UPPER CLEAR CREEK
SEDIMENT BUDGET

Prepared by the
Western Shasta Resource Conservation District

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INTRODUCTION

The Upper Clear Creek Watershed covers approximately 200 square miles of mostly mountainous terrain upstream of Whiskeytown Dam. The watershed lies immediately east of the Shasta-Trinity County boundary, and the eastern-most part lies about six miles west of the City of Redding. Elevations in the upper watershed range from 6,209 feet at the top of Shasta Bally to about 976 feet at the Whiskeytown Dam spillway. Clear Creek is part of the Upper Sacramento River Basin, and is an important tributary of the Sacramento River.

The Upper Clear Creek Watershed lies within the Klamath Mountains geological province, which is made up of a number of arcuate, concentric lithic belts separated by faults, and by linear ultra-mafic bodies, and granitic plutons. The geologic formations found within the Upper Clear Creek Watershed include sedimentary, metasedimentary, and volcanic rocks that are paleozoic in age and range from Middle Devonian to Mississippian.

Soils in the Upper Clear Creek Watershed have developed atop this bedrock geology over time due to physical, chemical, and biological factors that influence the parent rock material. Shallow soils are found atop narrow ridges and steep hillsides where weathering and erosion processes are active, while deep soils are found in areas of lowlands and rolling hills, where soil formation and accumulation outpaces erosion processes.

The steep and rugged topography and the faulted and fractured condition of the metasedimentary and other metamorphic rocks that cover most of the area make these soils susceptible to erosion. Exposed granitic rock, such as that on the Shasta Bally batholith and Mule Mountain Stock, also decomposes relatively quickly due to a lack of overburden pressure and relatively rapid weathering at surface temperatures and pressures.

SOILS IN THE WATERSHED

The following soils information was obtained from the *Upper Clear Creek Watershed Analysis, Shasta County California*, prepared for Western Shasta RCD by Tetra Tech, Inc. April 1999. Information on the soils found in the upper Clear Creek watershed have been gathered from the *Shasta County Soil Survey* (USDA, Soil Conservation Service 1974), Forest Service (USFS) *Soil Resource Inventory Report for the Shasta-Trinity National Forest* (Forest Service 1982), the Forest Service report *Soils and Vegetation of the French Gulch Quadrangle* (Mallory et al. 1973), and GIS data obtained from the State Soil Geographic (STATSGO) database developed by the National Cooperative Soil Survey (USDA, NRCS). The Shasta County Soil Survey describes soils found within the Whiskeytown National Recreation Area (WNRA), administered by the National Park Service (NPS), and the ISRMA and WFGMA, administered by Bureau of Land Management (BLM). The USFS Soil Resource Inventory describes soils found within the Shasta-Trinity National Forest, administered by the USFS. Soils and vegetation associations described by Mallory et al. (1973) cover only the lower half of the upper watershed south of Highland Ridge (near Five Mile Gulch) and Shirttail Peak (near East Fork of Clear Creek), and so are used to further describe soils and vegetation associations found within BLM and NPS lands.

Table 1
Main Soil Types found in the Upper Clear Creek Watershed

Soil Series	Percent Slope	Parent Material	Depth to Bedrock (inches)	Drainage	Permeability	Soil K Factor	Erosion Hazard
Mountain Soils							
Auberry	3-70	Gr	30-60	G	M		H-VHS
Chaix (and Chawanakee)	8-70+	Gr	18-60	G-E	MR		H-VH
Corbett	0-70+	Gr	24-60+	E	R		VH
Holland	0-70+	Gr	24-72+	G	M		H
Josephine	0-70	SS/SH	30-60+	G	M		M
Kanaka	0-70	Gr	20-40+	E	MR		H-VHS
Marpa	0-70+	SH/SS	20-40	G	M		M
Maymen	0-70+	SS/SH	4-20	E	M-R		M-HS
Stonyford	8-70	Mi/s	12-28	G-E	M-S		M-H
Sheetiron	30-70	Ms	21-42	G-E	M		M
Sites	0-70	Ms	36-60+	G	M		M
Skalan	40-60	M	40				L
Hugo	40-60	Mi/s	68				M
Deadwood	40-60	M	17				L
Etsel	40-80	SH	12				M
Skymor	40-80	Mi	17-19				L
Foothill Soils							
Auburn	8-70	Sch/Mi/s	10-28	G	M		M
Boomer	0-70	Mi	30-56	G-E	M-MR		M-HS
Goulding	8-70+	Mi	8-25	G-E	M		M-HS
Kidd	30-70+	Rhy	5-18	G-E	M-R		H-VHS
Neuns	0-70+	Mi	20-40	G-E	M		M-H
Terrace Soils							
Churn	0-30	Al	60+	G-MG	S-M		L-M

Parent Material: Gr: granitic; M: metamorphic; i: igneous; s: sedimentary; SS: sandstone; SH: shale; Sch: schistose; Rhy: rhyolitic; Al: alluvium
Drainage: G: good; E: excessive; M: moderate; MG: moderately good
Permeability: M: moderate; MR: moderately rapid; R: rapid; S: slow
Erosion Hazard: L: low; M: moderate; H: high; VH: very high; S: on slopes over 50 percent.

Mountain Soils
Mountain soils are found on nearly 124,450 acres, or 77 percent, of the upper Clear Creek watershed. Mountain soils include well-drained to excessively well-drained sandy loams, gravelly loams, and gravelly clay loams, formed from granitic and metamorphic rocks. Weathering of metamorphic and sedimentary rocks occurs along fractures and cleavage planes of structurally weak and less resistant clay layers. Weathering of these rocks leads to highly erosive tallus slopes and fine-grained sediment with a high clay content. Weathering of granitic rocks in the current climate regime of the area produces coarse textured particles with low clay content. These soils are friable and crumble easily, creating loose, unconsolidated sediment susceptible to erosion by wind and water. Mountain soils are generally found on moderate to steep to very steep slopes at elevations that range from 800 to 5,000 feet. Fire control on mountain soils is difficult because soils are steep and slopes are irregular. Weathered granite soils are found in the area of Shasta Bally and the Mule Mountain Stock in the southern end of the upper water-watershed, while the other mountain soil associations are found mainly north and west of the Willow Creek confluence.

The following gives a brief description of the different mountain soil associations found in the upper Clear Creek watershed (unless otherwise noted, descriptions have been taken from the Shasta County Soil Survey):

The Josephine-Marpa-Sheetiron association (JMSA)
JMSA is characterized by moderate to steep slopes, well-drained and somewhat excessively drained gravelly and very gravelly loams and clay loams underlain by sedimentary and metamorphic rocks of sandstone, shale and slate. The JMSA is made up of 30 percent Josephine, 25 percent Marpa, 15 percent Sheetiron, and 30 percent other (including Maymen and Sites) soils. JMSA soils are generally 18 to 60 inches deep, are found on hilly to very steep terrain, and have moderate erosion potential. These soils are mainly used for timber production; vegetation includes conifer-hardwood communities (including Douglas-fir, pine, oak and shrubs). Other uses include mining, recreation, wildlife habitat, and watershed.

Chaix-Corbett association (CCA)
The CCA is characterized by gently sloping to very steep, well-drained to excessively drained sandy loams and loamy coarse sands underlain by granitic rocks. The CCA is made up of 45 percent Chaix, 25 percent Corbett, and 30 percent other (including Holland and Kanaka) soils. CCA soils are generally 18 to 40 inches deep, are found on rough terrain in narrow valleys and ridgetops, and have high to very high erosion potential. These soils are generally used for timber production, wildlife habitat, and watershed; vegetation on these soils is mainly trees (including Ponderosa pine, Douglas-fir, white fir, and oak) with an understory of shrubs and a sparse cover of brush or grass.

Maymen-Stonyford association (MSA)
The MSA is characterized by steep and very steep, somewhat excessively drained and well-drained gravelly loams and gravelly clay loams underlain by sedimentary, metamorphic, and metamorphosed basic rocks of sandstone, shale, conglomerate, schist, and greenstone. The MSA is made up of 50 percent Maymen, 35 percent Stonyford, and 15 percent other (including Rockland, Boomer, Neuns, and Goulding) soils. MSA soils are generally 6 to 20 inches deep, are found on the sides of steep and very steep, entrenched valleys and narrow ridgetops, and have a moderate to high erosion potential. MSA soils are vegetated with chaparral made up of brush, a sparse understory of grass, and shrubs dominated by chamise and ceanothus, which when burned readily regenerate from subaerial root systems and cover the surface within a few years. These soils provide only a small amount of forage for livestock and so are generally used for watershed.

Neuns-Deadwood-Kindig families (NDKF)
The NDKF (as described in the FS Soil Resource Inventory) is characterized by gentle to steep slopes, well-drained gravelly loams and gravelly clay loams formed from metamorphosed shale. The NDKF is made up of 50 percent Neuns, 25 percent Deadwood, and 25 percent other (including Kindig and Marpa) soils. NDKF soils are generally 17 to 40 inches deep, are found on simple, steep to very steep, moderately to highly dissected mountain side slopes with sharp ridges, and have a low to moderate soil erosion potential. These soils are generally used for timber production, wildlife habitat and watershed; typical vegetation on NDKF soils includes Douglas-fir-Pine mixed conifer forest and mixed conifer-Canyon Oak forest.

Woodseye-Smokey-Nanny association (WSNA)
Neither the Woodseye nor Smokey soil series is described in the Shasta County Soil Survey or the FS Soil Resource Inventory. The Nanny soil series is described in the FS Soil Resource Inventory (1982) and is characterized by moderate slopes, fine-grained sandy loams to gravelly and cobbly sandy loams that are underlain by slightly acid gravels and cobbles. These soils are generally 20 to 60 inches deep, are found on the lower slopes of simple, shallowly dissected, steep to very steep mountainsides and along steep to very steep, rough to craggy ridges, and have a low erosion potential. Typical vegetation found on these soils includes mixed coniferous forest, white fir forest and upper montane mixed chaparral.

Foothill Soils
Foothill soils cover 25,681 acres, or 20 percent, of the upper watershed. Within the upper watershed, foothill soils of the Auburn-Goulding-Neuns association (AGNA) are found on rolling to steep hillsides at elevations generally below 3,000 feet. They occupy about 18,390 acres north, south and west of Whiskeytown Reservoir, and 7,291 acres along the mainstem Clear Creek (between French Gulch and Whitney Gulch), and the East Fork

Clear Creek. The following is a brief description of the foothill soils found in the upper Clear Creek watershed:

Auburn-Goulding-Neuns association (AGNA)
The AGNA is characterized by flat to very steep, well-drained gravelly loams, clay loams, and very gravelly silty clay loams underlain by partly metamorphosed volcanic rocks and fractured greenstone. The AGNA is made up of 30 percent Auburn, 30 percent Goulding, 15 percent Neuns and 25 percent other (including Boomer, Diamond Springs) soils. AGNA soils are generally 12 to 40 inches deep, are found on sides of narrow valleys in upper elevations and broad valleys in lower elevations, and have moderate to high soil erosion potential.

Terrace Soils
Terrace soils make up a minor portion of the upper Clear Creek watershed. They are found along the mainstem Clear Creek between Big Gulch and the Willow Creek confluence. Terrace soils found in the upper watershed include Anderson, Churn, Newton, Red Bluff, and Redding soil series. Anderson and Churn soils are moderately well-drained to somewhat excessively drained gravelly sandy loams and gravelly loams. They occur on low terraces between the alluvial floodplain and high terraces and were formed from recent alluvium of mixed sources. Newton, Red Bluff and Redding soils are well-drained and moderately well-drained gravelly and stony loams formed from older alluvium of mixed sources. Newton soils are found on moderately sloping to steep sides of terraces, Red Bluff soils are found along terrace tops, and Redding soils, which have a hardpan of indurated gravel about 13 inches below the surface, are found on high hummocky terraces.

Miscellaneous Land Types

Tailings and Placer Diggings
This land type occurs in areas that have been mined for gold by placer mining or dredging. Within the upper watershed, tailings and placer diggings occur along the East Fork Clear Creek tributary and the mainstem Clear Creek between the East Fork and the Willow Creek confluence. Dredge tailings occur on floodplains and low terraces, while placer diggings occur on high terraces. Dredge tailings are usually long, parallel steep ridges of cobbles and gravels separated by narrow troughs that may fill with water in the winter. Ridges are often bare, but troughs may contain sparse stands of cottonwood and willow. Placer diggings are irregular, random piles of cobbles and gravelly alluvium generally three to eight feet high. The height of the diggings and alluvial banks can become very steep and can reach 15 to 60 feet high. Vegetation on placer diggings is usually dense and can include manzanita, poison oak, ceanothus, interior live oak, and Grey pine.

Colluvial Land

This land type consists of gravels and cobbles that accumulate at the base of steep slopes from the draw of gravity. Within the upper watershed, colluvial land is found in long narrow tracts along the canyon bottoms of most of the Clear Creek tributaries (including Big Gulch, Dodge Creek, Fivemile Gulch, East Fork, French Gulch, Cline Gulch, Trail Gulch, Sawpit Gulch, Willow Creek, Grizzly Gulch, Boulder Creek and Crystal Creek). Colluvial soils occur perennial and intermittent tributaries and are subject to continuous or frequent flooding, depending on the flow conditions. Colluvium can consist of granite, metamorphic, and sedimentary rock, depending on the bedrock source. Colluvial lands are usually unstable and the surface is subject to movement from gravity and streamflow. Colluvial deposits range from shallow to very deep and often overlie bedrock or compacted colluvium. These unconsolidated sediments are excessively well-drained, generally have rapid runoff and have high erosion potential. Vegetation that does grow on these lands is similar to that on adjacent soils, but may have more canyon live oak and Douglas-fir.

Riverwash

This land type consists of nearly level or gently sloping sands and gravels that occur in stream channels and adjacent areas, subject to continuous or frequent flooding. Within the upper watershed, riverwash is found along the mainstem Clear Creek from just upstream of the Willow Creek confluence, downstream to the Mill Creek confluence near the Tower House area. Riverwash lands are excessively drained, have rapid permeability, and very high erosion potential.

Cobbly Alluvial Land

This land type consists of very gravelly, very cobbly, or very stony coarse textured alluvium that occurs in or adjacent to stream channels. Within the upper watershed, cobbly alluvial land occurs along the mainstem Clear Creek, north of Fivemile Gulch, and along a portion of the East Fork Clear Creek, between the First South Fork and the Third South Fork tributaries. This land type, which is frequently flooded, occurs as a somewhat continuous band of alluvium that is found between areas of rockland and bedrock outcrops. Runoff is very slow, and erosion potential is moderate.

Rockland and Rock Outcrops

This land type consists of exposed bedrock outcrops and shallow soils that occur in nearly level to very steep uplands in the mountainous parts of the upper watershed. It also occurs in some areas along steep hillslopes adjacent to the mainstem Clear Creek and in tributary canyons. This land type can consist of granitic, metamorphic, and sedimentary rocks, depending on the location and underlying geology. Rockland may support vegetation similar to that of adjacent soils but with less grass and more drought resistant plant species, such as canyon live oak, manzanita, toyon, buckeye, and yerba santa. It may also support riparian vegetation, where it occurs adjacent to stream channels.

Landslides
Landslides consist of rock fragments, soil and rubble that have moved down slopes in geologically recent times due to physical processes that act upon a mass of material. Within the upper watershed this land type is found along the steep hillslopes of the East Fork Clear Creek and near Monarch Mountain, southwest of Whiskeytown lake. Landslides are mainly found near areas underlain by Josephine, Behemotosh, and Sites soils, where slopes are moderately steep to very steep. This land type, typically composed of a gravelly to stony mixture of soil and broken bedrock, is well-drained and has high erosion potential.

SOIL EROSION

Soil erosion potential has been mapped within the upper Clear Creek watershed by the USFS, the BLM, and the NPS, based on soil type or association, vegetative cover, and percent slope. Sources used by these agencies include the Shasta County Soil Survey (USDA, NRCS 1974) and the Soil Resource Inventory of the Shasta-Trinity Forest Area (FS 1982). BLM also used the USFS report *Soils and Vegetation of the French Gulch Quadrangle* (Mallory et al. 1973) to determine erosion hazards in the ISRMA.

Erosion hazard is defined as the probable susceptibility of a soil to surface erosion on a 30 to 50 percent slope when all vegetation cover is removed (BLM 1997). Slopes in the upper watershed range from 0 to over 70 percent. The USFS used a classification of high, medium, and low erosion potential. The BLM classified soil erosion potentials in the ISRMA into slight, moderate, high, and very high erosion potential; and the NPS used a classification of severity, noting areas of severe erosion potential and secondary severe erosion potential.

As described in the ISRMA Final Plan and EIS (BLM 1997), soils with high erosion hazard ratings include "colluvial and alluvial material found in narrow tracts along streams, drainages, and slopes. Colluvial soils range from shallow to very deep overlying rock or compacted colluvium. These soils are excessively drained and have moderate permeability. Other soils with a high erosion hazard rating are located on steep slopes with excessive drainage and rapid permeability." Soils with moderate erosion hazard ratings "occur mostly on slopes adjoining streams. They are normally well-drained to excessively drained, have moderate to rapid permeability, and slow to moderate runoff." Soils with slight erosion hazard ratings "…are normally located along streams and ridgetops" and "…are generally deep (greater than 36 inches) and have a high infiltration rate and a high rate of water transmission through the soil profile. They occur on slopes of less than 15 percent and are well-drained."

Areas of high erosion potential found on USFS lands have been mapped west of Damnation Peak in the Blodgett Creek watershed, in the area surrounding the Clear Creek mainstem within the Slate Creek watershed, along the upper hillslopes at the eastern boundary of the Brush Creek watershed, in the Dodge Creek watershed south of Highland Ridge, and in an area at the base of Fivemile Gulch.

Soils with high erosion ratings have not been mapped within BLM lands in the upper Clear Creek watershed. Soils with moderate erosion hazard ratings on BLM lands in the ISRMA are found along the midslopes of the Big Gulch, East Fork, Cline Gulch, Grizzly Creek and Whiskey Creek subwatersheds. Soils with slight erosion hazard ratings are found within the Whiskey Creek subwatershed.

UPPER CLEAR CREEK EROSION INVENTORY

Methodology

The methodology for this erosion inventory was based on a similar inventory conducted in the Lower Clear Creak watershed by the Western Shasta Resource Conservation District. The reader is referred to the Final Report Upper Clear Creek Erosion Inventory 2003, Prepared by Western Shasta Resource Conservation District for details of the erosion inventory data, and how it was collected.

A Technical Advisory Committee (TAC) was formed consisting of BLM, WNRA, USFS, Sierra Pacific Industry (SPI), Natural Resources Conservation Service (NRCS) and two private landowners from within the watershed.

The TAC determined that assessment of both larger (100-year) and lesser (25-year) storm events was needed. The inventory focused on site-specific sediment sources such as roads, skid trails, landings, mining sites and residential development. The TAC's focus was on event driven erosion not annual erosion, therefore hillside sheet, rill, and stream bank erosion were not addressed, as the focus was on human-related disturbances.

One of the main requests of the USFS was that all culverts be inventoried regardless of sedimentation as this was a major interest to them. It was felt by the entire TAC that culverts do present the most likely source for sedimentation; therefore, it was decided to inventory all culverts. Culverts were to be given GPS coordinates along with other information regardless of the sedimentation possibilities.

Color infrared aerial photographs at a scale of 1:40,000 and black and white aerial photos at a scale of 1:40,000 were used to identify potential erosion sites and road networks. The aerial photos were flown in 1998, and were purchased from the United States Geological Survey. Shasta County Tax Assessors maps were used to assemble land ownership patterns. Landowners identified through the Assessors database were then sent a letter providing background information on the project's goals and objectives, as well as a postcard for the landowner to fill out and mail back granting or denying access to their property.

Landowners who granted access were contacted prior to the site visit and inventory. When possible, the crewmembers met with the landowners on their property to gather information regarding known erosion problems, boundaries, history, and possible hazards located on their property. An initial reconnaissance survey was then conducted on the property.

Once an erosion site was located, information was recorded on a standardized datasheet. In addition to general information, specific data included accessibility, the cause and nature of the problem, estimated future erosion volume, a sketch of the site and problem, and possible treatments. WNRA requested that sites inventoried within their jurisdiction not have possible treatments documented as they felt that the purpose of the inventory is to identify possible problem areas not generating design and implementation methods as this would require licensed engineers. It was also felt that there are several variables that need to be considered prior to design and implementation that a field technician may not be qualified to make. It was felt by the TAC that the treatment information would be beneficial; however where requested, no treatment types would be documented. Photos were taken at each large magnitude erosion site, and when possible, a Global Positioning System (GPS) was utilized at each site to record the precise location in Universal Transverse Mercator (UTM) coordinates. The locations of erosion sites were mapped on a large topographical map of the watershed, and erosion volume estimates were made using a direct volume calculation (gully, prism, or conical method). Ocular estimates were made on some of the smaller sites. Future erosion estimates were based on the amount of material expected to erode assuming no treatment was applied.

The information collected was then compiled into a Microsoft Access database. The database allows the information to be queried in order to prioritize restoration efforts. It was felt that using the Lesser Event data and Bigger Event data comparatively helped the prioritization process.

Data Summary

Approximately 51,000 acres were inventoried through 531 sites. Per a USFS request, eight sites inventoried included only culvert data collected from the culvert section. These eight sites had no current erosion problem, bringing the total number of sites having potential for sediment delivery to 523. Total estimated potential for erosion in the "lesser event" for the 531 sites inventoried is 51,585 cubic yards while the total estimated potential for the “big event” for these problems is 111,317 cubic yards. Table 2 shows the distribution of erosion and sediment by feature and erosion potential, based on event size. Totals for erosion and sediment potential in relation to event size are also included in Table 2.

The erosion inventory represents approximately one third the area of the watershed, and the acreage inventoried was not selected statistically, but was dictated by ownership permission for entry. With the limited treatment information the Technical Advisory Committee felt that the best method of assigning a sediment budget would be to assign a maximum dollar value to be spent of $10.00 per cubic yard saved. This has been proven by the Trinity RCD and the Western Shasta RCD to be a sufficient dollar amount to reduce sediment delivery to streams. This dollar amount can be greatly reduced by implementation methods and cumulative sites treated along entire road segments. The Technical Advisory Committee recommended that the data be summarized in Table 2, and the value of $10.00 per cubic yard be assigned to the sediment totals inventoried. The sediment budget, 51,585 cubic yards for the lesser event and 111,317 cubic yards for the big event, can be extrapolated over the rest of the watershed. However, it must be taken into account that the inventory data cannot be considered as "typical" because there was no way to strategize the sampling procedure. Soil types, aspect, slope, and parent material were not considered as part of the inventory criteria.

TABLE 2
Upper Clear Creek Watershed
Inventory Results
Event Size

FEATURE	SITES INVENTORIED	LESSER EVENT				BIG EVENT			
		HIGH	MED.	LOW	NONE	HIGH	MED.	LOW	NONE
CUTBANK	10	0	0	1	9	1	0	1	8
FILLSLOPE	361	10	73	157	121	76	101	171	13
LANDING	24	1	1	2	20	4	3	16	1
ROAD SURFACE	13	2	5	5	1	4	8	1	0
STREAM CROSSING	82	17	15	25	25	42	18	20	2
SWALE	34	2	2	10	20	4	17	12	1
OTHER	7	0	3	3	1	4	2	1	0
TOTALS	531	32	99	203	197	135	149	222	25
SEDIMENT YIELD		9,235	20,405	21,945	0	46,625	28,255	36,437	0
SEDIMENT TOTALS		51,585 cu. yd.				111,317 cu. yd.			

Note: sediment yield and sediment totals are represented in cubic yards.