

**Water Quality and Water Supply:
Protection and Enhancement
Methodology**

Forests and forestry practices can help protect, restore, and sustain water quality, water flows, and watershed health. Healthy urban and rural forested watersheds absorb rainfall and snow melt, slow storm runoff, recharge aquifers, sustain stream flows, and filter pollutants. Assessments should identify watersheds where continued forest conservation and management is important to the future supply of clean municipal drinking water, or where restoration or protection activities will improve or restore a critical water source. Resource strategies should include actions for managing and conserving these priority watersheds for water quality and supply, and other ecosystem services.

The objective of the two analyses is to identify high priority watersheds where continued conservation and management are important to future water supply and other beneficial uses. Primary water related assets are evaluated separately, but can be combined if needed. Threats to water resources are also evaluated. Areas with high assets and high threats are identified as priority watersheds.

About 40 percent of the state's developed water supply originates from the Sierra Nevada in the upland watersheds. Many factors in the headwater areas affect downstream water supply, water use, water quality, and flood management, and highlight the need for further coordination between upstream and downstream interests. Fire management, USFS Forest Management & timber harvest plans, and watershed & conservancy plans have major effects on upper watershed health and downstream river runoff.

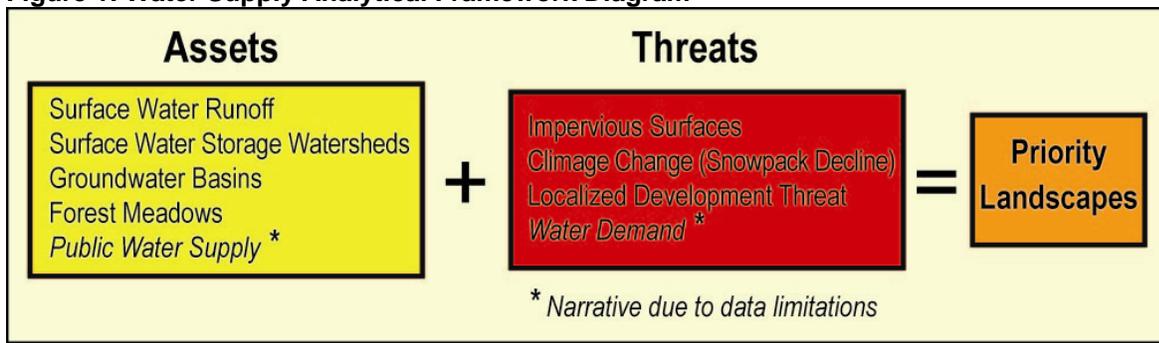
Analysis #1: Water Supply

The purpose of this analysis is to identify watersheds that serve as major sources of municipal water and are threatened by wildfire, development, and climate change.

WATER SUPPLY ANALYTICAL FRAMEWORK

The intersection of the highest assets to water supply and the greatest threats to water supply provide high priority landscape (HPL). For this analysis, four assets were combined to achieve the composite asset landscape. Three threats were also combined to create the composite threat landscape. Finally, the composite asset landscape and composite threat landscapes were intersected to produce the priority landscape (see figure 1).

Figure 1: Water Supply Analytical Framework Diagram



ASSET LAYERS FOR WATER SUPPLY

Contributing factors to water supply are the watersheds contributing to major reservoirs, the amount of surface water runoff, natural storage capacity via landscape features such as forest meadows and groundwater basins.

Asset #1: Water Storage Watersheds

Identify source watersheds supporting water supply by delineating the catchment area for major reservoirs in the state. The major reservoirs were taken from the Department of Water Resources list “Storage in Major Reservoirs” found at <http://cdec.water.ca.gov/cgi-progs/reservoirs/STORAGE>. The catchment areas were delineated using WBD watershed boundaries (<http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/>). Each reservoir serves as the “pour point” of the catchment. The value attributed to the catchment is the historic average stored in the watershed.

Much of the water storage in California is a system of reservoirs, such as on the American River of the Feather River. In these cases, the value attributed to the entire system catchment is the sum of the historic storage averages for all reservoirs within the system.

The water storage catchments were divided into high, medium, and low according to the following criteria, where acre feet are in 1000s:

- 3 (high) = 3,000 and greater acre feet historic annual storage
- 2 (medium) = 700 to 3,000 acre feet historic annual storage

1 (low) = 0.8 to 300 acre feet historic annual storage

After ranking the assets, a raster dataset was generated from the catchment areas with the state being covered by a 30x30 meter grid. Islands were excluded from the grid. The value assigned to the catchment areas in the 30m grid were ranks.

Asset #2: Runoff

Runoff was modeled using the Thornthwait water-balance program (<http://pubs.usgs.gov/of/2007/1088/>) using precipitation data from the PRISM climate mapping system (<http://www.prism.oregonstate.edu/>). The results of the model were a runoff estimate for every HUC 8 watershed in California.

The surface water runoff is an estimate of annual watershed runoff in mm/year. It is based on climate, land use, water use, and regulation data recorded from 1971 through 2000.

The WBD HUC8 watersheds were classed into three classes of surface water runoff meant to represent high, medium, and low amounts of runoff. For the purpose of identifying watersheds important to water supply, it was assumed that watersheds with high runoff generated the highest amount of water supply; watersheds with medium runoff generated a medium water supply; and watersheds with low runoff contributed a low amount to water supply.

The runoff estimates were broken into high, medium, and low as follows:

3 (high runoff, high asset value) = 351 – 2,909 (mm/yr)

2 (medium runoff, medium asset value) = 114 – 350 (mm/yr)

1 (low runoff, low asset value) = 10 – 114 (mm/yr)

After ranking the assets, a raster dataset was generated from the HUC8 watersheds using a 30 meter grid to represent the state. The value assigned to the grid was asset ranks.

Asset #3: Groundwater Basins

This asset identifies groundwater basins that contribute to water supply and determine high, medium, and low basin asset values.

Groundwater basins were delineated by California Department of Water Resources. Bulletin 118 describes groundwater resources and provides GIS data on groundwater basins: <http://www.water.ca.gov/groundwater/bulletin118/bulletin118update2003.cfm>.

The State Water Board provided information on level of groundwater use. Additional information was provided that identified vulnerable areas such as groundwater basins that are vulnerable to contamination. This information was provided from the Groundwater Ambient Monitoring and Assessment Program (GAMA): <http://www.swrcb.ca.gov/gama>.

Groundwater basins were ranked according to use and vulnerability.

3 (high) = high use basins that are also considered vulnerable to contamination

2 (medium) = high use basins that are not considered vulnerable to contamination

1 (low) = low use basins that are not considered vulnerable to contamination

Asset #4: Forest Meadows

Forest meadows function as a natural water storage device. The forest meadows asset layer was derived by extracting land cover types which describe forest meadow characteristics from the CALFIRE land cover/land use dataset and combining them with the US Forest Service dataset of montane meadows developed for the Sierra Nevada Forest Plan.

The land use/land cover dataset developed by CALFIRE and the US Forest Service in 2006 uses the California Wildlife Habitat Relationships system for identifying land cover types (<http://www.dfg.ca.gov/biogeodata/cwhr>) as well as the Anderson land use/land cover classification scheme (<http://landcover.usgs.gov/pdf/anderson.pdf>).

Forest meadows were defined by WHRTYPES

- 1) Wet Meadow
- 2) Annual Grassland
- 3) Fresh Emergent Wetland
- 4) Perennial Grassland

These types were limited to 4,000 feet and higher elevations. Furthermore, all Anderson land use types describing Urban or Built-up Land were discarded.

These areas were then added to the montane meadows layer developed for the Sierra Nevada Forest Plan:

(http://www.fs.fed.us/r5/rsi/projects/gis/data/calcovs/SNV_MontaneMeadowVeg.html).

Neither CALFIRE's land use/land cover dataset nor the US Forest Service dataset of montane meadows covered 16 HUC 12 watersheds in the northern part of Sequoia National Park. To fill this gap, herbaceous types were extracted from CALVEG tiles (EvegTile41B_00_v2 and EvegTile36A_01_03_v2).

The total area of forest meadow was summed by HUC12 watershed and the percent of forest meadow for each watershed was calculated. High, medium, and low asset values were assigned as follows:

3 (high asset value) = 2.4% and greater

2 (medium asset value) = 0.4% – 2.4%

1 (low asset value) = 0 – 0.4%

Composite Assets to Water Supply

The 30 meter grid of each asset was combined adding the ranks together to arrive at a final score. Water storage watersheds were weighted by 2 as they were deemed to contribute more directly and significantly to water supply.

The score was ranked to reflect high, medium, and low combined asset levels. The following criteria were used:

3 (high level) = combined score of 8 - 18

2 (medium level) = combined score of 4 - 7

1 (low level) = combined score of 1-6

THREAT LAYERS TO WATER SUPPLY

The threats to water supply examined in this analysis are impervious surfaces, projected development, and climate change. Development impacts water supply by increasing demand and through increased impervious surfaces. Through projected development we can also model future impervious surfaces. The impact of climate change on water supply varies by model, yet diminishing snowpack levels do appear to be directly related both to climate change and to decreased water availability.

Threat #1: Localized Development Threat

This threat identifies watersheds with threats from localized development. For additional information the reader is referred to the methods document for chapter T1.1, Development Impacts.

Threat#2: Impervious Surfaces

The impervious layer is an extract of the National Land Cover Database (NLCD) 2001 for California. The original data were produced through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium. <http://www.mrlc.gov/mrlc2k.asp>.

Ranks are as follows:

- 3 (high impervious surface, high threat) = > 70% impervious surface
- 2 (medium impervious surface, medium threat) = 30-70 % impervious surface
- 1 (low impervious surface, low threat) = 1 - 30% impervious surface

Threat #3: Climate Change (Snowpack Decline)

Changes in snowpack were evaluated using data from the GFDL climate model. The GFDL model predicts changes in climate based on a range of future emissions scenarios that were established by the Intergovernmental Panel on Climate Change's (IPCC's) Special Report on Emissions Scenarios (SRES). For this study the moderately high A2 emissions scenario was used. This scenario assumes that emissions continue to rise unabated at rate that is roughly four times the present rate of emissions (Cayan, 2006).

Snowpack was interpreted based on Snow Water Equivalent (SWE) data. SWE represents the amount of water contained in the snowpack. The rate of change in SWE was used to evaluate the expected decline in future snowpack.

Snow Water Equivalent was ranked based on the percentage of decline over time. The rate of decline was evaluated for two future time steps: 2010 to 2050 and 2050 to 2090. A 30 meter raster dataset was created for each scenario and ranked as follows:

- 3 (high threat) = 50 - 100% decline in SWE
- 2 (medium threat) = 0 - 50% decline in SWE

1 (low threat) = no expected loss

The ranked grids were combined into a single layer using a weighted sum. A higher weight was assigned to the grid in the first time period to represent a higher degree of certainty and expectation that these conditions are likely to occur. The following is the equation used to score the combined grid:

$$(\text{Grid_Time1} * .75) + (\text{Grid_Time2} * .25)$$

Cell values in the resulting grid are stored as integers with values ranging from 1 to 3 that correspond to low, medium, and high threat classes.

Composite Threat Layer

The four threat raster datasets were combined summing the ranks of each threat for a final score. The datasets were all combined equally with no weighting.

The resulting scores were ranked to represent high, medium, and low threat levels. The following criteria were used:

- 3 (high level) = combined score of 7 - 11
- 2 (medium level) = combined score of 4 - 6
- 1 (low level) = combined score of 1-5

PRIORITY LANDSCAPE FOR WATER SUPPLY

The overlay of the composite asset layer for water supply with the composite threat layer for water supply creates a Priority Landscape layer for water quality. The high priority landscape (HPL) identifies watersheds that are important sources of water supply and that coincide with high threats to water supply. This highlights areas where concern is necessary for maintaining watershed services important to water supply.

The combined threats raster and combined assets raster were combined, and ranks assigned using the following rule:

GRID1	GRID2	SCORE
1	1	1
2	1	2
3	1	3
1	2	2
2	2	2
3	2	3
1	3	3
2	3	3
3	3	3

Where:

- 3 = high priority landscape
- 2 = medium priority
- 1 = low priority

Data Used in This Analysis

The datasets used in this analysis are available at http://frap.fire.ca.gov/assessment2010/3.1_water.html. These are provided to document the analysis, and to provide the potential to replicate results. Updated versions of these datasets may be available from the various data providers.

Table 2: Data used in Water Supply Analysis

Analysis: Water Supply			
	Data theme	Dataset name	Purpose
THREATS			
	THREAT 1: Impervious Surfaces	thr_impervious09_1.gdb	Threat to water supply through Increased surface runoff, decrease infiltration, potential loss of water supply
Inputs	impervious surfaces	NLCD_Impervious09_1.gdb	Increased surface runoff, decrease infiltration, potential loss of water supply
	THREAT 2: Localized Development Threat	thr_developLOC09_11.gdb	Threat to water supply through increased population, water demand, and impervious surfaces
Inputs	EPA ICLUS	input_bhcs_iclus_ca.gdb	Potential future development
	County general plans	input_genplans_rr.gdb	Constraints on future development
	THREAT 3: Climate Change (Snowpack Decline)	thr_snowpack09_1.gdb	Used to depict loss in snowpack which will significantly deplete water supply
Inputs	Snowpack Decline from Climate Change Scenarios and Sea Level Rise Estimates for California, California Energy Commission	swe_gfdl_a2.gdb	Used to depict loss in snowpack based on the A2 emissions scenario using the GFDL global climate model.
ASSETS			
	ASSET 1: Surface Water Runoff	ast_runoff09_1.gdb	Asset depicting amount of available surface water
Inputs	Mean Annual Water Runoff by HU8	hucrunave.xls	Thornthwaite water balance model predicting runoff based on temperature and precipitation using PRISM climate data
	NRCS HU8 Watershed Boundaries	WBD.gdb	Used to spatially depict data
	ASSET 2: Surface Water Storage Watersheds	ast_water_storage09_3.gdb	Used to measure areas that contribute to water supply in major reservoirs.
Inputs	NRCS Watershed Boundaries	WBD.gdb	Used to delineate catchments
	National Inventory of Dams	NID_CA.mdb	Used to locate storage facilities

	Department of Water Resources monthly reservoirs storage levels	dwr_runoff_data.xls	Used to attribute water supply amounts stored in reservoirs
ASSET 3: Groundwater Basins		ast_groundwaterbasin09_1.gdb	Asset used to depict available groundwater supply
Inputs	Groundwater basins vulnerable to pollution	hydro_vulnerable_areas.gdb	Used to depict sensitive groundwater areas
	High use groundwater basins	high_use_gdwtr.gdb	Used to depict high use groundwater basins
	Low use groundwater basins	low_use_gdwtr.gdb	Used to depict low use groundwater basins
ASSET 4: Forest Meadows		ast_huc12_forstmdws09_1.gdb	Asset used to depict forest and range areas with natural ability to filter water
Inputs	Sierra Nevada Montane Meadows	SNV_MontaneMeadowVeg	Used to depict sierra nevada montane meadows
	Vegetation Types	input_fveg06_2.gdb	Used to depict vegetation types in sierra nevada montane meadows
	Watershed Boundaries	WBD.gdb	Used to generalize to HU12 level
Priority Landscape			
	PL:Water Supply	pl_t31_a209_2.gdb	Priority landscape for water supply
Other data			
	Watershed Boundaries	WBD.gdb	HU8, HU10, and HU12 used in analysis
	Hydro Regions	WBD.gdb	Subregions

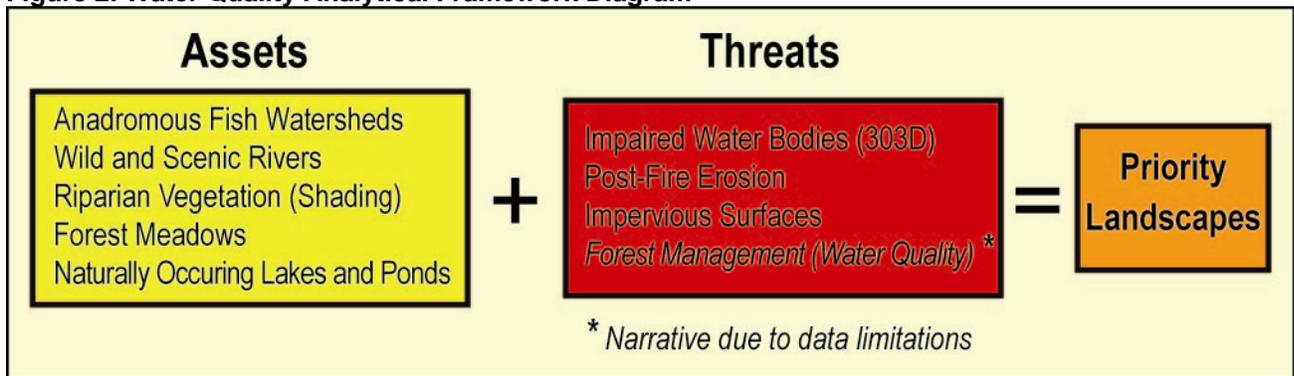
Analysis #2: Water Quality

The goal of the analysis is to identify priority landscapes where watersheds important to water quality are threatened by water quality threats.

WATER QUALITY ANALYTICAL FRAMEWORK

In this analysis, beneficial uses are used to represent assets to water quality. Five assets are combined to create a composite landscape of assets to water quality. Four threats are combined to create a composite landscape of threats to water quality. Finally, the composite asset and composite threat are intersected to create a priority landscape.

Figure 2: Water Quality Analytical Framework Diagram



Asset #1: Anadromous Fish Watersheds

This dataset depicts the current range of anadromous salmonids in California by Evolutionary Significant Unit (ESU) as defined by the National Marine Fisheries Service (NMFS). The three species represented are Coho, Chinook, and Steelhead. The ESUs have been improved to coincide with HU8 watershed boundaries. This dataset also depicts the historic range of anadromous salmonids in California modeled by NMFS using a variety of environmental factors meant to depict the intrinsic potential (IP) of salmonids to inhabit any certain spatial extent. (see <http://swfsc.noaa.gov/publications/FED/00425.pdf> for details).

It is inferred that areas with existing anadromous populations are of the greatest importance. Intrinsic potential of salmonid populations ranges are also important in terms of potential for restoration. For this assessment, the ESUs were given the highest rank for importance to water quality and IP was given a medium rank.

- 3 (high asset) = ESU;
- 2 (medium asset) = intrinsic potential model (IP).

Asset #2: Wild and Scenic Rivers

Watersheds that contain Wild and Scenic Rivers contain a range of beneficial uses including recreation and fish habitat. The GIS layer was developed based on the intersection of WBD watershed boundaries at the Hydrologic Unit 8 scale and Wild and Scenic Rivers (see http://www.fs.fed.us/r5/publications/water_resources/html/wild_scenic_rivers.html and

<http://www.friendsoftheriver.org/site/PageServer?pagename=FORCaliforniaWildScenic> for details. If any portion of a HU8 watershed contained a wild and scenic river, the entire watershed was attributed as wild and scenic. All wild and scenic watersheds received the highest asset rank, while all others received no rank.

3 (high asset) = HU8 watersheds that contain and support a wild and scenic river;
0 (no asset) = watersheds with no wild and scenic river.

Asset #3: Riparian Vegetation Cover

Intact riparian areas with tree cover support a variety of beneficial uses. Shade covering the streams moderates temperatures, creating better habitat for fish and insects. A healthy riparian area also contributes wood debris to streams, creating habitat for a variety of species.

Riparian areas were derived through a combination of the National Hydrography Dataset (NHD) and National Land Cover Dataset (NLCD). The NHD was used to locate streams and waterbodies. Perennial streams and waterbodies received a buffer of 100 meters while intermittent streams and waterbodies received a buffer of 50 meters (similar to USFS buffers in both the Northwest Forest Plan and the Sierra Nevada Plan).

The buffered hydrology was then intersected with percent canopy cover from the NLCD. This provides a riparian area with percent cover for all perennial and intermittent streams and waterbodies in California. The percent cover was grouped into three classes for non-desert streams, indicated high, medium, and low canopy cover for non-desert areas. A different class grouping was used in desert areas to more appropriately reflect arid and semi-arid conditions. The following groups were used to determine high, medium, and low ranks for riparian canopy cover in NON DESERT AREAS of California:

3 (highest asset) = 70 - 100 percent cover;
2 (medium asset) = 40 - 70 percent cover;
1 (lowest asset) = 1 - 40 percent cover;
0 (no asset) = 0 percent canopy cover.

The following groups were used to determine high, medium, and low ranks for riparian canopy cover in DESERT AREAS of California:

3 (highest asset) = 50 - 100 percent cover
2 (medium asset) = 25 - 50 percent
1 (low asset) = 1 - 25 percent
0 (no asset) = 0 percent cover

Asset #4: Forest Meadows

Forest meadows trap and filter sediments, improving downstream water quality. They also serve as natural storage devices, regulating flows and preventing erosion caused by storm events.

Forest meadows were extracted and created by combining three different data sets. First, CALFIRE's forest vegetation (fveg06_1) was used and herbaceous WHRTYPES equal to and above 4,000 feet were extracted using a 30 meter DEM for elevation. WHRTYPES included wet meadow, annual grassland, fresh emergent wetland, perennial grassland. Second, USFS

montane meadow data was used from their Sierra Nevada Forest Plan database (Please see http://www.fs.fed.us/r5/rsi/projects/gis/data/calcovs/SNV_MontaneMeadowVeg.html for more information on the USFS montane meadow dataset). All meadows from this dataset were used. Neither the forest vegetation (fveg) nor the USFS Sierra Nevada meadows dataset mapped meadows in the 16 HU12 watersheds in the northern part of Sequoia National Park. To map the meadows here, USFS CALVEG data was used. Herbaceous types were extracted at or above 4,000 feet.

The three data sources were then combined. The meadows data layer was then summarized by WBD HU12 watersheds. Ranks were assigned by classifying the percent of each watershed that was forest meadow.

3 (high asset) = 2.4 and greater percent of HU12 is montane meadow;
2 (medium asset) = 0.4 to 2.4 percent of HU12 is montane meadow;
1 (low asset) = >0 to 0.4 percent of HU12 is montane meadow.
0 (no asset) = 0 percent montane meadow.

Asset #5: Naturally Occurring Lakes and Ponds

Any natural lake provides an assortment of beneficial uses, providing the surrounding landscape remains ecologically sound. In addition to wildlife habitat, natural lakes allow sediments to settle out of turbid flows, they recharge groundwater, they are carbon sinks, and they provide abundant recreational opportunities such as fishing, wildlife viewing, boating, and if you're a complete idiot, paddle boarding.

Natural lakes are a subset of the National Hydrography Dataset (NHD). They were created by limiting the waterbodies dataset to FTYP 390, lakes and ponds. Furthermore, all lakes and ponds which were known to be constructed were omitted. All natural lakes were given the highest asset rank of 3.

3 (high asset) = all natural lakes;
0 (no asset) = all else.

Composite Assets to Water Quality

The 30 meter grid of each asset was combined adding the ranks together to arrive at a final score. Anadromous watersheds were weighted by 2 as they were assumed to be the most sensitive indicator of water quality.

The score was ranked to reflect high, medium, and low combined asset levels. The following criteria were used:

3 (high level combined asset) = combined score of 8 - 18
2 (medium combined asset) = combined score of 4 - 7
1 (low level combined asset) = combined score of 1-6

THREAT LAYERS TO WATER QUALITY

Pollutants are the greatest threat to water quality. This analysis uses the USEPA 303(d) list to produce a spatial data layer depicting pollutants. Sediment is listed as a pollutant on the 303(d) list. However, a variety of events can accelerate erosion rates, creating erosion events. This analysis uses a model of post-wildfire erosion rates as such a threat. Finally, the built environment can both increase surface water pollution and decrease the percolation capacity of the soil, thus its ability to filter sediment and chemical pollutants. This analysis uses two datasets to depict the effects of the built environment as threats.

Threat #1: Impaired Waterbodies (303(d))

This dataset sums the POTENTIAL SOURCES for listing a waterbody on the US EPA's 303(d) list by WBD HU10 watershed. The spatial data (lines representing streams and polygons representing bays, estuaries, lakes, etc.) was obtained from the California State Water Quality Control Board and contains all streams listed on the 303d list. These GIS layers were joined to a table (also from the California State Water Quality Control Board) that lists all impaired water bodies, the pollutant for which they are listed, and the potential source of that pollutant in a waterbody.

The sources used in this analysis (SRC_CAT in the regional water quality control board tables) are as follows: agriculture, atmospheric deposition, groundwater, construction and development, habitat modification, hydromodification, industrial wastewater, land disposal, marina and recreational boating, miscellaneous, municipal wastewater, natural sources, other runoff, resource extraction, silviculture, source unknown, unspecified non-point, unspecified point source, and urban runoff.

Each water body was intersected with a HU10 watershed. The number of causes per watershed was then summed. It was assumed that a greater number of threats implied a greater threat to water quality

The ranking is as follows:

- 3 (highest threat) = 9-14 sources of pollutants;
- 2 (medium threat) = 5-8 sources of pollutants;
- 1 (low threat) = 1 -4 causes of pollutants;
- 0 (no threat) = no listed water bodies.

Threat #2: Post-Fire Erosion

This data is derived from the post-fire erosion (PEROD04_1) data set generated by CALFIRE and resampled from 90 meters to 30 meters. It represents FRAP's best estimate of the Revised Universal Soil Loss Equation (RUSLE) in a post-wildfire environment. FRAP adapted RUSLE, used for agricultural soil loss, for wildland post-fire erosion based on the interaction of fire threat (FTHRT04_1) and vegetation (FVEG02_2) cover.

The equation to model post-fire erosion in this data set was developed for detachment capacity limited erosion in fields with negligible curvature and no deposition. It represents soil loss averaged over time and total area. The equation has the following form (Wischmeier and Smith 1978, Renard et al. 1991):

$A = R * K * L * S * C * P$, where:

A [ton/acre/year] is estimate average soil loss

R [Erosion Index units/year] is rainfall-runoff erosivity factor

K [tons/acre/unit R] is soil erodibility factor (source data STATSGO)

LS [dimensionless] is topographic (length-slope) factor (Moore and Burch 1986, Van Remortel et al. 2001)

C [dimensionless] is coverage factor, and

P [dimensionless] is prevention practices factor.

FRAP estimated the coverage factor (C) for post fire conditions by examining the relationship of major land cover types (WHR10NAME) and WHR density classes (WHRDENSITY) from the FRAP Multi-source Land Cover data set (v02_2) crossed with wildfire fuel rank (FUEL_RANK) from the FRAP Fire Threat (v04_1) data set. For example, areas with low vegetative cover and high fuel rank (high fuel rank indicates intense fires that can remove a large proportion of the cover) receive higher values. Areas of high cover and low fuel rank receive lower values, because after fire, a higher proportion of their original cover will remain. FRAP found that the coverage factor (C) had the greatest influence on the total erosion value so slight variations in C can produce very different results. FRAP researched the literature to find the best empirical measures of C in undisturbed and disturbed landscapes yet the values of C used in this model are still no better than rough estimates (Lopez et al. 1998, Dissmeyer and Foster 1981, 1980).

Rainfall intensity data (R) is the 2-year, 6-hour amount and comes from the NOAA Atlas 14, Volume 1, Version 3 estimates for Southeastern California (sa2yr06ha) and Atlas 2, Volume XI for the rest of the State (na2_ca_2yr6hr) (see <http://www.nws.noaa.gov/oh/hdsc>). These two datasets did not align properly and an ArcInfo GRID NIBBLE process was used to fill the gaps. Soil erodibility (K) is derived from the STATSGO soil dataset attribute KMEAN. The topographic length-slope factor (LS) was calculated using Van Remortel, Hamilton and Hickey's (2001) algorithm (rusle_ls_4_unix.aml, ver. 4, 12/18/2003) (see <http://www.yogibob.com/slope/slope.html>) on the elevation data set DEM9099_1.

FRAP did not include prevention practices (P) in the calculation of post-fire erosion potential. Because the RUSLE was developed for use in agricultural fields it has not been as extensively tested in natural land over landscapes.

Caution is also urged because this model does not reflect many other sources of erosion in the landscape, such as roads, agricultural practices, or other disturbances that expose bare ground to the effects of rainfall. These data can only be used to indicate the portion of erosion potential that comes from the direct effects of wildland fire on the landscape, and not any other factors.

For this analysis, the resulting soil loss estimates from the post-fire erosion model were grouped into 3 erosion classes based on A (tons/acres/year):

3 (high threat) = 51 to 1981 estimated tons/acres/year soil loss;

2 (medium threat) = 9-50 estimated tons/acres/year soil loss;

1 (low threat) = 1 – 8 estimated tons/acres/years soil loss'

0 (no threat) = no estimated loss.

Threat #4: Impervious Surfaces

The impervious layer is an extract of the National Land Cover Database (NLCD) 2001 for California. The original data were produced through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium. <http://www.mrlc.gov/mrlc2k.asp>.

Ranks are as follows:

- 3 (high impervious surface, high threat) = > 70% impervious surface
- 2 (medium impervious surface, medium threat) = 30-70 % impervious surface
- 1 (low impervious surface, low threat) = 1 - 30% impervious surface

Composite Threats to Water Quality

The four threats to water quality raster datasets were combined summing the ranks of each threat for a final score. The datasets were all combined equally with no weighting.

The resulting scores were ranked to represent high, medium, and low threat levels. The following criteria were used:

- 3 (high level) = combined score of 5-9
- 2 (medium level) = combined score of 3-4
- 1 (low level) = combined score of 1-2
- 0 (no threat) = combined score of zero.

PRIORITY LANDSCAPE FOR WATER QUALITY

The overlay of the composite asset layer for water quality with the composite threat layer for water quality creates a Priority Landscape layer for water quality. The high priority landscape (HPL) identifies watersheds that support a broad range of beneficial uses and that coincide with high threats to water quality. This highlights areas where stewardship projects are most needed to protect and enhance water quality.

The combined threats raster and combined assets raster were combined, and ranks assigned using the following rule:

GRID1	GRID2	SCORE
1	1	1
2	1	2
3	1	3
1	2	2
2	2	2
3	2	3
1	3	3
2	3	3
3	3	3

Where:

3 = high priority landscape, 2 = medium priority, and 1 = low priority

Data Used in This Analysis

The datasets used in this analysis are available at http://frap.fire.ca.gov/assessment2010/3.1_water.html. These are provided to document the analysis, and to provide the potential to replicate results. Updated versions of these datasets may be available from the various data providers.

Table 1: Data used in Water Quality Analysis

Analysis: Water Quality			
	Data theme	Dataset name	Purpose
THREATS			
	THREAT 1: Impaired Waterbodies	thr_impaired_wtrbdy09_1.gdb	Used to depict water quality impairments by summarizing all EPA 303(d) listed streams per HU8 watershed
Inputs	HU8 NRCS watersheds	WBD.gdb	Used to summarize 303(d) listing by watershed
	All waterbodies listed on 303(d) list	input_303d_water.gdb	Used to depict impaired waterbodies
	Pollutants for which waterbodies are listed	pollutants.xls	Used to attribute impaired waterbodies
	THREAT2: Post-Fire Erosion	thr_erosclass09_1.gdb	Threat to water quality from erosion following wildfire
Inputs	Post-Fire Erosion Potential	perod04_1.gdb	Used to model erosion after a wildfire
	THREAT 1: Impervious Surfaces	thr_impervious09_1.gdb	Threat to water quality through lack of percolation and increased pollutant runoff
Inputs	impervious surfaces	NLCD_Impervious09_1.gdb	Used to depict areas with lack of percolation and potential pollutant runoff
ASSETS			
	ASSET 1:Anadromous Fish Watersheds	ast_anadromous09_1.gdb	Asset depicting salmonid habitat as a beneficial use
Inputs	Evolutionary Significant Units for Coho, Chinook, and Steelhead	ESU.gdb	Used to depict areas with distinct salmonid habitat
	Intrinsic Potential Model for salmonid habitat	IP_Model.gdb	Used to depict areas with potential salmonid habitat which are currently obstructed by passage barriers.
	NRCS HU8 Watershed Boundaries	WBD.gdb	Used to summarize habitat by HU8

ASSET 2: Wild and Scenic Rivers		ast_wsr09_1.gdb	Asset depicting protected, free-flowing rivers.
Inputs	Wild and Scenic Rivers	wsr_08_dfg.gdb	Used to depict rivers within the National Wild and Scenic Rivers System.
	NRCS Watershed Boundaries	WBD.gdb	Used to generalize to HU8 level.
ASSET 3: Riparian Vegetation		ast_riparian_cover09_1.gdb	Asset depicting riparian quality
Inputs	National Hydrography Dataset	NHD11005_CA_Albers83.gdb	Used to depict waterbody locations
	Percent Canopy Cover	NLCD_Percent_Canopy.gdb	Used to depict amount of riparian forest as a proxy for riparian quality
ASSET 4: Forest Meadows		ast_huc12_forstmdws09_1.gdb	Asset used to depict meadows
Inputs	Sierra Nevada Montane Meadows	SNV_MontaneMeadowVeg	Used to depict Sierra Nevada montane meadows
	Vegetation Types	input_fveg06_2.gdb	Used to depict meadow vegetation types
	NRCS Watershed Boundaries	WBD.gdb	Used to generalize to HU12 level
ASSET 5: Naturally Occurring Lakes and Ponds		ast_natlakes09_1.gdb	Asset depicting natural lakes and ponds
Inputs	National Hydrography Dataset	NHD11005_CA_Albers83.gdb	Used to depict natural lake and pond locations
Priority Landscape			
	PL:Water Quality	pl_t31_a109_1.gdb	Priority landscape for water quality
Other data			
	Watershed Boundaries	WBD.gdb	HU8, HU10, and HU12 used in analysis
	Hydro Regions	WBD.gdb	Subregions

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Data and Analysis Limitations

Data Element ¹	Date	Source	Purpose	Currency ²	Completeness	Detail	Consistency	Relevance	Limitations
Surface Runoff	2009	USGS	Estimate mean annual runoff	F	G	F	G	E	Does not represent variability
Reservoir Storage	2009	DWR	Average storage by major basins	E	G	G	G	G	
Groundwater	2009	DWR; SWRCB	Represent groundwater asset	G	F	P	G	E	Lacks information on volume or condition of aquifer
Forest Meadows		FRAP; USFS	Supports water supply & water quality	F	F	F	P	E	Lacks information on quality or environmental condition
Salmon Watersheds	2009	NOAA	fish & other beneficial uses	G	G	F	F	F	Used as a proxy for beneficial uses
Wild & Scenic Rivers	2009		Recreation & other beneficial Uses	F	G	F	G	E	Does not measure condition
Riparian Cover		USGS	Identify streamside canopy cover	G	E	F	G	E	Based on USGS National Land Cover Data; coarse representation of riparian forest stands

Impaired Waterbodies	2006	SWRCB	Identify watersheds with known water quality impairments	G	G	F	F	E	Criteria for listing waterbodies may vary among regional water boards
Development	2003	FRAP	Represent threat from future development	F	E	F	E	E	Based on 2000 census, needs updating
Imperviousness	2009	EPA	Limit to groundwater recharge	G	G	F	G	E	Coarse; based on Landsat data
Snowpack	2009	CEC / Scripps	Represent expected decline in snowpack	E	G	P	G	E	coarse grid cells may not support finer scale analysis
Post-Fire Erosion	2003	FRAP	Estimate areas with high erosion potential	F	E	G	E	G	A basic model that lacks validation

1. Other data inputs required to create the above datasets or used as a reporting metric include fire perimeters, vegetation, land ownership.

2. E = Excellent; F = Fair; G = Good; P = Poor