenary 7
ECON7: tools may not be around in a couple of years. They are time sensitive (Allan 30)

- ECON7 can be part of ECON 4, and include where to find financial information, like agency web sites.
- Web site should have a list of funding sites. Funding fairs (Tom 29)

Bonds are time sensitive, so discussion of specific bonds is impractical in this report. However, to help the planner consider the range of options available generally, we provide examples of current bond fund opportunities. They include:

1) Proposition 1E Flood Corridor Protection Program
Reduce flood risk by implementing (1) non-structural projects including wildlife habitat enhancement or (2) avoiding damage by restoring biological processes in flood corridors

Eligible Applicants
- Local Public Agencies
- Non-Profit/Citizens' Groups

Funding
- $25 million in FY 2007-08 (Prop 84, §75032.5)
- $12.6 million in FY 2008-09 (Prop 84, §75032.5)
- Grant cap: $5 million per eligible project

2) Proposition 84 Chapter 3 Flood Protection Corridor Projects

Funding
- $40 million

3) Regional Flood Management Planning
Planning efforts to address flood management issues on a regional level
Funded planning efforts must be consistent with IRWM plans
Funding

- Up to $20 million
- To be managed in conjunction with IRWM planning grants

4) Urban Streams

Under this program put Eligible Applicants: local public agencies/non-profit groups

Funding: $18 million/grant cap $1 million per project (first funding anticipated in summer/fall 2008)

5) Subventions

Under this program put Eligible Applicants: Local public agencies

Funding: $100 million in FY 07-08 and $73.7 million in FY 08-09

6) Local Levee Assistance

Under this program put Eligible Applicants: Local public agencies. Two components: Local levee urgent repair (LLUR) and local levee evaluations (LOLE).

Funding: $40 million in FY 07-08 grant cap $5 million LLUR
$20 million in FY 07-08 grant cap $1 million LOLE
$10 million in FY 08-09 grant cap $1 million LOLE

More complete discussion of the funds available currently, as well as key agency web sites to consult for possible funding, can be found in the Implementation Report, Appendix 2.