Appendix A

Selected Properties Of Soil Units Found In Squaw Creek Watershed

Aquolls and Borolls: consists of stratified coarse sand to clay, stratified layers with mottles, stratified sandy loam to clay; some very gravelly, stratified alluvium. Aquolls consist of shallow and moderately deep, very poorly drained soils in valley floors and in drainages and are associated primarily with wet meadow vegetation such as carex, juncus, with some alder, willow and aspen. Aquolls commonly develop on broad flats in the flood plains of streams and have a high water table during most of the year. Borolls occur in valleys and drainages and consist of shallow and moderately deep, poorly drained soils with high amounts of rock fragments on the periphery of wet meadows. Associated vegetation mainly consists of carex, juncus, and grasses. Borolls have high water tables during part of the year.

Jorge Series: consists of deep well drained soils formed from andesitic, basalt and latite flow. Associated vegetation is mainly mixed conifers consisting of white fir, red fir and Jeffrey pine. Elevation range is 6,000 to 9,000 ft. The average annual precipitation is about 35 to 45 inches.

Meiss Series: consists of shallow, somewhat excessively drained soils formed from weathered andesitic rock. Associated vegetation is mainly grasses, scattered conifers (mostly red fir) and forbs consisting of squirreltail and wyethia, Elevation range is 6,000 to 10,000 ft. The average annual precipitation is about 50 to 80 inches. Depth to bedrock ranges from 12-20 inches. Rock fragments range from 5-35 percent.

Tallac Series: consists of deep, moderately well drained soils on lateral and terminal glacial moraines and outwash formed from weathered glacial deposits. Associated vegetation is mainly mixed conifers, consisting of red fir, white fir, Jeffrey pine, and some white pine. Elevation range is 5,500 to 9,000 ft. The average annual precipitation is about 40 to 80 inches. Depth to weathered rock ranges from 40-80 inches.

Waca Series: consists of moderately deep well drained soils formed from weathered andesitic mudflows and rhyolitic tuff. Associated vegetation is mainly semi-dense to dense stands of mixed conifer consisting of Jeffrey pine, white fir, sugar pine, and western white pine in stands of red fir. Elevation range is 6,000 to 9,000 ft. The average annual precipitation is about 35 to 80 inches. Depth to weathered andesitic tuff breccia or rhyolitic tuff ranges from 20-40 inches.

Windy Series: consists of deep, well drained soils formed from weathered andesitic mudflows. Associated vegetation is mainly red fir and white fir. Textures throughout the profile are sandy loam, fine sandy loam, coarse sandy loam or loam and cobbly, stony, gravelly or very gravelly. Elevation range is 6,000 to 9,000 ft. The average annual precipitation is about 60 to 80 inches. Depth to weathered rock ranges from 40-80 inches. Rock fragments range from 25-65 percent and averages more than 35 percent.

Rock Outcrops: consists of outcrops of glaciated granitic or volcanic rock.

Table 16. Selected properties, management considerations, and descriptions for soils found in the Squaw Creek watershed (modified after USDA, 1994).

Soil Unit	Map Unit	Depth (in)	Slope %	Erosion Hazard	Management Considerations	Description
Aquolls and Borolls	AQB	<30	0 to 5	High	High water table; subject to flooding	Small areas of Celio and Gefo soils, rock outcrop, subject to flooding, high water table. High amounts of rock fragements
Granitic rock outcrop	GRG	0	-	Na	Steep and very steep slopes; concentrated surface runoff and erosion of adjacent soils	Small areas of multiple soils, steep and very steep slopes, outcrops can produce conc runoff
Jorge Cryumbrepts	JSG	<47	30 to 75	High	Steep and very steep slopes; high water table; impermeable substratum at depth	Small areas of Fugawee and Tahoma soils, rubble land, steep and very steep slopes, coarse textures and high amount of rock fragements, high water table
Jorge-Waca-Tahoma	JWF	<47	30 to 50	High	Steep slopes; Waca soils have impermeable substratum at depth	Small areas of Fugawee and Windy soils, steep slopes, coarse textures, and high amount of rock fragments
Meiss gullied land – rock outcrop complex	MHG	<19	30 to 75	High	Steep and very steep slopes; shallow to bedrock; concentrated runoff	Small areas of Waca soils, wet may be located in gullies, alluvial fans present at bottom of gullies, steep and very steep slopes, reach field capacity readily, gullied land and rock outcrop produce conc runoff
Meiss-rock outcrop complex	MIE	<19	2 to 30	High	Shallow soils; prone to runoff and erosion on adjacent soils	Small areas of Waca soils, shallow to hard bedrock, reach field capacity readily
Meiss-rock outcrop complex	MIG	<19	30 to 75	High	Steep and very steep slopes; soils can generate concentrated runoff	Small areas of Waca soils, shallow to hard bedrock, reach field capacity readily
Meiss-rock outcrop complex, severely eroded	MIG3	<11	30 to 75	Very High	Steep and very steep slopes; surface soil eroded; surfa ce runoff	Small areas of Waca soils, shallow to hard bedrock, reach field capacity readily, steep and very steep slopes
Meiss-Waca complex	MKE	<19-32	2 to 30	Mod-High	Meiss soils are shallow to hard bedrock and	Small areas of Windy soils, shallow to hard bedrock, reach field

Soil Unit	Map Unit	Depth (in)	Slope %	Erosion Hazard	Management Considerations	Description
					produce surface runoff; Waca soils are moderately deep; impermeable substratum at depth	capacity readily
Meiss-Waca complex	MKF	19-32	30 to 50	High	Steep slopes; Meiss soils are capable of producing surface runoff; Waca soils have impermeable substratum at depth	Small areas of Windy soils, rock outcrop, reach field capacity readily, moderately deep, steep slopes
Meiss-Waca—Rock outcrop complex, severely eroded	MKF3	11-21	30 to 50	Very High	Steep slopes; weathered volcanic and tuff breccia mudflow rocks; surface runoff	Small areas of Meiss soils, rock outcrop, reach field capacity readily, moderately deep, steep slopes
Meiss-Waca-Cryumbrepts, wet complex	MLE	19-32	2 to 30	Mod to Very High	Meiss soils are shallow to hard bedrock, produce surface runoff; Waca moderately deep, impermeable substratum at depth; Cryumbrepts have high water table, puddling susceptibility, and impermeable layers at depth	Small areas of Windy soils, rock outcrop, reach field capacity readily, moderately deep, high water table
Meiss-Waca-Cryumbrepts, wet complex	MLG	19-32	30 to 75	High to Very High	Same as MLE only steeper slopes	Small areas of Windy soils and rock outcrop, steep and very steep slopes, shallow to hard bedrock, reach field capcity readily, moderately deep, high amounts of rock fragements, high water table
Rock outcrop, granitic Tinker complex	RRG	<33	30 to 75	High	Steep and very steep slopes; moderately deep soil, high amount of rock fragments; concentrated runoff from rock outcrop can increase erosion on adjacent soils	Small areas of Smokey and Tallac soils, high amounts of rock fragments, steep and very steep slopes, moderately deep
Rock outcrop, granitic-Tinker-Cryumbrepts,	RSG	<33	30 to 75	High to Very High	Steep and very steep slopes; Tinker soils are moderately deep; Cryumbrepts	Small areas of Tallac soils, steep and very steep slopes, high amounts of rock

Soil Unit	Map Unit	Depth (in)	Slope %	Erosion Hazard	Management Considerations	Description
wet complex					have high water table and puddling susceptibility; concentrated runoff from outcrop and increased erosion on adjacent soils	fragments
Rubble land-Jorge complex	STG	<47	30 to 75	High	Steep and very steep slopes; Jorge have coarse texture and high amount of rock fragments; rubble areas have potential for raveling	Included in this unit are small areas of Fugawee soils and Rock outcrop. Included areas make up about 15 percent of the total area. Steep and very steep slopes. Jorge soils have coarse textures and a high amount of rock fragements. Areas of Rubble land have a potential for ravelling.
Rubble land-Rock outcrop complex	SUG	0	30 to 75	-	Steep and very steep slopes; rock outcrop concentrates run off and can cause increased erosion on adjacent soils	Small areas of Jorge soils, areas of rubble land have potential for ravelling, conc runoff
Tallac very gravelly sandy loam	TAE	<41	2 to 30	High	Coarse textures; high amount of rock fragments	Small areas of Celio and Tinker soils, coarse textures, high amount of rock fragments
Tallac very gravelly sandy loam	TAF	<41	30 to 50	High	Steep slopes; coarse textures; high amount of rock fragments	Small areas of Tinker, Waca, Windy soils, coarse textures, high amount of rock fragments
Tallac-Cryumbrepts, wet complex	TBE	<41	2 to 30	High to Very High	Tallac soils have coarse texture, high amount of rock fragments; Cryumbrepts have high water table most of the year, susceptible to puddling, impermeable layers at depth	Small areas of Tinker, Waca, Windy soils, coarse textures, high amount of rock fragments
Tallac-Cryumbrepts, wet complex	TBF	<41	30 to 50	High to Very High	Same as TBE but on steep to very steep slopes	Small areas of Tinker, Waca, Windy soils, coarse textures, high amount of rock fragments, high water

Soil Unit	Map Unit	Depth (in)	Slope %	Erosion Hazard	Management Considerations	Description
						table
Tallac-Gullied land-Cryumbrepts, wet complex	THF	<41	30 to 60	High to Very High	Same as TBF and TBE. Gullied land areas produce concentrated runoff and can increase erosion of adjacent soils.	Small areas of Tinker, Meiss, Waca soils and Rock outcrop, coarse textures, high amount of rock fragments. Gullied land produce conc. Surface runoff, high water table
Tinker-Rock outcrop, granitic-Cryumbrepts, wet complex	TIE	<33	2 to 30	High to Very High	Tinker soils are moderately deep and have high amount of rock fragments; granitic outcrop can produce concentrated runoff that may increase erosion of adjacent soils; Cryumbrepts as TBE, TBF	Small areas of Tallac soils, high amounts of rock fragments, granitic outcrop
Tinker-Rock outcrop, granitic-Cryumbrepts, wet complex	TIG	<33	30 to 75	High to Very High	Same as TIE but formed on steep to very steep slopes	Small areas of Celio Tallac soils, high amounts of rock fragments, granitic outcrop, steep and very steep slopes
Rock outcrop, volcanic	VRG	0	30 to 75	-	Concentrated runoff on exposed outcrop can increase erosion on adjacent soils	Small areas of soil, steep and very steep slopes and concentrated runoff.
Waca-Windy complex	WAE	32-46	2 to 30	Moderate	High amounts of rock fragments; snowmelt accumulates over impermeable substratum	Small areas of metamorphic rock outcrop, glacial soils, high amounts of rock fragments, moderately deep
Waca-Windy complex	WAF	32-46	30 to 50	High	Same as WAE but formed on steep slopes	Small areas of Meiss and Tallac soil, high amount of rock fragments, moderately deep
Waca-Cryumbrepts, wet-Windy complex	WBF	32-46	30 to 50	High to Very High	Same as WAE, WAF; Cryumbrepts have high water table and impermeable layers	Small areas of Ahart, Meiss, Tallac, and Waca soil, steep slopes, high amount of rock fragments, moderately deep
Waca-Meiss complex	WDF	19-32	30 to 50	High	Steep slopes; Waca soils are moderately deep, have impermeable substratum; Meiss soils are shallow,	Small areas of Ahart, Tallac, Waca, rhyolitic substratum, high amount of rock fragments, moderately deep

Soil Unit	Map Unit	Depth (in)	Slope %	Erosion Hazard	Management Considerations	Description
					capable of producing surface runoff	
Waca-Meiss-Cryumbrepts, wet complex	WEE	19-32	2 to 30	Mod. to Very High	Characteristics of Waca, Meiss, and Cryumbrepts as described above	Small areas of Ahart, Tallac, Waca, rhyolitic substratum, high amount of rock fragments, moderately deep
Waca-Meiss-Cryumbrepts, wet complex	WEF	19-32	30 to 50	High to Very High	Same as WEE but on steep slopes	Small areas of Ahart, Tallac, Waca, rhyolitic substratum, high amount of rock fragments, moderately deep, steep slopes
Ledford Variant-Rock outcrop complex	WRG	<28	30 to 75	High	Steep and very steep slopes; deep, coarse texture; concentrated runoff from rock outcrop can increase erosion on adjacent soils	Small areas of Tinker soils, high amount of rock fragments, moderately deep

Note: Table and descriptions abstracted from *Soil Survey of the Tahoe National Forest* Area (USDA, 1994). Erosion hazard is based on little or no vegetative cover and the long-term average occurrence of two-year, six-hour storm events. Erosion hazard increases when storm frequency, intensity, and duration exceed long-term average occurrence. Very high and high erosion hazard – accelerated erosion will occur in most years. Moderate erosion hazard – accelerated erosion is likely to occur in most years. Low erosion hazard – accelerated erosion is not likely to occur, except in the upper part of the low erosion hazard range or during periods of above average storm occurrence.

Appendix B

Plant And Wildlife Species At Squaw Creek

The lower montane, upper montane, and subalpine vegetation zones of the Squaw Creek watershed include the following dominant habitat types: mixed conifer, Jeffrey pine, white fir, red fir, and subalpine forest habitats; montane chaparral; meadow; and riparian (Mayer and Laudenslayer, 1988). The watershed therefore provides habitat suitable for common species such as red-tailed hawk (*Buteo jamaicensis*), Stellar's jay (*Cyanocitta stelleri*), coyote (*Canis latrans*), black bear (*Ursus americanus*), raccoon (*Procyon lotor)*, and mule deer (*Odocoileus hemionus*), and species of terrestrial and arboreal rodents (Murphy and Knopp, 2000). To a lesser degree, habitat exists which may support select species of amphibians and reptiles, such as pacific tree frogs (*Pseudacris regilla*) and western aquatic garter snakes (*Thamnophis couchii*). A list of the more common wildlife species that may occur in the Squaw Creek watershed is provided below (Zeiner et.al., 1988).

Birds	Western Tanager (*Piranga ludoviciana*)	**Amphibians**	Pacific Tree Frog (*Pseudacris regilla*)
	Dark-Eyed Junco (*Junco hyemalis*)		American Bullfrog (*Rana catesbeiana*)
	Mallard (*Anas platyrhynchos*)		Western Toad (*Bufo boreas*)
	Canada Goose (*Branta canadensis*)		Long-Toed Salamander (Ambystoma macrodactylum)
	Mountain Chickadee (*Poecile gambeli*)	**Reptiles**	Western Fence Lizard (*Sceloporus occidentalis*)
	Steller's Jay (*Cyanocitta stelleri*)		Western Aquatic Garter Snake (*Thamnophis couchii*)
	Hairy Woodpecker (*Picoides villosus*)		Terrestrial Garter Snake (*Thamnophis sirtalis*)
	Downy Woodpecker (*Picoides pubescens*)		Rubber Boa (*Charina bottae*)
	American Robin (*Turdus migratorius*)		
	Red-Tailed Hawk (*Buteo jamaicensis*)		

Mammals	Yellow-Bellied Marmot (*Marmota flaviventris*)
	Douglas' Squirrel (*Tamiasciurus douglasii*)
	Golden-Mantled Ground Squirrel (*Spermophilus lateralis*)
	Coyote (*Canis latrans*)
	Raccoon (*Procyon lotor*)
	Beaver (*Castor canadensis*)
	Porcupine (*Erethizon dorsatum*)

Plant species found within the watershed are similar to those found elsewhere in the Sierra Nevadas. These include conifers, chaparral shrub species, meadow grasses and grasslike species (sedges, rushes), and riparian vegetation. Descriptions of the more commonly occurring species in the watershed are listed below (CalFlora, 2000).

Herbaceous	Buttercup	**Shrubs**	Greenleaf Manzanita (*Arctostaphylos patula*)
	Mountain Mule Ears and Arrow-Leaved Balsamroot		Pinemat Manzanita (*Arctostaphylos nevadensis*)
	Sulphur Flower		Huckleberry Oak (*Quercus vaccinifolia*)
	Dwarf Alpine Aster		Sierra chinquapin (*Chrysolepis sempervirens*)
	Meadow Penstemon		Bitterbrush (*Purshia tridentata*)
	Lupine		Creeping Snowberry (*Symphoricarpos mollis*)
	Thistle		Whitethorn (*Ceanothus cordulatus*)
	Columbine		Tobacco Brush (*C.*

			velutinus)
	Indian Paintbrush		Squawcarpet (*C. prostratus*)
	Snow Plant		Sagebrush (*Artemisia tridentata*)
	Shooting Star		Rabbitbrush (*Chrysothamnus naseosus*)
	California Corn Lily		Dogwood (*Cornus sericea*)
	Cow Parsnip	**Trees**	White Fir (*Abies concolor*)
	Mariposa Lily		Red Fir (*Abies* concolo)r
	Ranger Buttons		Jeffrey Pine (*Pinus jeffreyi*)
	Common Yarrow		Ponderosa Pine (*Pinus ponderosa*)
Grasses/ Grasslike	*Poa spp.*		Sugar Pine (*Pinus lambertiana*),
	Carex spp.		Incense Cedar (*Calocedrus decurrens*).
	Juncus spp.		Creek Alder (*Alnus incana*)
			Willow (*Salix spp*.)

It is important to note that a non-native plant species was observed during field data collection activities near the top of the Papoose chairlift. Tall whitetop (*Lepidium latifolium*) is an exotic plant originally from southeastern Europe and southwestern Asia and is a recognized noxious weed by the State of Nevada. Tall whitetop can crowd out native riparian vegetation in stream corridors, resulting in degraded wildlife habitat and accelerated streambank erosion (Donaldson and Johnson, 1999). Because the species was not observed in any of the drainages or primary stream channels, it is recommended that a botanist accurately identify the plant as tall whitetop and management activities be undertaken to control it quickly.

A recent (December 2001) California Natural Diversity Database (CNDDB) search in a nearby project area within the Truckee River watershed was referenced to determine the potential for the presence of special status species, including listed federal and state threatened, endangered, and candidate species. The database search resulted in previous occurrences of twelve species within the Tahoe City 7.5’ quadrangle, which includes the eastern half of the Squaw Creek watershed. Special interest species identified in or adjacent to the Squaw Creek watershed include:

- Mountain yellow-legged frog (*Rana muscosa*) in and near Squaw Valley;
- Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) in Pole Creek;
- Mountain Beaver (*Aplodontia rufa californica*) in Pole, Silver, and Deer Creeks;
- California Wolverine(*Gulo gulo luteus*) in Squaw Valley;
- Munroe’s Desert Mallow (*Sphaeralcea munroana*) in Squaw Valley;
- Donner Pass Buckwheat (*Eriogonum umbellatum var torreyanum*) in Squaw Valley and Silver Creek, and;
- American Manna Grass (*Glyceria grandis*) near Squaw Valley.

A number of special interest plant and wildlife species (such as those recognized by the California Department of Fish and Game and the USDA Forest Service) have the potential to occur in portions of the Squaw Creek watershed. A list of these species and their general habitat requirements is presented below, based upon several recognized references (Zeiner et.al., 1990; Bish, 1993; CalFlora, 2000; DFG, 2001):

Northern goshawk *(Accipiter gentilis)*: Uses a wide variety of forest ages, structural conditions, and successional stages. Foraging habitat is the transitional zone from wetland to forest and forest to shrubland, as well as riparian zones and mosaics of forested and open areas. Uses old-growth forest stands and large, dense deciduous stands as nesting sites. Home range size is 6,000 acres, consisting of nest area, fledging area, and foraging area.

Nest area is about 30 acres in size, usually in a mature forest stand that has a multi-layered canopy with dense to open understory on north aspects in drainages with streams. Within a home range there are typically two to four alternative nest areas. Nest trees exhibit characteristics such as a crotch, fork, or several limbs on one side to support the platform nest. Post-fledgling family area is about 420 acres of a mosaic of forest types that provide hiding cover for the fledglings and habitat for abundant prey. Foraging area is about 5,400 acres of shrublands, forests, and openings with perching trees to observe prey.

California spotted owl *(Strix occidentalis occidentalis)*: Generally nest in cool, shaded areas with well-developed understory. Prefer natural cavities in large-diameter trees with broken tops and mistletoe infestations. Will use mid-successional forests to some degree for foraging.

Require stands with high canopy closure for thermal regulation and hiding cover. Intolerant of high temperatures and are stressed at temperatures above 80° to 87°F. Tend to roost in small trees in the forest understory during warm weather and high up in the large trees during cold or wet weather. Layered canopy structure in old forests provides both types of roosts.

Mule deer *(Odocoileus hemionus)*: Prefer rocky or broken terrain at elevations near or at the subalpine zone and are most likely to be found in open forested regions. Require areas of shrub or similar cover for predator escape, foraging, and rearing.

Pileated woodpecker *(Dryocopus pileatus)*: Uses late successional stages of coniferous or deciduous forest, but also younger forests that have scattered, large, dead trees. Roost cavities are in live and dead trees within a mature or old stand of coniferous or deciduous trees. Roost and nest holes are nearly all created by decay rather than excavation. Roost and nest trees are typically in old-growth stands of fir and pine that have experienced little or no logging and have >60% canopy closures.

Mallard *(Anas platyrhynchos)*: Emergent wetlands with dense cover. May remain year-round wherever food and open water are available. Uses dry sites with dense, tall vegetation, including willow, shrubs, and herbaceous vegetation.

Black bear *(Ursus americanus)*: Prefer forested and shrubby areas but use wet meadows, ridgetops, burned areas, riparian areas, and avalanche chutes. Prefer mesic over dry sites and timbered over open areas. Use dense cover for hiding and thermal protection, as well as for bedding. Build dens in tree cavities, under logs, rocks, in banks, caves, or culverts, and in shallow depressions.

Blue grouse *(Dendragapus obscurus)*: Occurs in open stands of conifer, particularly fir, near water. Prefers conifers greater than 14 inches in diameter and greater than 40% canopy cover, and dense tree foliage for roosting, but nests on ground using shrubs and logs as cover.

Willow flycatcher *(Empidonax trailii)*: Large expanses of mature, continuous willow near water source.

Lahontan cutthroat trout *(Oncorhynchus clarki henshawi)*: Cool alpine streams with a diversity of instream habitat, including riffles, pools, and at least 25% stream bank cover. Lahontan cutthroat appear to be intolerant of competition or predation by non-native salmonids, and rarely coexist with them.

Rainbow trout *(Salmo gairderi)*: Medium to large alpine streams and large lakes. Spawns in the spring.

Brook trout *(Salvelinus fontinalis)*: Small to large alpine streams and lakes, spawns in the stream in the fall.

Great Gray owl *(Strix nebulosa)*: Occurs between 4,500-7,500 feet elevations in dense, old growth red fir, mixed conifer, and lodgepole pine forests near wet meadows.

California Wolverine *(Gulo gulo luteus)*: Habitats used in the southern Sierra Nevada include Medium to high elevation (6,400-10,800 feet) forest habitats of red fir, mixed conifer, and lodgepole pine near wet meadows and chaparral. Prefers low human disturbance.

<u>Townsend's big-eared bat</u> *(Corynorhinus townsendii)*: May use buildings, bridges, rock crevices and hollow trees or snags as roost sites. Forages in edge habitats along streams and areas adjacent to and within a variety of forested habitats.

<u>Sierra Nevada red fox</u> *(Vulpes vulpes necator)*: Red fir and lodgepole forests near meadows and similar forest openinings above 7,000 feet. Rock outcrops, talus slopes, and down logs are used for den sites.

<u>American marten</u> *(Martes americana)*: Dense (40 to 60 percent canopy closure), uneven-aged, old-growth conifer stands with understory habitat for prey (mice, voles). Martens usually den in large rotten logs and sometimes slash piles and use dense understory and log piles for denning and hiding. Martens typically avoid open areas adjacent to these forests.

<u>Mountain yellow-legged frog</u> *(Rana muscosa)*: Associated with streams, lakes and ponds in montane riparian, lodgepole pine, subalpine conifer, and wet meadows, mostly above 6,000 feet.

<u>Northern leopard frog</u> *(Rana pipiens)*: Occurs in or near quiet, permanent and semi-permanent water in with high vegetation cover and submerged and emergent aquatic vegetation cover.

<u>Galena Creek Rock Cress</u> *(Arabis rigidissima var. demota)*: Rocky area at the edge of aspen groves and brushy slopes.

Tahoe Draba *(Draba asterophora var. asterophora)*: Loose hillsides and slopes of decomposed granite at or above the timberline.

Cup Lake Draba *(Draba asterophora var. macrocarpa)*: North facing slopes above 9,000 feet above the timberline in coarse, decomposed granite (gruss).

Subalpine fireweed *(Epilobium howellii)*: Moist meadows and seeps in subalpine forests.

Donner Pass buckwheat (*Eriogonum umbellatum var. torreyanum*): Occurs in meadows and seeps in conifer and red fir forests in volcanic substrate.

Long-petaled Lewisia *(Lewisia longipetala)*: Grows in cracks in granitic slabs and moist gravelly volcanic soil directly below persistent snow on high elevation leeward slopes.

Sierra sedge *(Carex paucifructus*): Occurs under moist and wet conditions in streambank and meadow habitats between 4,000 and 10,000 feet in conifer and red fir forests.

American manna grass (*Glyceria grandis*): Occurs in freshwater wetlands, bogs, fens, meadows and seeps, and riparian and lake-margin habitats.

Donner Pass buckwheat (*Eriogonum umbellatum var. torreyanum*): Occurs in meadows and seeps in conifer and red fir forests in volcanic substrate.

Boggs Lake hedge-hyssop (*Gratiola heterosepala*): Occurs almost always in wetland habitats and vernal pools.

Plumas ivesia (*Ivesia sericoleuca*): Occurs in volcanic substrate in moist conditions in meadows and vernal pools in sagebrush scrub and pine forest habitats.

Stebbins phacelia (*Phacelia stebbinsii*): Occurs in meadow and seeps in foothill woodland and pine forest habitats.

Oregon fireweed (*Epilobium oreganum*): Occurs in moist and wet meadows, bogs, and fens between 4,000 and 10,000 feet in pine and red fir forests.

Marsh skullcap (*Scutellaria galericulata*): Occurs in moist meadows, seeps, and freshwater marshes between 4,000 and 7,000 feet in pine forest habitats.

Water bulrush (*Scirpus subterminalis*): Occurs in lake margin and freshwater wetland edge habitats.

Holly fern (*Polystichum lonchitis*): Occurs on granitic substrate between 6,500 and 8,500 feet in pine and red fir forests.

Shore sedge (*Carex limosa*): Occurs in wet meadows and bogs between 4,000 and 8,700 feet in pine and red fir forests.

Dissected-leaved toothwort (*Cardamine pachystigma var dissectifolia*): Occurs in rocky soil on serpentine substrate in chaparral habitat.

Appendix C

Historic Aerial Photographs Obtained from Tahoe National Forest

Number in parentheses indicates number of photographs from each flight line

Date	Flight Line	Photograph Number
06/27/39	CDJ	12-39, 12-40 (2)
06/27/39	CDJ	12-36, 12-37 (2)
06/28/39	CDJ	13-20,13-53 (2)
06/28/39	CDJ	13-18, 13-19, 13-20, 13-55 (4)
08/22/55	TA	2-5, 2-6, 2-7, 2-8, 2-9, 2-10, 2-11, 2-12, 2-13 (9)
07/15/66	EQL	9-268, 9-270, 9-271 (3)
07/16/66	EQL	11-78 (1)
07/16/66	EQL	11-75, 11-76, 11-16, 11-17 (4)
07/17/66	EQL	10-115, 10-116 (2)
07/21/66	EQL	14-113 (1)
07/12/72		1472-197, 1472-199, 1472-200 (3)
08/04/72		1972-170 (1)
09/12/72		0872-153, 0872-154, 0872-155, 0872-212, 0872-214 (5)
08/31/77	USDA 615170	377-94, 377-95, 377-96 (3)
09/06/83		1582-39, 1582-40, 1582-42, 1582-43 (2), 1582-71, 1582-74, 1782-125, 1782-127, 1782-169, 1782-171 (10)
07/16/87		487-147, 487-148, 487-204 (3)
07/31/92		692-83, 692-85, 692-115, 692-116, 692-122, 692-123, 692-124, 692-155, 692-163 (9)
07/12/97		1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-8, 1-9, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7, 2-8, 3-1, 3-2, 3-3 (20)
08/15/97		1097-15 (1)
08/15/97		997-37, 997-38, 997-66, 997-68 (4)

Appendix D

Data Collection Methodology and Site Descriptions

Sector Descriptions

Sector I: Squaw Creek Meadow - Sector I is comprised of the glacial valley of Squaw Creek from the confluence with the Truckee River to the upper parking lots at the lower tram terminal. Wetlands and dry meadows containing a mix of sedges and forbs, riparian vegetation, and a meandering reach of Squaw Creek characterize the valley. Relief on the valley floor is only a few feet. The valley geology consists of Quaternary alluvium overlying glacial outwash and lacustrine deposits. Fluvial processes that dominate in this sector include active channel migration, bank erosion, flooding, sediment storage, and transport. The stream has been modified in historic times by activities associated with grazing, recreational development, and restoration efforts (Hecht and Jett, 1988). Residential, recreational, and commercial development is the dominant land use in the valley.

Sector II: North-facing hillslope of Squaw Valley - Sector II is comprised of relatively steep north-facing slopes that border the meadow in Sector I. Vegetation consists of moderately dense mixed conifer forest that has been previously logged and some riparian vegetation along several tributaries to Squaw Creek. The geology is comprised of Tertiary volcanic and Quaternary glacial units. Glacial deposits associated with lateral moraines have been incised by existing tributaries in some areas, creating well-formed channels and alluvial/colluvial fans at the base of the hillslopes. Land use consists of commercial, forestry, and recreational (golf and ski resort) activities. Numerous unpaved maintenance roads, ski lifts, and ski runs are found in Sector II.

Sector III: South facing hillslope of Squaw Valley - Sector III is comprised of relatively steep south-facing slopes that border the meadow in Sector I. Vegetation consists of moderately dense mixed conifer forest and montane chaparral that has been previously logged and minimal amounts of riparian vegetation along minor drainages. The geology is similar to Sector II. Evidence of several landslides is apparent, particularly in the western portion of the sector. A few unpaved access roads are present on the slope running from the subdivision to the ridge. Land use consists of residential development and natural preserve. A secondary paved-road network typical of roads associated with subdivisions is present on the lower slopes.

Sector IV: South Fork of Squaw Creek - Sector IV contains the south fork of Squaw Creek and associated tributaries and has the same approximate boundaries as the subwatershed. Topography is characterized by very steep slopes on both the north and south sides of the prominent, narrow valley formed along the south fork. The westernmost part of the sector has steep slopes in a bowl-shape reflecting the cirque basin formed during glacial erosion of the south fork. Vegetation is sparse, consisting of subalpine conifer species and shrubs. Glacial deposits, which represent a potentially significant supply of fine-grained sediment, cover the granitic bedrock in much of the lower valley of the south fork except where the stream has incised through the glacial cover to the underlying bedrock. In the upper elevations of the south fork, the dominant geologic unit is volcanic (andesite) rock. Granite is found as prominent outcrops in the Headwall area, along the divide between the north and south forks below High Camp and on the south side of the lower part of the south fork valley. Extensive modification of stream channels (rerouting, channelization) using a variety of engineered structures has occurred as a result of recreational development. Sector IV contains the most extensive network of unpaved single and double track maintenance roads of any of the sectors. Recreational alpine skiing is the primary land use in this sector, with additional activities available during the off-season (e.g., hiking, horseback riding and mountain biking).

Sector V: North Fork of Squaw Creek - Sector V is characterized by steep slopes and has boundaries that are approximately the same as the north fork of Squaw Creek and associated tributaries. Vegetation is moderately sparse, consisting of subalpine conifer species and shrubs, with a higher percentage of plant cover than Sector IV. Geology is dominantly granitic bedrock, and large areas of exposed bedrock are common. Glacial features that are typically present in the valley of the north fork includes carved and plucked bedrock that forms frequent cliff faces, waterfalls, and glacially polished and striated granite. Ephemeral tributaries drain from volcanic rock (andesite) in the northern portions of the sector. Upper reaches of the north fork are structurally controlled by faulting that trends north to northwest. Land use in this less disturbed sector is limited to low impact recreation (hiking trails), with the exception of a few ski runs and unpaved roads in the westernmost part of the sector.

Data Collection Methods

Photographic digital image documentation and watershed reconnaissance – Watershed reconnaissance investigations were conducted to gain an overall impression of the watershed, assess potential sediment sources, identify geomorphic processes and features, and develop an appropriate large-scale assessment strategy. Reconnaissance also allowed for the proper selection of sample site locations and methods, characterization of potential impacts to the stream, characterization of alluvial deposits to assist in the development of the geomorphic history of the valley, and documentation and photography of road cuts. Digital images were collected of the sampling sites during installation and also during watershed reconnaissance to assist in the relocation and description of data sites and the documentation and analysis of geomorphic processes and watershed impacts.

Activities related to watershed reconnaissance included walking the entire meadow stream reach to determine appropriate locations for cross sections, and documenting and photographing signs of active erosional degradation and depositional aggradation, such as areas of exposed soil stratigraphy in the stream bed. Field reconnaissance assisted in confirming and updating the geologic map first created for the area by Birkeland (1962), and in identifying erosional and depositional geomorphic features, such as landslides, alluvial fans, and sediments dams behind fallen logs and processes (e.g., slope failures, gully development).

Stream channel cross sections – Stream banks can be large contributors of sediment through undercutting, meander migration, or bank failure. Repeat measurements of channel cross-sections can provide useful information regarding changes in the streambed and channel banks, the amount of sediment contributed by those sources, and width-depth ratio (w/d) changes. Monitoring changes in the width-depth ratio of a stream channel is important, as it serves as an indication of change in stream regime and sediment load (Knighton, 1998). A change from a low to high w/d often indicates aggradation or channel widening without increasing depth causing an increase in sediment load from bank erosion. A decrease in w/d most often indicates active incision, in response to changes in sediment load conditions or channel bank stabilization (e.g., rip rap).

The channel cross-section is a surveyed topographic profile from one bank of the stream to the other side (left to right bank, looking downstream). By conducting repeat measurements and superimposing the profiles, change can be documented, estimates of sediment erosion or deposition recorded, and inferences about geomorphic processes affecting the channel can be made (Lawler, 1993).

Cross sections were established in 2001 and resurveyed in 2002 following accepted methodology (Stott et al., 1986, Lawler, 1993). Two representative meadow section reaches containing four alternating pool and riffle sequences were identified, providing a total of eight cross sections established orthogonal to the direction of flow. Cross-section endpoints are marked using sections of 3/8" rebar as monuments to provide for accurate repeated surveys for this and subsequent studies. The endpoints are set back from the bank edge to allow for possible channel migration. The rebar endpoints are capped with 2" orange safety caps for public protection and to aid in relocation. An auto level and stadia rod was used to collect point elevation data along each cross sectional profile. The left bank rebar monument was surveyed in as the end point of each cross section. Elevation points along the profile were gathered in a manner designed to capture topographic irregularities (e.g., breaks in slope) in the streambed and banks. Undercut banks represent significant evidence of bank erosion and are accounted for in the cross sections.

Grab samples - Substrate grab samples were collected to assess in-stream sediment sources and sites of sediment storage (e.g., point bars). Transects were laid out across the point bars and samples were collected at regular intervals. Grab samples were collected from in-stream bars to further characterize material in transport during high flow events. Particle size analysis was performed on the grab samples to reveal the distribution of sizes transported and deposited during higher stream discharge events.

Soil pits - Surficial geologic materials were sampled from shallow pits to better understand the particle size of sediment contained in hillslope and stream deposits and eventually supplied to Squaw Creek. Soil pits were excavated near erosion monitoring stations to a depth of approximately 0.7 meters. Stratigraphy within the pit was sketched, described, and samples were collected for laboratory analysis to determine the size and composition of the hillslope material. Particle size analyses were performed in the Soil Characterization and Quaternary Pedology Laboratory at the Desert Research Institute. Digital images of each soil pit were also taken.

Erosion monitoring devices were installed to gather erosion rates for disturbed (e.g., ski runs, road cuts, landslides) and undisturbed hillslopes. The resulting erosion rates were used to approximate the rate at which sediment is entering the drainage network from roads and hillslopes. The methodology for each type follows below:

Erosion pin transects – Erosion-pin transects are a standard method used for measuring soil losses or gains on hillslopes and consists of inserting small diameter (5mm) pins into the soil and using the top of the pin as the measurement datum (Goudie, 1981; Wells and Rose, 1981; FAO 1993; Stott et al., 1986) (Figure 44). Erosion pin transects were established in areas exhibiting susceptibility to erosion, such as ski runs and downslope of roads, and in undisturbed forest and chaparral areas to assist in assessing erosion associated with landuse and landcover (Table 17). This allowed rates to be extrapolated to similar areas of landuse and landcover throughout the watershed, as suggested by Young and Saunders (1986).

Figure 44. Erosion pin for measuring rates of sediment movement on hillslopes.

At each site, transects were installed horizontally across the slope and vertically parallel to the slope, forming a cross pattern. Pins were placed at 2 meter intervals along the transect, unless an obstacle, such as a large rock was encountered, in which case the pin was installed 0.5 meters to either side of the obstruction. Pins were installed to approximately protrude above the soil surface 80 to 150 mm. On some pins, a small, lightweight washer was placed over the pin to aid in measurement and in determination of any erosion or deposition. Repeat measurements were made from June 2001 through July 2002 to record erosion or deposition activity at each pin. Because of the large area in which transects were located, it was not feasible to measure every site during a single visit. Therefore, some of the repeat measurements recorded change following small rainfall events, whereas some sites were relocated and measured prior to rain events. Erosion pin transects at higher elevations had fewer repeat measurements because early snows covered the sites preventing measurements. Erosion pin transects were photographed and locations recorded using a GPS (Global Positioning System) and verified using a topographic map. Data collection was repeated following the peak

Table 17. Erosion pin data collection sites and associated attributes.

Erosion Pin Site ID	Slope	*Aspect	Vegetation	Geology	Description	^Associated Landuse
EPII-1	22°	North facing	Yarrow	Glacial material	On ski slope behind golf course	Ski slope (d)
EPII-2	35°	North facing	Red fir Forest	Glacial material	Above road cut	Mixed conifer (u)
EPII-4	25°	North facing	Red fir, white fir, pinemat manzanita, Sugar pine, whitethorn	Andesitic	Under red fir forest canopy near top of ridge	Mixed conifer (u)
EPII-10	32°	North facing	Bare slope, red fir, white fir, pinemat manzanita, Sugar pine, whitethorn below site	Andesitic	To the west of the top of Red Dog chair, downslope of road	Road (d)
EPIII-1	27°	South facing	Jeffery pine, White fir, manzanita, whitethorn, creeping snowberry, mtn mohagany, mules ear	Glacial material	Above subdivision under forest canopy	Mixed conifer (u)
EPIII-2	20°	South facing	Manzanita, whitethorn, bitterbrush, mtn mahogany, currant, mules ear	Glacial material	Above subdivision under shrub canopy	Chapparal (u)
EPIII-3	25°	S	Mules ear, bitterbrush	Andesite bedrock and loose weathered andesite float	Above water tower just above west edge of subdivision	Chapparal (u)

Erosion Pin Site ID	Slope	*Aspect	Vegetation	Geology	Description	^Associated Landuse
EPIII-4	26°on hillslope 30° on cutbank	N	Some mules ear on hillslope portion	Exposed road cut, glacial material	Roadside cutslope at bottom of subdivision along Squaw Valley Road	Road (d)
EPIV-2	38°	N		Exposed road cut, andesitic	Cut slope below vegetated ski	Road (d)
EPIV-3	17°	E	Sparse grass, immature shrub	granitic	Ski slope, with road above	Ski slope (d)
EPIV-5	33° on steep, 18° on graded	E		granitic	Near road, old excavation site	Road (d)
EPIV-9	36°	E	Bare	andesitic	Below Squaw Peak	Bare rock (u)
EPV-1	25°	S	Bare	Granitic (gruss)	Near Squaw Creek	Bare rock (u)
EPV-2	27°	S	Bare	Granitic (gruss)	Near Squaw Creek	Bare rock (u)
EPV-3	34°	W	Sparse	Andesitic talus, sandy soils, outcrops of andesite	Steep slope	Bare rock (u)
EPV-7	32°	N	Sparse	Andesite	Ski run between Silverado and Solitude chairs.	Ski slope (d)

* N = north facing; S = south facing; E = east facing; w = west facing
^ (d) = disturbed; (u) = undisturbed

snowmelt runoff period the spring and summer of the 2002 field season. The additional data was used to refine the assessment of hillslope erosion rates and erosion susceptibility ranges as they relate to land use and seasonal variation.

Sediment fences – These simple, low cost measures were developed for the study to collect samples of sediment that are moving on hillslopes. Sediment fences consist of fine-mesh silt fencing attached to two foot lengths of 5” diameter fencing posts modeled after instrumentation described by Stott et al. (1986) (Figure 45). The fencing was installed below selected areas downslope of roads, in drainage ditches, and below selected culverts draining into the meadow in order to monitor the production of sediment derived from roads and residential development and assisted in determining their relative contributions of sediment derived. To serve as a general indicator of sediment movement, a line was painted at the top of the installed fence to act as the baseline sediment level. These sites were monitored throughout the 2001 and 2002 field seasons.

Figure 45. Erosion sediment fence to capture sediment from hillslopes, roadcuts, and culvert outlets. Red arrow indicates down slope direction.

Rill and gully development transects – These transects are similar to channel cross-sections and are used to estimate erosion associated with rills and gullies. For this study, rills are considered to be only a few centimeters wide and deep, such that width-depth ratios are near 1. Gullies are defined as steep-sided channels having a width or depth greater than 0.3 meters and active headward erosion or associated with watershed disturbances, such as road runoff (Nolan and Hill, 1991). Transects were installed across selected established rills and gullies and their width and depth recorded. Gully transects were established at two sites, on a road cutslope and on a graded ski slope (Figure 46). This data provides an estimate of the erosion rate in the area and the rate of development of rills, which have the potential to develop into larger gullies that can be significant producers and conveyors of sediment (Seginer, 1966; Kavvas and Govindaraju, 1992; Brunton and Bryan, 2000). Data were collected early during the 2001 field season and repeat measurements collected during 2002. Due to lack of precipitation (the primary mechanism by which rills form) and field observations noting no significant changes in rill or gully dimensions, repeat data for established rill and gully transects were not obtained at the end of the 2001 season.

Figure 46. Installation of gully cross section on ski slope.

Sample Field Data Form

EROSION PIN/SILT FENCE DATA FORM

DATE:___/___/___ SECTOR:________________
SITE ID #: EPV_02 RECORDERS: B Maholland
Slope _______ ______________
Horizontal Pin Transect
GPS Coords: Left Endpoint:_____________ Right Endpoint:_______________

Pin #	Height (mm)	Pin #	Height (mm)	Pin #	Height (mm)
1 0.5		8 14.5		15	
2 2.5		9 16.5		16	
3 4.5		10 18.5		17	
4 6.5		11		18	
5 8.5		12		19	
6 10.5		13		20	
7 12.5		14		21	

Vertical Pin Transect
GPS Coords: Top Endpoint:_____________ Bottom Endpoint:_____________

Pin #	Height (mm)	Pin #	Height (mm)	Pin #	Height (mm)
1 0.5		8 14.5		15	
2 2.5		9 16.5		16	
3 4.5		10 18.5		17	
4 6.5		11		18	
5 8.5		12		19	
6 10.5		13		20	
7 12.5		14		21	

Height is height of top of pin above soil surface. Pins are numbered left to right, looking upslope, and top to bottom of slope.

Silt Fence

Depth 1 (mm)	Depth 2 (mm)	Depth 3 (mm)	Depth 4 (mm)	Depth 5 (mm)

Depth 1 taken at left endpoint, Depth 3 mid-fence, depth 5 at right endpoint.

Notes: ____

____

____

GIS Study-Generated Data Layer Descriptions

Roads - Road databases were developed using a set of criteria that divided paved roads and dirt roads into two sub- categories each. Dirt roads were divided into single-track roads and defined as roads that are wide enough to accommodate a single vehicle, and double-track dirt roads were defined as those roads that are wide enough to allow two vehicles to pass side by side. Single-track and double-track dirt roads were assigned widths determined from averages of road observations on the DOQs: 6.6 m (20 ft) and 13 m (40 ft), respectively. The widths assigned to the two classes of paved roads, primary and secondary, were 9 m (30 ft) and 7.9 m (26 ft), respectively and were derived using the same method as the dirt roads. After the road widths were assigned to each road segment, a buffering operation was run in ArcView to determine the actual area (polygons) a road occupied in the study area. This buffered area accounts for the road and standard roadside (shoulder) exposed surface area (identified from aerial photographs). All of the road segment area measurements were then summarized by type for the study area.

Road cuts – Large road cuts that showed evidence of volumetric soil loss and were not covered by the buffering operation for the road database were identified and mapped during geomorphic reconnaissance. Digital images were taken of each roadcut and a digitized shapefile of polygons representing each roadcut was generated using ArcView 3.2.

Stream Ordering - Hydrologic modeling tools in ArcView were used to delineate subbasins of the Squaw Creek watershed and calculate the stream order classifications. Using the DEM, a flow direction raster file (grid) was calculated for the entire basin, and sub-watersheds were derived based on a minimum cell size for each basin. Next, a flow accumulation grid was processed which calculated the number of upslope cells flowing to a location. From the flow accumulation grid, stream network grids were calculated (Bullard et al., 2002). Stream orders were assigned to each stream segment, using both the Shreve and Strahler techniques, and manually verified.

<u>Meadow geomorphology</u> - Geomorphic feature mapping of the meadow portion of Squaw Creek was completed during the 2001 field season. Geomorphic features were then transferred and digitized from field maps using mosaicked DOQs, aerial photographs, topographic contours derived from 10-meter digital elevation models, and GPS meadow stream attributes in ArcView. Areas for each geomorphic polygon were computed from the digitized layer using ArcView.

<u>Stream thalweg and bank</u> - Stream banks and stream thalweg in the meadow portion of Squaw Creek were mapped using a differentially corrected Global Positioning System (GPS) unit during 2001. Stream bank and thalweg features then were checked and adjusted using mosaicked DOQs in ArcView to correct reception problems encountered by the GPS unit that occurred when mapping portions of the creek under dense canopy.

<u>Stream migration</u> - Aerial photographs from 1939, 1987, and 1997 were scanned as TIF files and imported into the GIS. Stream thalwegs within the meadow portion of the channel were digitized from each photo as polylines. The thalweg polylines were overlain onto mosaicked 1998 DOQs and then manually rotated using ArcView extension software, enlarged and aligned with reference features. Average stream migration was calculated by computing the average migration distances between 1939 and 2001 mapped

thalwegs for sections of the creek. Average yearly channel bank sediment contribution was calculated by taking the area between the 1939 and 2001 channel thalwegs and multiplying it by the average channel depth (thickness) and then dividing by the total number of years represented (2001-1939 = 62 years). This gives the average yearly volume of sediment contributed by channel bank erosion. Volumes were estimated by calculating the area of material eroded, the average bank height, and an average value of 1.5 g cm^{-3} (sandy loam) for sediment bulk density (Miller and Donahue, 1995). This bulk density value was chosen because most of the soils in the meadow reach of Squaw Creek are characterized as sandy loam.

Historic (1939) land cover and land use – Aerial photographs from 1939 were scanned as TIFF files and were then warped and georegistered to fit the rectified 1998 DOQ using an ArcView extension (ImageWarp). Land use and land cover polygons for 1939 were then digitized using stereo pairs and georegistered air photos in GIS.

Geology – Birkeland (1961) originally mapped geologic units for much of the Truckee River basin, which includes the Squaw Creek watershed. The geologic map was then digitized for the LRWQCB as an ArcView polygon shapefile. A new shapefile specific to the Squaw Creek watershed geology was created and modified for this study based on field reconnaissance and air photo analysis.

Appendix E: Sediment and Erosion Data for Squaw Creek Watershed

Based on the inherent mineralogy and the spatial distribution of glacial processes, the volcanic rock types of Squaw Valley are naturally more prone to erosion versus the granitic types under little to no vegetative cover conditions. Also resulting from the mineralogical make up, andesite weathers to produce finer, more easily transportable sediment. Table 18 shows the distribution of major rock types within the watershed, as well as their associated hillslope erosion rates as determined by erosion pin data. Table 19 provides a summary of calculations and annual erosion rates for each sample site. Figures 47 and 48 provide an overview of the relative erosion rates by landuse and geology, respectively.

Table 18. Distribution of rock types by area with associated annual hillslope erosion rates and soil particle size distribution.

	(a) Squaw Creek [A = 21.1^2 km]			(b) North Fork [A = 9.3 km^2]		(c) South Fork [A = 4.7 km^2]	
Geology	**Area (%)**	**HER**	**PSD**	**Area (%)**	**HER**	**Area (%)**	**HER**
Granite (Kg)	37	21-87	0.7	63	21-38	40	38-70
Andesite (Ta)	34	10-87	0.2-0.7*	33	25-54	40	22-50
Glacial Deposits (Qti)	20	22-67	0.2-0.3	< 1	--	17	--

HER: Hillslope erosion rate (mm/year).
PSD: Particle Size Distribution (fine fraction, d_{60}), mm
*Sample from EPV-3, which is located near watershed divide at high elevation and little soil development.

Table 19. Summary of annual hillslope erosion rates (mm/year) by sample site. Erosion rates determined from erosion pin data collected from 2001 through 2002 and averaged across transects (Wells and Gutierrez, 1982).

Erosion Pin Site ID	Sample Period Erosion Rate (ER_{sp}) (m/sample period)	Sample Period PPT Total (in/sample period)	Sample Period Erosion Rate (ER_t) (m/in of ppt)	Annual Avg PPT Total (in/year)	Sediment Rate Movement (m/year) = ER_{ppt}*Annual PPT	Sediment Rate Movement (mm/year) = ERppt*Annual PPT
EPII-1	*	52.66	*	71.28	0.0218	**22**
EPII-2	0.0182	52.66	0.0003	71.28	0.0246	**25**
EPII-4	0.0072	50.68	0.0001	71.28	0.0101	**10**
EPII-10	0.0260	52.66	0.0005	71.28	0.0352	**35**
EPIII-1	0.0173	52.66	0.0003	71.28	0.0234	**23**
EPIII-2	0.0363	52.66	0.0007	71.28	0.0491	**49**
EPIII-3	0.0639	52.66	0.0012	71.28	0.0865	**87**
EPIII-4	0.0494	52.66	0.0009	71.28	0.0668	**67**
EPIV-2	0.0368	52.66	0.0007	71.28	0.0497	**50**
EPIV-3	0.0520	52.66	0.0010	71.28	0.0704	**70**
EPIV-5	0.0284	52.66	0.0005	71.28	0.0384	**38**
EPIV-9	0.0164	52.66	0.0003	71.28	0.0221	**22**
EPV-1	0.0152	52.66	0.0003	71.28	0.0206	**21**
EPV-2	0.0283	52.66	0.0005	71.28	0.0382	**38**
EPV-3	0.0177	50.68	0.0003	71.28	0.0249	**25**
EPV-7	*	49.81	*	71.28	0.0539	**54**

* Erosion rates for EPII-1 and EPV-7 were collected only in 2001 and extrapolated to obtain rates for this table.

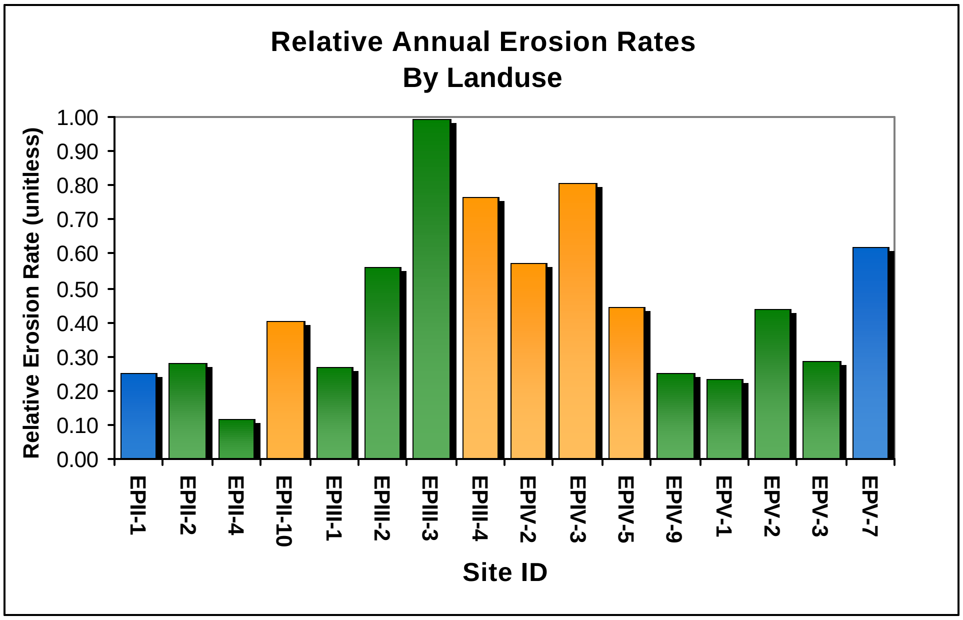


Figure 47. Comparative graph of erosion rates related to landuse.
Blue = ski run, Green = undisturbed, Orange = related to roads.

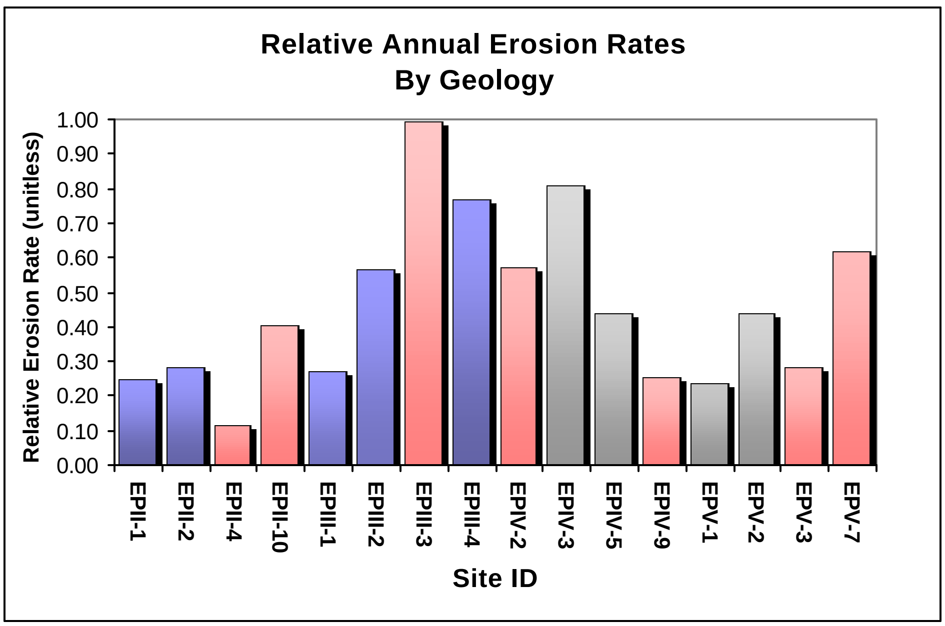
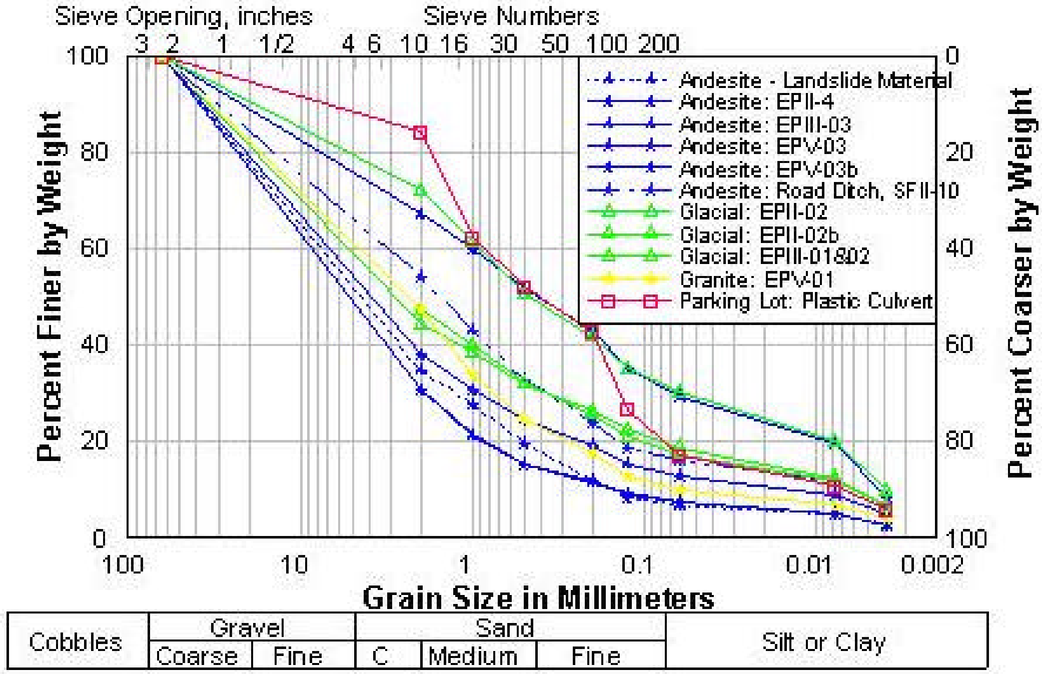
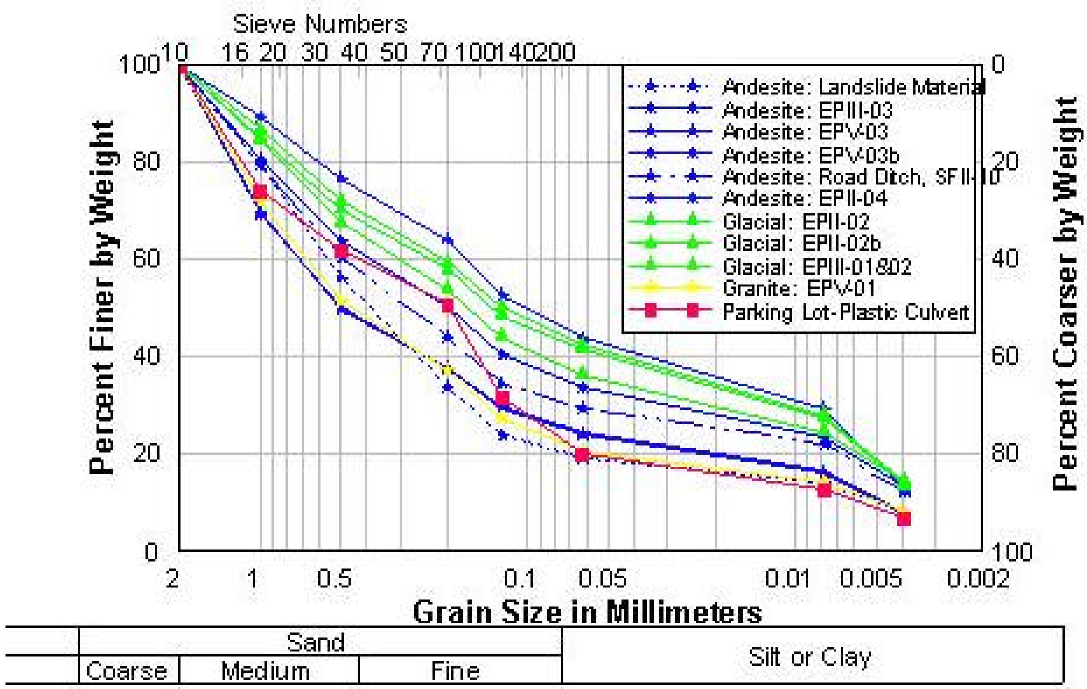


Figure 48. Comparative graph of erosion rates related to major rock types.
Blue = glacial deposits, Pink = Andesitic (volcanic) bedrock, Gray = granitic bedrock.

Appendix F

Particle Size Distribution Graphs for Bar and Hillslope Samples





Appendix G

Channel Cross-Section Data and Graphs

Initial Measurement June 2001		**Repeat Measurement** July 2002	
Site ID: XnI1-1			
Horizontal (ft)	Vertical (ft)	Horizontal (ft)	Vertical (ft)
0.00	4.39	0.00	4.35
6.70	4.46	6.70	4.48
7.60	3.31	7.60	3.37
12.80	1.79	12.80	1.87
13.60	1.59	13.60	1.08
14.20	0.43	14.20	0.43
17.40	0.26	17.40	0.31
20.80	0.39	20.80	0.38
26.30	0.15	26.30	0.15
30.60	0.00	30.60	0.00
32.50	0.01	32.50	0.05
33.58	0.01	33.38	0.55
33.50	0.51	32.67	1.00
33.38	0.96	32.65	1.24
32.94	1.20	32.53	1.73
32.75	1.69	32.68	2.35
32.50	2.31	32.50	1.80
32.80	2.39	32.80	1.81
33.80	3.52	33.80	3.23
34.90	3.74	34.90	4.08
35.80	4.53	35.80	4.30
41.30	4.70	41.30	4.99

Initial Measurement June 2001		**Repeat Measurement** July 2002	
Site ID: XnI1-2			
Horizontal (ft)	Vertical (ft)	Horizontal (ft)	Vertical (ft)
0.00	6.58	0.00	6.54
6.30	5.78	6.30	5.81
8.40	4.07	8.40	4.22
8.08	3.99	8.08	4.45
8.35	3.09	8.40	3.15
7.37	2.75	8.33	2.81
7.99	2.30	8.52	1.86
8.60	1.59	8.60	1.65
10.90	0.34	10.90	0.77
12.70	0.00	12.70	0.05
15.00	0.20	15.00	0.00
19.80	1.90	19.80	1.96
22.30	2.20	22.30	2.53
24.90	2.87	24.90	2.74
31.20	3.48	31.20	3.47
32.30	3.77	32.30	3.84
34.50	4.80	34.50	4.97
43.90	6.39	43.90	6.38

Initial Measurement June 2001		Repeat Measurement July 2002	
Site ID: XnI1-3			
Horizontal (ft)	Vertical (ft)	Horizontal (ft)	Vertical (ft)
0.00	4.73	0.00	4.77
2.90	4.70	2.90	4.67
8.60	3.66	8.60	3.60
14.80	2.22	14.80	2.13
16.20	1.64	16.20	1.70
17.60	1.43	17.60	1.41
19.60	0.31	19.60	0.45
23.50	0.69	23.50	0.34
32.70	0.00	32.70	0.00
34.00	1.21	34.00	1.09
35.00	1.57	35.00	1.52
35.49	1.98	35.49	1.93
36.42	2.86	36.48	2.81
36.38	3.27	35.00	3.22
35.18	3.39	35.00	3.34
35.43	4.08	35.36	4.03
36.08	4.86	35.94	4.81
35.40	4.14	35.40	3.92
36.60	4.95	36.60	4.77
42.20	4.97	42.20	4.94

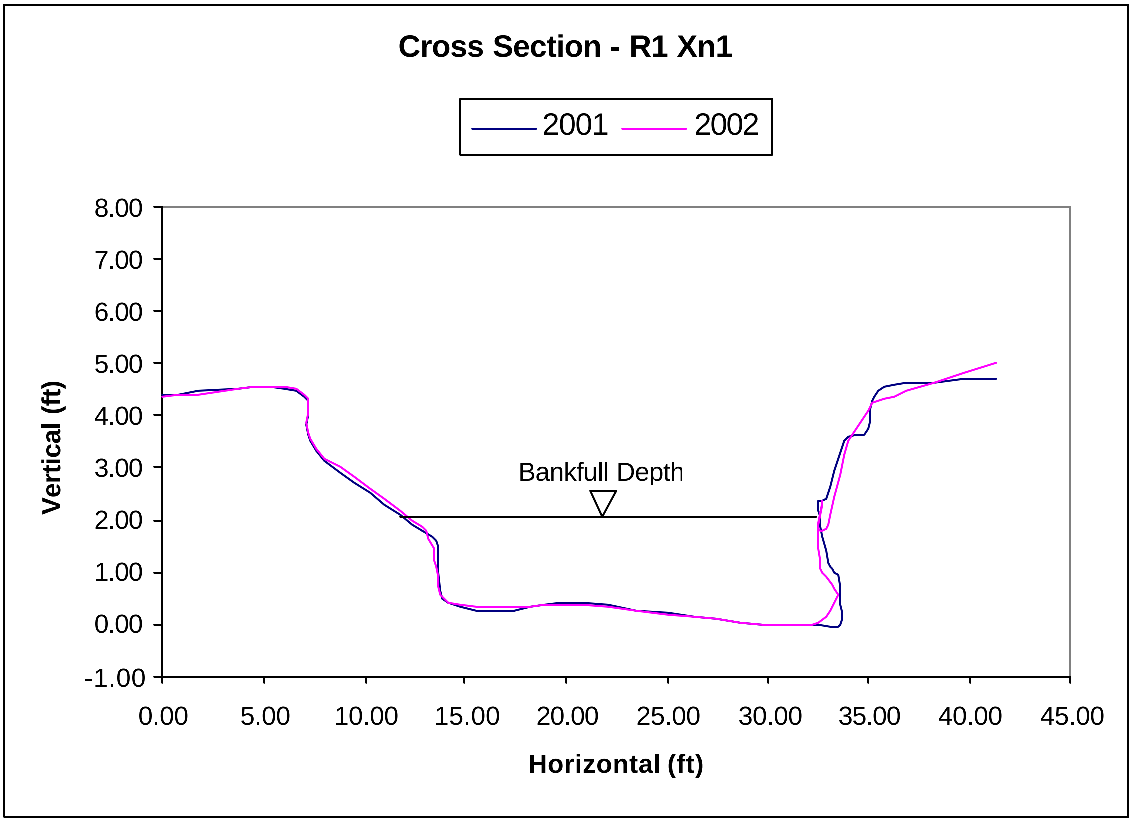
Initial Measurement June 2001		Repeat Measurement July 2002	
Site ID: XnI1-4			
Horizontal (ft)	Vertical (ft)	Horizontal (ft)	Vertical (ft)
0.00	6.86	0.00	7.39
3.40	6.81	3.40	7.27
6.30	5.76	6.30	6.28
12.50	5.58	12.50	6.07
19.50	4.54	19.50	5.14
22.60	4.17	22.60	4.56
26.40	2.83	24.00	3.98
29.20	1.83	26.40	3.47
30.20	1.61	29.20	2.49
34.90	0.40	30.20	1.67
36.50	0.00	34.90	0.39
37.70	0.87	36.50	0.00
39.60	1.92	37.70	0.21
40.40	0.74	39.60	1.20
41.30	1.66	40.40	0.49
43.30	3.71	41.30	2.06
44.20	4.36	43.30	3.81
44.46	4.77	44.20	4.54
44.37	5.31	44.23	4.95
44.54	5.57	44.69	5.49
44.45	6.01	44.87	5.75
44.37	6.96	44.95	6.19
50.30	6.97	44.20	7.14
		44.30	7.20
		50.30	7.42

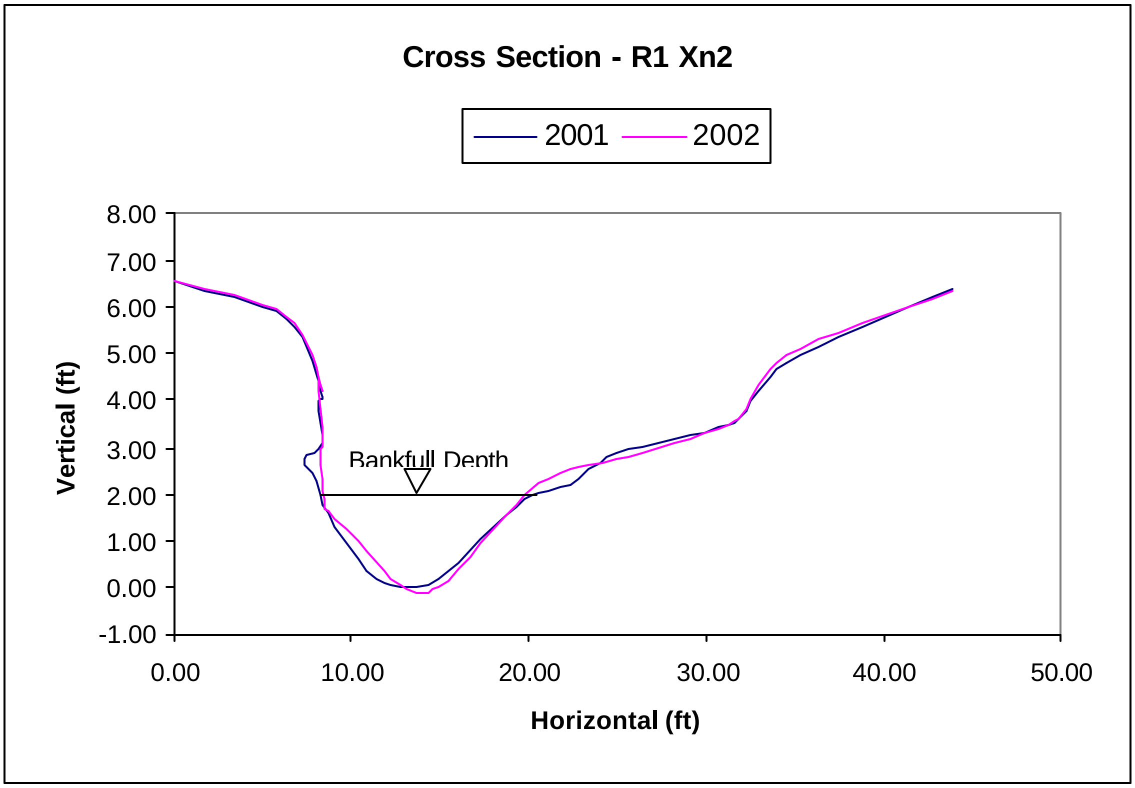
Initial Measurement June 2001		Repeat Measurement July 2002	
Site ID: XnI2-1			
Horizontal (ft)	Vertical (ft)	Horizontal (ft)	Vertical (ft)
0.00	7.56	0.00	7.53
7.40	7.51	7.40	7.64
10.40	6.82	10.40	6.64
10.50	6.63	10.50	6.64
10.04	5.66	10.18	5.67
9.25	5.36	10.03	5.37
9.51	4.78	9.81	4.79
10.50	4.33	10.50	4.34
14.40	2.91	15.11	2.80
15.80	1.47	15.80	2.35
15.90	0.37	15.90	1.10
18.50	0.00	18.50	0.00
24.00	0.15	24.00	0.30
32.00	3.34	32.00	2.98
34.40	4.05	34.40	3.75
38.00	6.22	38.00	5.94
50.00	6.61	50.00	6.58

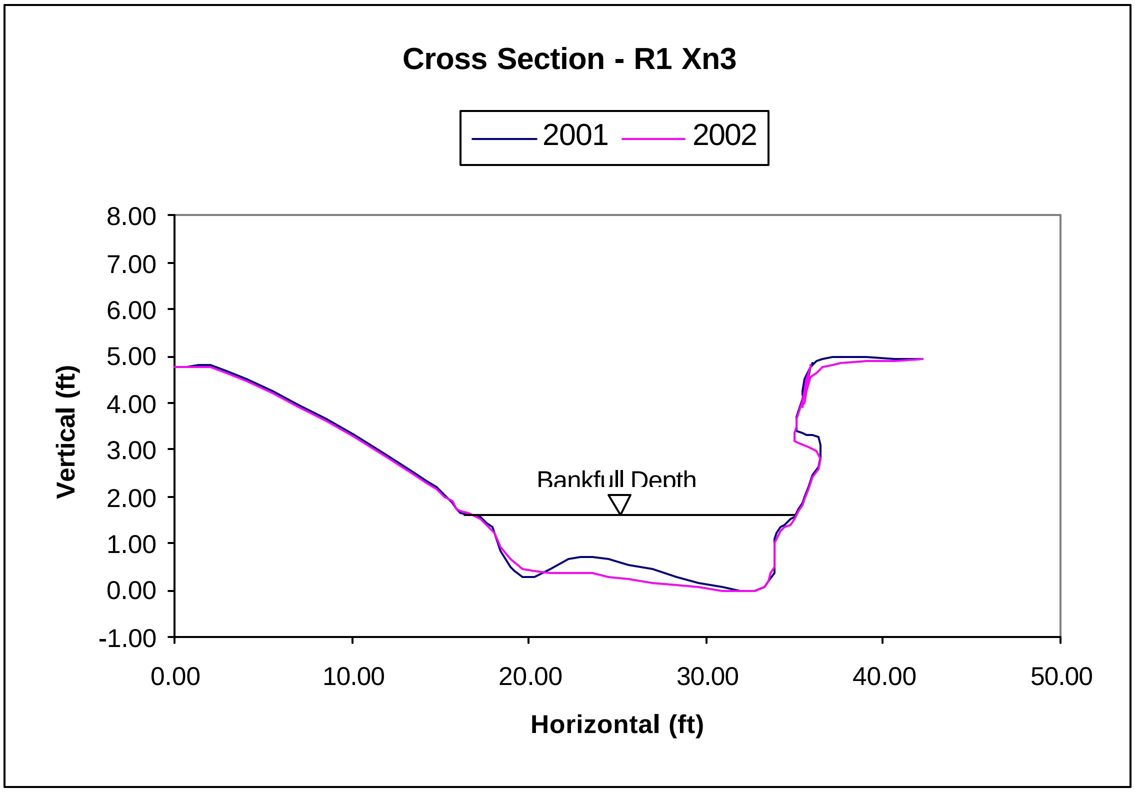
Initial Measurement June 2001		Repeat Measurement July 2002	
Site ID: XnI2-2			
Horizontal (ft)	Vertical (ft)	Horizontal (ft)	Vertical (ft)
0.00	5.45	0.00	5.48
5.60	4.45	5.60	4.51
8.30	4.45	8.30	4.56
15.00	4.29	15.00	4.36
26.00	4.36	26.00	4.36
30.10	2.51	30.10	2.54
43.90	1.45	43.90	1.19
50.90	0.00	50.90	0.00
53.50	0.30	53.50	0.39
54.10	1.57	54.10	1.60
54.60	1.57	54.60	1.51
55.00	1.98	55.00	1.60
55.48	2.48	55.92	2.10
55.83	3.17	56.57	2.79
55.41	3.76	56.97	3.38
55.00	4.27	56.21	3.89
55.15	4.68	55.00	4.79
55.20	4.61	55.20	4.86
59.40	5.39	59.40	5.36
62.80	5.43	62.80	5.47

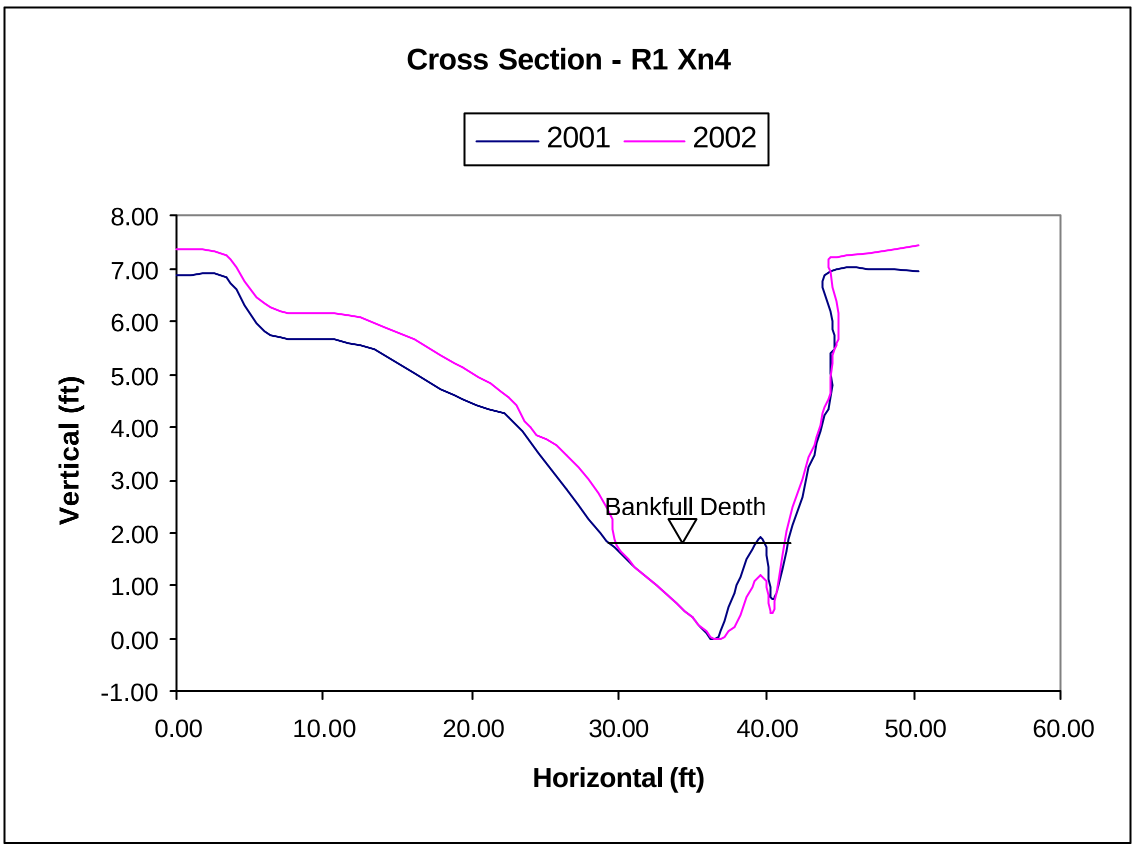
Initial Measurement June 2001		Repeat Measurement July 2002	
Site ID: XnI2-3			
Horizontal (ft)	Vertical (ft)	Horizontal (ft)	Vertical (ft)
0.00	5.69	0.00	5.48
3.50	5.22	3.50	5.06
5.90	4.54	5.90	4.38
12.00	3.61	12.00	3.43
14.80	3.77	14.80	3.60
19.10	3.02	19.10	2.88
21.60	2.97	21.60	2.99
33.80	1.92	33.80	1.52
37.80	1.17	37.80	0.89
41.50	0.00	41.50	0.03
43.50	0.32	43.50	0.01
45.30	0.61	45.30	0.00
46.40	0.96	46.40	0.22
47.00	1.33	47.00	3.30
48.30	3.21	48.30	3.03
50.50	4.23	50.50	4.10
54.40	4.53	54.40	4.39
59.50	4.27	59.50	3.99
65.20	5.72	65.20	5.45
71.30	6.12	71.30	5.80

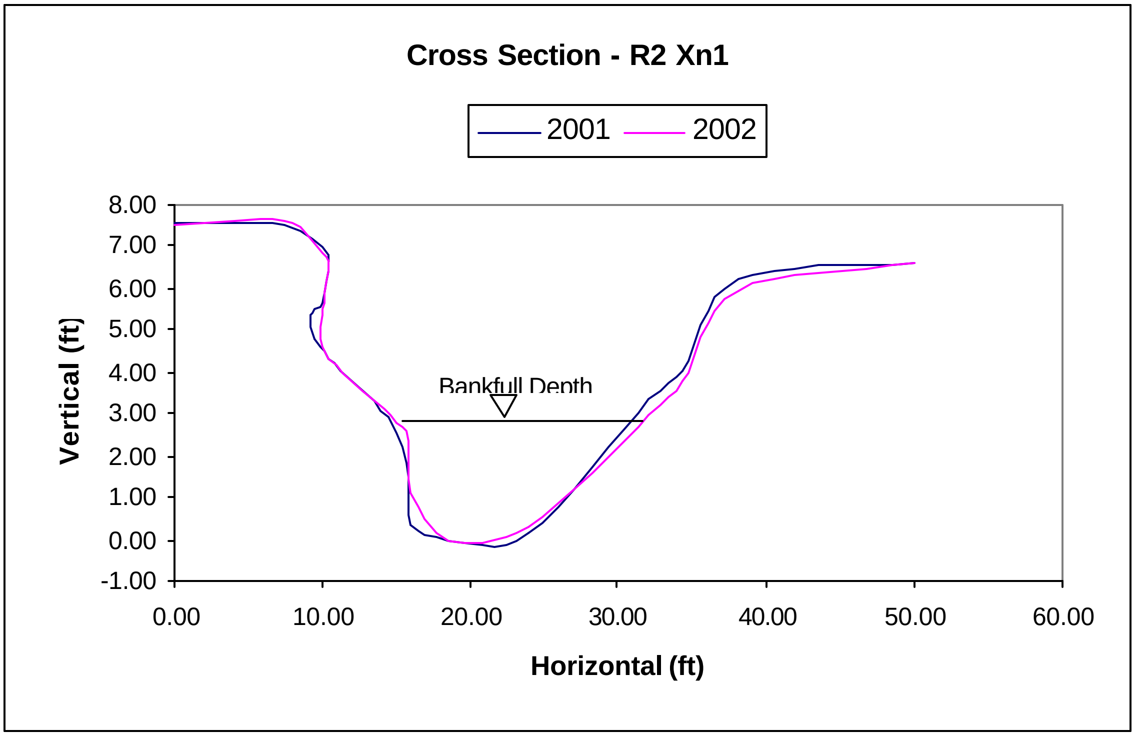
Initial Measurement June 2001		**Repeat Measurement** July 2002	
Site ID: XnI2-4			
Horizontal (ft)	Vertical (ft)	Horizontal (ft)	Vertical (ft)
0.00	5.04	0.00	5.10
14.50	4.88	14.50	4.98
15.10	3.63	15.10	3.65
15.70	3.47	15.70	3.56
16.90	4.01	16.90	3.10
18.10	1.23	18.10	1.33
19.70	1.05	19.70	1.05
20.30	0.63	20.30	0.84
21.10	0.68	21.10	0.75
21.70	0.15	21.70	0.21
24.90	0.00	24.00	0.00
31.60	0.59	24.90	0.13
35.40	0.97	31.60	0.70
37.20	1.87	35.40	1.20
38.90	2.47	37.20	1.96
41.40	3.69	38.90	2.76
53.50	3.75	41.40	3.78
70.00	4.73	53.50	3.87
		70.00	4.84

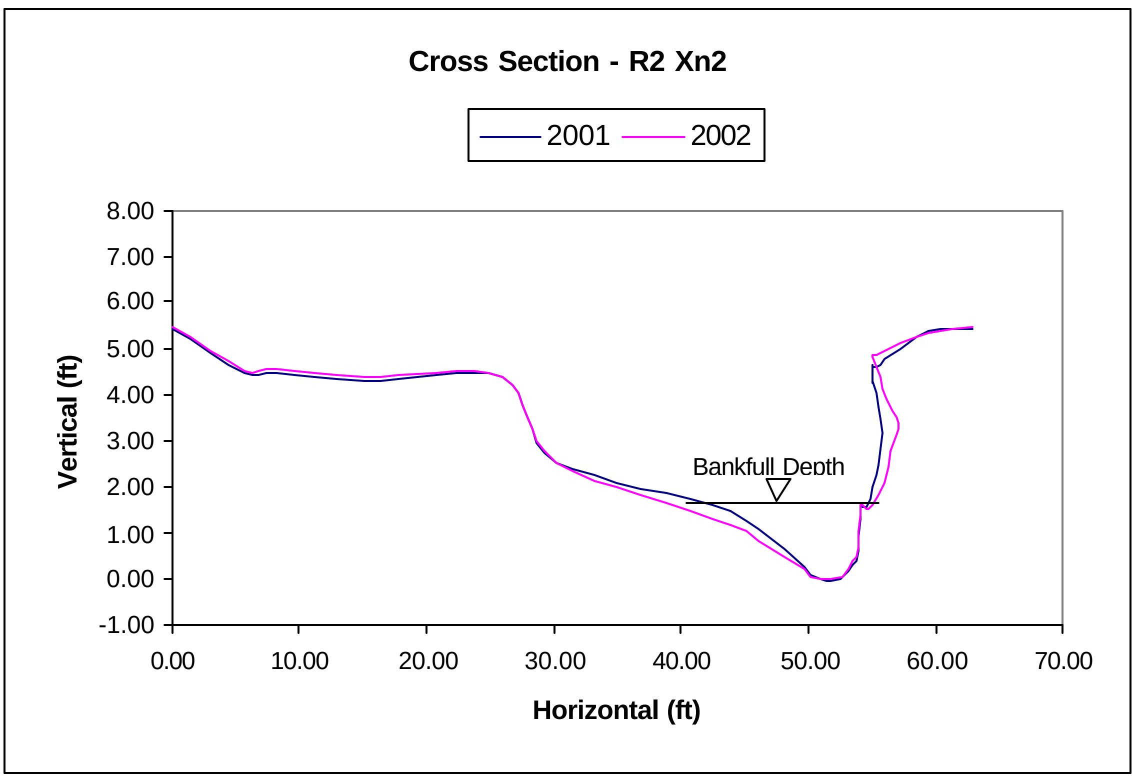

Cross Section - R1 Xn1
2001
2002
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
Vertical (ft)
Bankfull Depth
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
Horizontal (ft)

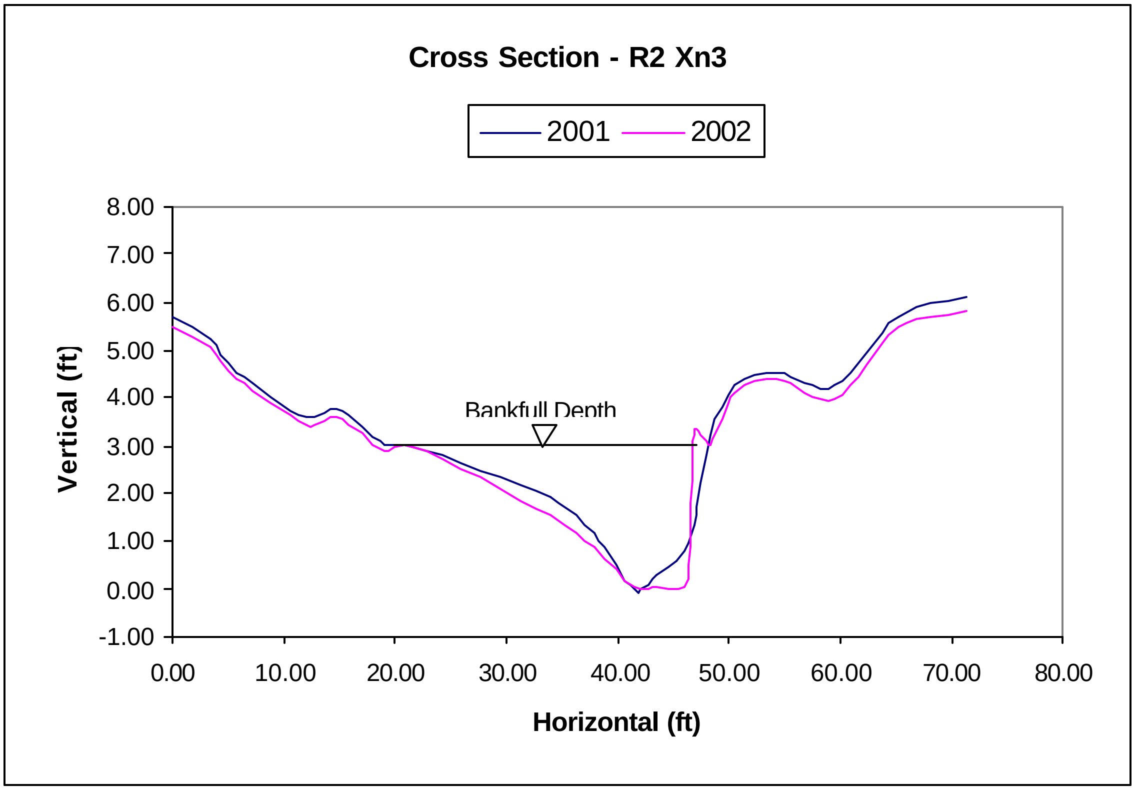

Cross Section - R1 Xn2
2001
2002
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
Vertical (ft)
Bankfull Depth
0.00
10.00
20.00
30.00
40.00
50.00
Horizontal (ft)

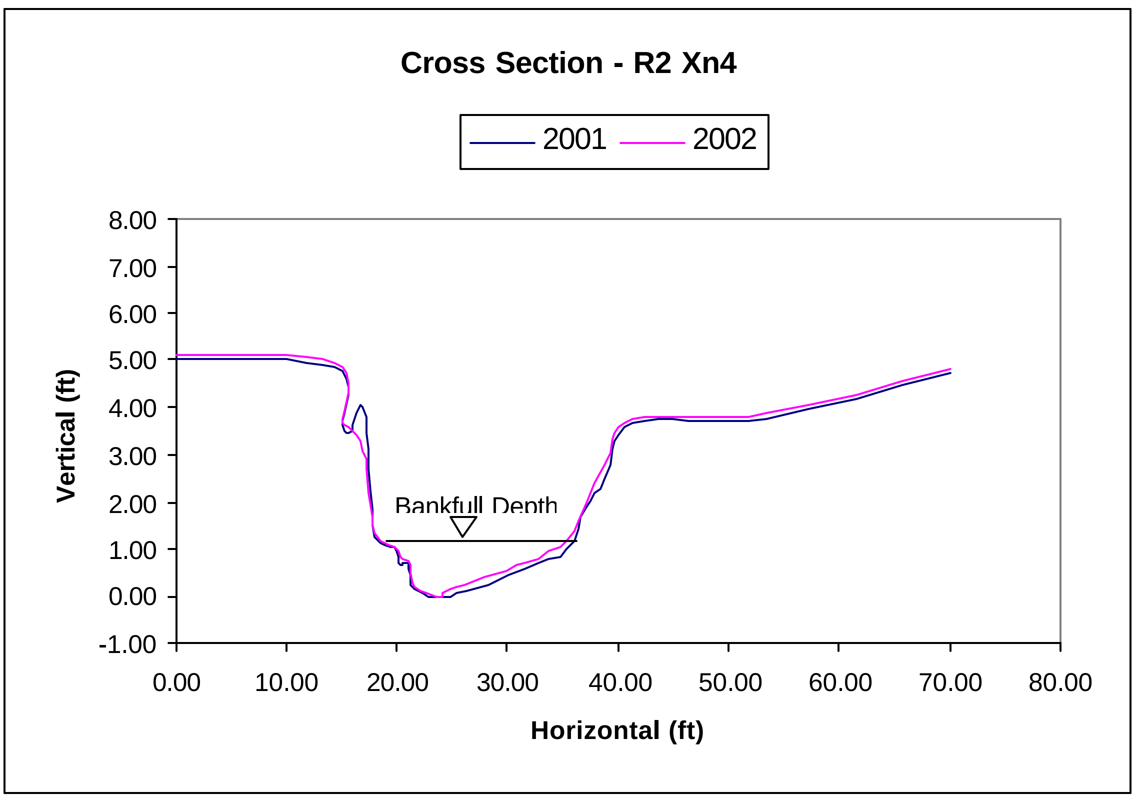

Cross Section - R1 Xn3
2001
2002
Bankfull Depth
Vertical (ft)
Horizontal (ft)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
0.00
10.00
20.00
30.00
40.00
50.00


Cross Section - R1 Xn4
2001
2002
Bankfull Depth
Vertical (ft)
Horizontal (ft)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00


Cross Section - R2 Xn1
2001
2002
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
Vertical (ft)
Bankfull Depth
0.00
10.00
20.00
30.00
40.00
50.00
60.00
Horizontal (ft)


Cross Section - R2 Xn2
2001
2002
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
Vertical (ft)
Bankfull Depth
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Horizontal (ft)


Cross Section - R2 Xn3
2001
2002
Bankfull Depth
Vertical (ft)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Horizontal (ft)


Cross Section - R2 Xn4
2001
2002
Bankfull Depth
Vertical (ft)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Horizontal (ft)

Appendix H

Erosion Susceptibility Model Development

Using the GIS, weighted erosion models were developed that incorporated the effects of roads, geology, soils, slope, land use, and land cover relative to erosional susceptibility for 1939 and 2002 (Figures 49 and 50). Each parameter was assigned a percentage value reflecting its relative influence on erosion susceptibility (e.g., 20%). Scale values for fields within each of these parameters were then assigned (1 to 9) on the basis of their relative importance for hillslope erosion potential, based on field data and review of literature. For example, slopes ranging from 0 to 5 percent received a scale rating of 1; slopes ranging from 5 to 10 percent received a 2, etc. Polygons of potential erosion were then created for each parameter and rated from 1 to 8, 1 being lowest erosional susceptibility, and 8 being the highest. Polygons with a rating of 6, 7, or 8 were designated as high erosion susceptibility, and polygons with 1, 2, or 3 were designated as low erosion susceptibility.

To determine areas of high erosion susceptibility, all slopes greater than 30º were identified and categorized as "steep" from the Squaw Creek 10 meter digital elevation model (DEM). Areas of chaparral and bare or marginally vegetated rock and soil that intersected steep slopes were designated as high susceptibility. However, granite outcrops were excluded due to the higher degree of resistance to erosion for this rock type in relation to the other dominant rock types occurring within the Squaw Creek watershed. Moderately steep slopes (15º – 30º) were next identified and categorized. Areas of chaparral, graded ski runs, and bare or marginally vegetated "very high erosion hazard" soils (as classified in the Tahoe National Forest Soil Survey, 1994) that

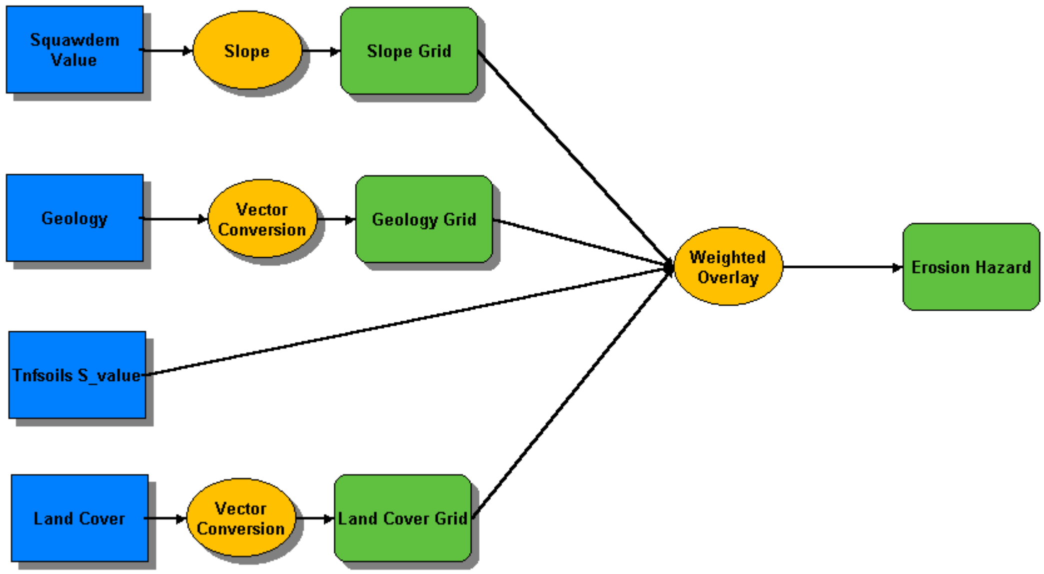


Figure 49. Flow diagram showing components of 1939 hillslope erosion susceptibility model.

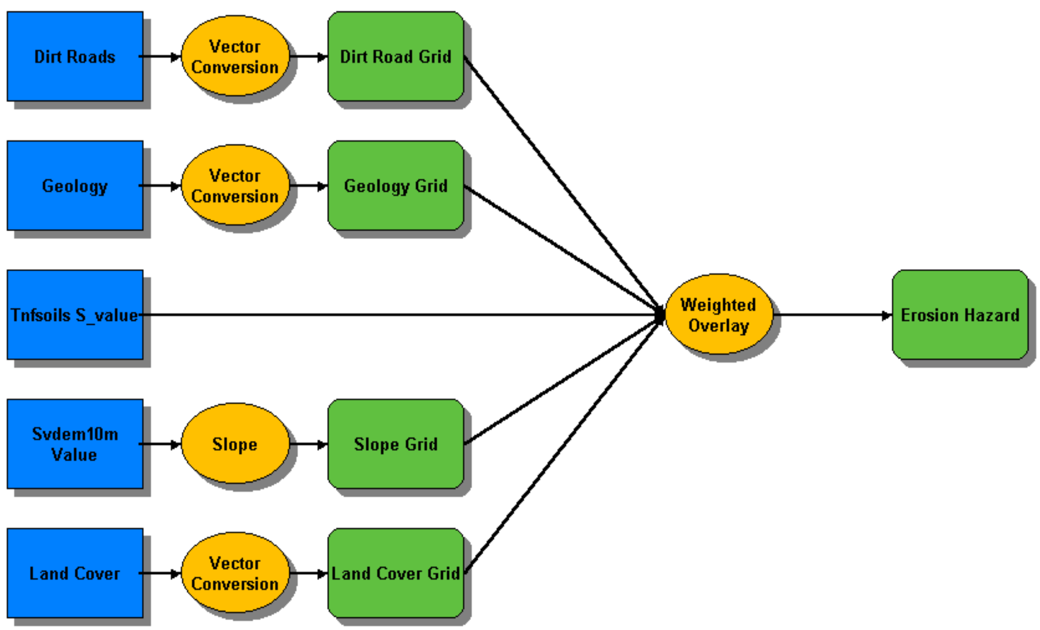


Figure 50. Flow diagram showing components of 2002 hillslope erosion susceptibility model.

intersected steep or moderately steep slopes and were intersected by significant road networks were categorized as having high erosion susceptibility. Lastly single and double track roads and major landslide scars were also categorized as high erosion susceptibility, regardless of slope.

To determine areas of low erosion susceptibility, all slopes less than 20º were identified and categorized as “moderate” from the Squaw Creek 10 meter digital elevation model (DEM). Areas of mixed conifer and forbs and grasses land cover classifications that occurred on moderate slopes were determined to be of low erosion susceptibility. Additionally, alpine meadow and non-flowing water body land cover classifications were identified as low erosion susceptibility, since these features act as storage sites for sediment transported to them.

Appendix I

Mapping of Alluvial Channel Geomorphological Features

Geomorphic feature mapping of the meadow portion of Squaw Creek was completed during the 2001 field season. Geomorphic features were then transferred and digitized from field maps using mosaicked DOQs, aerial photographs, topographic contours derived from 10-meter digital elevation models, and GPS of meadow stream attributes in ArcView. Areas for each geomorphic polygon were computed from the digitized layer using ArcView. Descriptions for the mapped geomorphic features depicted in Figures 51, 52, and 53 are given below.

Point Bar: Fluvial deposits of sand, gravel, and cobble located on the inside of meander bends. Vegetation cover is moderate and consists of early successional grasses and forbs such as fireweed.

Lower Point Bar: Fluvial deposits of sand, gravel, and cobble located on the inside of meander bends, but elevationally lower than other mapped point bar deposits. These features are located within the active channel boundary and are devoid of vegetation.

Upper Point Bar: Fluvial deposits of sand, gravel, and cobble located on the inside of meander bends, but elevationally higher than other mapped point bar deposits. Feature contains established early successional vegetation.

Mid-Channel Bar: Fluvial deposits of sand, gravel, and cobble located in the middle of the channel. These deposits are exposed during lower flow conditions and have established riparian vegetation such as willow.

Erosional Terrace: The tread of this type of terrace feature is formed by lateral erosion of bank material and is identified by exposed bank stratigraphy, slumped bank material, and topography which is lower than the adjacent meadow land, but higher than the channel bottom. Erosional terraces confine the channel and act as part of the active floodplain. Established vegetation consists of lodgepole pine, willow, and 100% grass cover. Some erosional terraces have an overlying veneer of fluvial deposition.

Depositional Terrace: Consists of uneroded, large fluvial deposits of cobbles, gravel, and sand. These features contain established riparian vegetation, such as willow, and 100% grass and forb cover (dominantly, prostrate lupine species). They are marked by flow lines for differing discharge stages and are elevationally similar to erosional terraces.

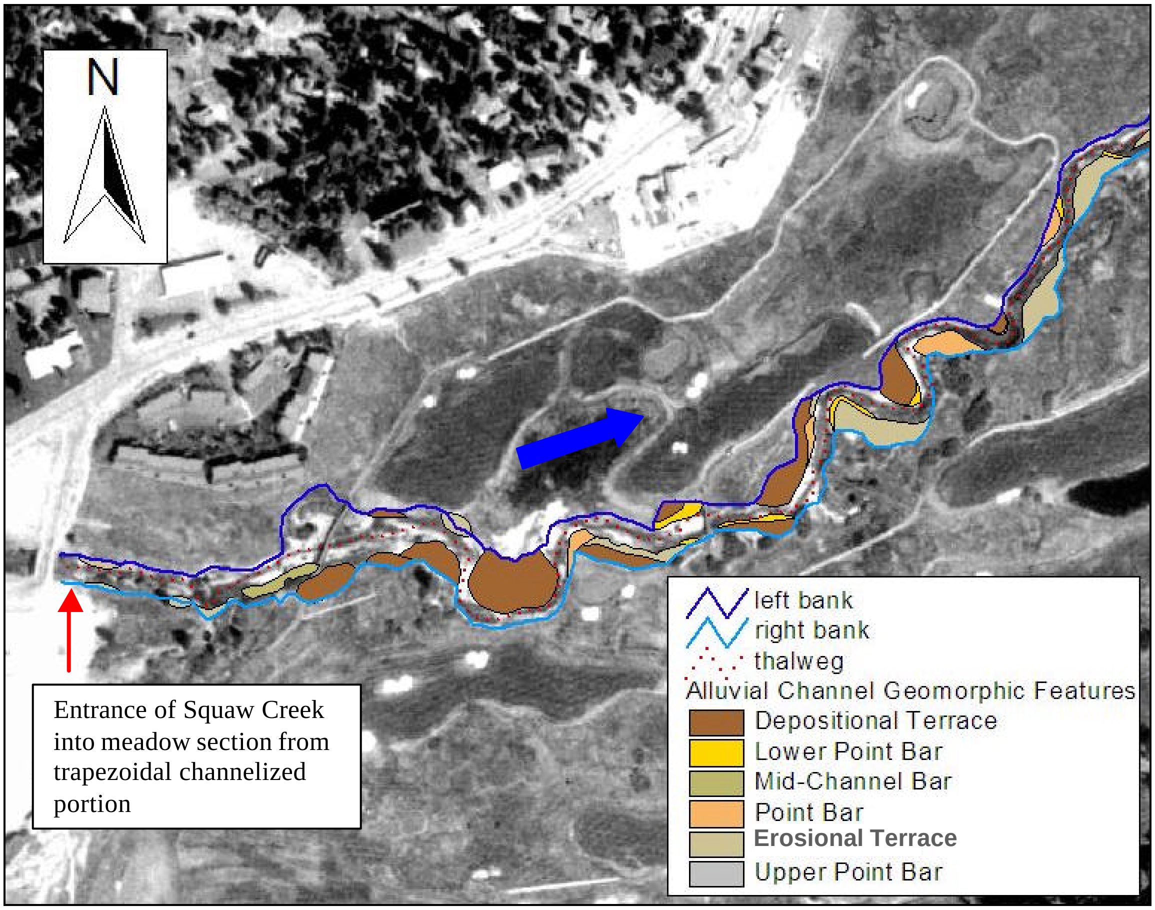


Figure 51. Mapped geomorphic features of the main valley alluvial channel (main stem) of Squaw Creek. Western most portion of the mapped section-Golf course surrounds creek. Blue arrow indicates flow direction.

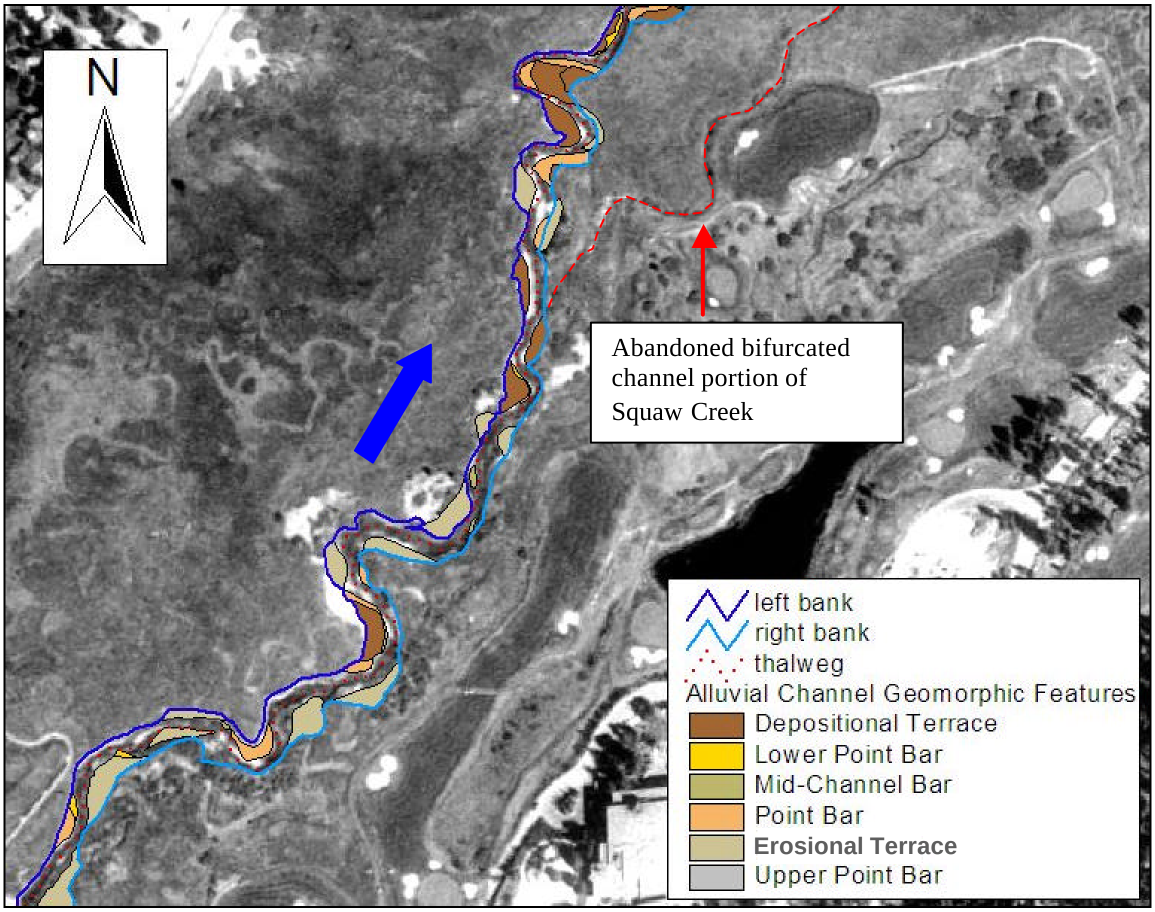


Figure 52. Mapped geomorphic features of the main valley alluvial channel (main stem) of Squaw Creek. Middle portion of the mapped section-Golf course on right hand side of stream. Blue arrow indicates flow direction.

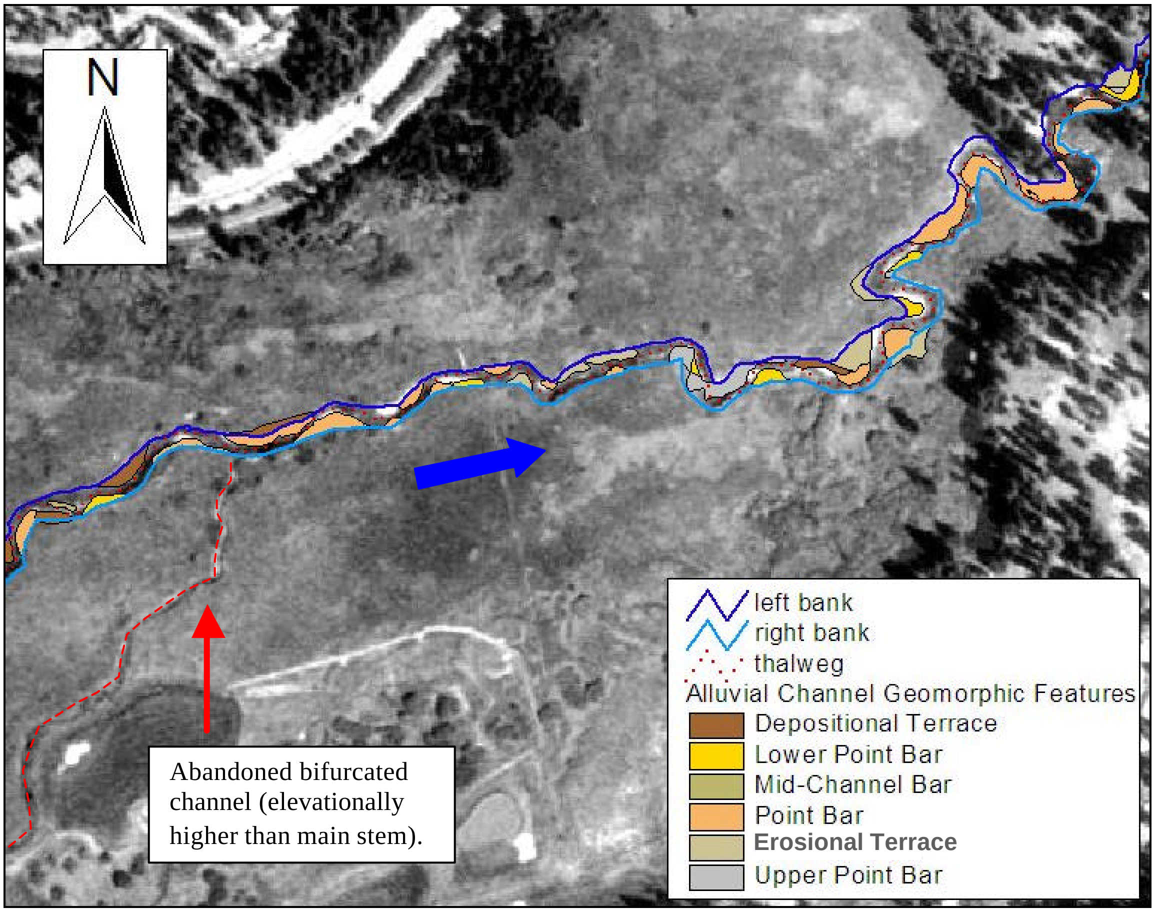


Figure 53. Mapped geomorphic features of the main valley alluvial channel (main stem) of Squaw Creek. Eastern most portion of the mapped section. Blue arrow indicates flow direction.