BIG CREEK WATERSHED ASSESSMENT REPORT

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SECTION 1

INTRODUCTION

Mission Statement

The Big Creek Watershed Management: Collaborative Plan for Hayfork's Municipal Water Source project is a comprehensive watershed management plan for the town of Hayfork's municipal watershed. The plan will define goals and objectives, outline strategies, and prescribe activities to restore and protect water quality and beneficial uses in the more than 19,084-acre Big Creek Watershed. Protection of water quality and beneficial uses, as outlined in the North Coast Regional Water Quality Control Plan (NCRWGCP), is mandated by both the Federal Clean Water Act (CWA) and the State Porter-Cologne Water Quality Act (Porter-Cologne) and is the fundamental reason and motivation for this assessment and management plan.

Purpose of Report

The intent of this watershed assessment report is to develop and document a scientific based understanding of the natural processes and active land management occurring in the Big Creek watershed. The report will provide the basis by which the watershed can be understood as an ecological system and will allow interested parties to understand the processes and interactions that occur within its boundaries. Of particular importance in the Big Creek watershed is the protection of water quality and water quantity for the municipal water supply for the community of Hayfork, California. This Watershed Assessment is an existing conditions report that will be used as an educational tool to help guide residents and stakeholders in prioritizing future watershed planning and restoration projects. It will be amended and extended as new information becomes available.

Project Funding Source

This watershed assessment, as part of the *Big Creek Watershed Management: Collaborative Plan for Hayfork's Municipal Water Source*, is funded through Proposition 40: The California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002. The intended purpose of Proposition 40 is:

> *To protect rivers, lakes, and streams to improve water quality and ensure clean drinking water; to protect beaches and coastal areas threatened by pollution; to improve air quality; to preserve open space and farmland threatened by unplanned development; to protect wildlife habitat; to restore historical and cultural resources; to repair and improve the safety of state and neighborhood parks*…….(SWRCB 2007).

The Division of Financial Assistance administers Proposition 40 funded programs including the Integrated Watershed Management Program (IWMP), available for pubic agencies and non profit organizations to fund projects for development of local watershed management plans and for implementation of watershed protection and water management projects

Problem Definition

The Big Creek watershed is a major tributary stream to Hayfork Creek, which is the main tributary to the South Fork of the Trinity River. The South Fork is the largest un-dammed Wild and Scenic River in California and has been included on California's Clean Water Act (CCWA) Section 303(d) list as water quality limited due to sediment. The sedimentation in the South Fork Trinity River watershed exceeds existing Water Quality Standards (WQS) necessary to protect the beneficial uses of the basin (EPA 1998).

In 1998, the North Coast Regional Water Quality Control Board (NCRWQCB) added temperature impairment to its 303(d) list for the South Fork Trinity River (EPA 1998). Temperatures in the lower South Fork and selected tributaries, particularly the lower portion of Hayfork Creek, have been implicated as being too high to fully support aquatic habitat. High temperatures could result from: natural conditions, water diversions (particularly in Salt Creek, Hayfork Creek, and Big Creek), loss of riparian vegetation in selected locations, and excess sedimentation that resulted in channel widening and decreased water depths (EPA 1998).

The beneficial uses of the water bodies as described in the North Coast Basin plan are the domestic use supply to approximately 1,500 users within the water district boundaries as well as some agricultural and industrial use. Recreation along the creek and at Ewing Reservoir is common for both locals and out of town tourists. Big Creek also provides cold freshwater habitat for steelhead and resident rainbow trout.

Need for Assessment

Currently the quality of water delivered under standard flows (non-storm) is excellent with no major human health issues. However, peak flow data is lacking. Past land-use practices (logging, mining and ranching) have accelerated erosion delivery processes and increased the potential for catastrophic wildfires. Mast-wasting and catastrophic wildfire would likely severely impair this critical watershed for decades. These are the primary pollutant threats to the beneficial uses derived from the watershed. The management plan would establish pollutant load targets for temperature and sediment, along with the specific strategies to reduce their potential impacts, protect beneficial uses, and improve water body quality.

Project Goals

Although our project will not immediately affect the ecological processes and environmental resources within the watershed boundaries, ultimately on-the-ground implementation of the planned watershed management projects will have a considerable influence on both. The completion of this project will provide a comprehensive management plan that will describe the ecological processes and environmental resources (including hydrologic, terrestrial, and aquatic) in the watershed, along with the most efficient and effective ways to manage for both the short and long term. A collaborative approach is being employed to draw on multi-disciplinary expertise and incorporate a diverse range of interests representing both the public and private lands to draft and adopt a widely supported plan for this critical at-risk watershed. To date, members of the Big Creek Collaborative include: representatives from the U.S. Forest Service (USFS), Natural Resource Conservation Service(NRCS), Trinity County Resource Conservation District (TCRCD), Trinity County Planning Department (TCPD), and Trinity County Waterworks District #1; concerned citizens, community representatives and private landowners; and staff members of Graham Matthews & Associates (GMA), North State Resources (NRS), and the Watershed Research and Training Center (WRTC).

Project Objectives
The primary objective of this Watershed Assessment and the final Big Creek Watershed Management Plan (BCWMP) are to identify areas within the watershed that contribute, or have the potential to contribute, excessive amounts of sediment delivery that influence turbidity in Big Creek. High levels of turbidity are the single greatest threat to the municipal water supply for the community of Hayfork and could affect other aquatic resources, such as fish habitat. The data derived from the Watershed Assessment, and the resulting analyses, will allow us to target the applicable pollutant sources and set parameters for maintaining watershed health. After identifying the threats to and factors directly affecting Big Creek, we will then develop projects and treatments to minimize threats to the resource values and ecological health of the watershed. We will also establish a comprehensive monitoring plan for measuring project implementation and effectiveness at achieving the identified watershed goals and objectives.

Watershed Assessment Tasks
To meet the objectives for the BCWMP for Hayfork's Municipal Water Source, the following tasks were identified for a comprehensive and detailed Watershed Assessment:

- Public meetings to conduct stakeholder watershed survey of resources at risk
- Formation of Big Creek Watershed Collaborative to act as a Technical Advisory Committee
- Watershed Resource Inventory (WRI)
  - Stream Flow and Sediment Monitoring WY 2007
  - Road Assessment
  - Landslide Inventory
  - Stream Condition Inventory
  - Fire and Fuels Assessment
  - Current and Historic Land Use
  - Current and Historic water Delivery Systems
- On-going stakeholder meetings and field trips to discuss progress of WRI and receive valuable feed-back
- Watershed Resource Analysis
  - Modeling to derive sediment budget
  - Fire behavior modeling to determine areas at risk for high severity fire
  - Streamflow, turbidity and temperature analysis
- Synthesis of Watershed Assessment Report

SECTION 1 REFERENCES

State Water Resources Control Board (SWRCB). 2007. *Introduction to the Basin Plan*, North Coast Regional Water Quality Control Board. Available on-line at: http://www.waterboards.ca.gov/northcoast/programs/basinplan/basin.html; last accessed on January 23, 2008.

U.S. Environmental Protection Agency. 1998. South Fork Trinity River/Hay fork Creek Sediment TMDLs, Final Draft.

SECTION 2

General Watershed Profile

Study Area
The Big Creek watershed is located in northern California, in central Trinity County. The watershed is a major tributary stream to Hayfork Creek; the largest tributary of the South Fork of Trinity River, which flows into the Trinity River and then to the Klamath River before entering the Pacific Ocean (Figure 2-1). In 1972, the South Fork Trinity River was named a Wild & Scenic River and remains the largest undammed river of its kind in California. The Big Creek watershed has a total drainage area of approximately 29.8 square miles (19,084 acres) and is 87.5 percent publicly owned land administered by the South Fork Management Unit of the Shasta-Trinity National Forest, the Bureau of Land Management, and Trinity County. The watershed has been the municipal water source for the community of Hayfork since 1952.

The community of Hayfork is an unincorporated community with a population of approximately 2,700 people. The town of Hayfork is located in Hayfork Valley, centrally located in Trinity County, about 40 miles west of Redding, California and 20 miles southwest of Weaverville, the County seat of Trinity County. The community of Hayfork is directly adjacent to the Big Creek watershed in a southwest direction.

Land Ownership and Management

Allocation of land ownership is divided between public and private lands with nearly ninety percent administered under public domain and the remaining ten percent under private ownership. Table 2-1 shows a detailed break down of land ownership allocation and Figure 2-2 shows the general location of land ownership within the Big Creek watershed.

Table 2-1. Land Ownership within Big Creek Watershed

	LAND OWNERSHIP	
Ownership	**Acres**	**Percent of Watershed**
Private / Other	2,387	12.5
Bureau of Land Management	566	3.0
Trinity County	291	1.5
U.S. Forest Service	15,840	83.0

Shasta-Trinity National Forest(STNF) was established in 1905 through 1907. Since 1906, over one-half million acres, or 1/4 of the National Forest has burned including some large stand replacing fires of the late 1800's. The 1906 San Francisco earthquake and reconstruction increased lumbering on the STNF. The lumber market decreased during the 1927 depression era and increased with the post WWII construction boom. With these industry ups-and-downs, only about 335,000 acres (about 16% of the STNF) have been harvested in some manner for wood products since 1910. Selection was the primary harvest system through the 1960s. Even-aged regeneration systems were implemented from about 1975 through the early 1990s. Regeneration harvest and tree planting has occurred on about 130,000 acres (6%) of the STNF (USDA 1999).

South Fork Management Unit (SFMU) of the STNF is based in Hayfork and contains the Hayfork and Yolla Bolla Ranger Districts. The SFMU encompasses over 590,000 acres. The SFMU is bounded along its western side by South Fork Mountain, one of the longest continuous ridgelines in North America. At the southern end of the unit are the Yolla Bolla Mountains and one of two wilderness areas with the unit, the Yolla Bolla/ Middle Eel Wilderness. Situated along the eastern side of the SFMU is the Chanchelulla Wilderness. The northern end of the unit is bounded by a series of ridgelines and peaks that include Pattison Peak, Hayfork Bally and Hayfork Divide.

Figure 2-3 shows the general location of land use allocation within the Big Creek watershed. Table 2-2 shows SFMU land use allocation within the Big Creek watershed by acres and percent of land area.

Table 2-2. U.S. Forest Service Land Use Allocations within Big Creek Watershed

U.S.F.S. LAND USE ALLOCATIONS IN BIG CREEK WATERSHED		
Allocation	**Acreage**	**Percent of Watershed**
Adaptive Management Area	2,530	13.3
Late Successional Reserve	13,492	70.7
Private / Other	3,062	16.0

Adaptive Management Areas (AMA) were established as a result of the 1994 Northwest Forest Plan and signaled the importance of adaptive management by establishing 10 adaptive management areas in western Oregon, western Washington and northern California. The state purpose of the AMA is:

> *".....to encourage the development and testing of technical and social approaches to achieving desired ecological, economic and other social objectives."*

With this focus, the AMA network can be expected to be a more effective participant with our agency leadership, key partners, elected leaders, interested citizens, communities and interest groups.

Late Successional Reserves (LSR) were established as a result of the Record of Decision (ROD) on Management of Habitat for Late-Successional and Old-growth Forest Related Species Within the Range of the Northern Spotted Owl. Late-successional forests are those forest successional stages that include mature and old-growth age classes (USDA and USDI 1994). Typically, such stands include live old-growth trees, standing dead trees (snags), and fallen trees or logs (USDA 1999a).

The management objective within LSRs is to protect and enhance conditions of late-successional forest ecosystems, including the reduction of the risk of large-scale disturbance, including stand-replacing fire, insect and disease epidemic, and major human caused impacts. The California Klamath Province and California Cascade Province have been identified as being included in an area of elevated risk to large-scale disturbance due to changes in the characteristics and distribution of the mixed-conifer forests resulting from past fire suppression (USDA 1999b).

Trinity County Waterworks District #1 currently operates and maintains a community water supply for approximately 2,450 in the community of Hayfork, California. Currently, water is supplied to the district by diverting flow from the Big Creek watershed to Ewing Reservoir where water storage is approximately 820 acre feet of water (Figure 2-4). From the reservoir water is pumped to the District treatment plant where it is treated, stored in a welded steel reservoir and gravity fed to the community through an existing delivery system (SHN 2004).

Water is diverted from the current diversion site on Big Creek in late spring of each year when water quality is optimal. Water is diverted until Ewing Reservoir is at or near full capacity. During the summer months, irrigation uses are significantly increased throughout the District, requiring the treatment plant to operate at 85 to 90 percent of maximum capacity. Approximately 75 percent of the water is used for irrigation by four of the District's largest consumers: the Fairgrounds, two schools, and the community park (SHN 2004).

Flows of Big Creek are diverted by a 14 foot concrete diversion dam (Photo 2-1) located approximately 2.5 miles northeast of Ewing Reservoir (Photo 2-2). The diversion dam also serves as an irrigation system for Big Creek Ranch. The diversion occurs on the east bank of the creek where the water supply is split between the Big Creek Ranch irrigation system and the diversion canal that supplies water to Ewing Reservoir. The water supply to the reservoir is conveyed across the creek via a flume (Photo 2-3), where it enters a 24-inch diameter concrete culvert. From the downstream end of the flume, an unlined canal extends for approximately 12,000 feet to Ewing Reservoir (OWE 1980).

The District is currently allowed to divert water from Big Creek beginning on November 1 through June 30 of each year. Most diversion occurs in late spring between April and May when water quality is optimal. The maximum allowable diversion is 14 cubic feet per second (cfs), providing that minimum flows (15 cfs) are set aside for fish and downstream irrigation demands along Big Creek (SHN 2004.)

Historical data indicate that the original diversion dam was completed approximately 1850 at the current diversion site. At that time, the diversion supplied water for mining activities. The diversion has been used since about 1890 under riparian water rights for agricultural irrigation of approximately 400 acres of pasture on Big Creek Ranch (DWR 1965). The current dam was constructed in approximately 1920 and a fish ladder added in the 1940s to facilitate fish passage to spawning habitat in upper Big Creek (Photo 2-4; C. Hair, personal communication, General Manager, Trinity County Waterworks District #1, 2007).

Prior to the completion of the Ewing dam protect in 1972, the initial water system constructed in 1953 consisted of a small 1,000,000-gallon reservoir and treatment/pumping plant on Big Creek approximately 0.5 miles upstream from the Highway 3 Bridge that served approximately 83 users (Figure 2-4). In 1958, the system's design capacity of 250 connections was exceeded, and by the summer of 1964, approximately 370 users were being served. At this time, the District began having problems with adequate water supply at the pumping plant due to upstream diversions along Big Creek during low flow periods (OWE 1980). To remedy this problem, a feasibility study was completed in 1965, the results of which indicated that the Ewing Project was the most viable alternative for upgrading the District's water supply and treatment to meet the demands of the service area.

To date, water supply from Big Creek during diversion months has not been a limiting factor for the District. Since water chemistry reporting began in 1972, there have not been any primary drinking water standard violations at the District. According to Craig Hair, General Manager at the District, water with high levels of turbidity from Big Creek is the greatest risk to water quality for the municipal water supply. High turbidity in Big Creek would most likely come from sediment inputs from mass wasting, chronic road or episodic road erosion, or sediment and ash yield subsequent to a catastrophic fire event. Current water treatment costs at the District are approximately $100,000 annually. Conservative estimates indicate that turbid water diverted from Big Creek could more than double treatment costs (C. Hair, personal communication, General Manager, Trinity County Waterworks District #1, 2007).

PHYSICAL DESCRIPTION

Topography

Big Creek is a major tributary of Hayfork Creek draining a basin of approximately 19,000 acres. Big Creek is a 4th order perennial stream that flows in a southerly direction through moderately steep mountainous terrain (USDA 1999b), through a narrow inner gorge canyon, and into a broad alluvial valley floor. The north and northwest watershed boundaries separate Big Creek from the main stem Trinity River basin. To the east and west are Duncan and Little Creek, respectively, both 4^{th} order perennial streams of Hayfork Creek. The elevation at the confluence with Hayfork Creek is 710 meters (2329 feet; Photo 2-5) rising to 1890 meters (6294 feet) in the upper watershed. There are 28 tributaries to Big Creek which have been classified into 13 subwatersheds (Figure 2-5).

Climate

Climate in the community of Hayfork and the Big Creek drainage are characterized by hot, dry summers and cool, moist winters, with an average annual temperature of 55 degrees F. Temperatures range from 28 degrees F in the winter to over 100 degrees in the summer months. The average annual precipitation for Hayfork is approximately 35 inches annually and precipitation in Big Creek ranges from 35 inches in the lower watershed up to 55 inches in the upper watershed (Figure 2-6), based on precipitation records obtained from the US Forest Service, Hayfork Ranger Station (SHN 2004).

The majority of the precipitation in this region occurs between the months of October and May, with over 80% between October and March. Most of the precipitation consists of rain, with snowfall occurring in the upper elevations zones of Big Creek, generally above 4,000 feet. Precipitation comes in moderate intensity storm events that persist for two to five days. Due to this short duration, relatively intense precipitation pattern, runoff can be intense, translating into saturated and subsequent unstable hillslopes. During years with heavy snowfall accumulation, runoff can intensify with rain-on-snow precipitation events as witnessed in 1964 and 1997 storms.

Occasional summer thunderstorms occur betweens the months of June and September. Precipitation is generally minimal during these summer storms, but they can lead to lightning strikes at higher elevation. Lightning is the single greatest contributor to fire ignitions in Big Creek watershed.

Geology

The underlying bedrock in Big Creek is mostly composed of Late Triassic to Middle Jurassic Hayfork Terrane and Hayfork Balley Meta formations in the upper eastern portion of the watershed with Oligocene nonmarine Weaverville Formation unconsolidated alluvium and terrace deposits in the lower valley (CWDR 1979; Figure 2-7). Hayfork Terrane consists of pyroxene meta-andesite with layers of slaty argillite, sandstone, pebble conglomerate, thin-bedded chert and sparse lenses of limestone (Irwin 1972). A large portion of the watershed consists of serpentinite and dioritic composition of the Ironside Mountain batholith (Jdi), which is an integral part of this terrane make it generally stable and landslides are a minor feature. A few remnants of the Weaverville Formation can be found in the Lower Big Creek subwatershed and consists of weakly consolidated mudstone, sandstone, conglomerate with an impervious dark green clay matrix and sparse interbeds of light colored tuff. This unit tends to be unstable especially around roadcuts and streambanks which have oversteepened slopes, but this terrane comprises less than 10 percent of the total study area (USDA 2000).

Soils

Soils are dominated by Neun, Deadwood, Hugo, Hollands, Skymore, Typic Xerorthents, and Dubakella families that vary from low to high erodibility (Figure 2-8). Erosion is dominated by fluvial processes with a small amount of small to moderate sized erosion sites (bank failures, slides, and mass wasting) that occur throughout the watershed. Channel alterations due to mining activities, road cuts and natural processes due to associated geology have contributed to bank erosion primarily along reaches of Middle and Lower Big Creek.

Vegetation

Vegetation throughout the upper Big Creek watershed consists predominantly of conifer and mixed conifer/hardwood forests with grasses and intermittent hardwood patches at lower elevations (Figure 2-9; Table 2-3). Conifer forests are the dominant forest type occupying 54 percent of the total area, followed by mixed conifer/hardwood forests with 37% of the total area.

Table 2-3. Vegetation cover type acreage and percentage of total watershed in Big Creek.

VEGETATION COVER TYPE WITHIN BIG CREEK WATERSHED		
Cover Type	**Acreage**	**Percent of Watershed**
Agriculture	32	<1
Barren Soil	44	<1
Conifer Forest	10,320	54
Hardwood Forest	243	1
Herbaceous	848	4
Mixed Conifer/Hardwood	7011	37
Shrub	495	3
Urban Area	43	<1
Water	50	<1

The vegetation in Lower Big Creek to the confluence with Hayfork Creek consists of a narrow riparian corridor running through irrigated pastureland and oak woodland. The riparian corridor is dominated by white alder (*Alnus rhombifolia*), various species of oaks (*Quercus sp.*), cottonwoods (*Populus sp.*), and scattered with grey (*Pinus sabiniana*) and ponderosa pines (*Pinus ponderosa*), as well as Douglas fir (*Psuedotsuga menziesii*). The understory in this riparian corridor is dominated by willow (*Salix sp.*), California hazelnut (*Corylus cornuta var. californica*), Himalaya blackberry (*Rubus armeniacus*), and wild mock orange (*Philadelphus lewisii*). The vegetation community in Middle Big Creek is predominantly mixed conifer and hardwoods with an understory of California hazelnut (*Corylus cornuta var. californica*), Pacific dogwood (*Cornus nuttallii*), blackcap raspberry (*Rubus leucodermis*), wild mock orange (*Philadelphus lewisii*) and various gooseberry species (*Ribes sp.*). In disturbed areas of Middle and Upper Big Creek, Himalaya berry (*Rubus armeniacus*), elderberry (*Sambucus nigra)*, wild grape (*Vitis californica*), and other exotics exist in the riparian zone. The upper watershed vegetation community is primarily forested with mixed stands dominated by conifers, with some hardwood and brush species. The dominant conifer species in the upper reaches are white (*Abies concolor*) and Douglas fir (*Psuedotsuga menziesii*), Pacific yew (*Taxus brevifolia*) , ponderosa pine (*Pinus ponderosa*), sugar pine (*Pinus lambertiana*), and incense cedar (*Calocedrus decurrens*). Dominant hardwood species include Pacific madrone (*Arbutus menziesii*), big leaf maple (*Acer macrophyllum*), and several oak species (*Quercus sp.*)(USDA 1999b).

A riparian vegetation survey conducted in 1998 found a total of one hundred and ninety-one species within 50 feet of the thalwag of Big Creek. Based on the assumption that field crews sampled on 40 to 60 percent of stream corridor's total diversity, a more accurate estimate of total plant species present in the watershed may be 318 to 447 species. This diversity is indicative of a healthy riparian zone for the southern region of the Klamath Mountains (USDA 1999b).

Fire History

Wildfire has been a natural part of California's mederterrain climate ecosystems in coniferous forests, chaparral, and oak woodlands for millennia. Fire plays and integral role in this fire adapted ecosystem where fire return intervals in neighboring watersheds have been estimated to have been every 11.5 to 16.5 years (Taylor and Skinner 2003). For this reason, any watershed assessment in California's mixed conifer forests in the southern range of the Klamath Mountains should include the role of fire and fuels.

Fires have burned throughout California and the West for thousands of year, but recent studies (e.g. Westerling et al. 2006) indicate that the size and frequency of large-scale catastrophic fires is increasing and as a result, have become more costly, dangerous and more difficult to suppress (Chang 1996; Skinner and Chang 1996; Agee 1998; Arno and Allison-Bunnel 2002; DellaSala et al. 2004; Stephens and Ruth 2005; Stephens and Sugihara 2006). Suppression tactics used by federal and state land managers throughout the 20th century have resulted in the virtual elimination of all fires in fire adapted ecosystems. The net result has been a change in vegetation structure that has led to more flammable materials that had previously been removed by small, frequent, low intensity surface fires (Agee 1993).

Fire played a major role in shaping the composition and successional stages of vegetative communities, especially forests. The forest has become more closed and multi-storied today from fire suppression (which became more aggressive in 1930's and then very effective after World War II fire-fighting technology) and climate change. Tree species composition has succeeded towards more shade tolerant, fire sensitive species such as white fir and away from more shade intolerant, fire resistant species such as ponderosa pine. Due to these changes in tree species composition, the forest is more sensitive to fire now than in the past. The fire regime has changed from a short interval, low intensity regime to a moderate to high intensity with infrequent intervals. White fir occurred less in mixed stands and was usually confined to upper elevations. In some eastern parts of the forest, fire tolerant black oak trees were more abundant.

Fire is the most important natural disturbance agent in the Big Creek watershed. The Little Fire in 1955 is the only documented fire in the watershed, burning 3,214 acres between Big Creek and Little Creek watershed. Approximately 1,800 acres burned exclusively in Big Creek (Figure 2-10). The fire was a moderate to moderate/low severity fire that burned understory vegetation and did little damage to larger conifers.

Lightning during summer thunderstorms continues to be the main source of ignition in the upper elevation zones of the Big Creek watershed and human induced fire ignitions are the main source at lower elevations near the town of Hayfork. A total of 341 documented fire starts have occurred in the Big Creek Fireshed analysis area (Figure 2-10) between 1911 and 2005. Of those 36% have been due to lighting and 64% were started along roadways, camping areas, ranches, and in the community of Hayfork.

Large fires have occurred in the Big Creek basin in the past, and regardless of the level of suppression, large fires will occur here again (Figure 2-10). The mix of residential development (exclusively in Lower Big Creek and Ewing Reservoir subwatersheds), agriculture (Lower Big Creek), recreational use, and transportation routes coupled with patterns of extreme fire weather during summer months put Big Creek at risk of human induced fire ignition leading to large-scale, high-severity fire. As the municipal water supply for the community of Hayfork, high to moderate severity fire could dramatically impact water quality in the basin, leading to a contaminated water supply for years.

Wildlife

For the purposes of the watershed resource inventory, and subsequent report, we identified aquatic species located in or directly adjacent to Big Creek and its tributaries. Terrestrial invertebrates and macroinvertebrates were not inventoried.

Fish Fauna

Spring-run (summer) steelhead, winter-run steelhead (*Onchorhynchus mykiss*) and Pacific lamprey (*Lampetra tridentate*) are the anadromous fish species that can currently be found in Big Creek. The historical presence of Chinook (*Oncorhynchus tshawytscha*) and Coho (*Oncorhynchus kisutch*) salmon in the watershed is undocumented. Non-anadromous fish species that occur in Big Creek are speckled dace (*Rhinichtys osculus*), Klamath small-scale sucker (*Catostomus rimiculus*) and resident rainbow trout (*Onchorhynchus mykiss*). Resident rainbow trout cannot easily be differentiated from steelhead and individuals found in the lower reaches of Big Creek could be either species (USDA 1999b).

Herpetofauna

Within the Big Creek watershed, the following species were observed during a Stream Condition Inventory conducted in 1998 by US Forest Service biologists: Foothill yellow-legged frogs (*Rana Boylei*), Pacific tree frogs (*Hyla regilla*), Pacific giant salamanders (*Dicamptodon ensatus*), rough-skinned newts (*Taricha granulose*), acquatic garter snakes (*Thamnophiscouchi couchi*), and western pond turtles (*Clemmys marmorata*)(USDA 1999b).

Macroinvertebrates

During the Stream Condition Inventory portion of the Watershed Resource Inventory for this project, we identified mayflies, caddisflies, stoneflies, water beetle larvae, *Diptera spp.*, water pennies, adult water beetles, and gilled snails.

LAND USE

Mining

Gold mining started in 1850, and continued until the late 1880's and early 1890's. Following the Great Depression and WWII, a resurgence of gold mining activities and mining claims along Big Creek resulted in response to high gold prices set by the Federal Reserve. Large mining tailings are still present along Big Creek at the confluence with Packers Creek and Upper Big Creek. A number of small mining claims are still active along Middle Big Creek. All current mining activities are conducted with non-mechanized equipment (shovels, picks, pry bars, and gold pans) during summer months when flows are low. Soil disturbances as a result of these mining activities are minimal. Figure 2-11 illustrates documented historic and active mining sites throughout Big Creek.

Grazing

Cattle ranching exists in the lower reaches of Big Creek as flows through private property. The primary land use in this portion of the watershed is allocated to cattle ranching and some hay and alfalfa production. The original Ewing Ranch was settled in the 1850's to supply agricultural products for the settlement of Trinity County (Trinity County Historical Society 1981). The diversion of irrigation water to Big Creek Ranch has been used since about 1890 under riparian water rights for agricultural irrigation of approximately 400 acres of pasture (DWR 1965).

Timber Management

Prior to the commencement of serious logging in the 1940s, 80% of the South Fork Trinity River basin was covered in fir and pine forest, with 20% in brush, grass and rock. Since that time, human impact to the basin has been substantial. By 1977, 52% of the watershed had already been logged and an additional 4% of the old growth had been burned. Total road length visible on U-2 photos was 3,456 miles, 92% of which were associated with timber harvests (CDWR 1979; PWA 1994). An undetermined, but substantial, amount of additional acreage has been affected by logging, road construction and wildfires in the basin since the 1977 inventory. Clearcut logging did not commence on National Forest lands in the South Fork Trinity River watershed until the 1970s. Under this silvicultural system, the Forest Service implemented a patchcut grid on much of their ownership. Oversight and control of plan layout, logging techniques and road building practices was minimal during this early period of land use (PWA 1994).

Based on historical aerial photography and anecdotal data, timber harvest in Big Creek did not commence until sometime in the early 1960s and extended into the early 1990s. The primary reason this watershed was not targeted earlier for timber extraction may have been the steep topography and risk of contamination to the municipal water supply. In 1965, approximately 8.5 square miles (30%) of the drainage had been harvested and by 1977 12.6 square miles (45%) (CDWR 1979). Figure 2-12 depicts the timber harvest history by the U.S. Forest Service in Big Creek.

Recreation

The primary recreational opportunities that have been observed in the Big Creek watershed are camping, hunting, gold panning, biking, running, swimming, horseback riding, rock climbing, and the use of Off-Highway Vehicles (OHVs). Fishing is not allowed on tributary streams of Hayfork Creek and is therefore not permitted on Big Creek.

Most recreational activities in Big Creek are relatively benign and do not cause major disturbances that could impact valuable natural resources. The major impacts from recreational activities come from OHV. Currently, there are no designated OHV trails in the watershed, and as a result, OHV users have created many of their own trails. Many of these trails are unstable and contribute significant amounts of sediment to streams.

Transportation

The major roads that run through Big Creek are important to the transportation network of Trinity County and the community of Hayfork. The two major roads are segmented and have varying surface types and jurisdictions. Big Creek Road (County Road No. 324) is a paved, two lane road that runs north of Highway 3 for approximately 4.5 miles before becoming a unpaved, rocked, two lane road to its intersection with USFS 4N16 (Figure 2-13). At the intersection with 4N16 that heads west to Big Bar, the County Road No. 324 becomes USFS 33N47, a native, rocked surface road that climbs steadily northeast along the main stem of Big Creek to the watershed divide with Soldier Creek. From the watershed divide, the 33N47 continues east for approximately 13 miles to Junction City along Highway 299 and the Trinity River. Running west from the intersection with County Road No. 324, the USFS 4N16 is a paved, one and half lane paved road that connects the Big Creek watershed with Big Bar to the north and Hyampom to the west

Big Creek Rd. is maintained for winter weather travel from its' intersection with Highway 3 to the point where it becomes a rocked native road, approximately 4.5 miles north where it crosses Big Creek. USFS 33N47 and 4N16 are not maintained for winter weather travel and are generally not passable from December through April in areas where snow accumulation is heavy. USFS 4N16 is a Level IV road, designed for passenger car and heavy truck traffic. USFS 33N47 is a Level III road, which is not advisable for low clearance two wheel drive passenger vehicles.

The road system through Big Creek is extremely important for emergency response, evacuation routs, alternative routs, and commuter traffic. County, federal, state, and private vehicles can be seen on a daily basis using the transportation route through Big Creek to access other portions of the county.

During the 1987 fires in the Hayfork Valley, roads running through Big Creek were used to transport firefighters and equipment from the main stem Trinity River basin into Hayfork. More recently, in 2003, and again in 2005, these transportation routes were used to bypass fires along the Pigeon and Bar Fires along Highway 299. During these more recent fire events, the routes through Big Creek were again used to transport firefighters. Highway patrol officers in Junction City were directing motorists over USFS 33N47, to Big Creek Road, and on to Highway 3 to continue on their way to the Pacific Coast.

LAND USE REGULATIONS

County General Plan and Zoning Ordinances

In California, the County General Plan is the official document used by planners and decision makers to guide land development and the use of natural resources within each county. The Plan is required by law to contain at the minimum land use maps, policies and information necessary to make consistent and informed decisions pertaining to current and long range development. Trinity County's General Plan was last adopted in 1973 and is considered both antiquated and outdated by today's standards and provides only the minimal guidelines deemed necessary. The General Plan is required to address seven elements which are: land use, circulation, housing, public safety, conservation, open space and noise (TCRCD 2006). The following elements are applicable in the Big Creek watershed.

Land Use Element
This element which addresses the Big Creek area in the chapter titled Hayfork Valley was last updated by the county in 1988. During the review process, the quality of development within this area was rated as one of the primary concerns that should be addressed in all future planning processes. Specifically, the goals that were established focused on: (1) encouraging land ownership that supports resource production, and (2) encouraging existing agricultural uses to continue (TCRCD 2006).

Open Space Element
This element is used to identify natural areas that the planning process should set aside for the protection of scenic values, fish and wildlife habitat, watershed protection, and resource rehabilitation. Using a zoning overlay process, it also identifies areas and recommends against development or the construction of permanent structures where natural processes such as geologic instability, floodplains, and other natural hazards may pose a threat to lives. Areas that meet the requirements for open space can be zoned as such in the subdivision or development process and can be set aside to remain in a natural and undeveloped state (TRCD 2006).

Conservation Element
The conservation element provides general guidelines that promote the conservation development and utilization of natural resources such as water, forests, soils, rivers, fisheries and wildlife. This element also addresses the conservation of native plants, natural landform features, scenic viewsheds and archaeological and historic sites that may be adversely affected through development. Areas that are given a conservation zoning overlay on top of the primary zoning are required to address guidelines established in this element when development of the property is proposed (TCRCD 2006).

All three of the above elements to the General Plan are applicable to all private lands within the Big Creek watershed but not to state or federal lands. In addition, there are several additional county zoning designations that can affect land use and development as well.

Hayfork Community Plan
The Hayfork Community Plan was developed to help to guide future growth and development in the community by balancing the need for housing, protecting lands with good soils for agricultural uses, avoiding development in areas subject to flooding or which are marginally suitable for residential use, protecting water quality and encouraging actions that will lead to economic diversification. The plan also addresses the quality of life in the Hayfork area by establishing policies to protect air and water quality, aesthetics, soils, fish and wildlife values and to encourage cultural, educational, and recreational opportunities (Hayfork Community Plan 1996).

Chapter 6. Natural Resources

Section A, Item 6h. Restoration of Riparian and Wetland Areas

This plan (prepared in August 1994 by the Department of Agriculture: Soil Conservation Service) is aimed at enhancing "the water quantity and quality in the be accomplished through: (1) landowner education and assistance in the conservation of ranch and water resources; (2) improvement of water conveyance systems and redirection of conserved water to increase surface flows for aquatic habitat and fisheries, and; (3) restoration of riparian corridors." Implementation of the plan is achieved by voluntary participation of riparian landowners utilizing the work, funding and expertise of The Trinity County Resource Conservation District and Trinity River Restoration Program.

Section C, Item 3. Non-TPZ Timberlands.

Not all timberland must be designated TPZ (over half the timberland in the Plan Area is not designated TPZ). Some timberlands do not qualify for TPZ status (parcel too small, not of sufficient site class, etc.) and therefore receive a different zoning designation (Agricultural Forest for example). Some landowners whose land might qualify for TPZ status do not elect to have it designated TPZ so that the land may more readily be converted to non-timber use. Subdivision of small timberland holdings for residential use is one of the primary threats to forestland across the state.

Section H. Water Quality

The major potential sources for degradation of water resources within Plan Area watersheds are: 1) resource management; 2) urban/rural development; and; 3) water diversion.

1. Resource Management

Resource management (logging, road building, mining, etc.) can result in higher than natural runoff and sediment rates in streams. Specifically, erosion and declines in water quality can result from:

- road building and log skidding near or across streams
- cut and fill work necessary for road construction
- landings and pads constructed during logging operations (which can result in rills and gullies if not properly installed)
- vegetation removal
- herbicide misuse
- broadcast burning (can increase raindrop erosion/reduce sediment trapping)

Numerous factors contribute to or reduce the potential for erosion that results from the:

- inherent stability of each site
- steepness of the slope
- extent of previous disturbance and soil compaction

- extent of vegetation removed
- amount and nature of the precipitation (rain or snow) on site
- method of logging used (tractor or cable)
- acreage managed
- mitigation measures taken to minimize erosion
- re-vegetation practices

2. Urban/Rural Development

"Like resource management activities, urban development can adversely impact water quality. Residential development can result in increased stormwater runoff which can lead to excessive erosion and siltation. Poor soils and failed septic systems can contaminate surface and groundwater. Residential development along streams often results in a decrease in riparian vegetation which can increase erosion and siltation (Hayfork Community Plan 1996, p. 6.20)."

3. Water Diversions

"As the population of the Plan Area grows, additional diversions on local creeks will occur unless otherwise prohibited. The reduction of flows in creeks during the summer increases the water temperature which can result in adverse impacts to aquatic wildlife. Reduced flows also reduce a stream's ability to absorb and dissipate sediment/pollutants (Hayfork Community Plan 1996, p. 6.20)."

Chapter 7. Hazards

Section A. Fire Hazards

"Based on the increase in wildland fires in recent years, declining funding for fire protection services and continued residential growth in the wildland/urban interface, fire protection and fire hazard reduction should continue to grow as key considerations in local, regional and state-wide land use decision making (Hayfork Community Plan 1996, p. 7.1)."

The following is a summary of goals and activities established in the Hayfork Community Plan that apply directly to the protection of water quality and beneficial uses in the Big Creek watershed:

- Encourage Trinity County Waterworks District #1 to plan for the expansion and retention of valuable water supplies for future generations;
- Maintain and enhance the water quality and quantity of area streams by reviewing development proposals and public agency and private land management practices for potential impacts to water quality;
- Require site-specific mitigation measures for projects likely to result in siltation and/or pollution of streams;
- Support efforts to improve and/or conserve the amount and quality of water resources in the Hayfork basin;

- Encourage public and private actions necessary to prevent degradation of water quality;
- Periodic monitoring of surface waters (for bacteria and other common pollutants) should occur to determine if water quality conditions are changing;
- Agricultural lands should be given a land use designation of Agriculture and zoned to establish densities which encourage continued agricultural use;
- Residential zoning shall be discouraged in agricultural areas;
- All land divisions shall be designed to preclude the creation of additional parcels with riparian water-rights;
- Encourage public and private land managers to consider water, air, and visual qualities as well as recreational uses while managing timberlands;
- Retain riparian corridors and wetlands within Big Creek watershed, as well as other perennial and ephemeral streams, springs, seeps, wet meadows, pools….;
- Encourage amendment of the Trinity County Zoning Ordinance to include the setbacks from, and other alternative protection measures for, riparian and wetland areas as recommended by the California Department of Fish and Game in Recommendations to Help avoid Significant Fish, Wildlife and Native Plant Impacts...December 16, 1994;
- Encourage development and enhancement of wildlife habitat through controlled burning, planting, water development and mechanical land manipulation;
- Recognize and encourage wildlife management activities, including: bird watching, scientific studies, educational purposes and hunting and fishing;
- Work with the Forest Service and CDF to identify existing critical fuel breaks and areas where new fuel breaks should be developed. Encourage the Forest Service and CDF to develop and maintain the identified fuel breaks;
- Work with interested neighborhood groups and the CDF to identify, develop, and (whenever possible) secure funding for neighborhood fire/fuel reduction programs.

Timberland Production Zone (TPZ)

The Timberland Production Zone, California Government Code 51130-51134, authorized by the Timberland Productivity Act of 1982 and administered by the State Board of Forestry and Fire Protection, applies to actively managed timberland with a minimum of 160 acres and requires a minimum time commitment of 10 years to receive the benefits of taxing the property on the basis of growing and harvesting timber and its compatible uses. This zoning is an incentive for landowners to keep productive timber lands from being developed and defaulting on the agreement prior to expiration of the contract term carries substantial monetary penalties (TCRCD 2006). A parcel of private timberland at the headwaters of Big Creek and large tracts of private timberlands along the lower sections of Big Creek are zoned for TPZ

Trinity County Mining Ordinance No. 315-230 and 315-596
To ensure compliance with Chapter 9 of the Public Resource Code that deals with the California Surface Mining Act of 1975 (administered by the California Department of Conservation, Office of Mine Reclamation), Trinity County has adopted ordinances No. 315-230 and No. 315-596 that regulate mining on private lands. Ordinance No. 315-230 The intent of the regulations is to minimize adverse affects on the environment by requiring either the reclamation or the restoration of areas that are disturbed by mining activities and to protect public health and safety. All mining activities require the obtainment of an approved use permit as well as a reclamation or restoration plan. Mining operations on public lands must meet the established federal guidelines (TCRCD 2006).

California Forest Practice Rules
Since passage of the Z'Berg-Nejedly Forest Practice Act of 1973, forest practices on private lands in California have been governed by the Forest Practice Rules (FPRs), administered by the California Department of Forestry and Fire Protection (CDF). The purpose of the FPRs "is to implement the provisions of the Z'berg-Nejedly Forest Practice Act of 1973 in a manner consistent with other laws, including but not limited to, the Timberland Productivity Act of 1982, the California Environmental Quality Act (CEQA) of 1970, the Porter Cologne Water Quality Act, and the California Endangered Species Act. The provisions of these rules shall be followed by Registered Professional Foresters (RPFs) in preparing Timber Harvesting Plans, and by the Director in reviewing such plans to achieve the policies described in Sections 4512, 4513, of the Act, 21000, 21001, and 21002 of the Public Resources Code (PRC), and Sections 51101, 51102 and 51115.1 of the Government Code. It is the Board's intent that no THP shall be approved which fails to adopt feasible mitigation measures or alternatives from the range of measures set out or provided for in these rules which would substantially lessen or avoid significant adverse impacts which the activity may have on the environment. The THP process substitutes for the EIR process under CEQA because the timber harvesting regulatory program has been certified pursuant to PRC Section 21080.5," (2005 California Forest Practice Rules).

In order to implement the intent of the Z'Berg-Nejedly Forest Practice Act of 1973,

> "(a) RPFs who prepare plans shall consider the range of feasible silvicultural systems, operating methods and procedures provided in these rules in seeking to avoid or substantially lessen significant adverse effects on the environment from timber harvesting. RPFs shall usethese rules for guidance as to which are the most appropriate feasible silvicultural systems, operating methods and procedures which will carry out the intent of the Act.
>
> While giving consideration to measures proposed to reduce or avoid significant adverse impacts of THPs on lands zoned TPZ, the RPF and Director shall include the following legalconsideration regarding feasibility:
> (b) In determining whether a THP conforms to the intent of the Act, the Director shall be guided by the following principles:

(1) The goal of forest management on a specific ownership shall be the production or maintenance of forests which are healthy and naturally diverse, with a mixture of trees and under-story plants, in which trees are grown primarily for the production of high quality timber products and which meet the following objectives:

(A) Achieve a balance between growth and harvest over time consistent with the harvesting methods within the rules of the Board.

(B) Maintain functional wildlife habitat in sufficient condition for continued use by the existing wildlife community within the planning watershed.

(C) Retain or recruit late and diverse seral stage habitat components for wildlife concentrated in the watercourse and lake zones and as appropriate to provide for functional connectivity between habitats.

(D) Maintain growing stock, genetic diversity, and soil productivity.

(2) Individual THPs shall be considered in the context of the larger forest and planning watershed in which they are located, so that biological diversity and watershed integrity are maintained within larger planning units and adverse cumulative impacts, including impacts on the quality and beneficial uses of water are reduced." (2005 California Forest Practice Rules)

Northwest Forest Plan

The "Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl [NSO]" commonly known as the Northwest Forest Plan or NW ROD, amended the "Regional Guide for the Pacific Southwest Region" (August 1984). The NW ROD significantly constrained management activities on the Shasta-Trinity National Forests, including the Big Creek watershed, as outlined in the "Record of Decision for the Final Environmental Impact Statement for the Shasta-Trinity National Forests" (ST ROD 1995; TCRCD 2006). Some of the key provisions of the NW ROD (as per the ST ROD) that apply to the Big Creek watershed are as follow:

A. Old-growth Forests and Biological Diversity:

Scheduled timber harvests are not permitted in Late Successional Reserves (LSRs) or in Riparian Reserves (RRs). "The primary emphasis of these reserves is protection and enhancement of late seral stage (old-growth forest) and riparian habitat."

"Additionally, within land allocations where timber harvest is planned [Matrix & AMA], a minimum of 15 percent of the Forests will be retained to provide further connectivity and dispersal. Snags will be retained within regeneration harvest units at levels sufficient to support species of cavity nesting birds. An adequate supply of down logs and coarse woody debris are maintained to meet the needs of wildlife species and ecological functions."

"Additionally, the Forest Plan provides for diversity of age classes across the forest by requiring retention of at least 5 percent of each seral stage."

B. Threatened, Endangered, and Sensitive (TES) Species:

1. Protection buffers will be provided for the rare and locally endemic species.
2. Protection for [TES] species is provided for outside of withdrawn and reserved areas by Forest-wide Standards and Guidelines.
3. NSO viability is provided for by the system of [LSRs], [RRs], and retention standards within the Matrix and AMA. Also, NSO nesting sites mapped prior to January 1994 will be protected by a 100 acre area around the nesting site.
4. The Shasta-Trinity Forest Plan provides for viability of goshawks through land allocations and standards and guidelines for late successional dependent species.

C. Aquatic Conservation Strategy ("…to restore and maintain the ecological health of watersheds and aquatic ecosystems…")

1. "Riparian Reserves – [are] lands along streams, lakes, and watersheds and unstable and potentially unstable areas." "Primary objectives on these lands are to maintain and enhance riparian structures and functions of streams, confer benefits to ripariandependent and associated species other than fish, enhance habitat conservation for organisms that are dependent on the transition zone between upslope and riparian areas, improve travel and dispersal corridors for terrestrial animals and plants, and provide for connectivity of LSRs.
2. Watershed analysis – procedures for conducting analyses that evaluates geomorphic and ecologic processes operating in specific watersheds.
3. Watershed restoration – a comprehensive, long-term program of watershed restoration to restore watershed health and aquatic ecosystems, including the habitats supporting fish and other aquatic and riparian-dependent organisms." (ST ROD)

WATER LAW

Two types of water use are recognized under California law: riparian rights and appropriative rights. The State Water Resources Control Board (SWRCB) has jurisdiction over water use permits in California and acts as arbiter of all disagreements over water rights. All water rights in the state must meet reasonable beneficial use standards; wasteful use of water can be contested and unreasonable use can be stopped by order of the SWRCB.

Riparian Rights

Riparian rights are those where water is extracted for use on lands that directly boarder the stream. Any owner of a parcel immediately adjacent to a water course has the right to take water for domestic and agricultural use at any time unless specific deed restrictions are stated in the title to the land. Riparian rights do not require a permit from the SWRCB, however, the SWRCB requests that riparian water users file a statement of diversion and use.

Water may be diverted from upstream areas for delivery to downstream riparian lands as long as agreements are in place with the land owner at the point of diversion and no damage is inflicted on intervening land owners. Riparian rights are not superior by virtue of prior use, so proposed new reasonable use and streamflow diversions have equal standing under the law. Because of these statues, the SWRCB can not resolve differences between holders of riparian water rights. If insufficient water is available for all riparian users, ultimate recourse is in the courts. Water taken by virtue of riparian water rights cannot be impounded for deferred use. Riparian water rights also cannot be transferred to non-riparian owners (SWRCB 2008).

Appropriative Rights

Any removal of water from stream side areas for delivery to non-adjacent parcels constitutes appropriative use, which requires a permit from the SWRCB. Appropriative water use prior to December 1914 has automatic standing as a permitted use. If challenged, a pre-1914 appropriative right must be documented both in terms of date of first use and continuing subsequent use. A "record of use" can be filed to document historical use of water and to preserve standing against future challenges. The record of use often comes from living memory of people who established such rights and if they die before such a record is made, substantiation of the appropriative right against later challenges may be difficult. Appropriative rights may be lost if not used for a period of five years (SWRCB 2008).

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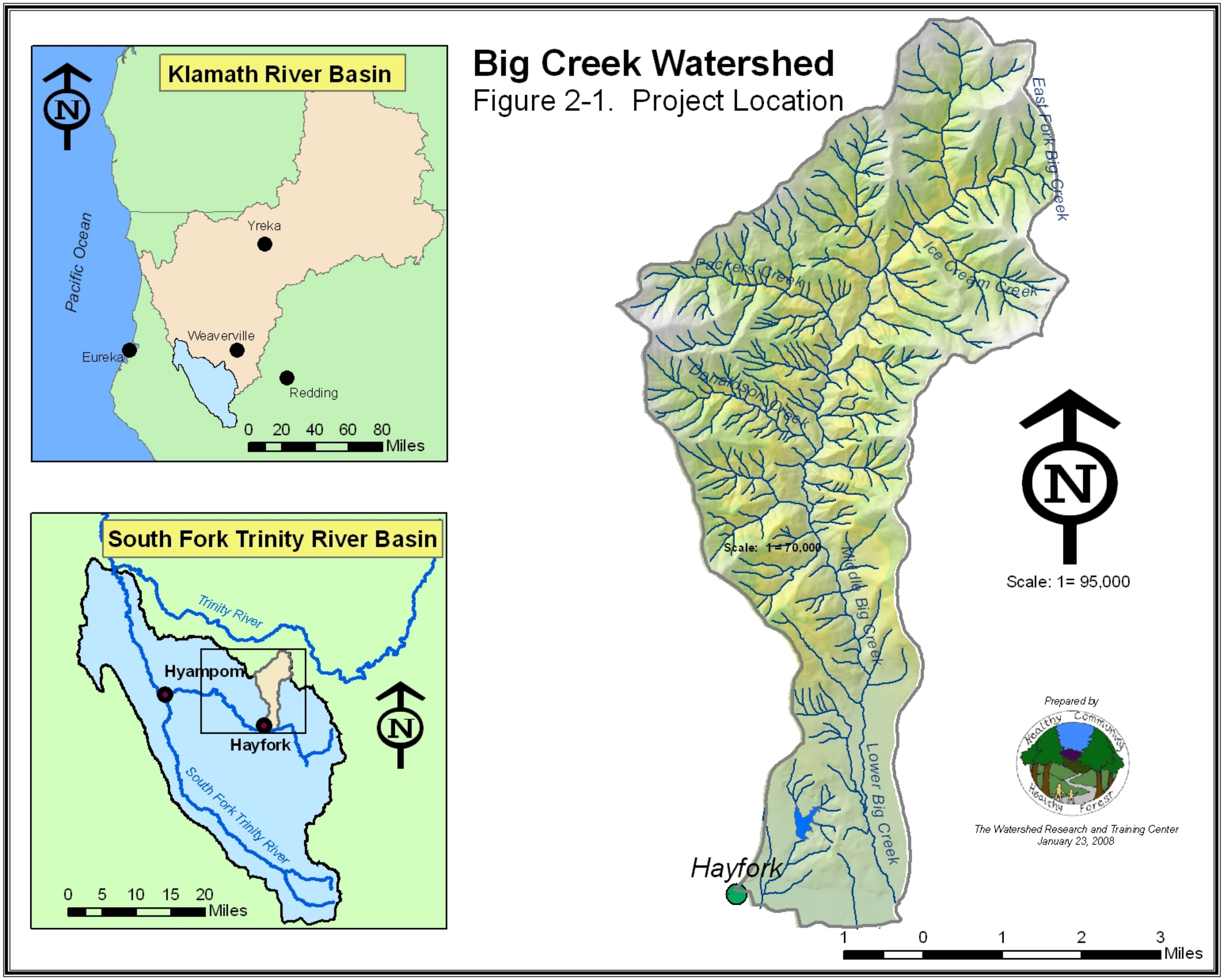
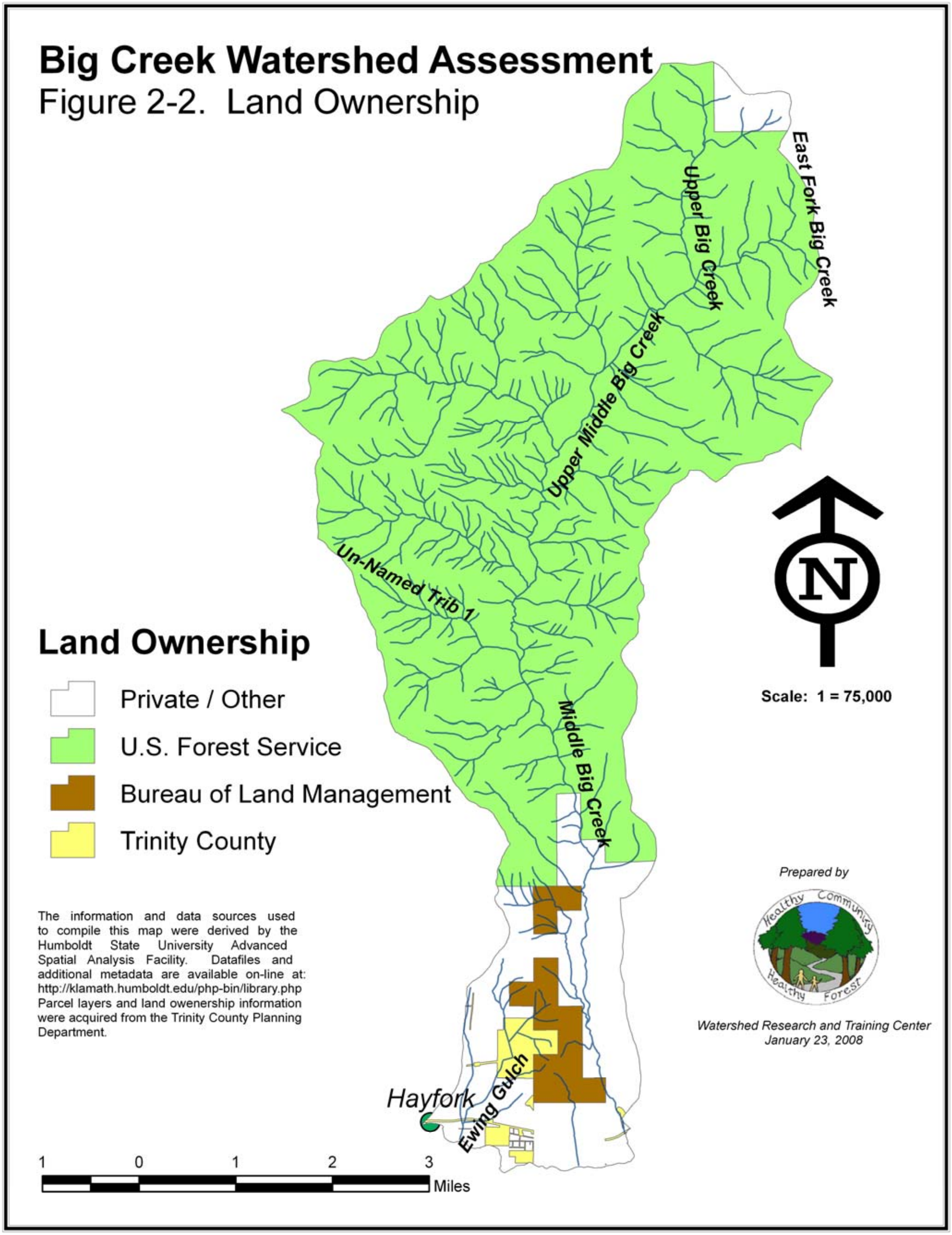
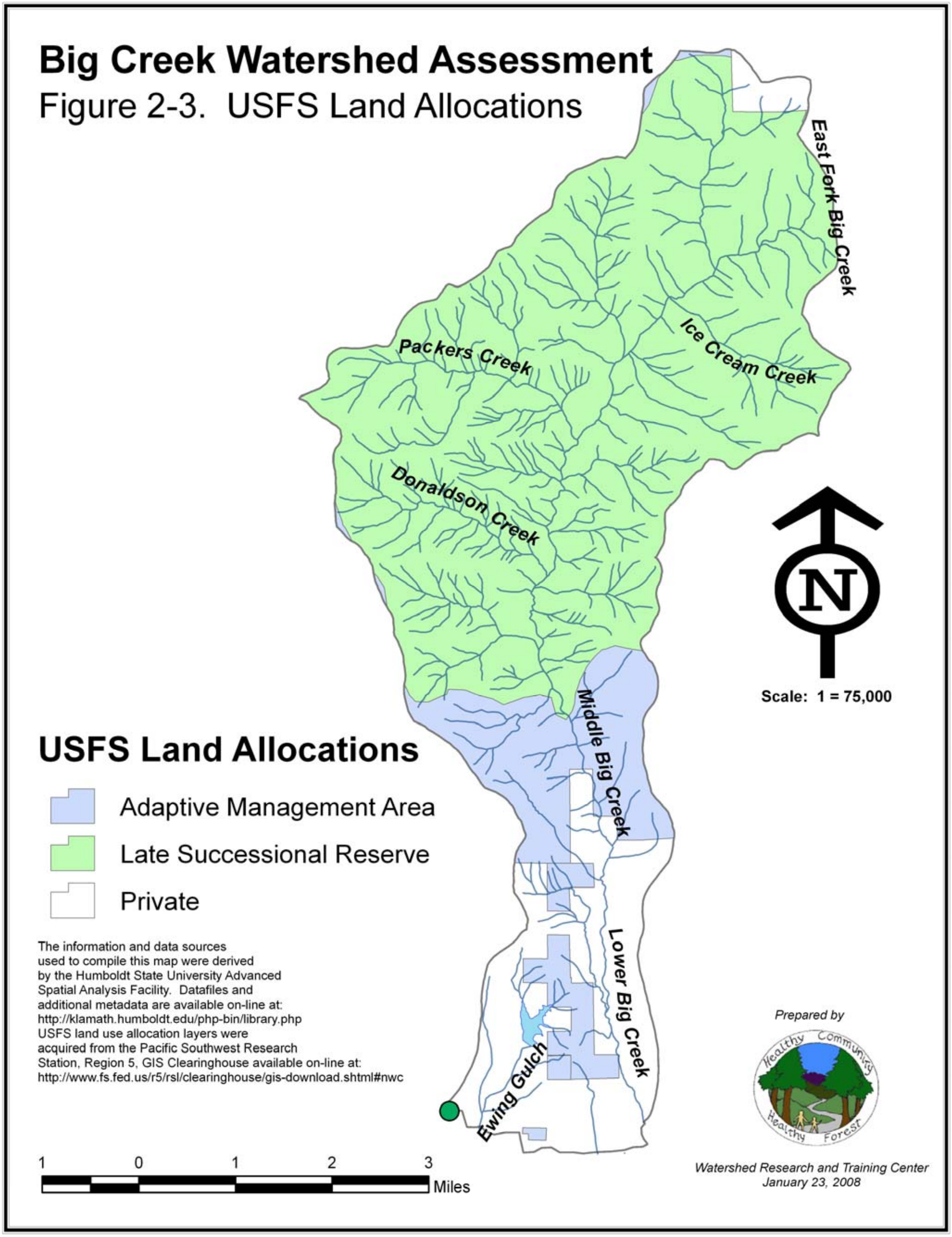
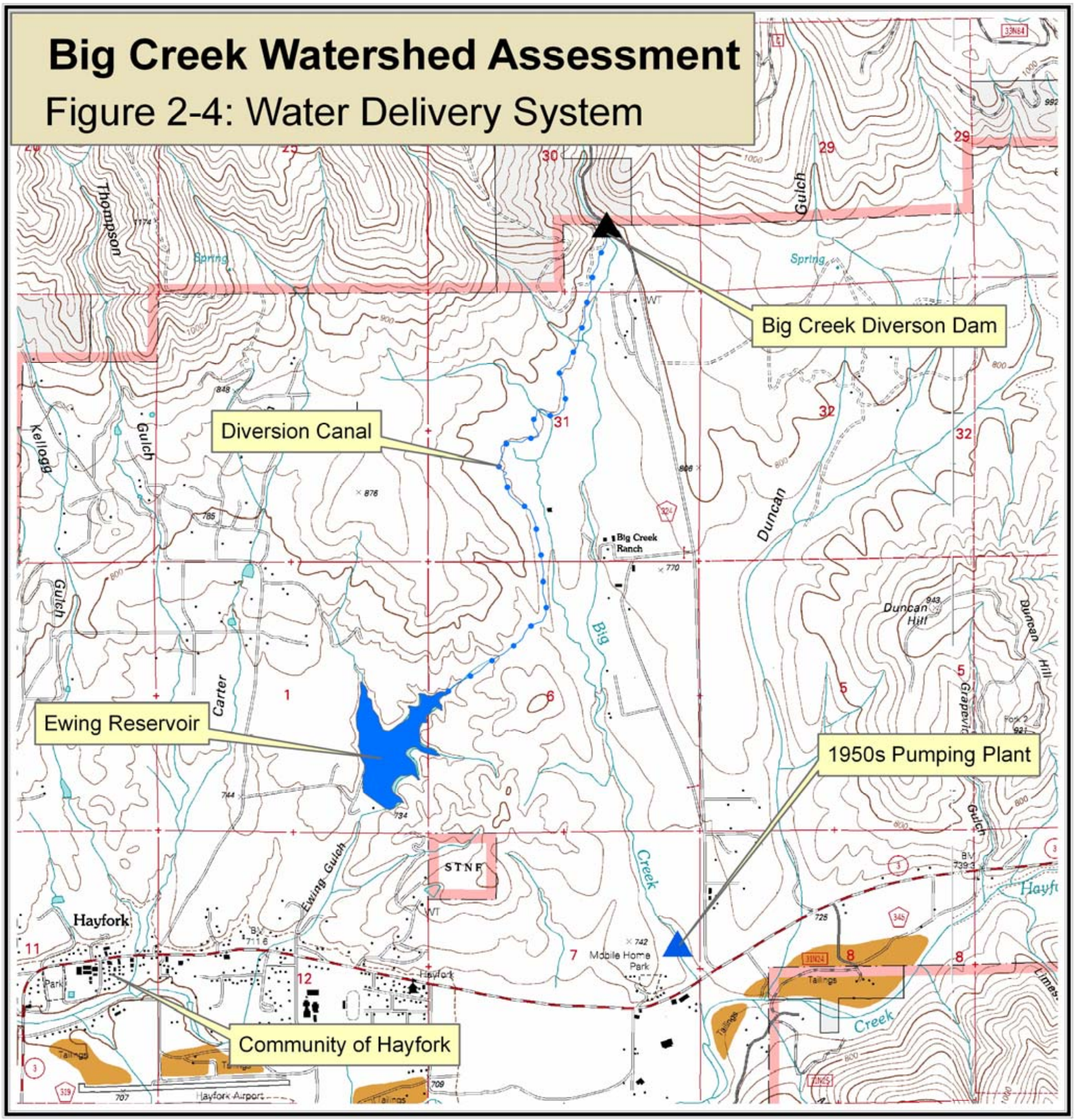

Big Creek Watershed
Figure 2-1. Project Location
Klamath River Basin
Pacific Ocean
Yreka
Weaverville
Eureka
Redding
0 20 40 60 80
Miles
South Fork Trinity River Basin
Trinity River
Hyampom
Hayfork
South Fork Trinity River
0 5 10 15 20
Miles
East Fork Big Creek
Packers Creek
Ice Cream Creek
Donaldson Creek
Scale: 1=70,000
Middle Big Creek
Lower Big Creek
Hayfork
Scale: 1= 95,000
Prepared by
Healthy Community Healthy Forest
The Watershed Research and Training Center
January 23, 2008
1 0 1 2 3
Miles



Big Creek Watershed Assessment
Figure 2-2. Land Ownership


Big Creek Watershed Assessment
Figure 2-3. USFS Land Allocations
East Fork Big Creek
Ice Cream Creek
Packers Creek
Donaldson Creek
Middle Big Creek
Lower Big Creek
Ewing Gulch
N
Scale: 1 = 75,000
USFS Land Allocations
Adaptive Management Area
Late Successional Reserve
Private
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php USFS land use allocation layers were acquired from the Pacific Southwest Research Station, Region 5, GIS Clearinghouse available on-line at: http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml#nwc
1 0 1 2 3
Miles
Prepared by
Healthy Community
Healthy Forest
Watershed Research and Training Center
January 23, 2008



Prepared by

Healthy Community Healthy Forest

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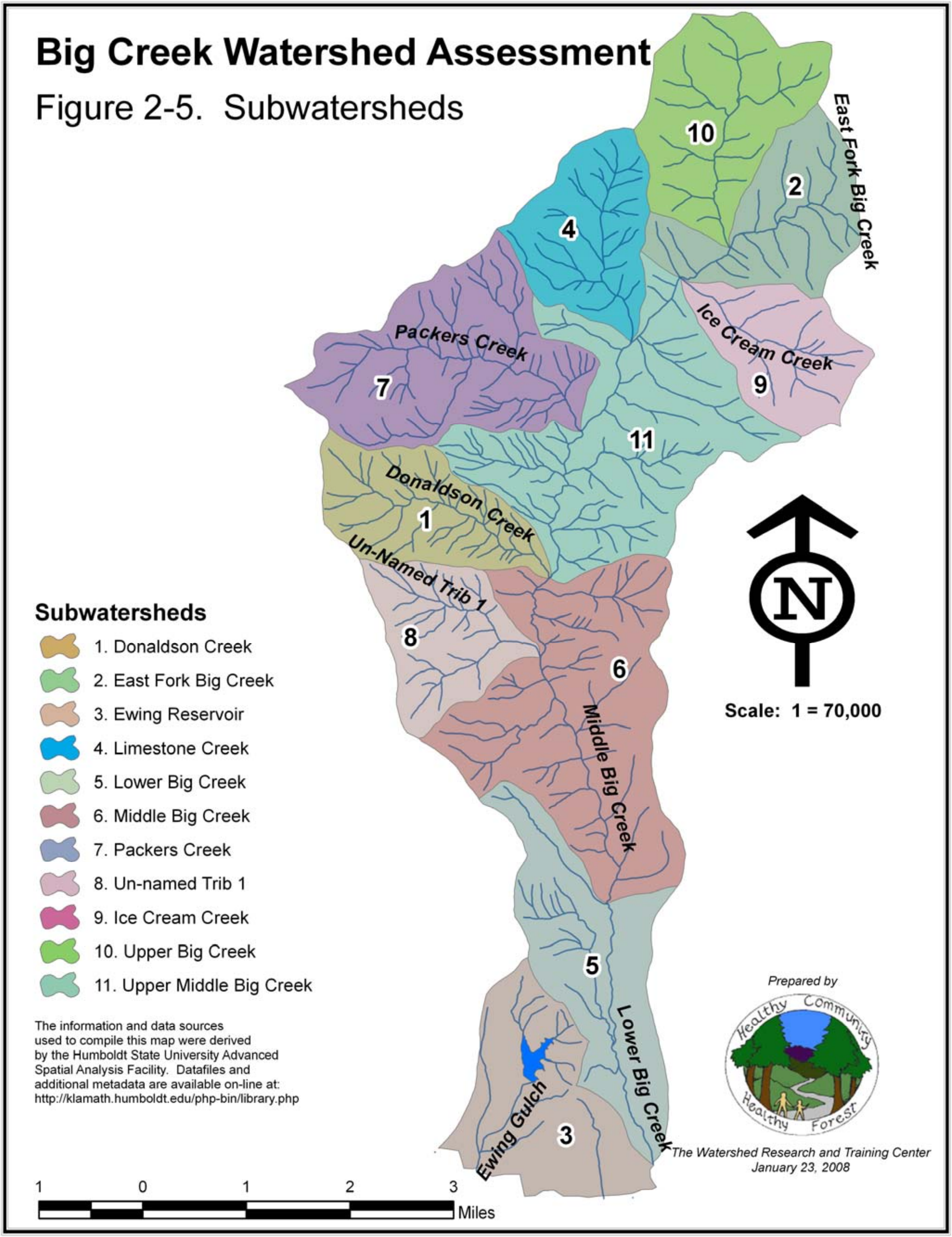
0.5 0 0.5 1 1.5 Miles

Reference maps and information used to create this figure were provided by the Trinity County Waterworks District #1, P.O. Box 217, Hayfork, CA 96041.

N

Scale 1 = 30,000


Big Creek Watershed Assessment
Figure 2-5. Subwatersheds
East Fork Big Creek
Ice Cream Creek
Packers Creek
Donaldson Creek
Un-Named Trib 1
Middle Big Creek
Lower Big Creek
Ewing Gulch
10
2
4
9
7
11
1
8
6
5
3
N
Scale: 1 = 70,000
Subwatersheds
1. Donaldson Creek
2. East Fork Big Creek
3. Ewing Reservoir
4. Limestone Creek
5. Lower Big Creek
6. Middle Big Creek
7. Packers Creek
8. Un-named Trib 1
9. Ice Cream Creek
10. Upper Big Creek
11. Upper Middle Big Creek
The information and data sources
used to compile this map were derived
by the Humboldt State University Advanced
Spatial Analysis Facility. Datafiles and
additional metadata are available on-line at:
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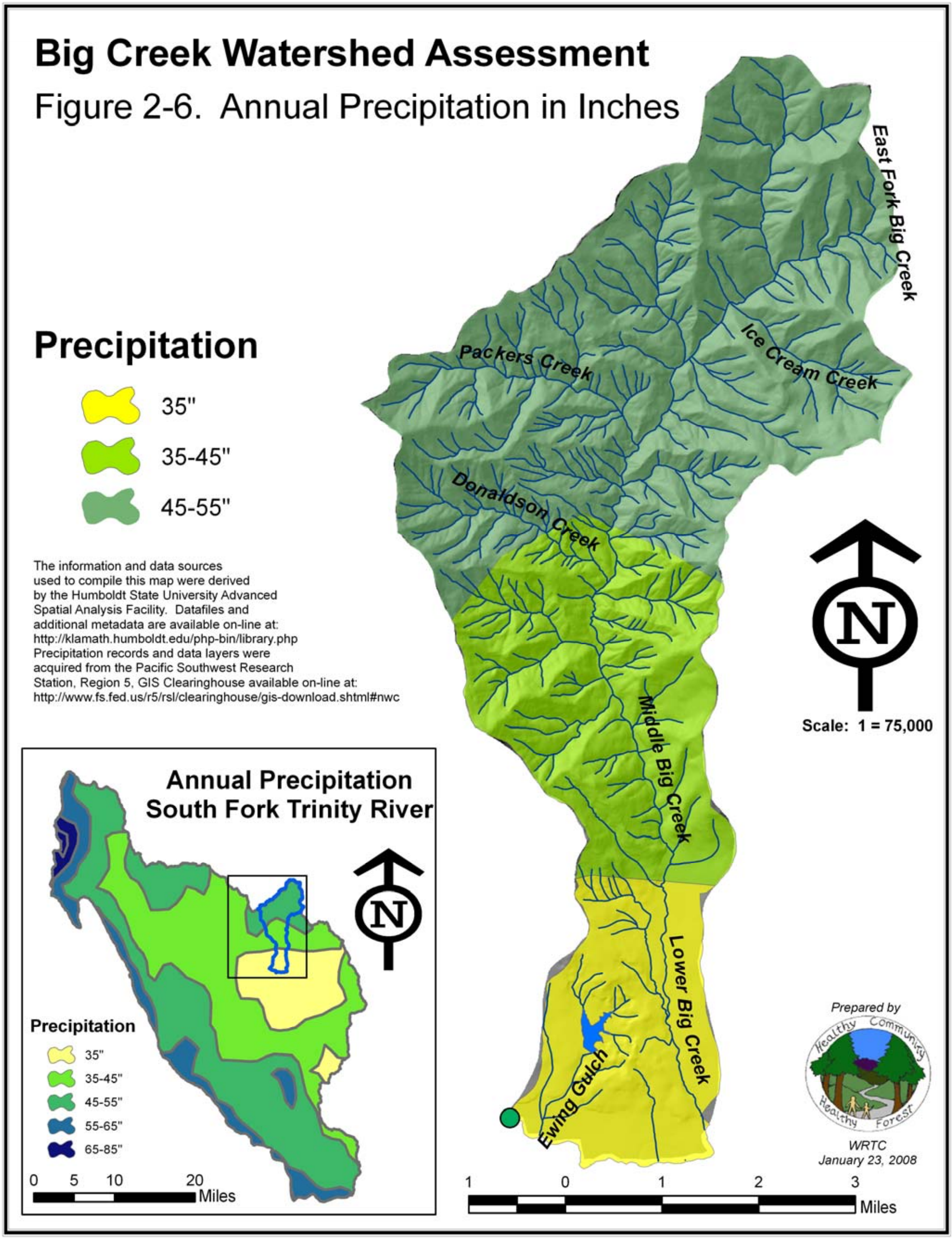
Prepared by
Healthy Community
Healthy Forest
The Watershed Research and Training Center
January 23, 2008
1 0 1 2 3
Miles


Big Creek Watershed Assessment
Figure 2-6. Annual Precipitation in Inches
Precipitation
35"
35-45"
45-55"
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php Precipitation records and data layers were acquired from the Pacific Southwest Research Station, Region 5, GIS Clearinghouse available on-line at: http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml#nwc
East Fork Big Creek
Ice Cream Creek
Packers Creek
Donaldson Creek
Middle Big Creek
Lower Big Creek
Ewing Gulch
N
Scale: 1 = 75,000
Annual Precipitation
South Fork Trinity River
N
Precipitation
35"
35-45"
45-55"
55-65"
65-85"
0 5 10 20
Miles
Prepared by
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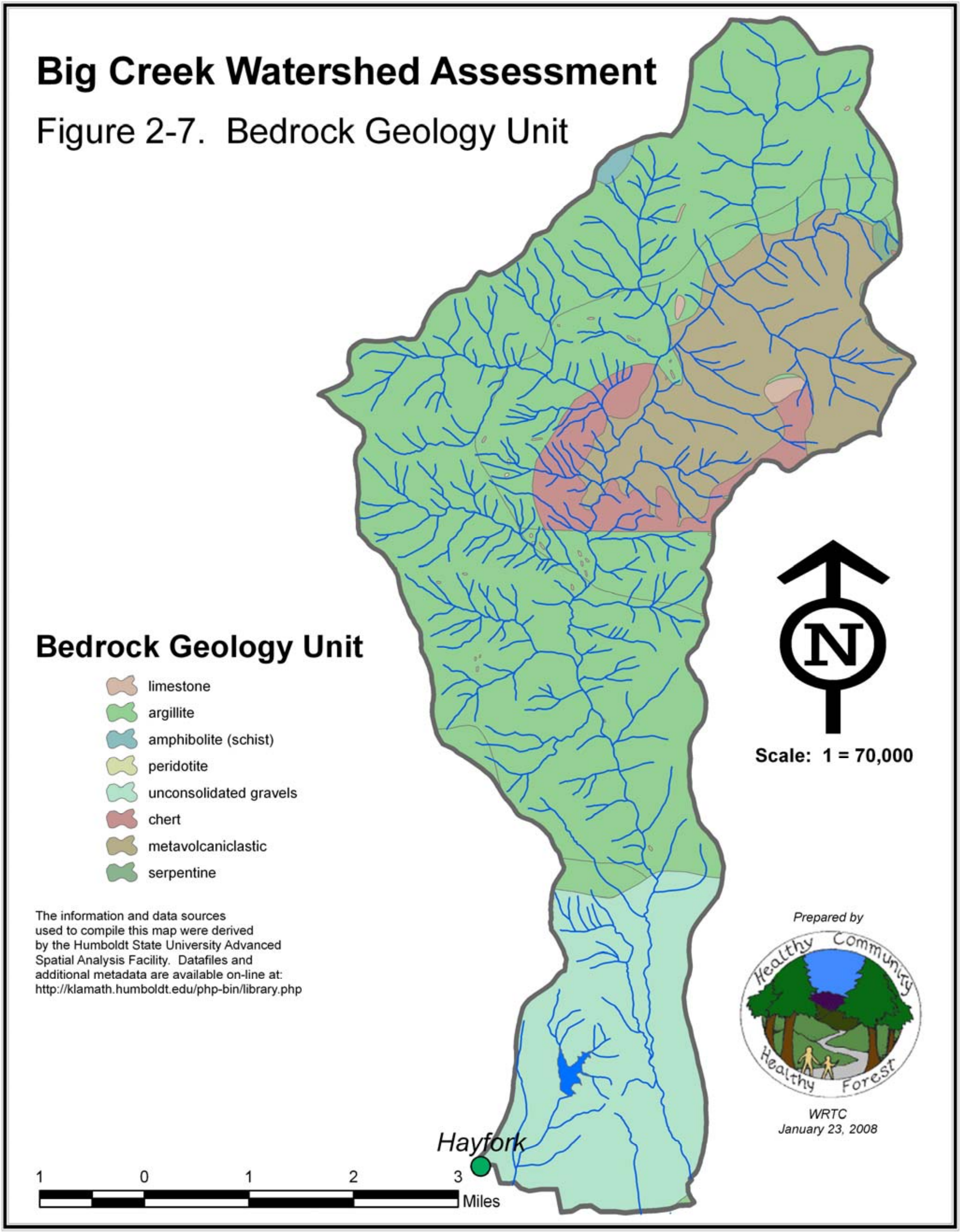
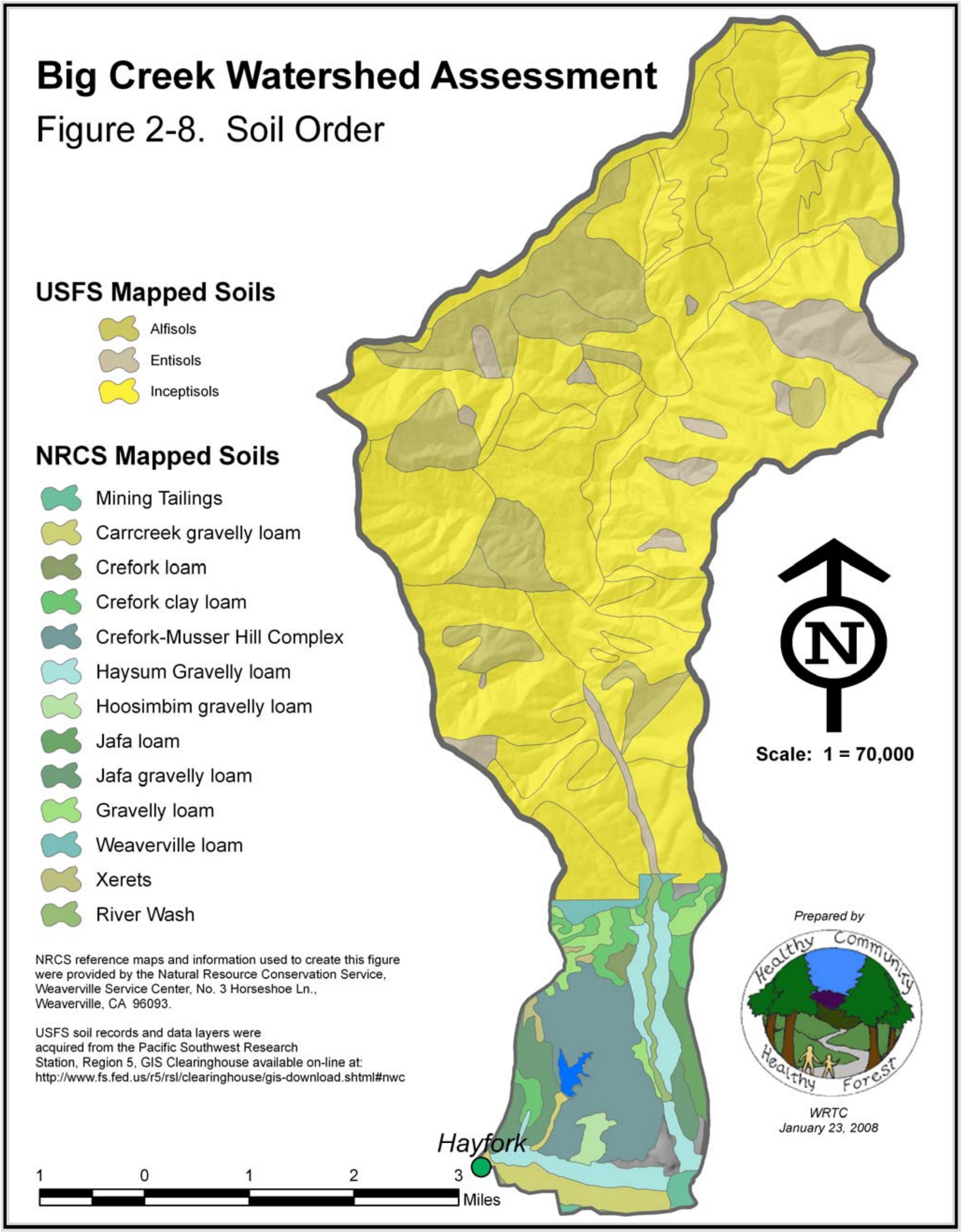
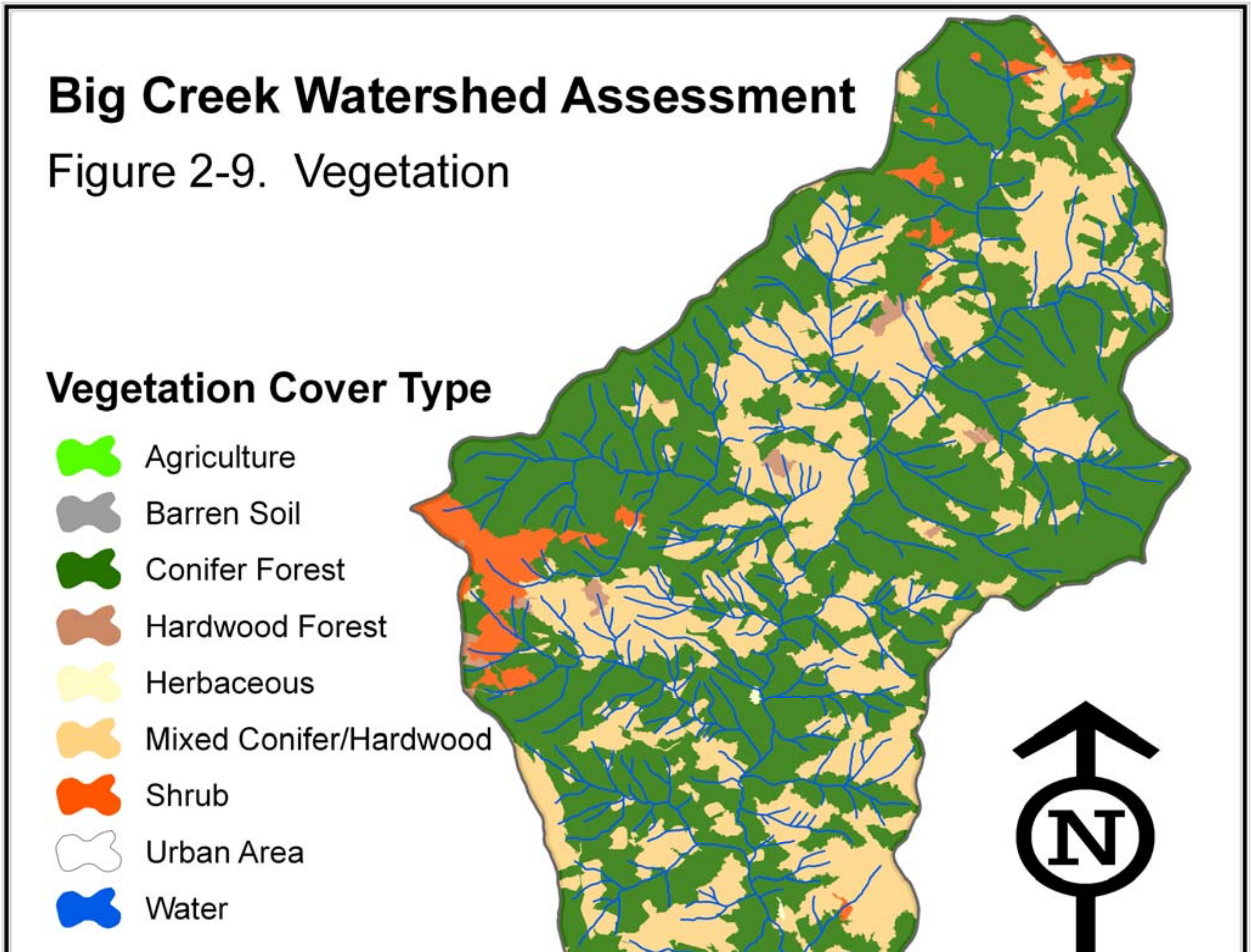
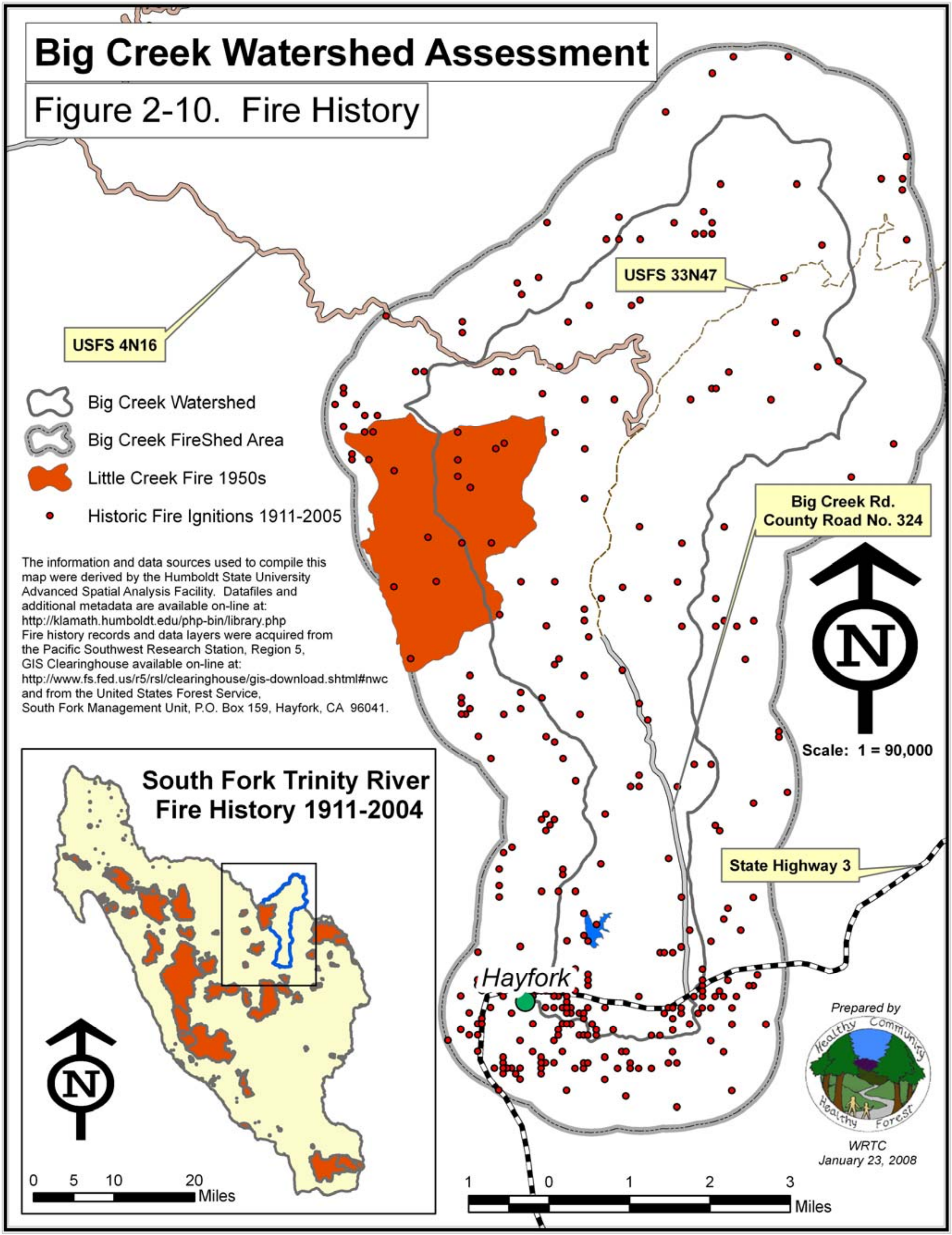
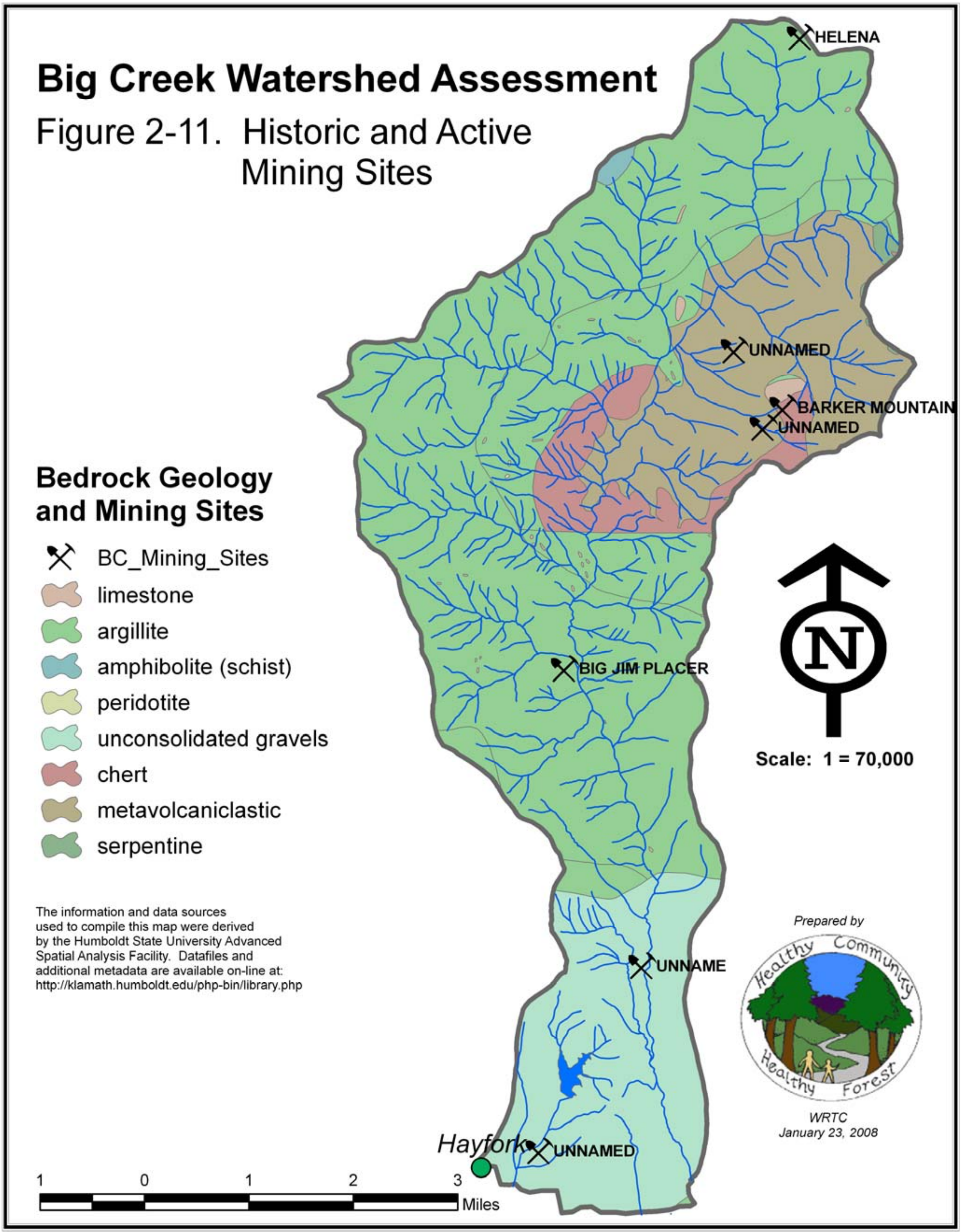
Healthy Forest
WRTC
January 23, 2008
1 0 1 2 3
Miles


Big Creek Watershed Assessment
Figure 2-7. Bedrock Geology Unit
Bedrock Geology Unit
limestone
argillite
amphibolite (schist)
peridotite
unconsolidated gravels
chert
metavolcaniclastic
serpentine
The information and data sources
used to compile this map were derived
by the Humboldt State University Advanced
Spatial Analysis Facility. Datafiles and
additional metadata are available on-line at:
http://klamath.humboldt.edu/php-bin/library.php
Scale: 1 = 70,000
Prepared by
Healthy Community
Healthy Forest
WRTC
January 23, 2008
Hayfork
1 0 1 2 3
Miles

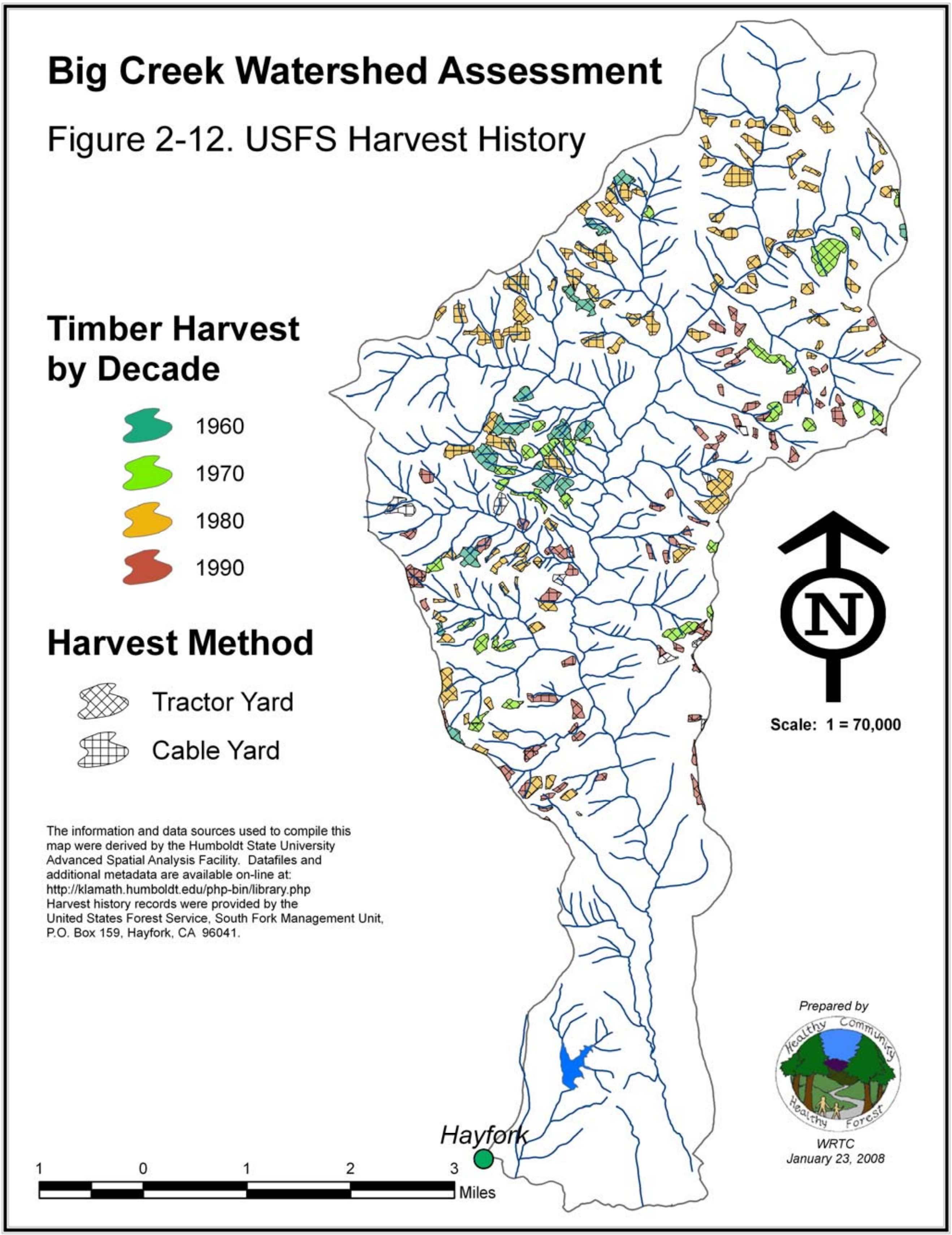

Big Creek Watershed Assessment
Figure 2-8. Soil Order
USFS Mapped Soils
Alfisols
Entisols
Inceptisols
NRCS Mapped Soils
Mining Tailings
Carrcreek gravelly loam
Crefork loam
Crefork clay loam
Crefork-Musser Hill Complex
Haysum Gravelly loam
Hoosimbim gravelly loam
Jafa loam
Jafa gravelly loam
Gravelly loam
Weaverville loam
Xerets
River Wash
NRCS reference maps and information used to create this figure were provided by the Natural Resource Conservation Service, Weaverville Service Center, No. 3 Horseshoe Ln., Weaverville, CA 96093.
USFS soil records and data layers were acquired from the Pacific Southwest Research Station, Region 5, GIS Clearinghouse available on-line at: http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml#nwc
Scale: 1 = 70,000
Hayfork
1 0 1 2 3
Miles
Prepared by
Healthy Community Healthy Forest
WRTC
January 23, 2008


Big Creek Watershed Assessment
Figure 2-9. Vegetation
Vegetation Cover Type
Agriculture
Barren Soil
Conifer Forest
Hardwood Forest
Herbaceous
Mixed Conifer/Hardwood
Shrub
Urban Area
Water
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php Additional vegetation records and data layers were acquired from the Pacific Southwest Research Station, Region 5, GIS Clearinghouse available on-line at: http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml#nwc
N
Scale: 1 = 70,000
Prepared by
Healthy Community
Healthy Forest
WRTC
January 23, 2008
Hayfork
1
0
1
2
3
Miles


Big Creek Watershed Assessment
Figure 2-10. Fire History
USFS 4N16
USFS 33N47
Big Creek Watershed
Big Creek FireShed Area
Little Creek Fire 1950s
Historic Fire Ignitions 1911-2005
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php
Fire history records and data layers were acquired from the Pacific Southwest Research Station, Region 5, GIS Clearinghouse available on-line at: http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml#nwc
and from the United States Forest Service, South Fork Management Unit, P.O. Box 159, Hayfork, CA 96041.
Big Creek Rd.
County Road No. 324
N
Scale: 1 = 90,000
South Fork Trinity River
Fire History 1911-2004
State Highway 3
Hayfork
Prepared by
Healthy Community Healthy Forest
WRTC
January 23, 2008
0 5 10 20
Miles
1 0 1 2 3
Miles



Big Creek Watershed Assessment
Figure 2-11. Historic and Active Mining Sites
Bedrock Geology and Mining Sites
BC_Mining_Sites
limestone
argillite
amphibolite (schist)
peridotite
unconsolidated gravels
chert
metavolcaniclastic
serpentine
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php
HELENA
UNNAMED
BARKER MOUNTAIN
UNNAMED
BIG JIM PLACER
UNNAME
Hayfork
UNNAMED
N
Scale: 1 = 70,000
Prepared by
Healthy Community
Healthy Forest
WRTC
January 23, 2008
1
0
1
2
3
Miles


Big Creek Watershed Assessment
Figure 2-12. USFS Harvest History
Timber Harvest by Decade
1960
1970
1980
1990
Harvest Method
Tractor Yard
Cable Yard
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php Harvest history records were provided by the United States Forest Service, South Fork Management Unit, P.O. Box 159, Hayfork, CA 96041.
Scale: 1 = 70,000
N
Hayfork
1
0
1
2
3
Miles
Prepared by
Healthy Community
Healthy Forest
WRTC
January 23, 2008

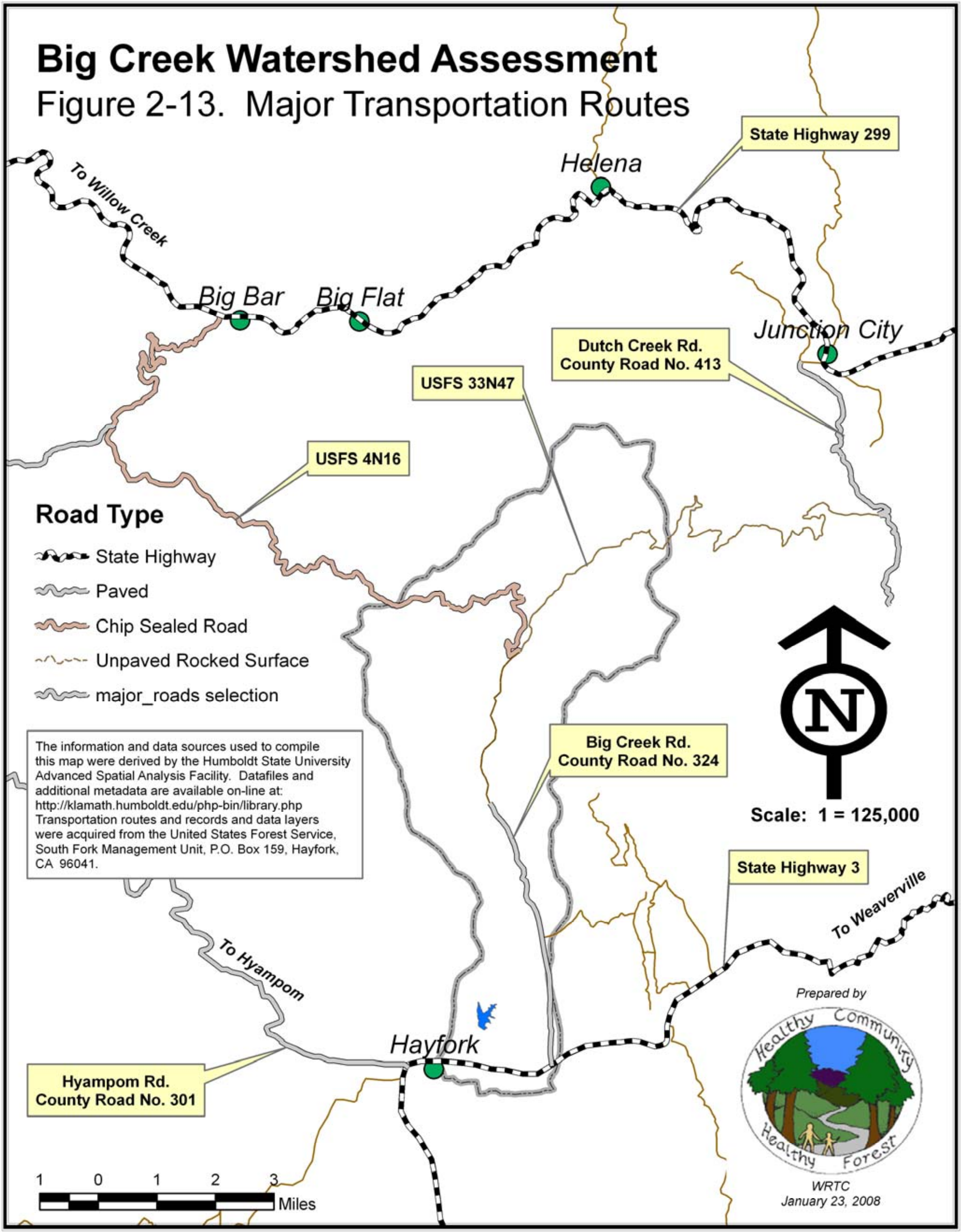

Big Creek Watershed Assessment
Figure 2-13. Major Transportation Routes
State Highway 299
Helena
To Willow Creek
Big Bar
Big Flat
Junction City
Dutch Creek Rd.
County Road No. 413
USFS 33N47
USFS 4N16
Road Type
State Highway
Paved
Chip Sealed Road
Unpaved Rocked Surface
major_roads selection
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php Transportation routes and records and data layers were acquired from the United States Forest Service, South Fork Management Unit, P.O. Box 159, Hayfork, CA 96041.
Big Creek Rd.
County Road No. 324
N
Scale: 1 = 125,000
State Highway 3
To Weaverville
To Hyampom
Hayfork
Hyampom Rd.
County Road No. 301
1 0 1 2 3
Miles
Prepared by
Healthy Community
Healthy Forest
WRTC
January 23, 2008

Photo 2-1 Concrete diversion dam along main stem Big Creek. Diversion supplies municipal water supply for town of Hayfork and agricultural irrigation.

Photo 2-2 Ewing Reservoir located approximately one mile north of the community of Hayfork, California. The reservoir provides 820 acre-feet of water storage for approximately 2,450 users.

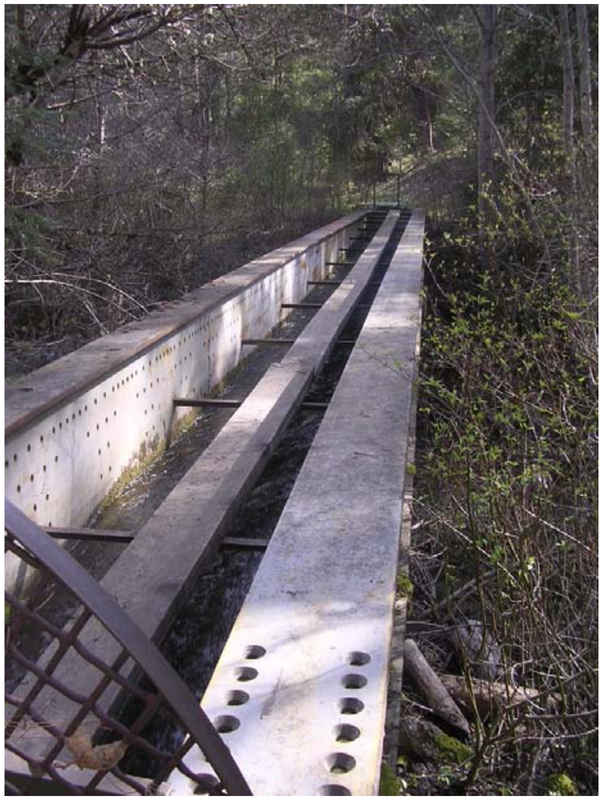


Photo 2-3 Water flume over Big Creek that delivers water from diversion site to Ewing Reservoir 2.5 miles to the southwest.

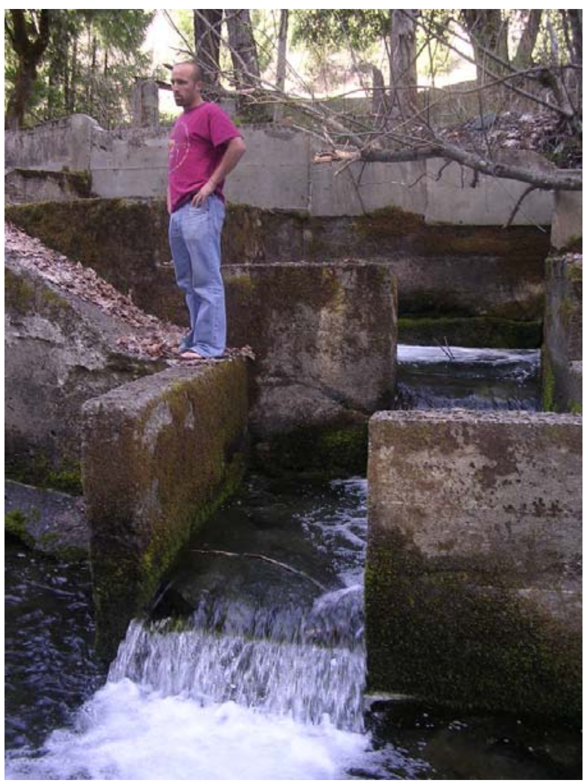


Photo 2-4 Fish ladder on Big Creek constructed in early 1940s.

Photo 2-5 Confluence of Big Creek and Hayfork Creek near former Sierra Pacific mill site.

SECTION 3

Past Projects and Studies in Project Area

An integral part of effective watershed management is to draw from existing data sets and reporting to determine where data and knowledge gaps may exists for the area of interest. Once these data gaps have been established, designing a watershed resource inventory strategy becomes more specific and streamlined. More extensive data collections may help to answer specific questions related to resource issues and shed light on the steps necessary to mitigate their negative effects. As such the opportunities arise, these studies may provide sufficient direction to land managers for setting implementation work prioritizations. Studies should be amended in the future as new information from surveys, inventories, monitoring reports, and other analyses are made available; or if other issues are addressed. New information may describe impacts from natural events and/or management activities, and compare those impacts against baseline conditions described from previous data. In response to the new information and analyses, future assessments and management plans will enable adaptive management of watershed activities and conditions.

The Big Creek watershed has not been the direct focus of many assessment projects, however, Hayfork Creek and the South Fork of the Trinity River have been the focus of several large-scale analyses that have looked at land management and its impacts to water quality from non-point pollution sources, such as sediment.

The purpose of this section is to review past assessments, studies and projects that have been conducted for the South Fork Trinity River watershed, and more specifically, for the Hayfork Creek subbasin and Big Creek. The objective here is to undertand the major findings from each of these documents and determine how these findings may be applicable to the results of the current Big Creek Watershed Assessment.

Action Plan for the South Fork Trinity River and its Fisheries (1994)
Prepared by: Pacific Watershed Associates, P.O. Box 4433, Arcata, CA, 95518.

Project Summary
The objectives of the South Fork Restoration Action Plan were to identify the principal factors limiting the recovery of anadromous salmonid stocks of the South Fork Trinity River, and to develop a listing of projects and actions needed to accelerate the recovery of stream habitat and fish populations throughout the basin. Recommendations included in this plan are based on the best technical information available for the South Fork Trinity River basin and its resources.

This Action Plan reviewed the current state of knowledge regarding watershed conditions, fish habitat and the status of salmonid stocks in the 1000 mi^2 South Fork Trinity River basin. It outlined appropriate land treatments, channel treatments, water conservation and pollution prevention measures, land use changes, fisheries management techniques and educational programs needed to affect fisheries protection and watershed stabilization, and begin the proactive process of fisheries recovery in the most cost-effective manner possible.

Findings/Recommendations

- The major limiting factor on Big Creek is apparently related to stream flow diversion. Downstream migration is hindered, stream habitat diminished and stream temperatures are elevated.
- Problems with water diversions, mining, minor landslides, surface erosion from roads, private logging, placer mining and grazing all affect conditions in Big Creek.
- [Big Creek] can be characterized as being moderately sensitive to cumulative erosion and sedimentation effects. It is perhaps more sensitive to grazing and mining practices which directly cause channel impacts, or to agricultural and domestic water drawing practices which reduce stream flows and elevate summer stream temperatures.
- Recommendations for improving water supply and water quality in [Big Creek] include replacing irrigation ditches with piped diversions, using a computer model to coordinate and time water withdrawals,.......... excluding cattle from stream side areas and restoring riparian zones. Re-establishing a multi-tiered riparian forest, with willows and alders at stream side and cottonwoods or conifers on flood terraces, has also been recommended.
- To implement the broad variety of recommendations and restoration action items identified for the basin, we have suggested the formation of a community-based decision-making group acting through a Coordinated Resources Management Plan (CRMP).

South Fork Trinity River: Coordinated Resource Management Plan (CRMP; 1996)
Prepared by: Patrick Truman & Associates and Pacific Watershed & Associates

Project Summary
Coordinated Resource Management and Planning (CRMP) is a resource planning, problem solving, and management (decision making) process that allows for direct participation of everyone (stakeholders) concerned with resource management in a given planning area. The stated goals of the SFTR CRMP are to: (1) develop and implement a coordinated resource management plan for the recovery of the fisheries and economies of the South Fork Trinity River Basin, and (2) promote equality, cooperation and voluntary participation among all members of the CRMP process. The stated objectives of the SFTR CRMP are to: (1) provide the leadership necessary to bring diverse interest groups to agreement on resource management opportunities, (2) perform upland watershed analysis and inventory, (3) determine risk potential for sediment yield from private and public land, (4) assess water quality and quantity improvement opportunity, (5) increase forest productivity through soil conservation, (6) provide access to, and facilitate transfer of, technical information and expertise, and (7) serve as a liaison between the agencies, industries and local grass roots groups.

Recommendations/Findings

- Water quality and quantity are the major limiting factors to fisheries recovery in this management unit.
- Water diversions and water pollution along with high summer water temperatures are negatively affecting fish habitat in this reach and in downstream reaches.
- In management unit #5 (including Big Creek watershed) it is important to pursue conservation practices to reduce water use and to allow for adequate riparian habitat to protect and shade the streams in order to reduce temperatures. In many cases this may mean fencing off the riparian zone to protect it from cattle.
- Efforts to reduce water temperatures through a riparian revegetation program utilizing a mix of conifer and deciduous species should continue, as well as additional reductions in water diversions through installing more efficient delivery systems and improvements in irrigation operations.
- Continued monitoring of water quality conditions along this reach of Hayfork Creek is important, especially in demonstrating the need for a sewage treatment plant for the community to improve water quality.
- Plans for this management unit should include additional riparian exclusionary fencing, revegetating riparian zones, upland fuels reduction and erosion control projects on private lands, water quantity and quality projects such as piping old, leaky irrigation ditches.

South Fork Trinity River and Hayfork Creek Sediment TMDL (1998)
Prepared by: U.S. Environmental Protection Agency, Region 9

Project Summary
This TMDL addresses sediment loading in the entire South Fork Trinity River basin, including Hayfork Creek and its tributaries. The components of the TMDL are: a problem statement, including assessment of instream and upslope conditions; identification of instream numeric targets, intended to interpret and apply the narrative WQS and represent acceptable instream conditions for cold water fish; an analysis of significant sediment sources that have in the past or are presently impacting the stream system; a linkage analysis to assess the magnitude of reductions necessary to attain the numeric targets; an allocation of loads, which distributes needed load reductions among various sources; and several other sections designed to address considerations set forth in Section 303(d) of the Clean Water Act or the implementing regulations at 40 CFR 130.7.

Findings/Recommendations

- The sedimentation in the South Fork Trinity River watershed was judged to exceed the existing Water Quality Standards (WQS) necessary to protect the beneficial uses of the basin, particularly the cold water fishery. Accelerated erosion from land use practices and natural sources impacts the migration, spawning, reproduction, and early development of cold water fish such as spring and fall run chinook salmon and steelhead trout.
- In the Hayfork Creek sub-basin, roads and bank erosion are the most significant components of the overall sediment production, largely due to the fact that mass wasting is a much less significant process in that sub-basin.

- Non-management surface erosion is more significant in [Big Creek] due to past fires as well as to chaparral vegetation types, which do not protect the surface slopes as well as tree coverage.
- Harvest-related surface erosion from harvest units is estimated at about 9 tons/mi2/yr, respectively.
- Existing information suggests that high temperatures could result from: natural conditions, water diversions (particularly in Hayfork Creek), loss of riparian vegetation in selected locations, and excess sedimentation that resulted in channel widening and decreased water depths.
- Improve substrate size distribution: Percent Fine Sediment <0.85 mm; Target Level: < 14%.
- Decreased Hillslope/Road-Related Sediment Production.
- Road Crossing Diversion Potential: Target Level: <1% of crossings with diversion potential in the basin.
- Road Crossing Failure: Target Level: < 1% of all roads would potentially fail. Adequate crossing failure protection is defined as culverts and crossings sized to pass the 100 year flood, including snowmelt, and associated sediment and debris.

Stream Condition Inventory Report: Big Creek (1999)
Prepared by: U.S. Forest Service, Shasta-Trinity National Forest, South Fork Management Unit, Hayfork, California.

Project Summary
Fisheries personnel from the South Fork Management Unit located on the Shasta Trinity National Forest conducted a stream condition inventory and biological inventory survey on Big Creek starting on July 12, 1999 and ending on August 9, 1999. The objectives of the field-extensive inventory are to collect information that will result in a description of the watershed's conditions at a specific point in time. The biological inventory is conducted to establish the presence or absence of anadromous fish fauna as well as to establish baseline juevenile fish densities for Big Creek.

Findings/Recommendations
- Establishment of sensitive reaches as monitoring sites to measure applicable stream attributes primarily for Reaches 1 and 2. Cross-sections and longitudinal profiles are the best way to measure hydrologic.
- Determine stream conditions and habitat capability for East Fork Big Creek, Donaldson, Packers and Limestone Creeks. Establish non-point source contribution of fine sediment input to Big Creek from these tributaries.
- Conduct spawning surveys for steelhead on an annual basis to establish which areas are viable for redd excavation, the conditions of these spawning areas, and the distribution and number of adults utilizing the lower, middle and upper reaches of Big Creek.
- Livestock grazing is a concern in riparian areas. Limited and controlled riparian grazing could increase riparian vegetation, stabilize banks, increase LWD recruitment, and decrease summer and low flow temperatures.

- Installation of additional habitat improvement structures on Big Creek would show only minor short-term improvement of fish habitat.
- Structures installed in 1993 and 1994 have failed during high flows, several are functional, while others are nonfunctional and/or need maintenance.
- A more efficient irrigation system for pasture irrigation is needed to increase stream flows and reduce sediment inputs from irrigation ditches.

Middle Hayfork and Salt Creek Watershed Assessment (2000)
Prepared by: U.S. Forest Service, Shasta-Trinity National Forest, South Fork Management Unit, Hayfork, California.

Project Summary
The watershed analyses for Middle Hayfork and Salt Creek watersheds provided a broad, landscape-scale evaluation of the watersheds that allow public, private, and government agencies to plan for future management of resources at a project level scale. Wherever possible the document has been arranged in a manner that will allow each watershed to be evaluated separately. This watershed analysis can be considered one step of an iterative process for developing our knowledge about the physical and ecological conditions and processes that occur within the Middle Hayfork and Salt Creek ecosystems. Existing conditions are compared with historic conditions to evaluate impacts, describe trends and infer the possible causes of change through time.

Findings/Recommendations (Water Quality and Watershed Enhancement, only)
- Conduct fluvial geomorphology and hydrologic assessments of fish bearing streams. Information about flows and channel conditions are currently lacking and are necessary to evaluate channel restoration opportunities.
- Address the water quality data limitation by implementing a water quality monitoring program to gain a better understanding of current water quality conditions and to assess water quality changes of management activities.
- Reduce road related sediment delivery to stream channels by:
    - Converting native surface roads to gravel roads;
    - Rocking inside ditches more resistant to erosion by concentrated flow;
    - Stabilizing cut and fill slopes;
    - Increasing the frequency of road drainage structures in order to reduce erosion of road surfaces by concentrated flow;
    - Armoring road crossing fill slopes and improving drainage from crossings,
    - Armoring drainage structure outlets to reduce erosion of fill slopes.
- Conduct Stream Conditions Inventories and channel typing surveys to determine where it would be appropriate to install wood structures to create pool habitats and enhance sediment routing.
- Evaluate fish bearing streams for opportunities to re-connect the channel with the floodplain. This will have a positive effect on summer low flows because groundwater flow will increase summer flows.
- Restore the historic hydrologic and sediment regimes of fish bearing streams by implementing a fuels reduction and prescribed fire program to reduce the occurrence of high intensity fires and water use by overstocked stands. This will

increase stream discharge during the low flow period, reduce low flow water temperatures, and provide increased channel substrate diversity.

- Explore opportunities to test the reintroduction of low intensity prescribed fire in riparian zones to reduce fuel loading.
- Improve riparian stand conditions by utilizing timber thinning where appropriate. Thinning programs could occur in the Big Creek, Tule Creek, and Philpot Creek watersheds.

South Fork Trinity Water Quality Monitoring Project (2003)
Prepared by: Trinity County Resource Conservation District, P.O. Box 1450, Weaverville, California, 96093.

Project Summary
The South Fork (SF) Trinity River watershed in Trinity County has been listed as a sediment impaired water-body in California's 1995 CWA 303(d) list, adopted by the State of California North Coast Regional Water Quality Control Board (NCRWQCB). Implementation of sediment TMDL standards for a watershed with highly divergent sediment sources, due to differing bedrock geology and land management, such as the SF Trinity River, requires much more detailed information compared to less complex watersheds. Without specific information developed at a sub-watershed level, load allocations and reduction levels to meet specified targets are only crude estimates. Although the SF Trinity River has a considerable amount of existing information in many areas, a number of areas lack any appreciable data, and existing information does not allow refinement of source areas and allocations with any reasonable certainty beyond a main sub-watershed level.

The purpose of this report is to compile, summarize, and analyze baseline hydrologic and sediment transport data for the SF Trinity River watershed that could be used for TMDL implementation and monitoring. This study combines office-based analyses of aerial photographs and GIS coverages with extensive streamflow, sediment transport, and geomorphic data collection.

Recommendations/Findings

- Though treated separately, three of the Barker Creek (adjacent watershed to Big Creek) sub-watershed station totals exceeded all datalogger sites except Grouse Creek.
- Sediment yields do not appear to be related to simple metrics of watershed disturbance such as road density or percent watershed harvested.
- A detailed program of streamflow and sediment transport measurement has quantified substantial differences in sediment yield between sites.
- Although not all sites were computed, review of data collected within sub-watersheds indicates that measurement of streamflow and sediment transport can be an effective technique to identify sub-watershed areas that are producing sediment at higher rates.
- The strength of relationships between turbidity and suspended sediment for individual sites, suggests that measurement of turbidity could define sediment

yields at a management level once streamflow rating curves had been developed. Since turbidity is far easier and less expensive to measure than suspended sediment, this may be a more cost effective approach to evaluating relative sediment yields. In addition, technology is now available to monitor turbidity continuously, even at fairly remote sites.

- High flow measurements or slope-area estimates of discharge would greatly increase the accuracyof load estimates at the following stations using existing sediment load ratings: BGCH3 (Big Creek), BCH3, BCSR, SCSCG, BTBV, and PCH3.

SECTION 4

Watershed Resource Inventory (WRI) Description

To assess the current resource conditions in Big Creek and evaluate their long-term impact on water quality and beneficial uses in the basin, a multi-step approach was employed:

1) Collected existing GIS data for the basin;
2) Determined where there were data gaps or altogether missing data;
3) Conducted on-going stream monitoring of temperature, flow, turbidity and suspended sediment along 9 strategically located monitoring sites throughout watershed;
4) Formulated a inventory strategy using existing USFS inventory protocol;
5) Conducted Watershed Resource Inventory (WRI) of core resource conditions;
6) Performed periodic quality assurance and quality control checks on data collection;
7) Generated GIS layers and resource inventory database;
8) Analyzed newly acquired data and preexisting data using GIS and other spatial modeling software;
9) Drew conclusions from analysis and document them in the Watershed Assessment Report (WAR).

Existing Data

Existing data used for the analysis was acquired from: (1) GIS technicians at the Hayfork Ranger District of the South Fork Management Unit; (2) water quality data and maps from Trinity County Waterworks District #1; (3) a copy of the Hayfork Community Plan (1996); (4) water monitoring data from the South Fork Trinity River Stream Monitoring Report (GMA 2003), and (5) Statewide, Regionwide & Planning Area Layer Descriptions and Data Downloads, Forest Service, Region 5 (USDA 2008).

Data Collection

Data acquired from the above sources was useful for determining property ownership, land use categories, and land use history. Data on current conditions was lacking for many of the core resource conditions that were necessary components of the WRI.

To derive the Big Creek sediment budget a road inventory, landslide inventory, and extensive stream monitoring were performed. Graham Matthews & Associates give a detailed summary of the methods used during stream monitoring in Section 7. North State Resources give a detailed summary of the methods used during the road assessment and landslide inventory in Section 8.

Existing data on fuel conditions was provided in GIS format by the USFS South Fork Management Unit, however, the accuracy of this data was lacking due to the age of the data and the methods used to derive the data. A fuel condition inventory was completed by members of the WRTC staff to assess the accuracy of the existing data layers and modify those data layers to more accurately reflect current fuel conditions. A detailed summary of the methods used during the fire and fuel assessment are outlined in Section 6.

Data on current stream conditions were not available is GIS format. Two stream condition inventories had been completed for Big Creek in 1989 and 1999 and were available in hardcopy form only. An extensive stream condition inventory was completed by WRTC staff to document existing conditions along three sensitive reaches of Big Creek. The information derived from this inventory will be useful not only for determining current conditions in the stream, but also for monitoring restoration projects or disturbances that may occur in the basin over time. A detailed summary of the methods used during the Stream Condition Inventory are outlined in Section 5.

WRI Strategy

One of the main objectives was to establish data compatibility between existing USFS data sets and data acquired during the WRI. Where applicable, current USFS inventory protocol was used for data collection to help streamline the pre-NEPA data collection process necessary for project implementation on federal land. The Operating Agreement between the USFS and WRTC for the Big Creek Watershed Management Project specifies that all Stream Condition Inventory (SCI) and Road Assessment Protocol (RAP) were to be conducted using USFS designed data collection methods. Prior to project implementation the USFS will be required only to validate that the data is still current and accurate to satisfy pre-NEPA requirements and begin implementation of restoration projects specified in the Big Creek Watershed Management Plan.

SECTION 4 REFERENCES

USDA Forest Service. 2005. *Stream Condition Inventory (SCI).* USDA For. Serv. Tech. Guide, Version 5.0. 111 p.

USDA Forest Service. 2006. *Project Level Roads Analysis Handbook*, Shasta-Trinity National Forest, South Fork Management Unit, Hayfork Ranger District, Hayfork, California, 96041.

USDA Forest Service 2008. *Statewide, Regionwide & Planning Area Layer Descriptions and Data Downloads, Forest Service, Region 5*. Available on-line at: http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml#nwc; last accessed on February 14, 2008.

SECTION 5

Stream Condition Inventory (SCI)

The purpose of the Pacific Southwest Region Stream Condition Inventory (SCI) is to collect intensive and repeatable data from stream reaches to document existing stream conditions and make reliable comparisons over time within or between stream reaches. SCI is therefore an inventory and monitoring program. It is designed to assess effectiveness of management actions on streams in managed watersheds (non-reference streams), as well as to document stream conditions over time in watersheds with little or no past management or that have recovered from historic management effects (reference streams). The main objective of SCI are to: (1) Inventory stream reaches using standard, measurable protocols to collect consistent region wide existing stream condition data, and (2) Monitor stream reaches over time to compare conditions within or between reaches at a reasonable level of statistical confidence (generally the detection of a 20% change with an 80% confidence level; USDA 2005).

Measured Attributes

The SCI consists of stream features, or attributes, that are useful in classifying channels, evaluating the condition of stream morphology and aquatic habitat, and making inferences about water quality. Attributes are collected at selected reaches on streams of interest. Reaches are permanently marked to reduce variability when measurements are repeated (USDA 2005). The following is a description of the core attributes that were measured and documented along three sensitive reaches of Big Creek. A more detailed account of the specific methods used to collect the data is outlined in *Stream Condition Inventory (SCI), Technical Guide, Pacific Southwest Region, Version 5.0.*

Particle Size Distribution

Streambed materials are key elements in the formation and maintenance of channel morphology. These materials influence channel stability, resistance to scour during high flow events, and also act as a supply of sediment to be routed and sorted throughout the channel. The amount and frequency of bedload transport can be critically important to fish spawning and other aquatic organisms that use stream substrate for cover, breeding, or foraging.

Particle size distribution can change over time as a result of management activities and/or natural disturbances. Detecting change is important for making decisions related to managing aquatic communities and ecological processes.

Large Woody Debris (LWD)

Large wood is important to the morphology of many streams. It influences channel width and meander patterns, provides for storage of sediment and bedload, and is often most important in pool formation in streams. Large wood is also an important component of instream cover for fish, as well as providing habitat for aquatic insects and amphibians. Large wood influences on stream ecology vary with size of the stream and size of the wood (small wood is easily transported in large systems).

Bankfull Stage
The bankfull stage corresponds to the discharge at which channel maintenance is often the most effective. This discharge is a major factor in shaping channels sensitive to disturbance by management activities, such as gravel bed streams. The bankfull stage discharge is associated with a momentary maximum flow that has a recurrence interval of about 1.5 years.

Cross Section
Channel cross-section measurements express the physical dimensions of the stream perpendicular to flow. They provide fundamental understanding of the relationships of width and depth, streambed and streambank shape, bankfull stage and floodprone area, etc. All of these are important attributes of channel condition and indicators of the health of aquatic and riparian ecosystems. Cross-section measurements also serve as essential criteria for stream classification. Monumented cross-sections are used to determine channel condition and trend since they can be monitored repeatedly.

Surface Water Gradient
Gradient of the stream surface is an essential element of many stream classification systems and a primary attribute for stratifying sensitive reaches in the R5 SCI database. In addition, knowledge of gradient helps provide understanding of the geomorphological processes shaping the channel. Gradient must be measured in order to compare the reach with other reaches in the SCI database, and to help classify the reach stream type.

Width to Depth Ratio
Stream width-to-depth ratio is a key indicator of channel condition. A low width-to-depth ratio generally indicates good conditions for aquatic flora and fauna and riparian vegetation. Low width-to-depth ratios result in deeper water for aquatic species and a higher water table to support growth of riparian and meadow vegetation.

Entrenchment Ratio
Stream discharges greater than bankfull strongly influence the character of the channel. The interaction of these flows with the channel floodplain plays a major role in sediment transport and storage, streambank stability, and channel morphology. Entrenchment ratio is defined as the ratio of flood prone width to bankfull width as measured at twice the maximum bankfull depth. This measure is intended to quantify channel confinement.

Habitat Type
At the broadest resolution level, fluvial geomorphologists recognize fast water (riffles, runs, etc.) and slow water (pools) as the two primary stream habitat unit types. These units are an important core attribute because they are the base stratification of habitats that support aquatic life.

Forest management can alter the character of fast and slow water habitat units by changing the amount of sediment, water, and LWD contributed to streams. Excessive sediment can smooth channel gradient by filling pools. Removal or reduction in woody debris reduces sediment storage and eliminates local hydraulic variability that influences habitat unit development. Habitat types change throughout streams based on gradient and valley form. Over time these changes are based on stream flow or changes in hydrologic character.

Pools

Pools are an important component of habitat for aquatic organisms. They are important for different reasons to different aquatic species and may provide deep water and cool summer temperatures, winter refuge, and areas for rearing of fish and amphibians. They are also important components and indicators of channel morphology. Residual pool depth is measured to characterize pools in the survey segment because it reduces variability in pool depths that result from differences in stage.

Pool Tail Surface Fine Sediment

Watershed and streambank disturbance often result in increased sediment input to streams. Increased fine particles in the stream substrate can impair aquatic food production and decrease survival of young salmonids. Salmonid mortality is increased when water interchange between streams and redds is reduced by fine sediment and by filling interstitial spaces resulting in barriers to movement of alevins. Particles of 2 mm or less are the principal barriers, although particles up to 8mm have resulted in increased mortality.

Streambank Stability

Channel stability is a key indicator of channel condition. Stable streambanks are essential for achieving desired stream channel morphology. Stable banks maintain or help restore low width-depth ratio which in turn helps maintain a high water table, vegetative productivity and favorable habitat for aquatic and riparian dependent wildlife. In many low gradient channels, unstable banks are a major erosion source.

Stream Shading

Stream temperature has impacts on the health, behavior, and survival of aquatic organisms and is strongly influenced by streamside shading. Streamside vegetation is a primary source of energy to most streams. Manipulation of riparian vegetation that affects shade to aquatic systems is a key Forest Service management concern.

Stream Shore Water Depth

This attribute is an important indicator of channel morphology in low gradient streams (<2%) with fine textured banks. Streamshore water depth is closely related to other indicators of channel conditions (bank angle and undercut bank) of channel conditions that provide cover and resting areas for aquatic species. Platts, et al. (1987) note that streamshore depth is critical for young-of-the-year salmonids.

Streambank Angle

Bank angle is an important factor in aquatic habitat on many stream reaches. It influences shading, vegetation potential, bank stability, etc. Streambanks that are vertical or undercut provide more habitat value than banks sloping away from the streambed.

Undercut banks provide excellent cover for fish, and are recognized as a component of healthy streams.

Aquatic Fauna
Surveys such as SCI are sometimes the only record of the presence of aquatic species. With the increasing number of species of concern (TES species, mollusks, etc.) and increasing occurrences of exotic species (zebra mussel, mud snails, bullfrogs, etc.), having surveyors look for aquatic species and noting their presence is important in understanding frequency and distribution patterns.

This attribute is intended to identify the basic aquatic biota present in the stream, and may identify the need for more intensive biological surveys. Communication with other agencies is important in order to make surveyors aware of any key species that may be present, as well as make appropriate identification keys available.

V*w
Pools are important habitat components for fishes and other aquatic organisms. Accelerated inputs of fine sediment are known to affect pools by reducing their volume, particularly during periods of low discharge. V* is a measure of the relative volume of fine sediment in a pool. The weighted mean value of V* for a reach, V*W, is a sensitive indicator of a channel's response to the volume of fine sediment delivered from its watershed.

SCI RESULTS

The Stream Condition Inventory (SCI) component of the WRI took place between July 10, 2007 and August 2, 2007. U.S. Forest Service technicians facilitated four days of training and data collection for various attribute data for Sensative Reaches 1, 2 and 6—Figures 5-2, 5-3, and 5-4, respectively. Members of the WRTC staff finished data collection for Reaches 2 and 6 and collected additional data on Reach 1 in subsequent weeks. Figure 5-1 shows the location and distribution of the sensitive reaches surveyed along Big Creek.

Big Creek Reach 1
Shasta-Trinity National Forest
Surveyors: Ben Letton, Ryen Rourke
Date of survey: August 1, 2007

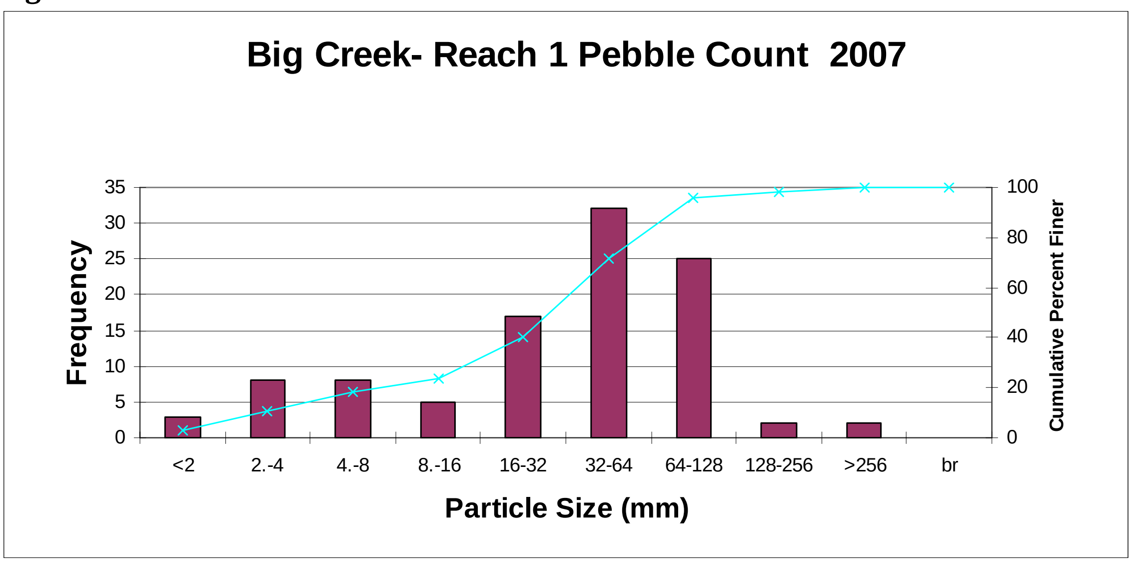
Big Creek is a tributary to Hayfork Creek, which flows into the South Fork Trinity River. Big Creek was surveyed on . Big Creek can be reached by taking Highway 3 south towards Hayfork. Reach 1 begins at the Highway 3 where it crosses Big Creek (10T 0487829 4489139) and extends 6295 feet to the confluence of a prominent tributary (10T 0487263 4490772) that drains the western portion of Big Creek ranch. The monitoring protocol used is found in Stream Condition Inventory Version 5.0, 2005. Exceptions to this were shade measurements, which were measured with a spherical densiometer. A LaMott limnology kit was used to provide base line water quality. All measurements were made in tenths of feet, unless noted otherwise. All references to direction (stream bank) are facing downstream. All length measurements are in reference from the beginning of the reach, which starts downstream and travels upstream (i.e. cross section 3 is 750 feet from the beginning of reach).

Pebble Counts

A Stream Condition Inventory pebble count was conducted in the middle of the reach, and in a area that best characterizes the whole surveyed reach. Particle sizes were recorded for four riffles along 10 transects perpendicular to flow. A more detailed account of the specific methods used to collect the data is outlined on pages 16-17 of the *Stream Condition Inventory (SCI), Technical Guide, Pacific Southwest Region, Version 5.0.*

Figure 5-5 illustrates the results of the modified Wolman pebble count performed on Big Creek. Udden-Wentworth size classes are presented for comparison by frequency of occurrence and percent accumulation.

Figure 5-5



Large Woody Debris

There were 18 total pieces of large woody debris (LWD) counted in the reach. This equates to 15 pieces of LWD/ mile. LWD was classified by length and diameter in feet. LWD is wood that is ½ average bank full width or longer.

Cross Sections

Three permanent cross sections were placed within the sensitive reach. Mean gradient for these three cross sections was 1 %.

Figures 5-6 and 5-7 are the three permanent cross sections placed in Big Creek. Stakes were placed on both banks, at equal height, above the flood plain. Readings were taken from left bank, looking downstream, to right bank at appropriate intervals to characterize the stream. Waters edge (red) and bank full (green) are noted.

Figure 5-6.

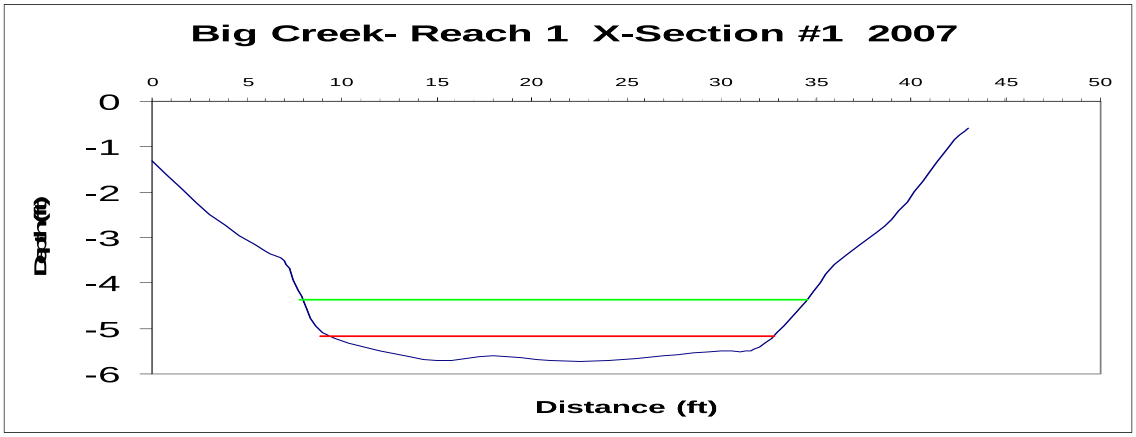
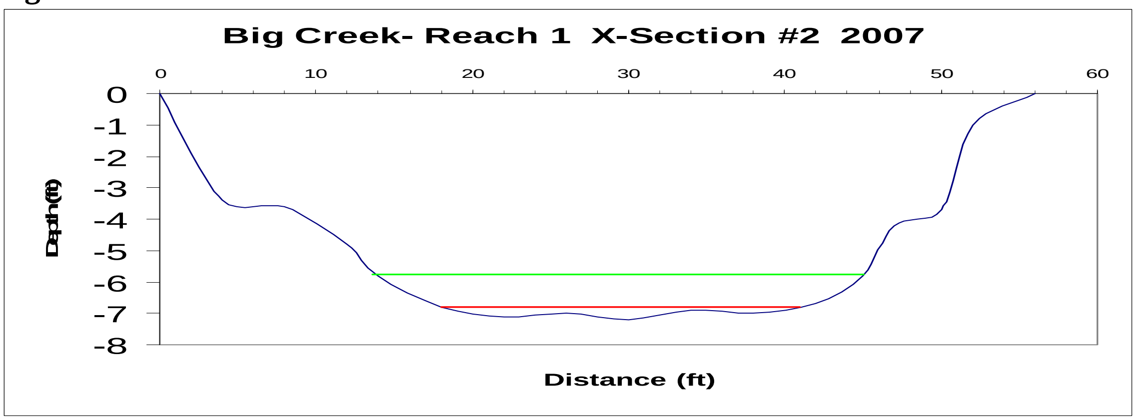


Figure 5-7.



The watershed crew did 3 W/D's instead of 3 X-sections.

Width-to-depth Ratios

These width-to-depth measurements are from our cross section measurements and two separate (non-permanent) width-to-depth measurements. Mean width-to-depth ratio for stream survey was 28.1. Mean entrenchment ratio was 1.2. Mean bank full and flood plain widths were 30.3 ft and 37.0 ft.

Figures 5-8 through 5-12 show the five width-to-depth measurements taken on Big Creek. Depth measurements were made from left bank, looking down stream, to right bank at appropriate intervals to characterize the stream. Water level is marked in red.

Figure 5-8.

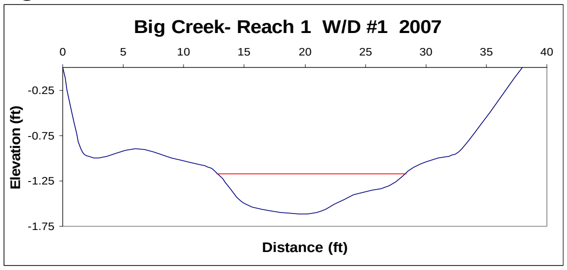


Figure 5-9.

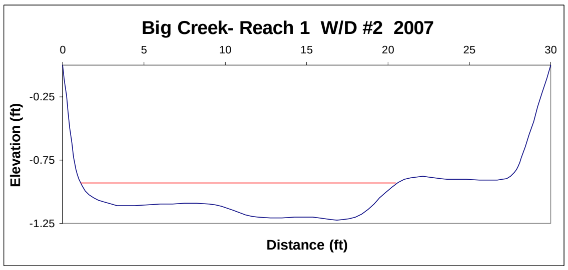


Figure 5-10.

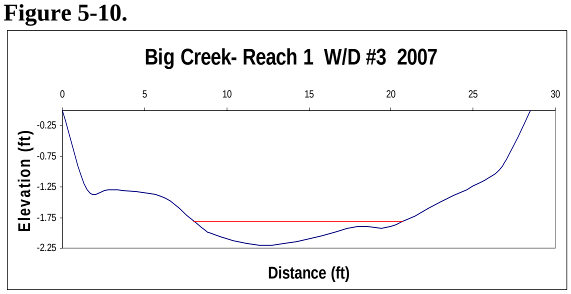


Figure 5-11.

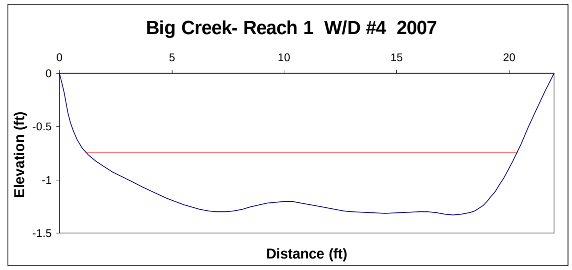
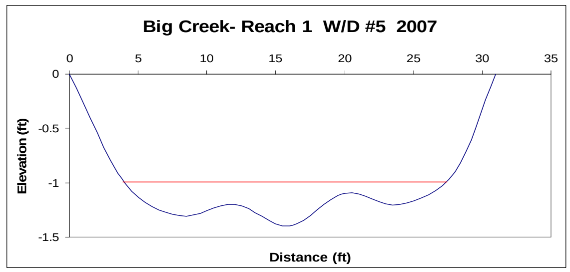


Figure 5-12.



Pools/ Riffles
Pools made up 3203 ft. of the measured length of the reach, and riffles accounted for 3092 ft. of the measured length of the reach. Mean residual maximum pool depth was 2.3 ft. Mean residual pool tail crest was 0.40 ft. Pool Tail Fines were measured three times at the tail end of every pool, average fines recorded was 29%.

Stream Bank Stability
Stream bank stability measurements were made from the streambed to the stream bank, along both banks, at 50 points along the reach.
Table 1 shows the total percentages of stream bank stability for each category.

Table 5-1.

	1 (stable)	2 (vulnerable)	3 (unstable)
% Stability rating	47	36	17

Stream Shade
Shade measurements were taken at 50 locations within the survey segment. Mean shade was 73 %.

Bank Angle
Bank angle measurements were made along both banks at 50 points along the Reach 1. The mean bank angle was 142 degrees.

Aquatic Fauna
Rainbow trout *Oncorhynchus mykiss* were observed throughout the reach.

Water condition Monitoring
Water chemistry was not performed on Big Creek. Water temperature was not recorded.

Table 5-2

Big Creek Reach 1- 2007 SCI Summary

Sensitive Reach Statistics.			
		feet	meters
Channel Type	F4		
Mean gradient	1%		
Reach length		6295	1918.7
Mean bankfull width		30.3	9.2
POOLS			
# of pools	45		
Total pool length		3203	976.3
Mean pool length		71.2	21.7
Mean residual pool max. depth		2.3	0.7
Mean residual pool tail crest		0.4	0.1
Pools per mile	37.7		

Avg. % pool tail fines	29.0		
FASTWATER			
# of fastwater habitats	45		
Total fastwater length		3092	942.4
Mean fastwater length		68.7	20.9
WOOD			
Total pieces LWD	18		
Minimum debris length	15 ft.		
LWD per mile	15		
Total single pieces	11		
Total aggregate pieces	7		
Total aggregates	1		
PEBBLES			
% sands	3		
% gravel	84		
% cobble	13		
% boulders	4		
% bedrock	0		
% embedded	n/a		
WIDTH TO DEPTH			
Mean width to depth for survey	28.1		
Mean entrenchment for survey	1.2		
GPS			
Start of survey	10T 0487829 4489139		
End of survey	10T 0487263 4490772		
Cross section #1	10T 0487763 4489220		
Cross section #2	10T 0487430 4490195		
Cross section #3	n/a		
OTHER			
Mean canopy cover/shade	73.02		
Mean bank stability	1.7		
Mean bank angle	142.09		
Wilderness	no		
Aquatic fauna present			

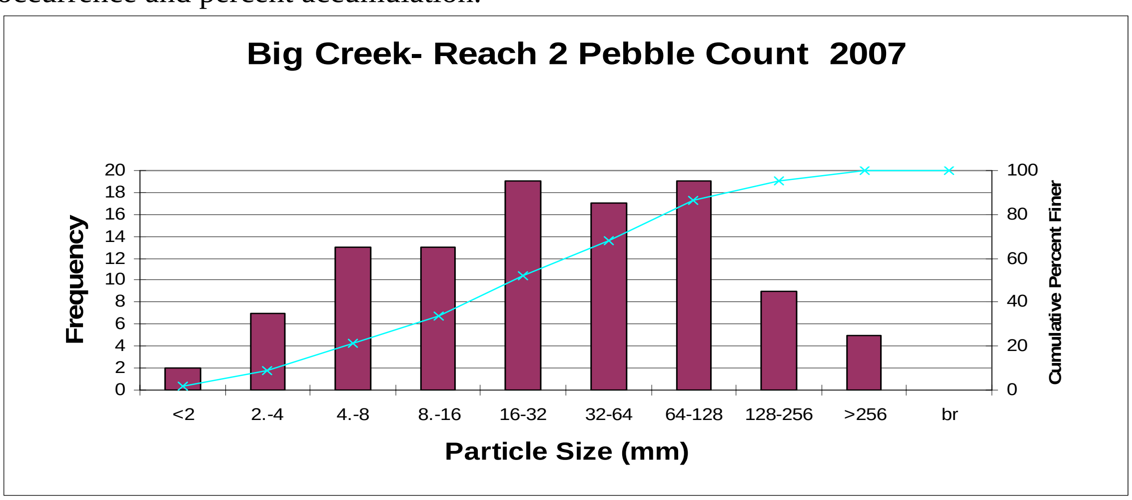
* Bank stability rating: 1 stable with vegetation >75%,
2 unstable with vegetation >75%, 3 unstable and vegetation <75%.

Big Creek- Reach 2- 2007 S.C.I.
Shasta-Trinity National Forest
Surveyors: Ben Letton, Ryen Rourke
Date of survey: July 10, 2007

Big Creek is a tributary to Hayfork Creek, which flows into the South Fork Trinity River. Reach 2 of Big Creek was surveyed on 7/9 and 7/10/2007. The survey section was 3360 feet long. Big Creek can be reached by taking Highway 3 south towards Hayfork. Take Big Creek Road, which is 1 mile east of Hayfork, past the Big Creek Ranch. The start of Reach 2 is located approximately 1 mile past the private property boundary. At this point, a dirt road drops off to the west side of Big Creek Road. Drop down into Big Creek at the southernmost end of the dirt road. Walk approximately 150 feet downstream to flagged pool head. The end of the reach is 3360 feet upstream from this point at the upstream end of the Big Creek Road bridge. The monitoring protocol used is found in Stream Condition Inventory Version 5.0, 2005. Exceptions to this were shade measurements, which were measured with a spherical densiometer. A LaMott limnology kit was used to provide base line water quality. All measurements were made in tenths of feet, unless noted otherwise. All references to direction (stream bank) are facing downstream. All length measurements are in reference from the beginning of the reach, which starts downstream and travels upstream (i.e. cross section 3 is 2335 feet from the beginning of reach).

Pebble Counts
A Stream Condition Inventory pebble count was conducted in the middle of the reach, and in a area that best characterizes the whole surveyed reach. Particle sizes were recorded for four riffles along 10 transects perpendicular to flow. A more detailed account of the specific methods used to collect the data is outlined on pages 16-17 of the *Stream Condition Inventory (SCI), Technical Guide, Pacific Southwest Region, Version 5.0.*

Figure 5-13 illustrates the results of the modified Wolman pebble count performed on Big Creek. Udden-Wentworth size classes are presented for comparison by frequency of occurrence and percent accumulation.



Large Woody Debris
There were 9 total pieces of large woody debris (LWD) counted in the reach. This equates to 14 pieces of LWD/ mile. LWD was classified by length and diameter in feet. LWD is wood that is ½ average bank full width or longer.

Cross Sections
Three permanent cross sections were placed within the sensitive reach. Mean gradient for these three cross sections was 1.7%.
Figures 5-14 through 5-16 are the three permanent cross sections placed in Big Creek. Stakes were placed on both banks, at equal height, above the flood plain. Readings were taken from left bank, looking downstream, to right bank at appropriate intervals to characterize the stream. Waters edge (red) and bank full (green) are noted.

Figure 5-14.

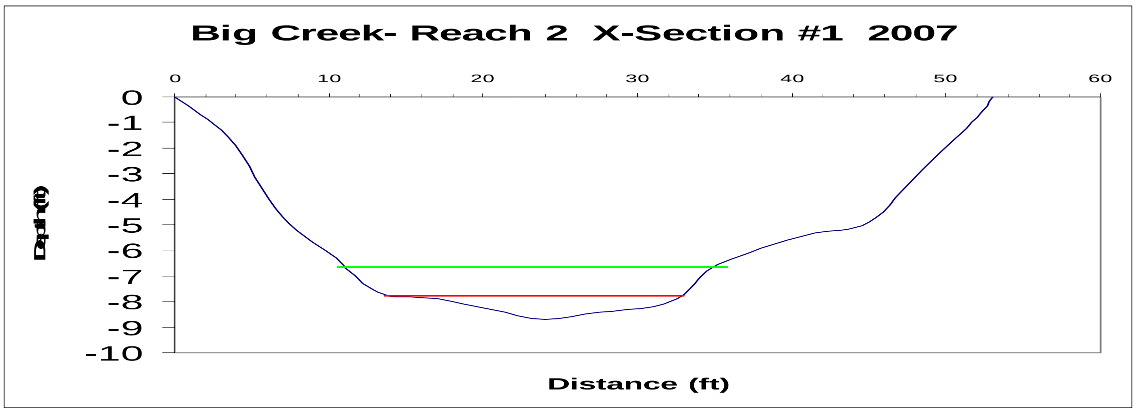


Figure 5-15.

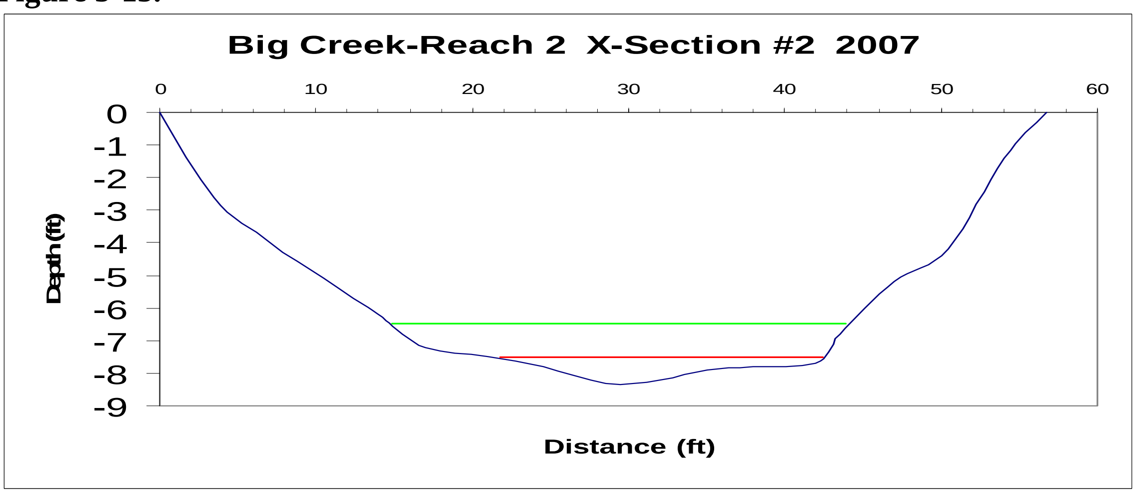
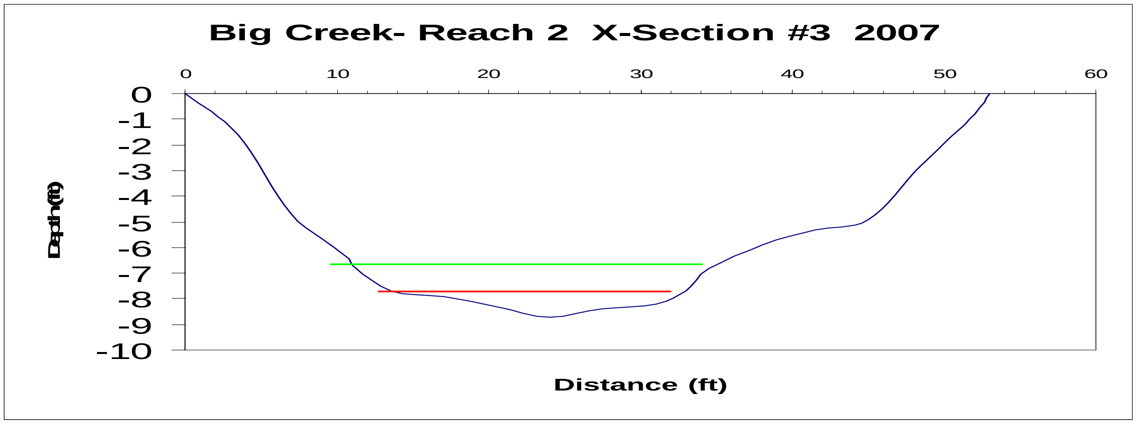


Figure 5-16.



Width-to-depth Ratios

These width-to-depth measurements are from our cross section measurements and two separate (non-permanent) width-to-depth measurements. Mean width-to-depth ratio for stream survey was 25.2. Mean entrenchment ratio was 1.4. Mean bank full and flood plain widths were 27 ft and 38.9 ft., respectively.

Figures 5-17 through 5-21 show the five width-to-depth measurements taken on Big Creek. Depth measurements were made from left bank, looking down stream, to right bank at appropriate intervals to characterize the stream. Water level is marked in red.

Figure 5-17.

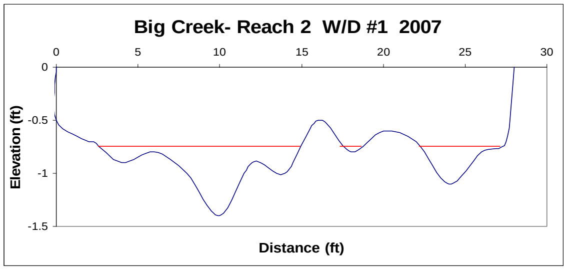


Figure 5-20

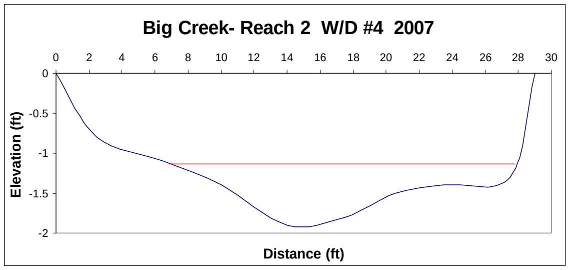


Figure 5-18

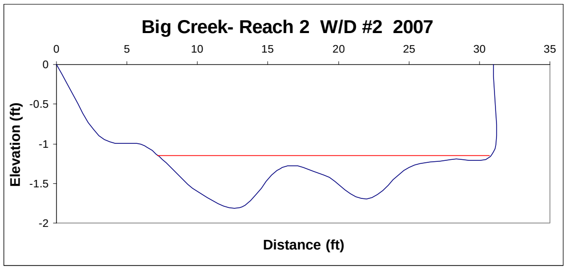


Figure 5-21

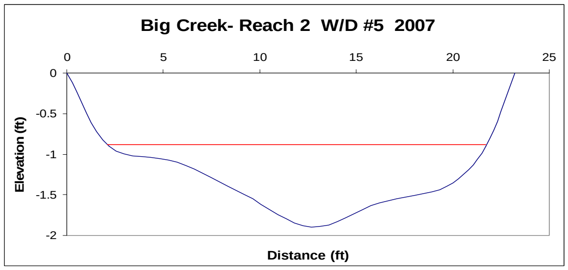
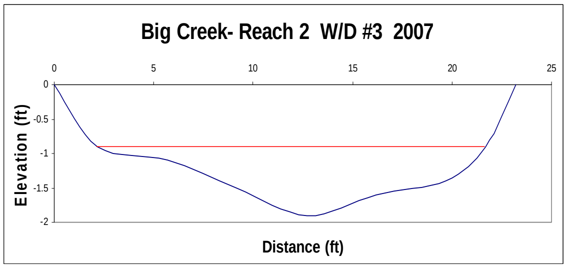


Figure 5-19



Pools/ Riffles
Pools made up 864 feet of the measured length of the reach, and riffles accounted for 2496 feet of the measured length of the reach. Mean residual maximum pool depth was 1.8 ft. Mean residual pool tail crest was 0.7 ft. Pool Tail Fines were measured three times at the tail end of every pool, average fines recorded was 3%.

Stream Bank Stability
Stream bank stability measurements were made from the streambed to the stream bank, along both banks, at 50 points along the reach.
Table 2 shows the total percentages of stream bank stability for each category.

Table 5-3

	1 (stable)	2 (vulnerable)	3 (unstable)
% Stability rating	62	35	3

Stream Shade
Shade measurements were taken at 50 locations within the survey segment. Mean shade was 89.5 %.

Bank Angle
Bank angles were not recorded.

Aquatic Fauna
Rainbow trout *Oncorhynchus mykiss* were observed throughout the reach. Pacific giant salamanders *Dicamptodon tenebrosus* and Yellow-legged frogs *Rana boylii* were also observed.

Macroinvertebrates
Using a kicknet, we identified mayflies, stoneflies, caddisflies, Diptera spp., water beetle larvae, water pennies, a Hellgramite, and gilled snails. Reach 2 of Big Creek scored a 21 (17-22 is Good) on the macroinvertebrate index.

Water condition Monitoring
Table 2 displays the water chemistry data. Water temperature was not recorded.

Table 5-4.

N03(ppm)	P03(ppm)	D0(ppm)	C02(ppm)	Si(ppm)	pH	Ca(ppm)	Mg(ppm)	total
< 0.2	< 0.2	9	7	N/A	8	84	40	124

Table 5-5.

Big Creek Reach 2- 2007 SCI Summary

Sensitive Reach Statistics.			
		feet	meters
Channel Type	B4		
Mean gradient	1.7		
Reach length		3360	1024.1
Mean bankfull width		27	8.2
POOLS			
# of pools	20		
Total pool length		864	263.3
Mean pool length		43.2	13.16736
Mean residual pool max. depth		1.8	0.6
Mean residual pool tail crest		0.7	0.2
Pools per mile	31.4		
Avg. % pool tail fines	3.0		
FASTWATER			
# of fastwater habitats	20		
Total fastwater length		2496	760.8
Mean fastwater length		124.8	38.0
WOOD			
Total pieces LWD	9		
Minimum debris length	13.5 ft.		
LWD per mile	14		
Total single pieces	9		
Total aggregate pieces	0		
Total aggregates	0		
PEBBLES			
% sands	2		
% gravel	69		
% cobble	28		
% boulders	4		
% bedrock	1		
% embedded	-		
WIDTH TO DEPTH			
Mean width to depth for survey	25.2		
Mean entrenchment for survey	1.4		
GPS			
Start of survey	10T 0486819 4495042		
End of survey	10T 0486493 4495926		
Cross section #1	10T 0486741 4495269		
Cross section #2	10T 0486692 4495404		
Cross section #3	10T 0486543 4495686		
OTHER			

Mean canopy cover/shade	89.48		
Mean bank stability	1.41		
Mean bank angle	0		
Wilderness	no		
Aquatic fauna present			

* Bank stability rating: 1 stable with vegetation >75%,
2 unstable with vegetation >75%, 3 unstable and vegetation <75%.

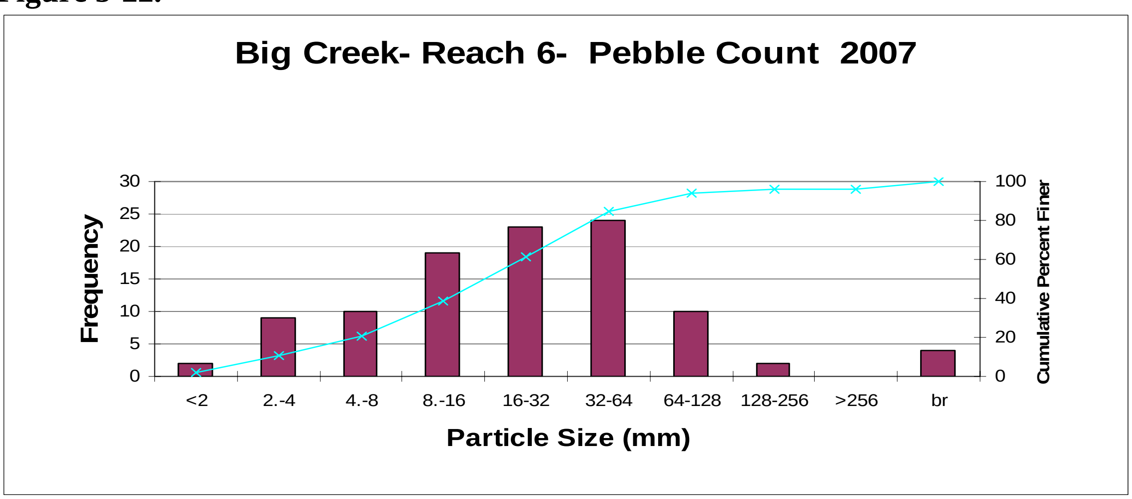
Big Creek- Reach 6- 2007 S.C.I. Report
Shasta-Trinity National Forest
Surveyors: Ben Letton, Ryen Rourke
Date of survey: July 14, 2007

Big Creek is a tributary to Hayfork Creek, which flows into the South Fork Trinity River. Reach 2 of Big Creek was surveyed on 7/10 and 7/11/2007. The survey section was 4777 feet long. Big Creek can be reached by taking Highway 3 south towards Hayfork. Take Big Creek Road, which is 1 mile east of Hayfork, past the Big Creek Ranch. Proceed to the 34N47 Rd. and continue until you cross the bridge over Limestone Creek. Park at the campground that is immediately north of the bridge. Walk down the trail to Big Creek, and then 100 feet downstream to the Big Creek/ Limestone Creek confluence. The start of the reach is the confluence. The monitoring protocol used is found in Stream Condition Inventory Version 5.0, 2005. Exceptions to this were shade measurements, which were measured with a spherical densiometer. A LaMott limnology kit was used to provide base line water quality. All measurements were made in tenths of feet, unless noted otherwise. All references to direction (stream bank) are facing downstream. All length measurements are in reference from the beginning of the reach, which starts downstream and travels upstream (i.e. cross section 3 is 4350 feet from the beginning of reach).

Pebble Counts
A Stream Condition Inventory pebble count was conducted in the middle of the reach, and in a area that best characterizes the whole surveyed reach. Particle sizes were recorded for four riffles along 10 transects perpendicular to flow. A more detailed account of the specific methods used to collect the data is outlined on pages 16-17 of the *Stream Condition Inventory (SCI), Technical Guide, Pacific Southwest Region, Version 5.0.*

Figure 5-22 illustrates the results of the modified Wolman pebble count performed on Big Creek. Udden-Wentworth size classes are presented for comparison by frequency of occurrence and percent accumulation.

Figure 5-22.



Large Woody Debris
There were 69 total pieces of large woody debris (LWD) counted in the reach. This equates to 76 pieces of LWD/ mile. LWD was classified by length and diameter in feet. LWD is wood that is ½ average bank full width or longer.

Cross Sections
Three permanent cross sections were placed within the sensitive reach. Mean gradient for these three cross sections was 2.7%.
Figures 2-4 are the three permanent cross sections placed in Big Creek. Stakes were placed on both banks, at equal height, above the flood plain. Readings were taken from left bank, looking downstream, to right bank at appropriate intervals to characterize the stream. Waters edge (red) and bank full (green) are noted.

Figure 5-23.

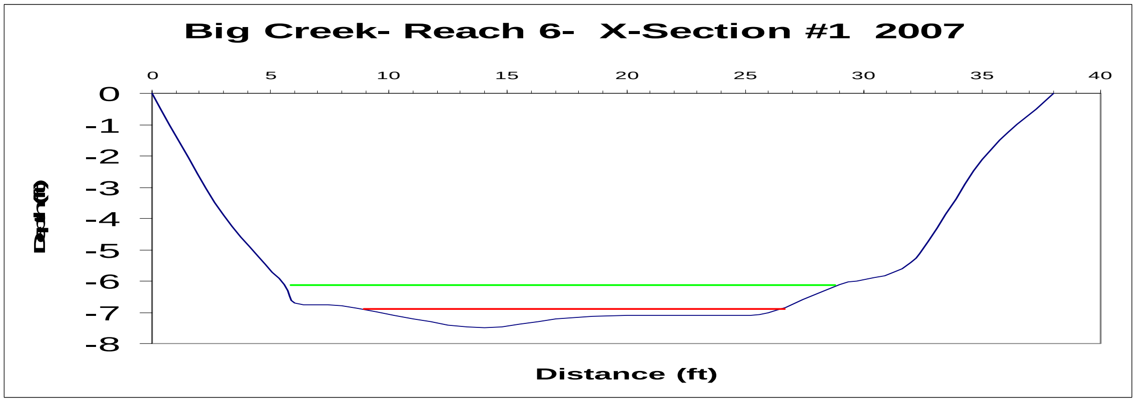


Figure 5-24.

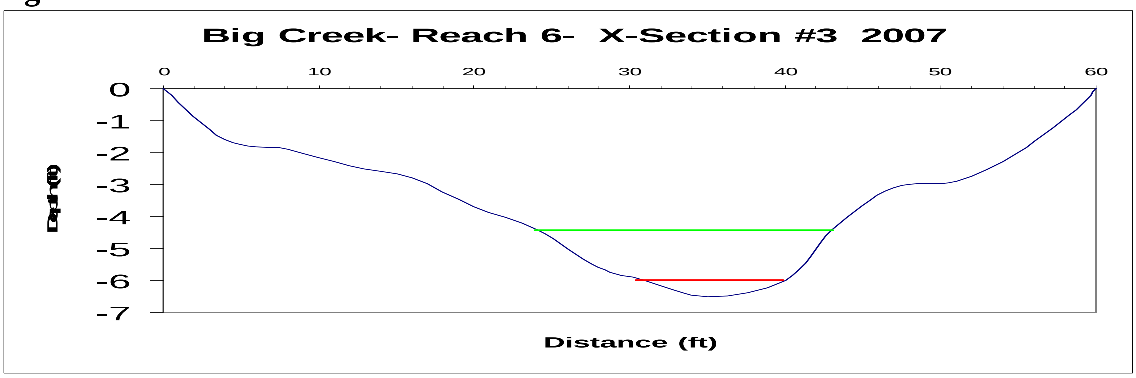
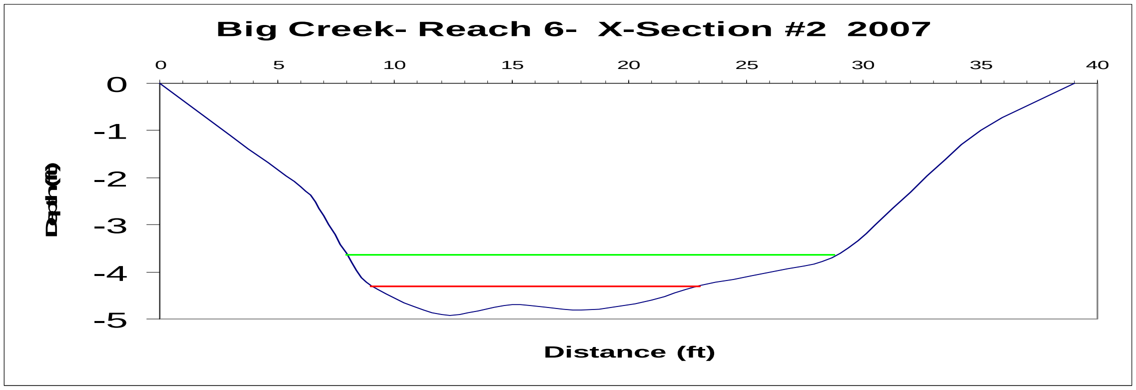


Figure 5-25.



Width-to-depth Ratios

These width-to-depth measurements are from our cross section measurements and two separate (non-permanent) width-to-depth measurements. Mean width-to-depth ratio for stream survey was 21.2. Mean entrenchment ratio was 1.4. Mean bank full and flood plain widths were 19.9 ft and 27.1 ft., respectively.

Figures 5-26 through 5-30 show the five width-to-depth measurements taken on Big Creek. Depth measurements were made from left bank, looking down stream, to right bank at appropriate intervals to characterize the stream. Water level is marked in red.

Figure 5-26.

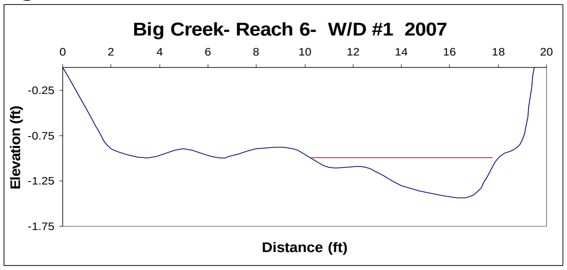


Figure 5-29

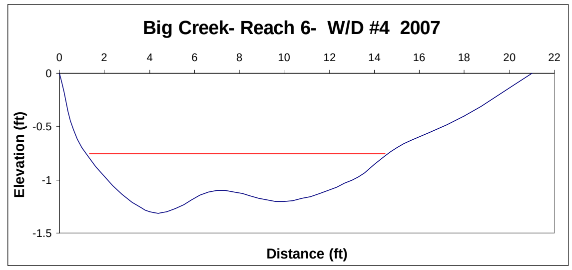


Figure 5-27.

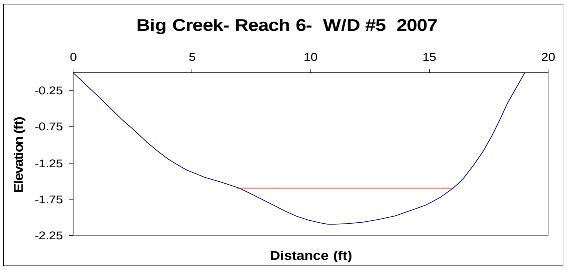


Figure 5-30

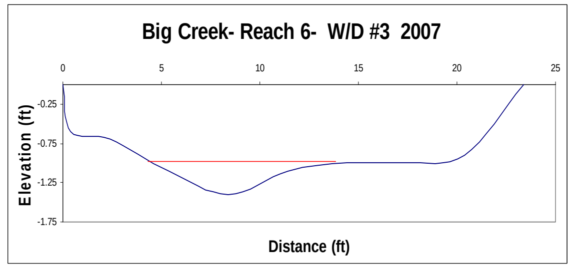
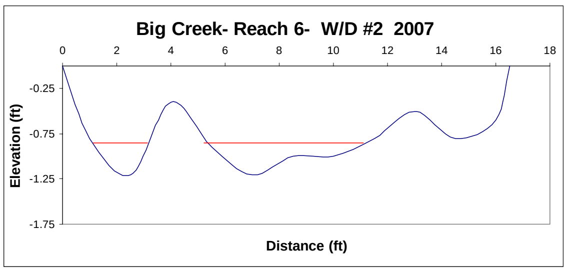


Figure 5-28.



Pools/ Riffles
Pools made up 1878 ft of the measured length of the reach, and riffles accounted for 2909 feet of the measured length of the reach. Mean residual maximum pool depth was 1.6 ft. Mean residual pool tail crest was 0.5 ft. Pool Tail Fines were measured three times at the tail end of every pool, average fines recorded was 6.5%.

Stream Bank Stability
Stream bank stability measurements were made from the streambed to the stream bank, along both banks, at 50 points along the reach.
Table 2 shows the total percentages of stream bank stability for each category.

Table 5-6

	1 (stable)	2 (vulnerable)	3 (unstable)
% Stability rating	67	29	4

Stream Shade
Shade measurements were taken at 50 locations within the survey segment. Mean shade was 92.4 %.

Bank Angle
Bank angles were not recorded due to stream gradient exceeding 2%.

Aquatic Fauna
Rainbow trout *Oncorhynchus mykiss* were observed throughout the reach. Pacific giant salamanders *Dicamptodon tenebrosus* and crawfish were also observed.

Macroinvertebrates
Using a kicknet, we identified mayflies, caddisflies, stoneflies, water beetle larvae, Diptera spp., water pennies, adult water beetles, and gilled snails. Reach 6 of Big Creek scores a 21 (17-22 is Good) on the macroinvertebrate index.

Water condition Monitoring
Table 1 displays the water chemistry. Water temperature was not recorded.

Table 5-7

N03(ppm)	P03(ppm)	D0(ppm)	C02(ppm)	Si(ppm)	pH	Ca(ppm)	Mg(ppm)	total
< 0.2	< 0.2	9	7	N/A	8	88	32	120

Table 5-8.

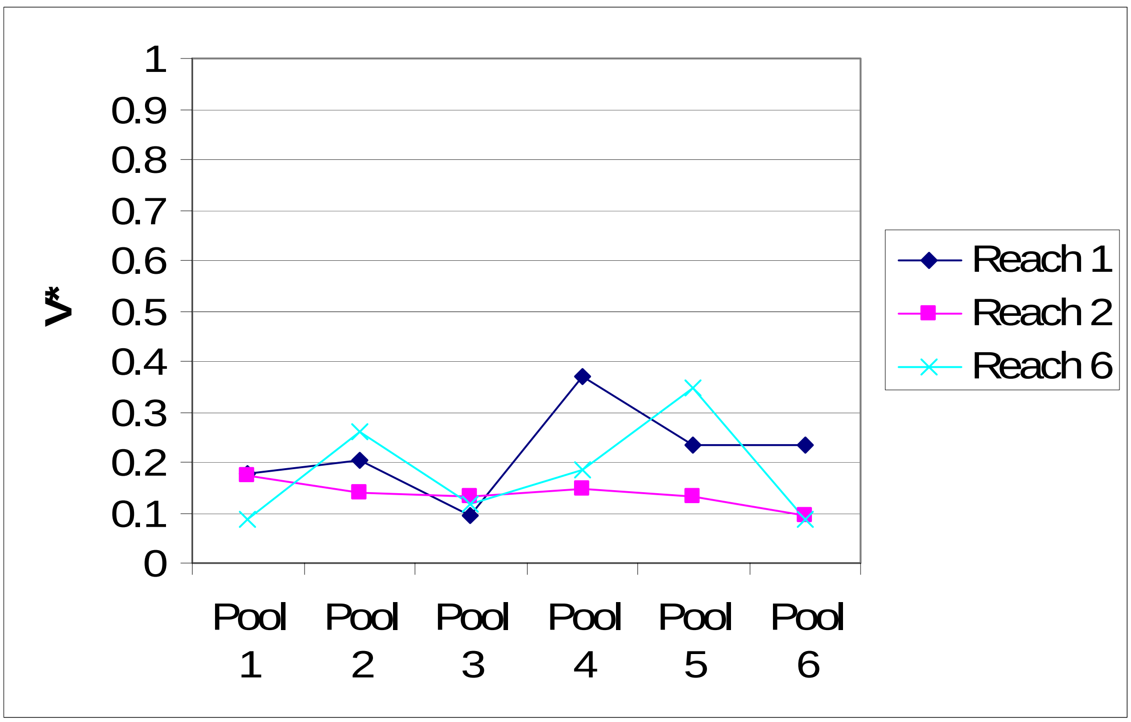
Big Creek Reach 6- 2007 SCI Summary

Sensitive Reach Statistics.			
		feet	meters
Channel Type	B4		
Mean gradient	2.7		
Reach length		4787	1459.1
Mean bankfull width		19.9	6.1
POOLS			
# of pools	61		
Total pool length		1878	572.4
Mean pool length		30.8	9.4
Mean residual pool max. depth		1.6	0.5
Mean residual pool tail crest		0.5	0.2
Pools per mile	67.3		
Avg. % pool tail fines	6.5		
FASTWATER			
# of fastwater habitats	61		
Total fastwater length		2909	886.7
Mean fastwater length		47.7	14.5
WOOD			
Total pieces LWD	69		
Minimum debris length	10 ft.		
LWD per mile	76		
Total single pieces	43		
Total aggregate pieces	26		
Total aggregates	5		
PEBBLES			
% sands	3		
% gravel	76		
% cobble	13		
% boulders	0		
% bedrock	5		
% embedded			
WIDTH TO DEPTH			
Mean width to depth for survey	21.2		
Mean entrenchment for survey	1.4		
GPS			
Start of survey	10T 0487492 4501667		
End of survey	10T 0488398 4502681		
Cross section #1	10T 0487882 4502105		
Cross section #2	10T 0488190		

	4502476		
Cross section #3	10T 0488281 4502653		
OTHER			
Mean canopy cover/shade	92.44		
Mean bank stability	1.37		
Mean bank angle	0		
Wilderness	no		
Aquatic fauna present			

* Bank stability rating: 1 stable with vegetation >75%,
2 unstable with vegetation >75%, 3 unstable and vegetation <75%.

Figure 5-31. Summary of V* calculations for Reaches 1, 2 and 6.



CONCLUSIONS

The primary intention of this SCI was to collect intensive and repeatable data from three unique stream reaches along Big Creek to document existing stream conditions. With the results gathered during this inventory, land managers will be able to make reliable comparisons over time within or between stream reaches. These comparisons will enable land managers and citizens to assess the effectiveness of future restoration projects in managed portions of Big Creek, as well as to document stream conditions over time in portions of Big Creek with little or no past or future management.

Matrix of Factors and Indicators for Shasta-Trinity National Forest

The criteria used to determine whether baseline conditions are contributing to a properly functioning 4th order, anadromous stream were developed by Level 1 representatives

Allen Taylor, Fisheries Biologist (NMFS); and Loren Everest, Fisheries Biologist (USFS).

Physical Barriers

Reach 1 contained two physical barriers during 2007 low flow inventory. Barriers consist of small black plastic/rock dams to divert water into an irrigation canal and to create greater pool depth for livestock watering. These dams appear to be removed during higher flow. During low flows these dams will restrict the movement of juvenile fish from one refugia location to another. Additionally, no fish screens were observed covering diversion culvert at the diversion site. To ensure that fish passage is improved and the risk of fish diversion is minimized, appropriate structures such as a small fish ladder or side channel and a fish screen should be installed at these sites. (Functioning at Risk).

Reach 2 is above the diversion dam and contains no physical barriers that would not allow fish passage (Properly Functioning).

Reach 6 contains no physical barriers that would not allow fish passage (Properly Functioning).

LWD

Reach 1: There were 18 pieces of LWD in 6295 ft. (15 pieces/mile). Although all of these pieces had 16 inch dbh's, none of them had lengths greater than 50 ft. LWD is not properly functioning in this reach of Big Creek.

Reach 2: There were 9 pieces of LWD in 3360 ft. (14 pieces/mile). However, none of these pieces had lengths greater than 50 ft. **LWD recruitment is not properly functioning**.

Reach 6: There were 69 pieces of LWD in 4787 feet. (76 pieces/mile). However, less than 5 of these pieces had lengths greater than 50 feet. LWD is not properly functioning.

Pool Frequency

Reach 1: 45 pools in 6295 ft.=38 pools/mile. Frequency is 1 pool every 139.9 ft. (1 pool every 4.6 bankfull widths). A properly functioning stream would have at least one pool every 3-7 bankfull widths. Only 11 out of the 45 pools had depths greater than 36 inches. Half of the pools in a properly functioning stream would have maximum depths of 36 inches or more. Pool frequency is properly functioning, but the maximum depth component is not.

Reach 2: 20 pools in 3360 ft.=31 pools/mile. Frequency is 1 pool every 168 ft. (1 pool every 6.2 bankfull widths). A properly functioning stream should have at least one pool every 3-7 bankfull widths. Only one of the pools had a maximum depth greater than 36 inches. The pool frequency is properly functioning, but the maximum depth component is not.

Reach 6: 61 pools in 4787 feet.=67 pools/mile. Frequency is 1 pool every 78 ft. (1 pool every 3.9 bankfull widths). A properly functioning stream would have at least one pool every 3-7 bankfull widths). None of the 61 pools had maximum depths of 36 inches. Pool frequency is properly functioning, but the maximum depth component is not.

Off-Channel Habitat
Reach 1: There was minimal backwater habitat (Functioning

Reach 2: There was minimal backwater habitat.

Reach 6: There was minimal backwater habitat.

Width-to-Depth Ratio
Reach 1: Mean W/D was 28.1, which indicates proper function. W/D ratios greater than 12 are characteristic of properly functioning B channels.

Reach 2: Mean W/D ratio was 25.2, which indicates proper function. W/D ratios greater than 12 are characteristic of properly functioning B channels.

Reach 6: Mean W/D ratio was 21.2, which indicates proper function. W/D ratios greater than 12 are characteristic of B channels.

Streambank Condition
Reach 1: Bank stability appears to be functioning at risk, with 47% stablility, 36% vulnerability, and only 17% instability.

Reach 2: Bank stability is functioning properly, with 62% stability, 35% vulnerability, and 3% instability.

Reach 6: Bank stability is functioning properly, with 67% stable, 29% vulnerable, and only 4% instability.

Floodplain Connectivity
Reach 1: There was limited floodplain connectivity.

Reach 2: There was limited floodplain connectivity

Reach 6: There was limited floodplain connectivity

Substrate Character
Reach 1: The mean percent pool tail fines was 29%, well above the limit of proper substrate function.

Reach 2: Mean percent pool tail fines was 3%, this level indicates a properly functioning system.

Reach 6: Mean percent pool tail fines was 6.5%, this indicates a properly functioning system.

V*

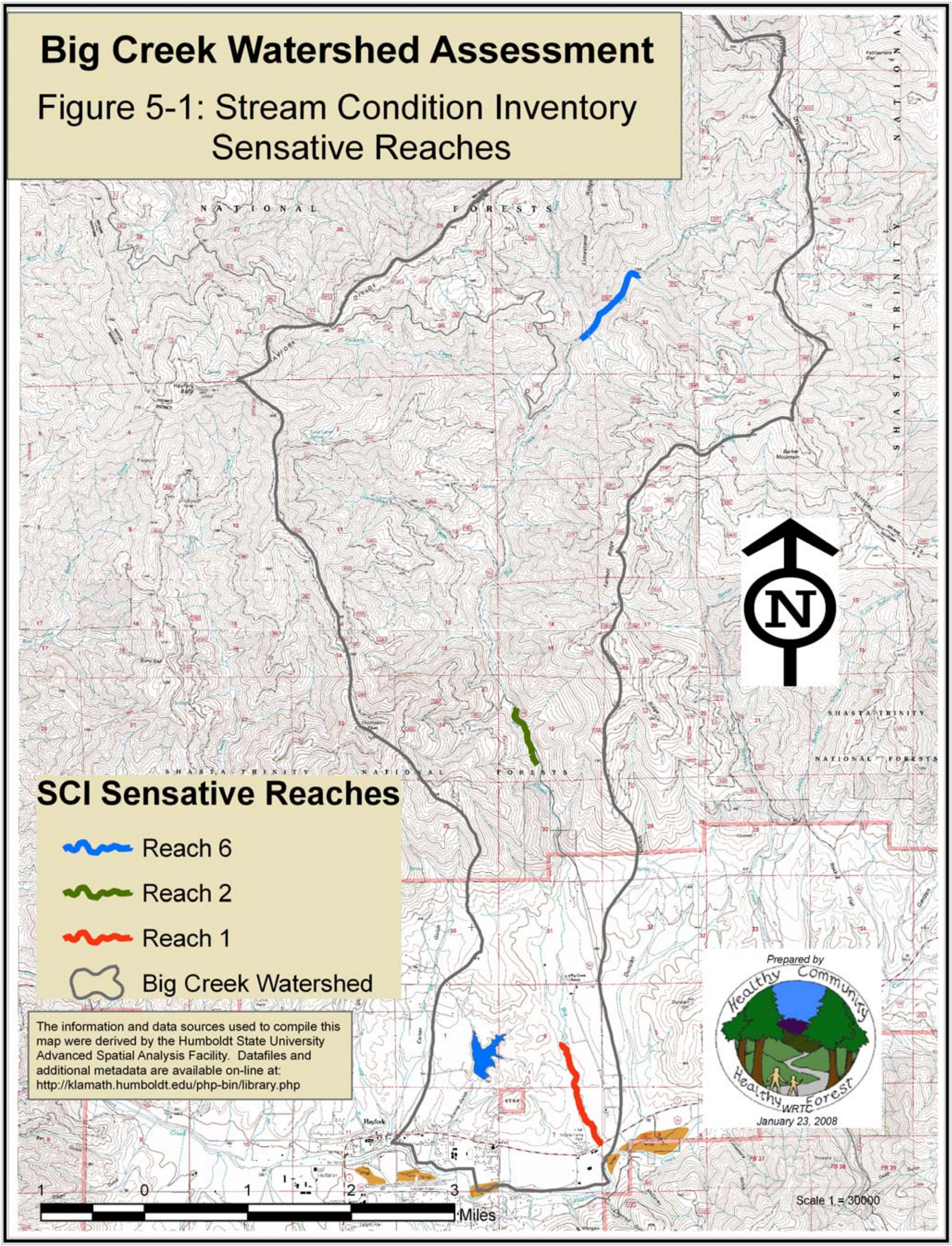
Reach 1: Variability of V* was high for this reach, suggesting that more samples need to be taken. Mean V* was equal to 0.22 for this reach. This value is within the range of V* measurements taken for the main stem Trinity River in 1991 (0.09-0.29), but are relatively high for a 4th order stream with stable upper watershed bedrock geology such as Big Creek. Pool tail fines level (29%) are very high for this reach, which validate mean V* (0.22). Further samples are recommended.

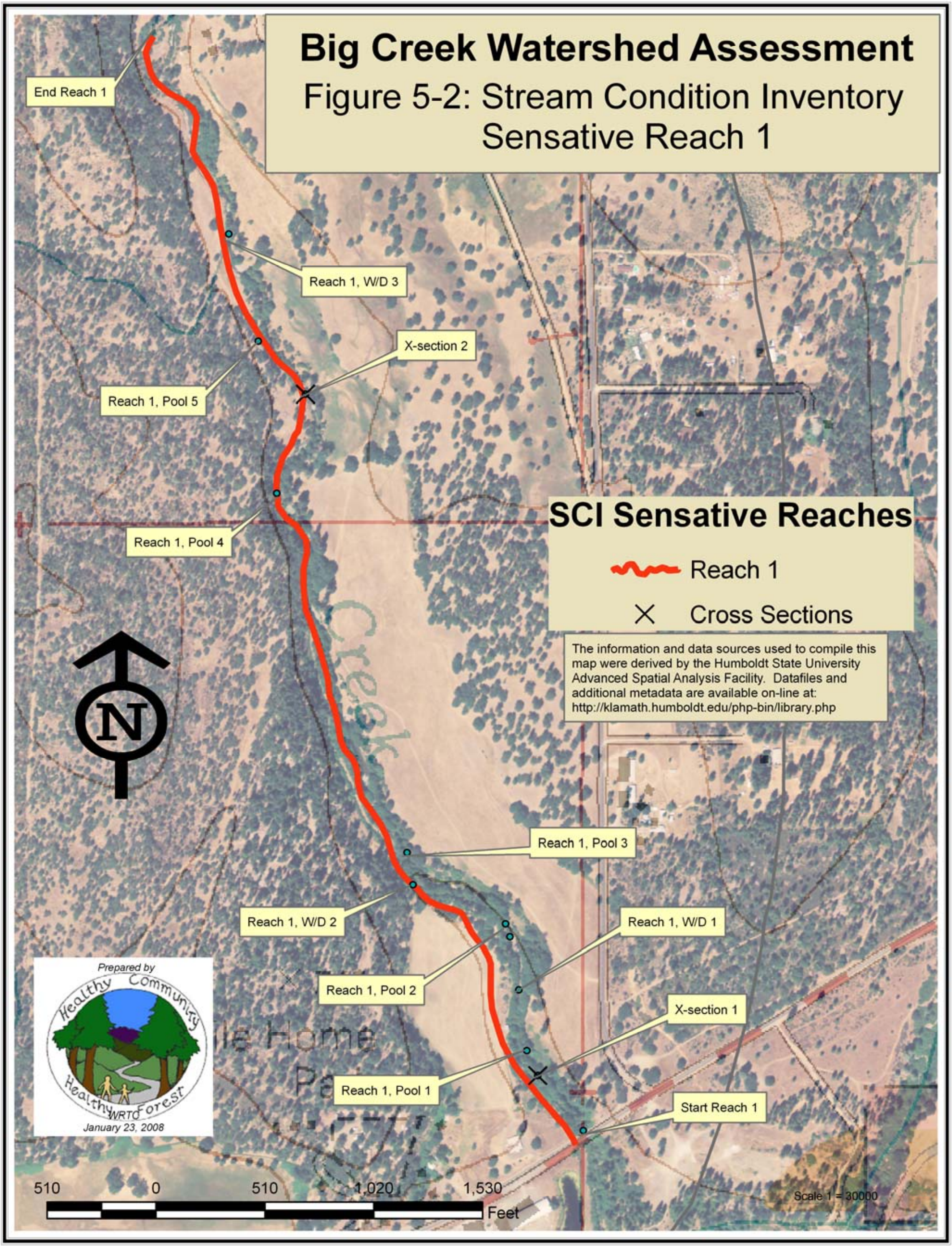
Reach 2: Variability of V* was low for this reach, suggesting a good sample. Mean V* equal to 0.13. This value is appropriate for the type of geologic setting of this portion of the stream. Pool tail fines level (3%) are low for this reach, which validate mean V* (0.13). More samples are recommended.

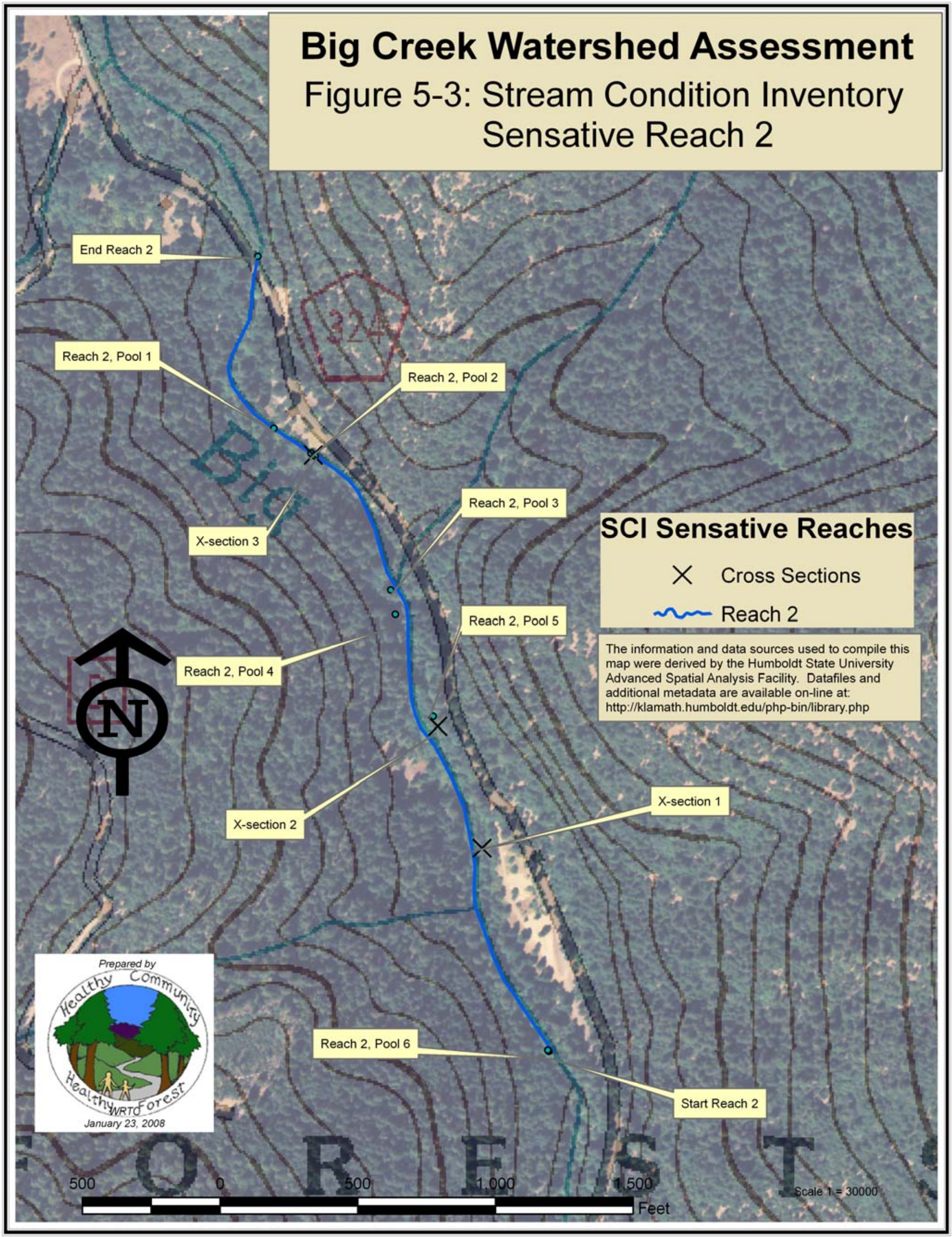
Reach 6: Variability of V* was high for this reach, suggesting more samples need to be taken. Mean V* equal to 0.18. This value is moderately high for this type of geologic setting for this portion of the stream. Pool tail fines level (6.5%) are low for this reach, which suggest that the mean V* value may be inaccurate. More samples are needed.

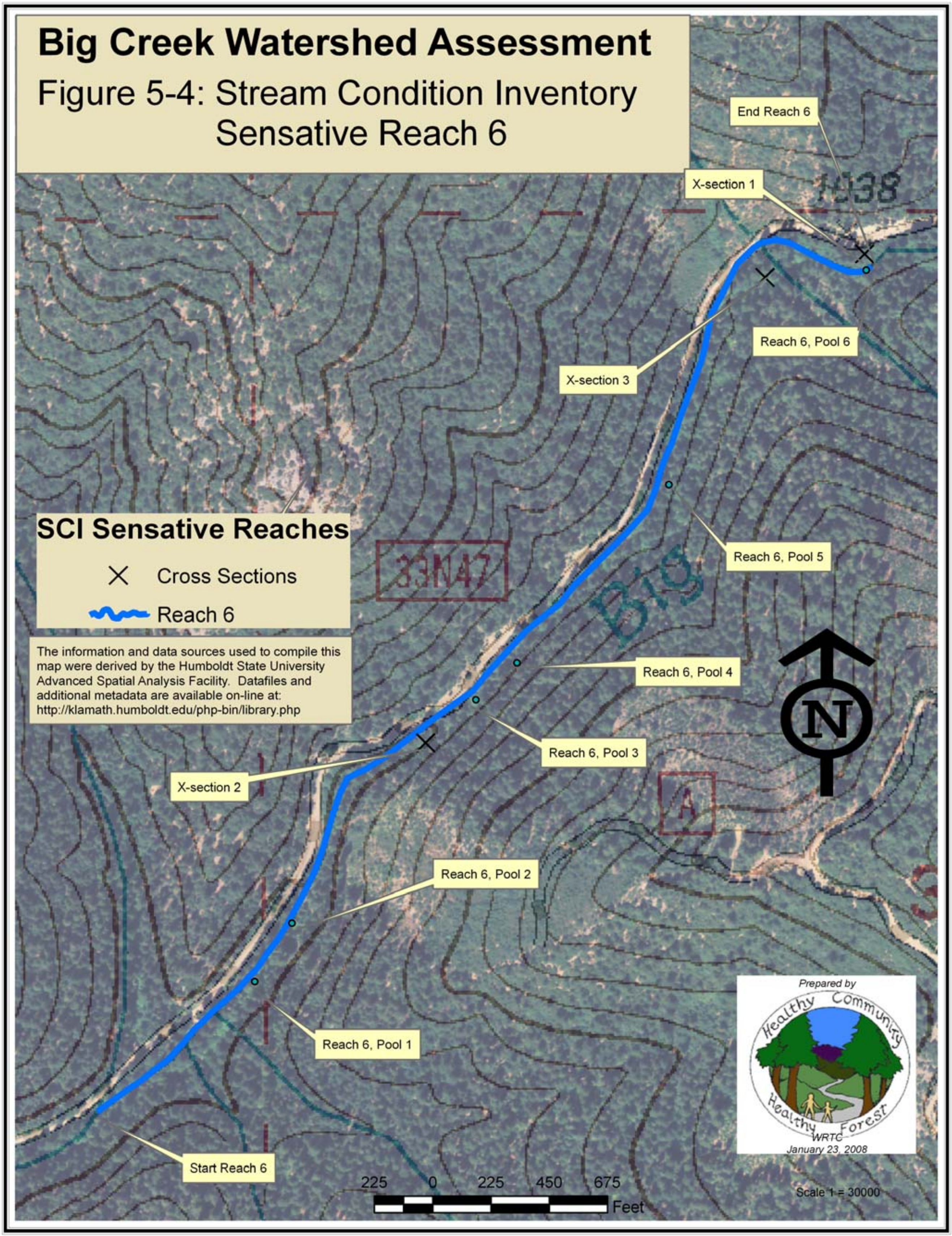
SECTION 5 REFERENCES

USDA Forest Service. 2005. *Stream Condition Inventory (SCI)*. USDA For. Serv. Tech. Guide, Version 5.0. 111 p.


Big Creek Watershed Assessment
Figure 5-1: Stream Condition Inventory
Sensative Reaches
SCI Sensative Reaches
Reach 6
Reach 2
Reach 1
Big Creek Watershed
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php
Prepared by
Healthy Community Healthy Forest
WRTC
January 23, 2008
Scale 1 = 30000
1 0 1 2 3
Miles
NATIONAL FORESTS
SHASTA-TRINITY NATIONAL FORESTS
Hayfork


Big Creek Watershed Assessment
Figure 5-2: Stream Condition Inventory
Sensative Reach 1
End Reach 1
Reach 1, W/D 3
X-section 2
Reach 1, Pool 5
Reach 1, Pool 4
SCI Sensative Reaches
Reach 1
Cross Sections
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php
Creek
N
Reach 1, Pool 3
Reach 1, W/D 2
Reach 1, W/D 1
Reach 1, Pool 2
X-section 1
Reach 1, Pool 1
Start Reach 1
Prepared by
Healthy Community
Healthy Forest
WRTC
January 23, 2008
510 0 510 1,020 1,530
Feet
Scale 1 = 30000


Big Creek Watershed Assessment
Figure 5-3: Stream Condition Inventory
Sensative Reach 2
End Reach 2
Reach 2, Pool 1
Reach 2, Pool 2
Reach 2, Pool 3
X-section 3
Reach 2, Pool 4
Reach 2, Pool 5
X-section 2
X-section 1
Reach 2, Pool 6
Start Reach 2
SCI Sensative Reaches
Cross Sections
Reach 2
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php
N
Prepared by
Healthy Community
Healthy Forest
WRTC
January 23, 2008
500
0
500
1,000
1,500
Feet
Scale 1 = 30000


Big Creek Watershed Assessment
Figure 5-4: Stream Condition Inventory
Sensative Reach 6
End Reach 6
X-section 1
Reach 6, Pool 6
X-section 3
Reach 6, Pool 5
SCI Sensative Reaches
Cross Sections
Reach 6
33N47
Big
Reach 6, Pool 4
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php
Reach 6, Pool 3
X-section 2
Reach 6, Pool 2
Reach 6, Pool 1
Start Reach 6
Prepared by
Healthy Community
Healthy Forest
WRTC
January 23, 2008
225 0 225 450 675
Feet
Scale 1 = 30000
N

SECTION 6

FIRE AND FUELS ASSESSMENT

CONSEQUENCES OF CATESTROPHIC FIRE

Water

Water supplies are one of our resources most directly affected by catastrophic fire. The loss of ground cover, such as needles and small branches, and the chemical transformation of burned soils make burned watersheds more susceptible to erosion. Following large wildfires, increased runoff and erosion from burned areas can affect the chemical composition of surface water in a watershed. In areas where fire severity was high, elevated levels of manganese and phosphates have been detected in surface water up to five years after fires. Erosion continues to occur at an accelerated rate on steep hillsides in severely burned areas, even after there are signs of vegetation recovery.

Post-fire water quality changes can include: (1) increased stream temperatures due to reduced riparian cover; (2) higher levels of nutrient rich ash increasing turbidity; and (3) greater sediment delivery to watercourses. Sediment yields can increase by a factor of 50 in forested watersheds and can persist for 8-10 years after major fire events (Wohlgemuth et al. 2006). Increases in sediment yields will vary considerably based on fire severity, climate, topography, soils, and vegetation communities.

The source of sediment yield is generated from hillslope erosion and mobilized stream channel deposits. Mobilization of in-stream sediment is a result of increased streamflow quantity due to reductions in transpiration and soil infiltration (Rowe et al. 1954; Baker 1990). Surface erosion is greatest where fires have completely removed surface litter and duff, resulting in direct raindrop impact and overland flow. This effect is more pronounced with high severity burns and less pronounced with low severity burns, where the amount of vegetation and soil disturbance is minimized. Large erosion events such as debris torrents and landslides may be triggered where slopes are steep and root systems have been reduced or destroyed by higher severity fire (Thode et al. 2006).

Soils

The frequency and severity of wildfire affects the magnitude of accelerated erosion. Wildfire increases the potential for accelerated erosion primarily through its effects on vegetation and soil. During an intense wildfire, all vegetation may be destroyed, and the organic material in the soil may be burned away or may decompose into water-repellent substances that prevent water from percolating into the soil. As a result, even normal rainfall may result in unusual erosion from burned areas. The potential for fire to increase erosion increases with fire severity, soil erodibility, steepness of slope, and intensity or amount of precipitation. However, low intensity fires, such as prescribed burn, will burn at temperatures seldom exceeding 200 degrees F, with flame height generally less than three feet and causing little or no soil damage (CDF 1999).

Air
Suppression of wildfires provides a short-term benefit to air quality by reducing the amount of vegetation consumed, thereby reducing smoke emissions. However, by delaying a natural event to a later date, poor air quality is simply pushed to a future time. When fire occurs, it is often during a time of year that traps smoke and particulate matter within the valley, intensifying the time and duration of effects. Additionally, large wildfires result in the burning of larger fuels than would be unlikely to burn under a natural fire regime. By fostering larger unregulated fires, the watershed has seen larger acreages of fire and longer durations of smoke that greatly impact air quality. Estimating the impacts from air pollutants is difficult in general, and is more complex in a wildland setting. Wildfire smoke, and in some cases that from prescribed fire, can affect visibility, human health and pollution rights (CDF 1999).

Wildlife
The major impact of wildfire on wildlife centers on its influence on vegetation structure and composition. The loss of down and dead woody material, during wild and prescribed burns, removes essential structural habitat components for a variety of wildlife and reduces species diversity. Loss of brush fields and forestlands restrict the ability of wildlife to forage for food and find shelter. Fire has the potential to accentuate impacts to fish and wildlife associated with other landscape fragmentation and development (timber harvesting, road building, and forest management practices).

For fish, the primary concerns relative to fire are increases in water temperature, sediment loading, stream cover, and the long-term loss of woody debris from stream channels. The most severe effects on fish habitat from wildfire occur when riparian vegetation (streamside forest) is lost. This vegetation plays an important role by providing shade, and providing a food source. Streamside vegetation also decreases the rate of erosion along stream banks.

Changes in species composition from intense wildfire favor early successional habitat and its assorted wildlife populations. Significant increase in browsing species population (such as deer) is common following severe fire. Physical movement of animals is also enhanced after wildfire. Low intensity fires do not generally result in significant changes to vegetation composition and resulting wildlife species, but may have similar benefit by increasing the diversity of vegetative mosaics providing better food and cover border areas.

Human Resources
Wildfire poses a significant risk to human health and property. Historic fires in 1987 threatened the community of Hayfork and surrounding private property (Photo 6-1 and 6-2). More recently, the Hyampom Fire (2001) burned hundreds of acres and threatened to destroy homes to the north of Hayfork. Wildfires in neighboring communities of Trinity County, including the Lowden Fire (1999) in Lewiston, California and the Oregon Fire (2001) near Weaverville, California have seen wildfire destroy millions of dollars worth of private property, including timber resources. These losses are both economic and

social, as many non-renewable historic buildings are destroyed, as well as the memories of hundreds of families.

Timberland losses can be significant during wildfire. The most noticeable direct effect is the loss of timber and its economic value. Catastrophic stand replacing fires tend to remove much usable wood fiber from the landscape due to the intense fire conditions. Any remaining timber is generally of low quality, low value, scattered over the fire area, and has a reduced economic value. Reforestation efforts are expensive and time consuming, generally in excess of $500 per acre. The resulting forests require periods of intensive management with no economic return for up to 60 years. Indirect effects of wildfire on timberlands include loss in soil productivity, changed forest successional characteristics, reduced forest health and increased risk of insect and disease infestations.

While concentrated recreation within the watershed is limited, due to the due to steep terrain, the watershed does provide for considerable dispersed recreation (hunting, fishing, hiking, sight-seeing. Areas burned that attract visitors for hunting will diminish in value after wildfire, as visitors are not attracted to burned forests. Wildlife that loose habitat and forage will disperse to other locations, resulting in lower hunter numbers for several years. Additionally, wildfires that significantly change the vegetation composition (forest to brush) result in visitors by-passing these areas.

FUEL ASSESSMENT AND INVENTORY

To analyze the current conditions of fuel and fire behavior in the Big Creek basin, members of the WRTC staff worked closely with fuels specialists at the Hayfork Ranger Station of the South Fork Management Unit using protocol that has been developed specifically for landscape level fire planning. ***FireShed*** is a multi-step process that utilizes a set of current landscape conditions (data layers on vegetation, weather, and topography) into computer modeling programs and outputs are generated that summarize fire behavior characteristics across the watershed. Areas that have high probability of extreme fire behavior can be targeted for pre-fire restoration work to help protect water resources.

Steps in *Fireshed* Assessment

- Select area of interest/watershed boundary based on project priorities
- Describe goals and desired conditions
- Assign treatment types based on standards and guidelines
- Describe existing conditions for fire behavior, habitat, forest health, and community protection
- Identify opportunities and project proposals to move the existing landscape toward desired conditions for fire behavior, forest health, and habitat

Selecting Area of Interest

Ideally, ***FireShed*** is run at a landscape scale (hundreds of thousands of acres) to predict fire behavior and identify restoration opportunities that encompass multiple watersheds and land ownerships. The focus of this project is on the Big Creek watershed (19,084 acres), which is a relatively small area to analyze fire behavior with current modeling software. To more accurately depict fire behavior between watersheds, we buffered the Big Creek watershed boundary by 2 miles to incorporate portions of adjacent watersheds and fuels conditions that currently exist there (Figure 6-1). By buffering the watershed boundary by 2-miles, the analysis will more accurately summarize how fire would behave when it initiates both outside and within the Big Creek watershed. For example, in the 1950s a fire initiated in the Little Creek watershed adjacent to Big Creek, burned over the watershed boundary separating the two basins, and burned several thousand acres in Big Creek (Figure 6-1).

Describing Goals and Desired Conditions

The primary intention of this ***FireShed*** analysis is to: (1) identify opportunities to reduce hazardous fuels to minimize the risk of unplanned and unwanted catastrophic wildfire events within the Big Creek watershed, and (2) restore and maintain fire-adapted and fire resilient ecosystems to protect water quality and enhance water quantity.

Specific landscape treatments to reduce hazardous fuels to minimize the risk of high severity fire and subsequent water contamination will be outlined in detail in the Big Creek Watershed Management Plan.

Methods

To evaluate fire behavior in Big Creek using the ***FireShed*** as an analysis tool, we utilized fire behavior models to highlight areas at risk of high severity fire. Two fire behavior models developed by the USFS (FARSITE[1] and FlamMap[2]; USDA 2007) were used to generate a burn severity map classified into three categories: high, moderate, and low severity (Figure 6-2). Table 6-1 shows how burn severity was derived from three output layers: flame length (Figure 6-3), rate of spread (Figure 6-4), and crown fire activity (Figure 6-5).

To calculate post-fire sediment yield we used the Erosion Risk Management Tool (ERMiT) developed by the U.S. Forest Service. The model was developed for land managers to assess post-fire erosion mitigation risk and erosion events occurring after a fire.

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[1] **FARSITE** (available on-line at: http://www.firemodels.org/content/view/112/143/) has the ability to analyze fire growth at the landscape scale. FARSITE uses spatial information on ***elevation, slope, aspect, canopy cover, fire behavior fuel models, stand height, crown base height,*** and ***crown bulk density*** as well as information on temporal information concerning ***weather, wind, and fuel moisture*** to run fire growth simulations and generate fire behavior outputs. Outputs give specific GIS compatible raster files depicting fire growth, behavior and intensity.

[2] **FlamMap** (available on-line at: http://www.firemodels.org/content/view/14/28/)**-** FlamMap is a simplified version of FARSITE requiring the same input data while generating similar fire behavior outputs. FlamMap is an ideal tool to compare relative fire behavior changes resulting from fuel model modifications. FlamMap offers an additional tool that FARSITE does not, ***Treatment Optimization Model (TOM)***. This portion of the modeling software allows the user to evaluate the topological effects of fuel treatments.

Table 6-1. Generation of Burn Severity from FARSITE and FlamMap Output Data

Burn Severity	Flame Length (ft)	Rate of Spread (ft/hr)	Crown Fire Activity
No Data	0 = no data	0 = no data	0 = no data
Low	0-4	0-660	1 = surface
Moderate	4-8	660-1650	2 = passive
High	8 +	1650 +	3 = active

Data Input Files

The data input layer for the two fire modeling programs mentioned above is called a landscape file (.LCP). LCP files were provided by Shasta-Trinity National Forest USFS fuel specialists model surface fire in FlamMap and FARSITE using seven spatial themes: ***elevation, slope, aspect, canopy cover, fire behavior fuel models, stand height, crown base height,*** and ***crown bulk density***. Elevation, slope and aspect are derived directly from Digital Elevation Models (DEM) and have been verified to be spatially accurate. Because vegetation characteristics change over time, the agreement between reference data and mapped data can be quite low if input data layers are not regularly updated. Due to the complexity of mixed-conifer plant communities in the southern range of the Klamath Mountains, thematic accuracy assessments have found data describing vegetation composition and structure to be low.

Historical fire data was used to predict areas where ignitions are more likely to occur (along road ways, close to populated areas, along ridges) and how fire events behaved in the past. Using ignition point data from 1911-2004, "cluster analysis" determined approximately ten areas in the watershed where human induced or naturally occurring fire ignitions were more likely to occur. Using a center point from those ten areas, a fire ignition layer was derived and used as an input file for the two fire behavior models. Additional data used as inputs for FlamMap and FARSITE included historical weather data provided by USFS fuel specialists.

Ground Truthing Existing Vegetation Data

To improve the overall accuracy outputs generated by the two fire modeling programs, an accuracy assessment of current fuel conditions in Big Creek was conducted by members of the WRTC staff. During the assessment, a team of technicians collected attribute data on ***canopy cover, fuel model, stand height, crown base height, and crown bulk density*** from selected locations within the watershed. Sampling plots were established in six dominant Wildlife Habitat Relationship (WHR)[3] vegetation classifications: Sierra Mixed Conifer (SMC), Ponderosa Pine (PPN), Douglas Fir (DFR), Montane Chaparral (MCP), Montane Hardwood-Conifer (MHC), Montane Hardwood (MHW), and White Fir (WFR)(Figure 6-6). Six sampling plots were visited within each of the six WHR types; for a total of 36 plots. Minority WHR classes that constitute <1% of the total area (i.e. barren areas, urban areas, and water) of the watershed were not considered during sampling. Sampling locations were strategically chosen along major roadways for ease of access.

[3] A full description of these vegetation classifications can be found in *A Guide to Wildlife Habitats of California*, CA Department of Fish & Game, 1988.

The attribute data gathered at each sampling plot were used to establish patterns of change in vegetation structure and composition between the reference data (sampling plot) and the source data (canopy cover, fuel model, stand height, crown base height, and crown bulk density digital layers). For example, in WHR type SMC, source data may have shown a canopy cover of 60%, with average crown base height of 15. Field verification may have shown a canopy cover of 85% with average crown base height of 20.

Using the attribute data collected in the field from the dominant WHR types, adjustments to the source data sets were made in GIS to reflect a more accurate depiction of current vegetation conditions. The updated data layers were then used as inputs in FlamMap and FARSITE to predict fire behavior, severity and intensity.

Running Models

Using the updated vegetation data layers, topographical, and weather inputs, we were able to generate wildfire risk and hazard maps using GIS compatible fire modeling software. The results of the analysis show areas where wildfire risk[4] and hazard[5] are greatest and would impact valuable resources including: water, soil, air, wildlife, and human resources. For the purposes of this analysis, we focused on the impacts of high severity fire areas on water quality in Big Creek and Ewing Gulch (the basin above Ewing Reservoir). The project area was stratified between Ewing Gulch and Big Creek because of significant differences in topography, soils, and vegetation types.

Using FlamMap and FARSITE outputs, fire severity was classified into three classes: High, Moderate and Low severity (Figure 6-2). Generally, high severity fire poses the greatest risk to forested watersheds, where post-fire sediment yields can exceed unburned levels by as much as 50 times (Anderson 1949; Wohlgemuth et al. 2006). To calculate potential sediment yield we focused specifically on areas where fire severity is predicted to be greatest (approximately 13% of the total watershed area).

To calculate post-fire sediment yield we used the Erosion Risk Management Tool (ERMiT) developed by the U.S. Forest Service. The model was developed for land managers to assess post-fire erosion mitigation risk and erosion events occurring after a fire. ERMiT is a web-based application that uses Water Erosion Prediction Project (WEPP) technology to estimate erosion, in probabilistic terms, on burned and recovering

---

[4] Fire risk is the chance that a fire will start in a particular area. Although lightning is an important cause of forest fires, human starts are the most common source of ignition. The greatest number of activities with fire starting potential are found close to home. Roads, hiking trails, campgrounds and picnic areas are also high risk areas for fires ignited by smoking, vehicles (parking in tall grass or faulty exhaust systems), warming fires, or camp stoves and lanterns (Baldwin 2005).

[5] Fire hazard is the interaction of fuels (vegetation, buildings, and other flammables), topography, and weather (temperature, humidity, wind speed and direction, time since last rain). The interaction of these factors affects fire behavior (the rate of spread and intensity of fire), which affects the effectiveness of suppression efforts and the fire-fighting resources required. Higher hazard ratings indicate the potential for extreme fire behavior, difficulties in suppression, and increased resource damage (Baldwin 2005).

forest, range, and chaparral lands with and without the application of erosion mitigation treatments. Based on 20 to 40 individual WEPP runs, ERMiT produces a distribution of rain event sediment delivery rates with a probability of occurrence for each of five post-fire years (USDA 2006).

RESULTS

Figure 6-7 shows predicted sediment yield tons/acre/year in high risk areas following high and low severity fire events in Big Creek. Figure 6-8 shows predicted sediment yield tons/acre in high risk areas following high and low severity fire in Ewing Gulch.

Figure 6-7. Predicted sediment yield in tons/acre/year in high risk areas following high and low severity fire in Big Creek.

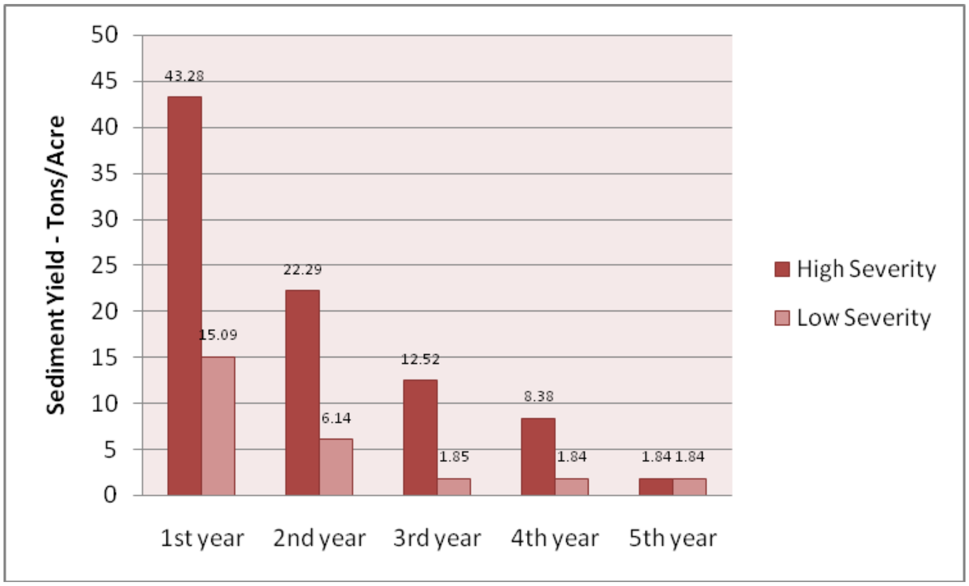

Figure 6-8. Predicted sediment yield in tons/acre/year in high risk areas following high and low severity fire in Ewing Gulch.

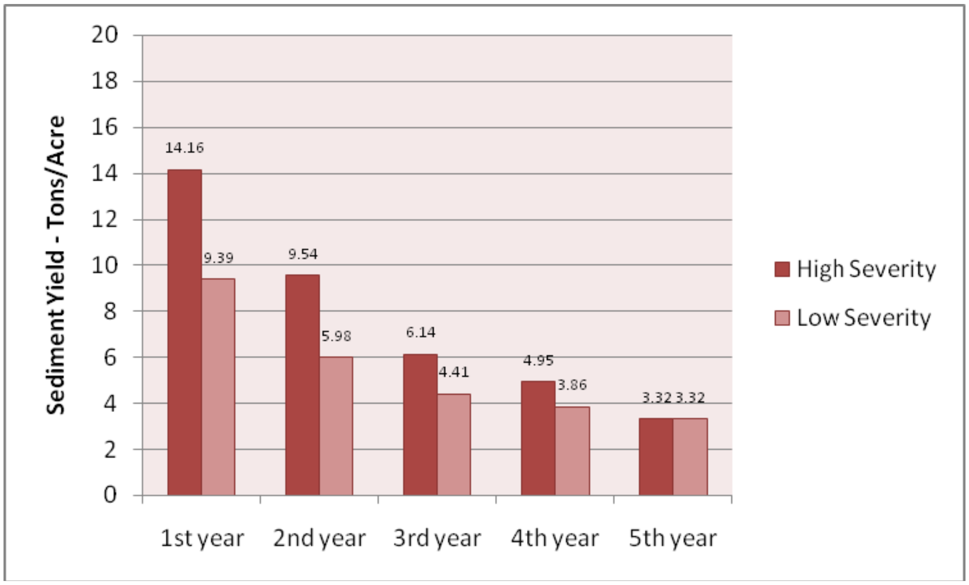

Table 6-2. Predicted sediment yield tons/year by burn severity for Big Creek and Ewing Gulch analysis areas.

Analysis Area	High Risk Acres	Burn Severity	Predicted Sediment Yield Tons/Year					Total Tons of Sediment 5-years Post-fire
			1st	2nd	3rd	4th	5th	
Big Creek	2058	High	89,070	45,873	25,766	17,246	3,787	181,742
		Low	31,055	12,636	3,807	3,787	3,787	55,072
Ewing Gulch	540	High	7,646	5,152	3,315	2,673	1,793	20,579
		Low	5,070	3,229	2,381	2,084	1,793	14,557

Table 6-2 illustrates the predicted cumulative sediment yield per acre in Big Creek and Ewing Gulch for a 5-year period of time following high and low severity fire. ERMiT does not estimate sediment yield beyond 5 years. The 5th year of predicted sediment yield following both high and low severity fire for Big Creek (Figure 6-7) is 1.84 tons/acre. This is approximately three times the background level (0.66 tons/acre/year) calculated by the NetMap sediment budget model (Section 8, Table 7) for the same area. Fifth year predicted sediment yield following both high and low severity fire for Ewing Gulch is 3.32 tons/acre/year. This is approximately thirteen times background level (0.24 tons/acre/year) calculated by the NetMap sediment budget model (Section 8, Table 7) for the same area. Based on these results it is unclear how quickly sediment yield would return to background levels but conservative estimates show that post-fire sediment yield can remain elevated for as much as 10 years after a fire (Rowe et al. 1954).

Conclusions

The Lowden Fire (1999) and the Oregon Fire (2001) are recent, large-scale fires in Trinity County that have threatened the communities of Lewiston and Weaverville, respectively. Both fires resulted in large areas of high severity burn that have seen elevated levels of erosion as much as eight years following the fire. Higher erosion rates have led to serious management problems including: landslides, sedimentation of streams, road failures, plugged culverts, loss of soil used for agriculture and failed water systems. Post-fire restoration efforts are now underway to mitigate the negative effects of erosion. Fortunately, neither of these fires has affected the municipal water supplies of Lewiston and Weaverville.

Post-fire effects on water quality for municipal water supply is a concern that faces many public and state land managers. Historically, post-fire rehabilitation efforts occur where fires exhibit low spatial complexity, high intensity, and high severity. Post-fire rehabilitation projects are generally selected on a site by site basis within the burned area, without broad-scale assessment of condition or causal mechanisms. Many of these rehabilitation measures are warranted to maintain levels of water quality, but the approach of treating the "symptom" and not the "source" falls short of restoring hydrologic function (Thode et al. 2006) and ecosystem health.

The ideal restoration approach is a preemptive approach, where natural fire regimes are restored to enhance watershed process and functions, rather than emergency rehabilitation measures to burned watershed that are piecemeal and expensive. An integrated landscape approach is necessary to develop a land management strategy that promotes ecosystems function and maintains beneficial uses for humans. Big Creek is a high priority for this type of integrated approach because it is the domestic water supply for the town of Hayfork, California and it provides essential habitat for anadromous and resident fish species.

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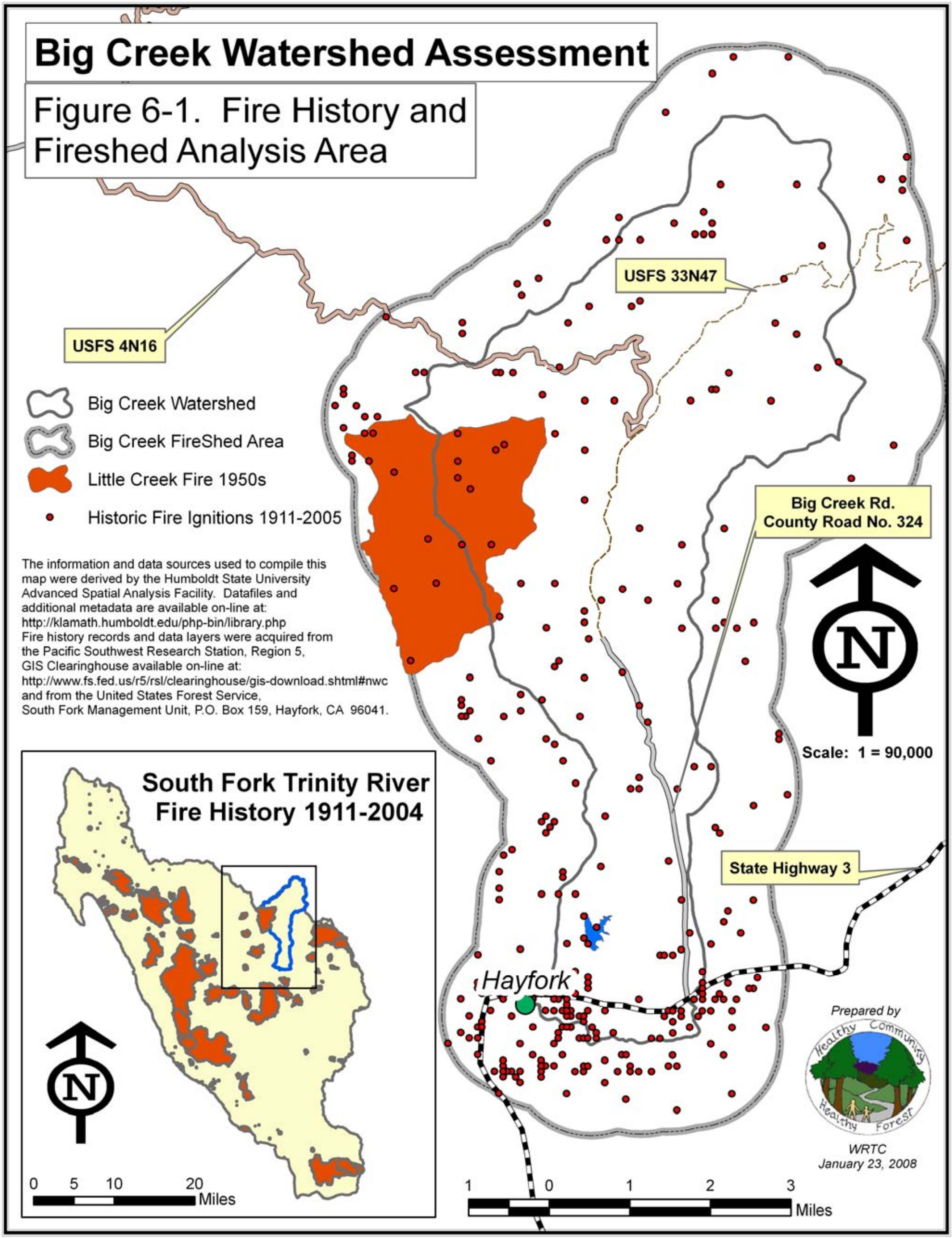
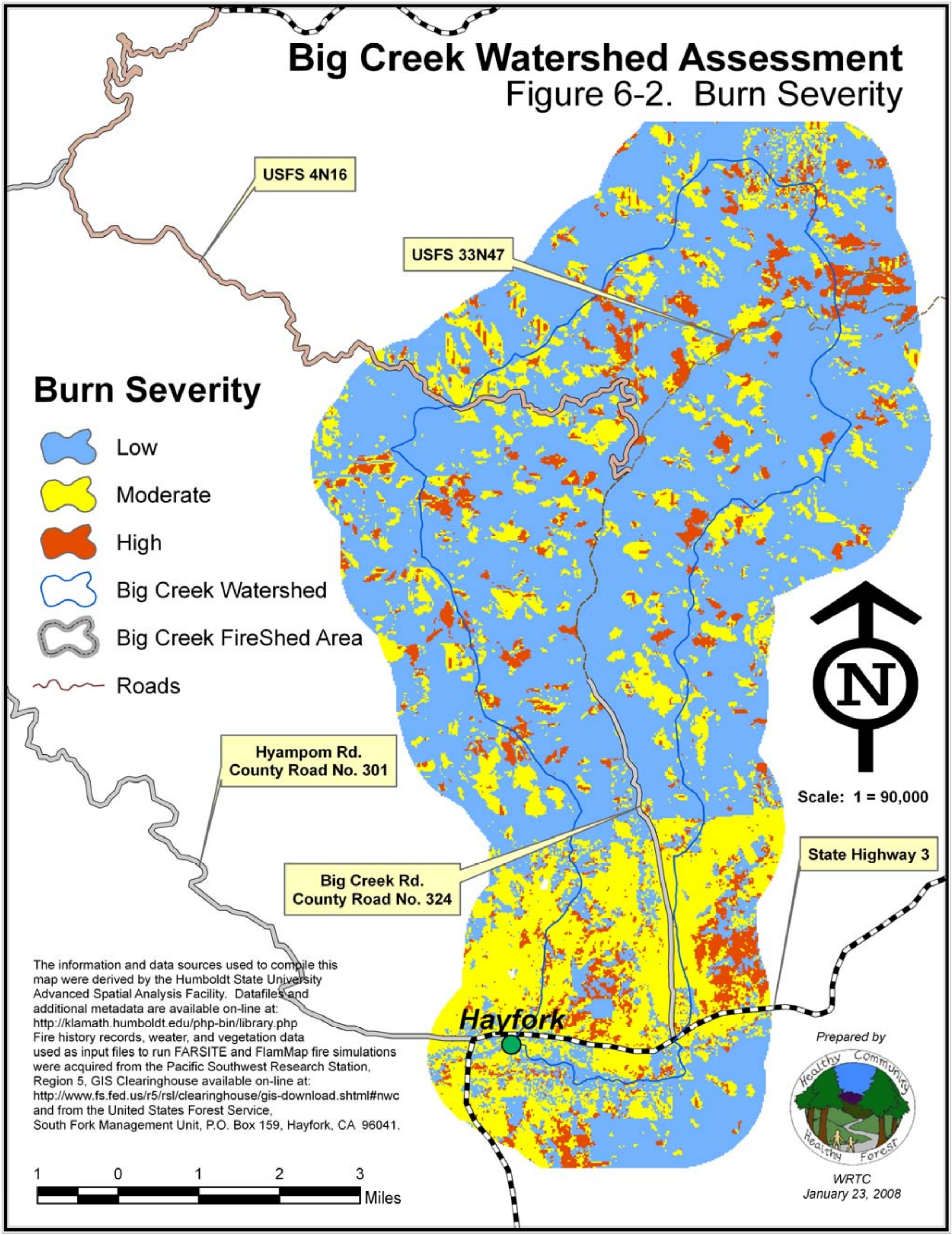

Big Creek Watershed Assessment
Figure 6-1. Fire History and Fireshed Analysis Area
USFS 4N16
USFS 33N47
Big Creek Watershed
Big Creek FireShed Area
Little Creek Fire 1950s
Historic Fire Ignitions 1911-2005
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php Fire history records and data layers were acquired from the Pacific Southwest Research Station, Region 5, GIS Clearinghouse available on-line at: http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml#nwc and from the United States Forest Service, South Fork Management Unit, P.O. Box 159, Hayfork, CA 96041.
Big Creek Rd. County Road No. 324
N
Scale: 1 = 90,000
State Highway 3
South Fork Trinity River Fire History 1911-2004
N
0 5 10 20 Miles
Hayfork
Prepared by
Healthy Community Healthy Forest
WRTC
January 23, 2008
1 0 1 2 3 Miles


Big Creek Watershed Assessment
Figure 6-2. Burn Severity
USFS 4N16
USFS 33N47
Burn Severity
Low
Moderate
High
Big Creek Watershed
Big Creek FireShed Area
Roads
N
Hyampom Rd.
County Road No. 301
Scale: 1 = 90,000
State Highway 3
Big Creek Rd.
County Road No. 324
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php
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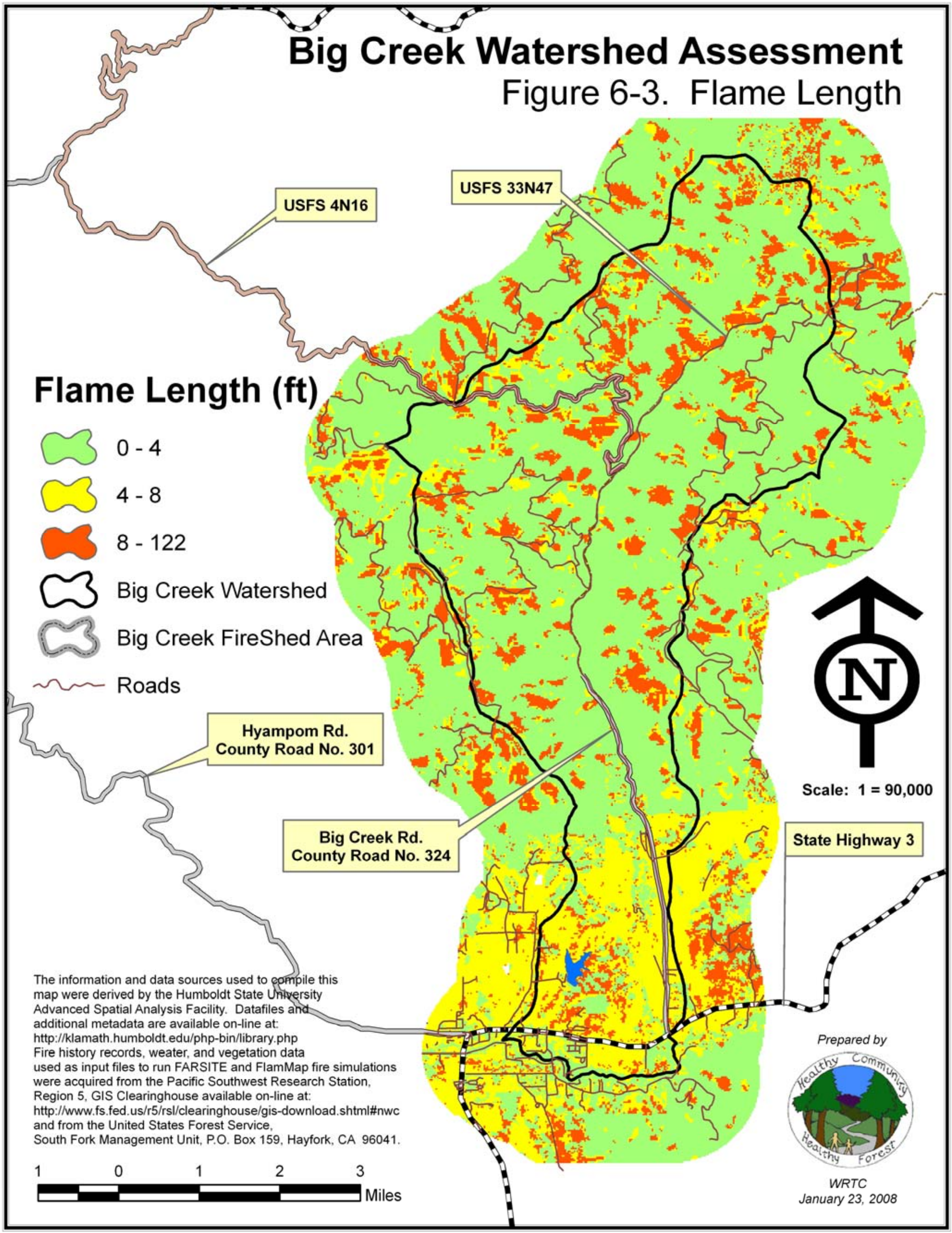
Hayfork
Prepared by
Healthy Community
Healthy Forest
WRTC
January 23, 2008
1 0 1 2 3
Miles


Big Creek Watershed Assessment
Figure 6-3. Flame Length
Flame Length (ft)
0 - 4
4 - 8
8 - 122
Big Creek Watershed
Big Creek FireShed Area
Roads
USFS 4N16
USFS 33N47
Hyampom Rd.
County Road No. 301
Big Creek Rd.
County Road No. 324
State Highway 3
Scale: 1 = 90,000
The information and data sources used to compile this
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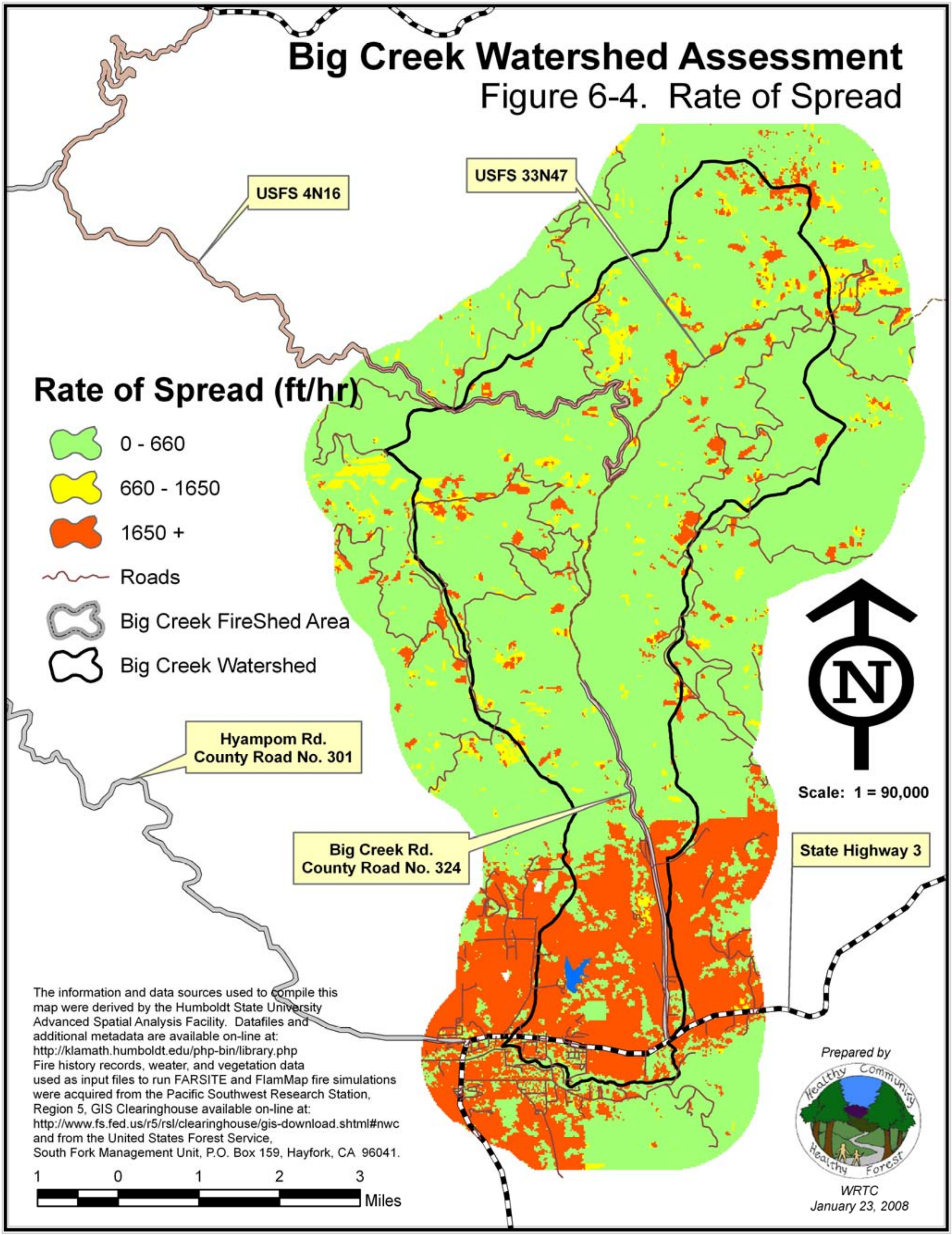
Big Creek Watershed Assessment
Figure 6-4. Rate of Spread
USFS 4N16
USFS 33N47
Rate of Spread (ft/hr)
0 - 660
660 - 1650
1650 +
Roads
Big Creek FireShed Area
Big Creek Watershed
Hyampom Rd.
County Road No. 301
Big Creek Rd.
County Road No. 324
State Highway 3
N
Scale: 1 = 90,000
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php Fire history records, weater, and vegetation data used as input files to run FARSITE and FlamMap fire simulations were acquired from the Pacific Southwest Research Station, Region 5, GIS Clearinghouse available on-line at: http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml#nwc and from the United States Forest Service, South Fork Management Unit, P.O. Box 159, Hayfork, CA 96041.
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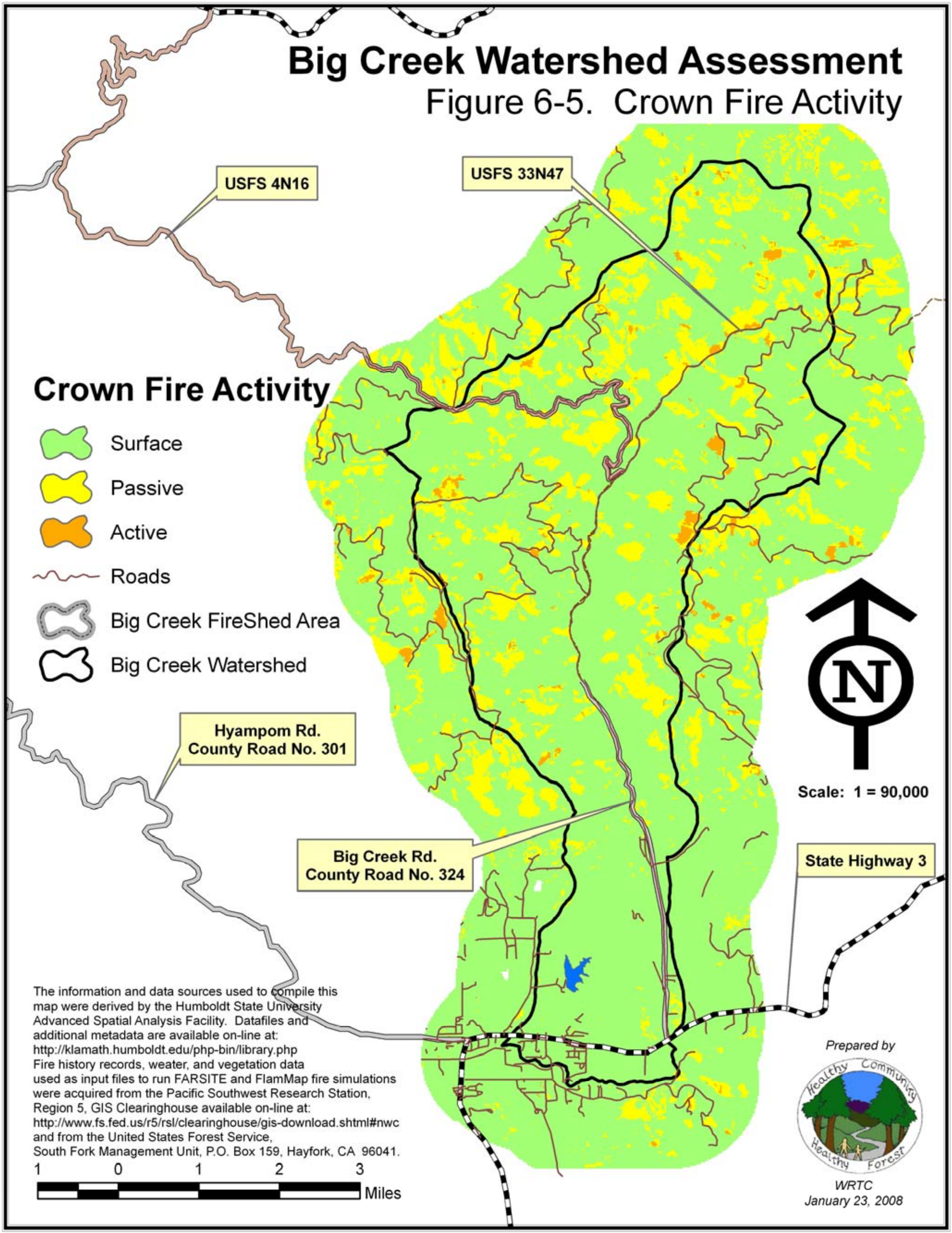

Big Creek Watershed Assessment
Figure 6-5. Crown Fire Activity
USFS 4N16
USFS 33N47
Crown Fire Activity
Surface
Passive
Active
Roads
Big Creek FireShed Area
Big Creek Watershed
Hyampom Rd.
County Road No. 301
Scale: 1 = 90,000
Big Creek Rd.
County Road No. 324
State Highway 3
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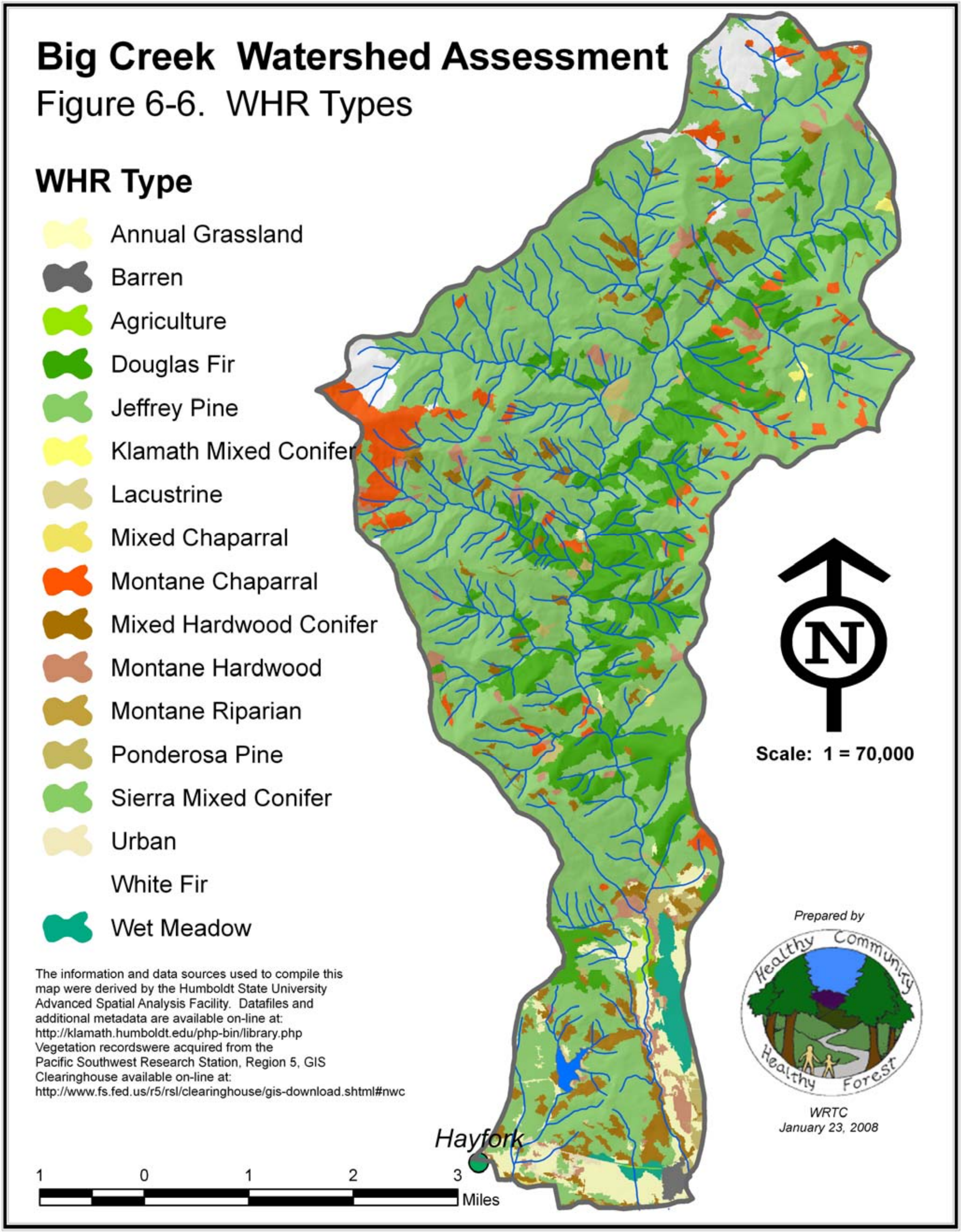

Big Creek Watershed Assessment
Figure 6-6. WHR Types
WHR Type
Annual Grassland
Barren
Agriculture
Douglas Fir
Jeffrey Pine
Klamath Mixed Conifer
Lacustrine
Mixed Chaparral
Montane Chaparral
Mixed Hardwood Conifer
Montane Hardwood
Montane Riparian
Ponderosa Pine
Sierra Mixed Conifer
Urban
White Fir
Wet Meadow
The information and data sources used to compile this map were derived by the Humboldt State University Advanced Spatial Analysis Facility. Datafiles and additional metadata are available on-line at: http://klamath.humboldt.edu/php-bin/library.php Vegetation recordswere acquired from the Pacific Southwest Research Station, Region 5, GIS Clearinghouse available on-line at: http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml#nwc
Hayfork
1 0 1 2 3
Miles
N
Scale: 1 = 70,000
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January 23, 2008

Photo 6-1. Mixed-conifer forest burned by high severity fire in 1987. Community of Hayfork can be seen top right of photo. (Image courtesy of Dick and Lonnie Jessee)

Photo 6-2. Areas that experienced intense, high severity fire may have contributed large amounts of sediment to tributary streams of Hayfork Creek. (Image courtesy of Dick and Lonnie Jessee)

Section 7: BIG CREEK WY2007-2008 STREAMFLOW AND SEDIMENT MONITORING REPORT

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BIG CREEK WY2007-2008 STREAMFLOW AND SEDIMENT MONITORING REPORT

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WY2007-2008 STREAMFLOW AND SEDIMENT MONITORING

1.0 INTRODUCTION

The purpose of this report is to: (1) provide an overview of field and office methodologies employed for streamflow, turbidity/SSC, and water temperature data collection and analysis, and (2) present results of Big Creek mainstem and tributary WY2007 and WY2008 hydrologic data collection and analysis. Detailed descriptions of these procedures are provided in the GMA Surface-Water Monitoring Quality-Assurance Plan and the GMA Sediment Laboratory Quality-Assurance Plan (GMA 2007). Only the most relevant figures and tables are included in the text of this report. Supporting hydrologic data (Figures and Tables) are provided in the Appendices.

The Big Creek Watershed is located within the Hayfork Creek watershed, a tributary of the South Fork Trinity River (Figure 1). The watershed drains 27.3 mi^2 and has a stream density of about 5 mi/mi^2. The average annual precipitation is about 50 inches with most of it in the form of snowfall. Spring snowmelt and regional rain-on-snow events drive runoff. Baseflow is high relative to other tributaries within the Hayfork Creek watershed and summer water temperatures tend to be cool. There are several mapped springs within the watershed that issue from headwater areas (Figure 1) (GMA Water Quantity and Quality Monitoring Plan, 2007).

The lack of long-term water quantity and quality data for the Big Creek watershed has been identified as a data gap. Monitoring of various hydrologic and water quality parameters will provide useful information related to the amount of irrigated agriculture and domestic water usage and sediment input to Big Creek from upland erosional sources. These data will be used to identify sediment source areas, verify the upland sediment budget, and recommend water quantity and quality restoration and mitigation activities (GMA Water Quantity and Quality Monitoring Plan, 2007).

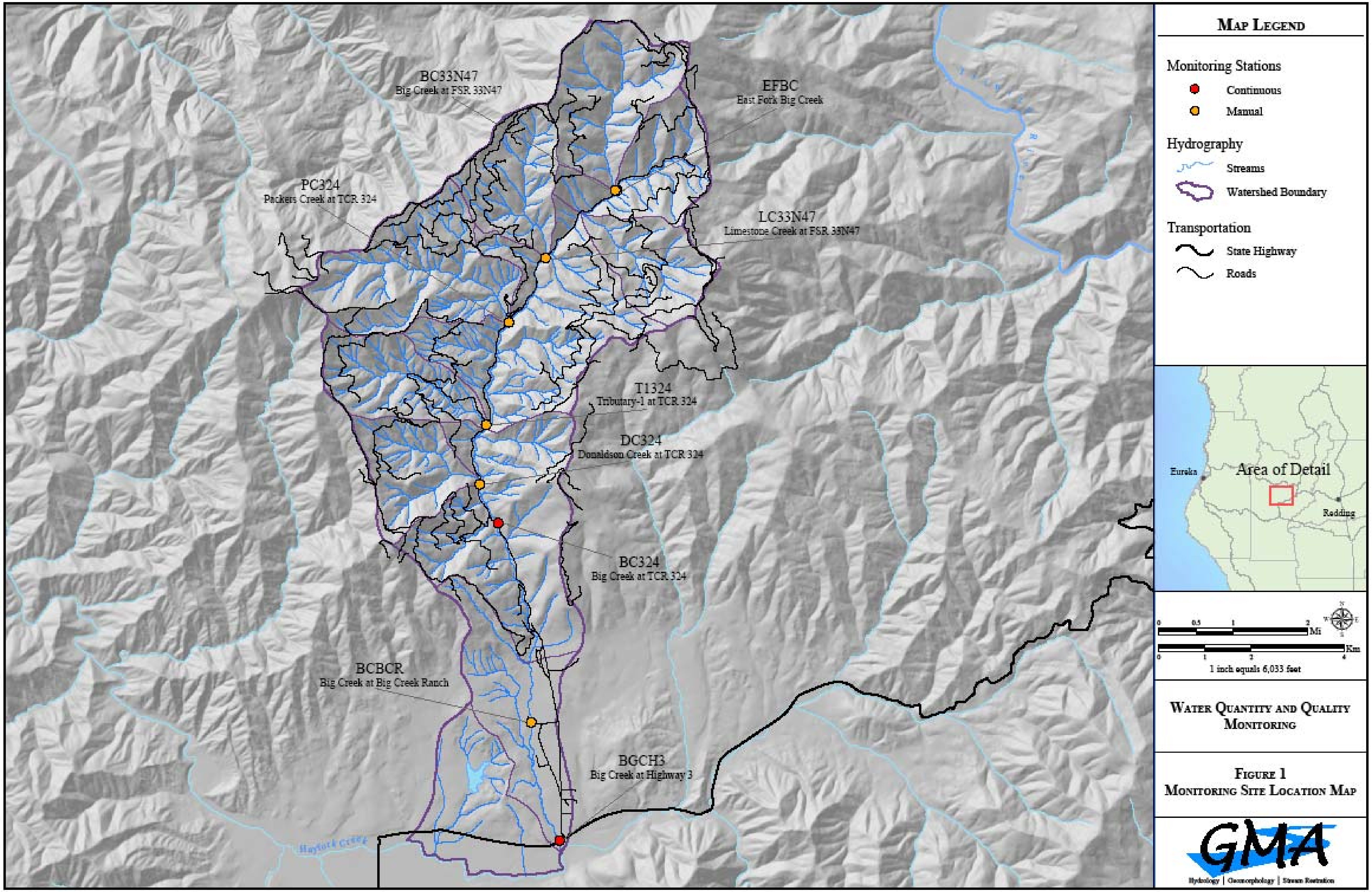
This study was undertaken for The Watershed Research and Training Center, Hayfork, CA.

2.0 SCOPE AND OBJECTIVES

The scope of the Streamflow and Turbidity Monitoring is to develop streamflow, water temperature, and sediment transport datasets for the Big Creek watershed. The work consisted of the following tasks:

1. Install and operate 2 continuous monitoring stations for discharge, water temperature and turbidity/suspended sediment concentration,
2. Install and operate 6 manual monitoring stations for periodic turbidity/suspended sediment sampling,
3. Collect streamflow measurements and periodic turbidity and suspended-sediment samples,
4. Develop stage/discharge relationships and various sediment relationships for the 2 continuous gaging sites,
5. Compute streamflow records,
6. Estimate suspended-sediment loads for the period of record, and
7. Compare sites and data sets where appropriate.

Initially, the project was developed as a single year study. However, due to a dry water year in 2007, and the limited amount of data collected, the project was extended through Water Year 2008. This report



BC33N47
Big Creek at FSR 33N47
EFBC
East Fork Big Creek
PC324
Packers Creek at TCR 324
LC33N47
Limestone Creek at FSR 33N47
T1324
Tributary-1 at TCR 324
DC324
Donaldson Creek at TCR 324
BC324
Big Creek at TCR 324
BCBCR
Big Creek at Big Creek Ranch
BGCH3
Big Creek at Highway 3
Hayfork Creek
Map Legend
Monitoring Stations
Continuous
Manual
Hydrography
Streams
Watershed Boundary
Transportation
State Highway
Roads
Eureka
Area of Detail
Redding
1 inch equals 6,033 feet
Water Quantity and Quality Monitoring
Figure 1
Monitoring Site Location Map
GMA

summarizes and analyzes data collected in WY07 and WY08.

3.0 METHODS

3.1 Streamflow

3.1.1 Stage Measurement

Staff plates were attached to channel iron that was driven into the streambed at the two continuous monitoring sites as stage measuring devices. Water level, or stage, was measured directly off the staff plate at these locations. At manual monitoring locations, T-posts were driven into the streambed and used for stage references. Water levels were measured from the top of the T-post to the water surface and recorded as negative values.

3.1.2 Continuous Stage Recorders/Manual Stage Recorders

Continuous stage recorders were installed at 2 locations in the Big Creek watershed: Big Creek at Trinity County Road 324 and Big Creek at Highway 3 (see Table 1 for abbreviations and general description). Equipment at the continuous stage recorder stations included Campbell Scientific, Inc. CR510 data collection platforms (DCP), and Design Analysis Associates, Inc. H-310 SDI-12 pressure transducers. Recording intervals were set to 15 minutes. Batteries were replaced and the DCP's were downloaded to a laptop computer on a regularly scheduled basis. Gage height records were checked against observed staff height observations to verify proper gage operation. Corrections were applied to the gage height record when necessary.

At the end of May and the beginning of June 2007 the DCP's and H-310 pressure transducers were removed from BGCH3 and BC324 and replaced with Global Water Level Loggers (Model WL-16, 0-15 ft) which were purchased by the Hayfork Watershed Research and Training Center. The Watershed Research and Training Center purchased the Global Water Level Loggers so that they may continue to monitor streamflow in the future. The Global Water Level Loggers remained in place and were used to record continuous stage through WY2008.

Manual stage recording stations were installed at 6 sites in the Big Creek watershed: Donaldson Creek at TCR 324, Tributary-1 at TCR 324, Packers Creek at TCR 324, Limestone Creek at FSR 33N47, Big Creek at FSR 33N47, and East Fork Big Creek (see Table 1 for abbreviations and general description).

TABLE 1
BIG CREEK WATERSHED
General Site Description WY 2007 - 2008

SITE NAME	ACRONYM	STATION #	Pressure Transducer Installed	Turbidity Probe Installed	Crest Gage Installed
Big Creek at Highway 3 Near Hayfork, CA	BGCH3	11528440	yes	yes	yes
Big Creek at TCR 324 Near Hayfork, CA	BC324	11528430	yes	yes	yes
Donaldson Creek at TCR 324	DC324	---	no	no	no
Tributary-1 at TCR 324	T1324	---	no	no	no
Packers Creek at TCR 324	PC324	---	no	no	no
Limestone Creek at FSR 33N47	LC33N47	---	no	no	no
Big Creek at FSR 33N47	BC33N47		no	no	no
East Fork Big Creek	EFBC	---	no	no	no

The full site name, the site abbreviation and equipment installed at the site are shown in Table 1. The monitoring station locations are depicted on a map of the watershed in Figure 1.

3.1.4 Streamflow Measurements

Streamflow measurements were collected at the two continuous monitoring sites using standard hydrologic practice. Measurements were performed by wading at the gage location. Streamflow equipment for wading measurements included a 4ft top-set wading rod, JBS Instruments AquaCalc 5000 - Advanced Stream Flow Computer, and either a Price AA or Pygmy magnetic head current meter. At very high stages, flows were taken at BGCH3 using a bridgeboard at the downstream side of the road crossing.

In general, and when practical, standard USGS methods were used when making discharge measurements. During periods of rapidly changing river stage, fewer verticals were used in order to improve the accuracy of the measurements. Deviations from standard methods included: Price AA meters were occasionally used below the minimum depth recommended due to hydraulic conditions (turbulence) at the sites.

3.1.5 Rating Curves

All discharge measurements were entered and cataloged using a form similar to the standard USGS 9-207 discharge measurement summary form. Forms summarizing all discharge measurements made during the study period for each of the continuous sites are contained in the Appendices to this report. After collection of the discharge measurements, a discharge-rating curve was developed for each station by plotting the stage/discharge pairs and electronically hand fitting a curve. Stage/discharge pairs were evaluated and ratings were developed within the WISKI Suite of software. The WISKI Suite is a comprehensive hydrologic time-series database management system developed by Kisters AG. The suite consists of three parts, WISKI, BIBER, and SKED. WISKI manages and computes all time-series data, BIBER is used to evaluate and catalog discharge measurements, and SKED is used to develop and manage rating curves. The WISKI Suite includes complete USGS standards for surface water computations. These standards include USGS computational methods according to WSP 2175, Measurement and Computation of Streamflow vols.1 and 2, Multiple Ratings with log offsets, shifts and stage adjustments, gage height and datum correction, and standard printouts such as primary computation sheets, mean daily value summaries, rating tables, and shift tables. During the study period, the WISKI suite was used to develop all rating tables and performed all computations for continuous surface-water gaging stations. The Appendices include the following for each of the continuous sites; 9-207 discharge measurement summary tables, discharge rating curves, discharge rating tables, and discharge hydrographs.

The accuracy of streamflow records depends primarily on (1) the stability of the stage-discharge relation or, if the control is unstable, the frequency of discharge measurements, and (2) the accuracy of observations of stage, measurements of discharge, and interpretation of records (Rantz 1982). During the study period, efforts were made to develop accurate streamflow records which included (1) the use of check measurements to verify the accuracy and determine the repeatability of discharge measurements and (2) the use of standard hydrologic practice in gaging station operation and maintenance.

.

A combination of factors, however, allows the two continuous stations to attain "Fair" and in some cases "Estimated" accuracy. This is generally due to the limited number of measurements collected, as well as the hydraulic conditions at the sites. Station accuracies are defined as follows: "Excellent" means that about 95 percent of the daily discharges are within 5 percent; "good" within 10 percent; and "fair" within 15 percent. "Poor" means that daily discharges have less than "fair" accuracy.

3.2 Water Temperature

Continuous water temperature recorders were installed at 2 locations in the Big Creek watershed: Big Creek at Trinity County Road 324, and Big Creek at Highway 3 (see Table 1 for abbreviations and general description). During the first year of the study (WY2007) Equipment at the continuous water temperature recorder stations included Campbell Scientific, Inc. CR510 data collection platforms (DCP), and Design Analysis Associates, Inc. H-310 SDI-12 pressure transducers (with water temperature). Recording intervals were set to 15 minutes.

At the end of May and the beginning of June the DCP's and H-310 pressure transducers (with water temperature) were removed from BGCH3 and BC324 and replaced with Hobo water temperature thermistors that were purchased by the Hayfork Watershed Research and Training Center. The Watershed Research and Training Center purchased the Hobo thermistors so that they may continue to monitor water temperature in the future. These data have not been transferred to GMA and will not be included in this report. Further, because the H-310 pressure transducers were not re-installed at the continuous monitoring sites, water temperature was only recorded by the DTS-12 turbidity probes. These data are included in this report.

During the study period, no calibration of the water temperature equipment was performed and no audit water temperature data were collected. The WISKI suite was used to catalogue and analyze the continuous water temperature data. The Appendices at the end of this report include a plot of the Day Max, Day Min, and the 7-day Day Max Moving Average for each of the continuous temperature monitoring sites.

3.3 Sediment Transport

3.3.1 Turbidity and Suspended-sediment Sampling

Depth-integrated and Grab turbidity and suspended-sediment concentration (SSC) sampling was performed at all monitoring stations. Sediment samples were collected using either a US DH-48 Depth-Integrating Suspended-Sediment Sampler (for wadeable flows) or by directly dipping the sample bottle at the grab sample location. Sampling locations for the continuous sites were located at or near streamflow measurement sections.

Standard methods according to Edwards and Glysson (1988) were generally used for sampling, although transit rates were not determined. Since transit rates were not determined, some samples may not be truly iso-kinetic. In addition, due to the number of sites being sampled, a tag line was not always set during sampling; instead the distance between verticals was estimated. For each sample the location, time, stage, number of verticals, distance between verticals and bottle # were recorded, along with whether a field replicate had been taken. At locations where it was not possible to get a depth-integrated sample, grab samples or modified depth-integrated samples were taken, and this information was recorded.

Samples were kept chilled after collection and stored in ice chests. Turbidity values obtained from suspended-sediment samples are referred to as lab turbidities. Lab turbidity values were obtained within 48 hours, unless otherwise noted, using a LaMotte Instruments 2020 turbidimeter. The USGS Handbook for Water-Resources Investigations, chapter 6.7, states that values obtained from the LaMotte turbidimeter should be reported in Nephelometric Turbidity Ratio Units (NTRU) (Anderson 2004). Suspended-sediment concentrations were determined in the GMA sediment lab following USGS and ASTM D-3977 protocols. The GMA lab participates in the USGS Sediment Lab Quality Assurance Program and has been inspected and approved by the USGS.

3.3.2 Continuous Turbidity Sampling

During the study period, continuous turbidity sensors were operated at the two continuous monitoring stations (BGCH3 and BC324). Equipment at the continuous turbidity recorder stations included Campbell Scientific Inc. CR510 data collection platforms (DCP), and Forest Technology Systems, Inc. DTS-12 turbidity probes. Recording intervals were set to 15 minutes. Batteries were replaced and the DCP's were downloaded to a laptop computer on a regularly scheduled basis. DTS-12 turbidity sensors have a wiper, which reduces the potential for biological fouling. The turbidity sensors were attached to booms that were mounted on cables strung between trees. The booms and sensors were mounted in the channel, at varying heights above the streambed. Turbidity values obtained from the sensors will be referred to as field turbidity. Turbidity is reported in units which correspond to the instrument design as defined in the USGS TWRI Book 9-A6, chapter 6.7. The USGS Handbook for Water-Resources Investigations reports that the Forest Technology Systems, Inc DTS-12 instruments are designed to record in Formazin Nephelometric Units (FNU) (Anderson 2004).

At the end of May and the beginning of June 2007, the DCP's and DTS-12 turbidity probes were removed from BGCH3 and BC324. The equipment was re-installed in November 2007 for use in WY08.

3.3.3 Sediment Transport Rates and Loads

Turbidity and suspended-sediment concentration data were analyzed by developing relationships for SSC versus turbidity at each of the continuous monitoring sites. In addition, relationships for SSC versus discharge were developed to fill in periods were the turbidity record was missing or considered faulty. Data pairs were plotted against each other and a computer generated power equation was produced in order to define the relationship. Suspended- sediment discharge and load estimates were computed in WISKI using turbidity or discharge as a surrogate for suspended-sediment concentration. Data were not analyzed at the manual monitoring sites.

4.0 RESULTS

4.1 Streamflow

4.1.1 Streamflow Measurements

Streamflow measurements were collected from February 2007 through June 2008. Nine discharge measurements were made at the lower site, BGCH3, while eleven measurements were made at the upper site, BC324. The range of discharge measurements collected during the study period was adequate for the development of stage-discharge relationships.

All streamflow measurements were entered and cataloged using a modified version of the standard USGS-type 9-207 discharge measurement summary form. The 9-207 form summarizing all streamflow measurements made during the study period for each site is contained in the appendices.

4.1.2 Rating Curves

Log-Log stage-discharge rating curves were developed in WISKI for the 2 continuous monitoring sites. Rating curves were electronically hand plotted.

Big Creek at Hwy 3 Nr. Hayfork, CA -- 11528440

Nine discharge measurements ranging from 2.65 cfs to 324 cfs were made at BGCH3. Measurements made after the January 4, 2008 storm event, indicated that the application of a stage-variable shift was necessary. Measurements 15-18 were used to develop Stage Variable Shift (SV) SV08-01. SV08-01 affects flows between the gage heights of 3.81ft. and 6.04 ft. SV08-01 was brought into effect directly on

January 4, 2008 at 08:30 hours and remained in effect for the remainder of the computational period. The range of flows collected at the site was adequate for the development of stage-discharge Rating 3.1.

Big Creek at TCR 324 Nr. Hayfork, CA -- 11528430

Eleven discharge measurements ranging from 9.94 cfs to 113 cfs were made at BC324. During the first year of the study, measurements made at BC324, with the exception of measurement 4, indicate that shift development is not necessary. Measurement 4 (Poor), made on May 24, 2007, initially indicated a shift to the lower end of the stage-discharge Rating 1.1. Measurement 5 (Fair), made on May 25, 2007 was made to check the accuracy of measurement 4. A different measurement section and a different meter were used for measurement 5. Measurement 5 verifies the validity of the low end of the Rating 1.1. Measurements 4 and 5 further indicated that selection of the correct discharge measurement section is crucial at BC324. During the second year of the study, measurements made after the January 4, 2008 storm event indicated that the application of a stage-variable shift was necessary. Measurements 9-11 were used to develop Stage-Variable Shift (SV) SV08-01. SV08-01 affects flows between the gage heights of 3.56 ft. and 5.00 ft. SV08-01 is brought into effect directly on January 4, 2008 at 11:00 hours and was in effect for the remainder of the computational period. The range of flows collected at the site was adequate for the development of stage-discharge Rating 1.1.

The stage-discharge ratings developed for BGCH3 and BC324 along with their associated validities can be found in the Appendices of this report. If these stage-discharge ratings are used in the future, it is important they be verified and updated with additional discharge measurements.

4.1.3 Discharge Hydrographs

Discharge hydrographs were produced from the continuous gage height records and discharge rating tables for each of the continuous sites. Discharge records for each of the continuous sites, BC324 and BGCH3 should be considered Fair in quality. A fair record rating means that there is anywhere from 10% to 15% error associated with the streamflow computations. The error associated with the streamflow computations is attributed to the hydraulic conditions at each of the sites as well as to the timing and number of discharge measurements.

Four distinct, but not necessarily independent, storm events occurred during the first year of the study (January, 2007 through September, 2007). One storm event occurred in the second week of February, one during the last week of February, and finally, two during the first two weeks of March. The largest storm of the period occurred between February 8th and February 14th. Unlike the first year of the study, the second year of the study contained numerous storm events as well as a significant spring snow-melt event. Four distinct, but not necessarily independent, storm events are visible on the hydrographs. The first storm event occurred in the middle of October; the second event at the beginning of December; the third event at the beginning of January, and the last event was at the end of January. The largest storm peak of the period occurred between January 3rd and January 9th.

Unlike Water Year 2007, which was a warm and dry year with very little snow pack, Water Year 2008 was a more typical year with high elevation snow and low elevation rain. In Water Year 2008, a significant spring snow-melt event began during the first week of February and continued through the end of the study period.

The shape of the discharge hydrographs for each of the sites is very similar during winter rain-on-snow and rain generated runoff events (Figure 2 and 3). Accretion was difficult to assess due to upstream diversions for agriculture and public drinking water use. Eight events were evaluated for accretion: the two events that occurred in February, 2007, the two events that occurred in October, 2007, the three events that occurred during December 2007, and the January 2008 event. The accretion rates calculated for the six events ranged from 6% (December 24, 2007) to 66% (January 4, 2008). The wide range of calculated values is indicative of a watershed that experiences snow, rain-on-snow, and rain generated events. Accretion was not evaluated by individual storm type. Typically, many more events would be evaluated, however given the short duration of the study that was not possible.

During periods of streamflow withdrawals for agricultural irrigation and public drinking water purposes the hydrographs have dissimilar shapes. Big Creek at TCR 324 nr. Hayfork, CA is above the agricultural and drinking water diversion points in the basin and represents the full natural surface water flow at the gaging location. Big Creek at Hwy 3 nr. Hayfork, CA is below the agricultural and public drinking water diversion and for the purposes of this study will be used to evaluate surface water diversions. Irrigation return flow and interception of ground water, which have not been evaluated between the two gaging stations, would be potential sources of error in the analysis of surface water diversions. Four events were evaluated for surface water diversions: the diversion cycle that begins on April, 2, 2007, the diversion cycle that begins on May 9, 2007, the cycle that begins on April 2, 2008, and the diversion cycle that begins on May 11, 2008. Since accretion rates can vary substantially depending on water year and climatic conditions and the fact that is was not always possible to directly calculate accretion values prior to each diversion cycle, the values below should be considered estimates.

The hydrographs for the diversion cycle that begins on April 2, 2007 clearly show the amount of water that was diverted upstream of BGCH3. The cycle begins in a period of naturally declining flow (6% accretion) and therefore makes for a fairly straightforward analysis. The irrigation diversion is first noticed at BGCH3 on April 2, 2007 at 14:30 hours and flows begin to stabilize at 21:30 hours that same day. Inspection of the upstream and downstream station at 21:30 hours indicated that roughly 32% of the water is being diverted upstream of BGCH3. The hydrograph for the diversion cycle that begins on May 9, 2007 is more complicated than the previous example since this cycle begins during an already occurring upstream diversion, therefore making it impossible to estimate accretion just prior to the beginning of the new cycle. For the purposes of this analysis we will assume that natural accretion during this time period would be roughly 3%, half the value calculated in April. Inspection of the hydrographs clearly indicates that the diversions were adjusted on May 9, 2007 at around 11:30. The flows begin to stabilize at BGCH3 at 13:15 hours the same day. Inspection of the upstream and downstream flows and using the assumption that accretion is roughly 3% indicates that roughly 49% of the water is being diverted upstream of BGCH3. The hydrographs for the diversion cycle that begin on April 2, 2008 clearly show that diversion upstream of BGCH3 is increased at 19:00 hours. The flows begin to stabilize at 23:15 hours. Inspection of the hydrographs at this point in time and estimated accretion of 3% indicates that roughly 9% of the water is being diverted upstream of BGCH3. The diversion rate is increased on April 3, 2008 at 12:45 resulting in 19% of the water being diverted. The May 11, 2008 diversion cycle begins at 17:00 hours and flows begin to stabilize at BGCH3 by 22:15 hours of the same day. Inspection of the two hydrographs and assuming 3% accretion indicates that 67% of the water is being diverted between BC324 and BGCH3.

Some of the potential errors associated with the above estimates include: cumulative errors associated with the discharge records, unknown and unmeasured irrigation return flows and ground water interception, and finally the limited dataset that the estimates were generated with.

Discharge hydrographs for each of the continuous sites can be found in the Appendices of this report.

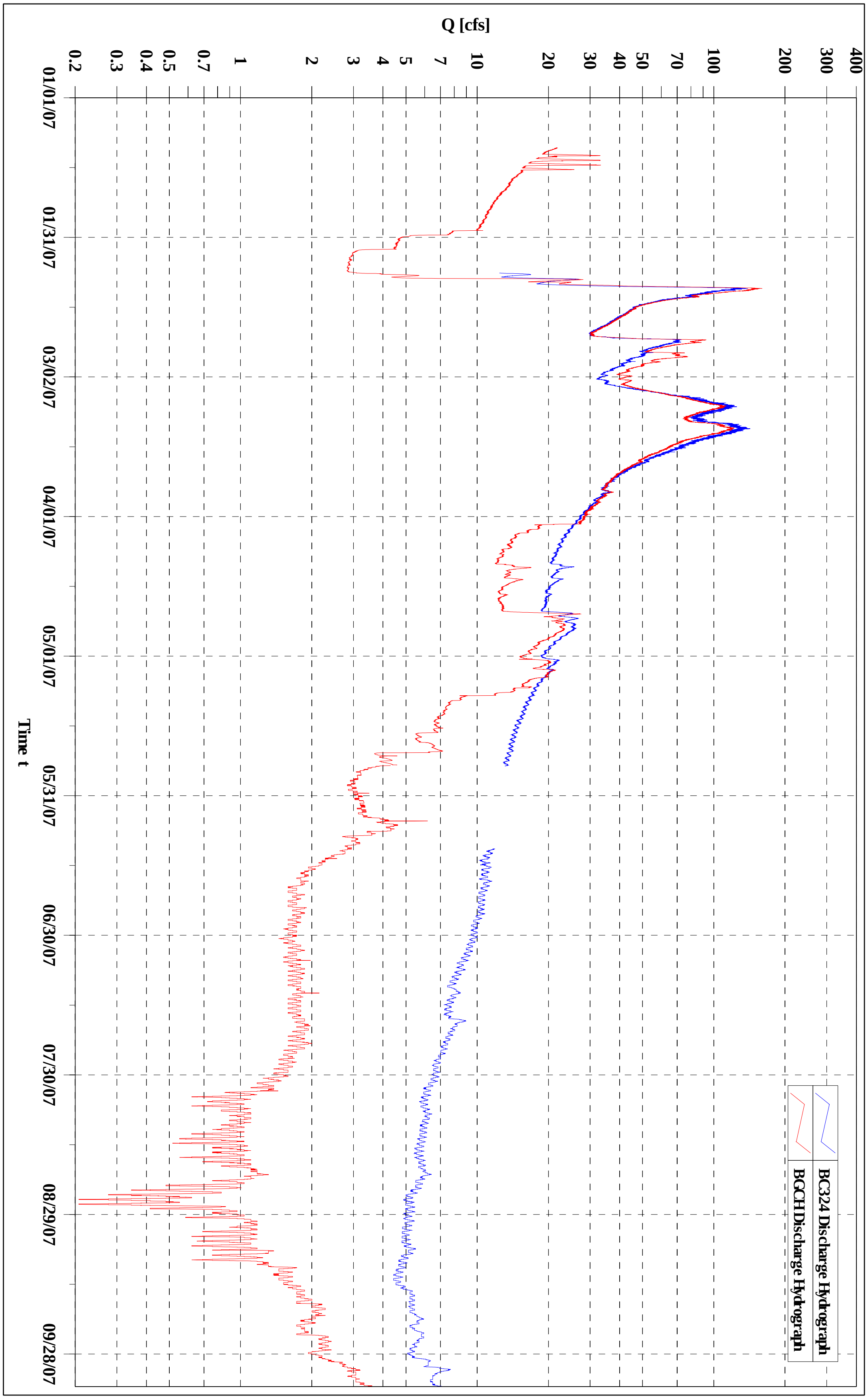


Figure 2. Comparison of Water Year 2007 Discharge Hydrographs -- BC324 11528430 and BGCH3 11528440

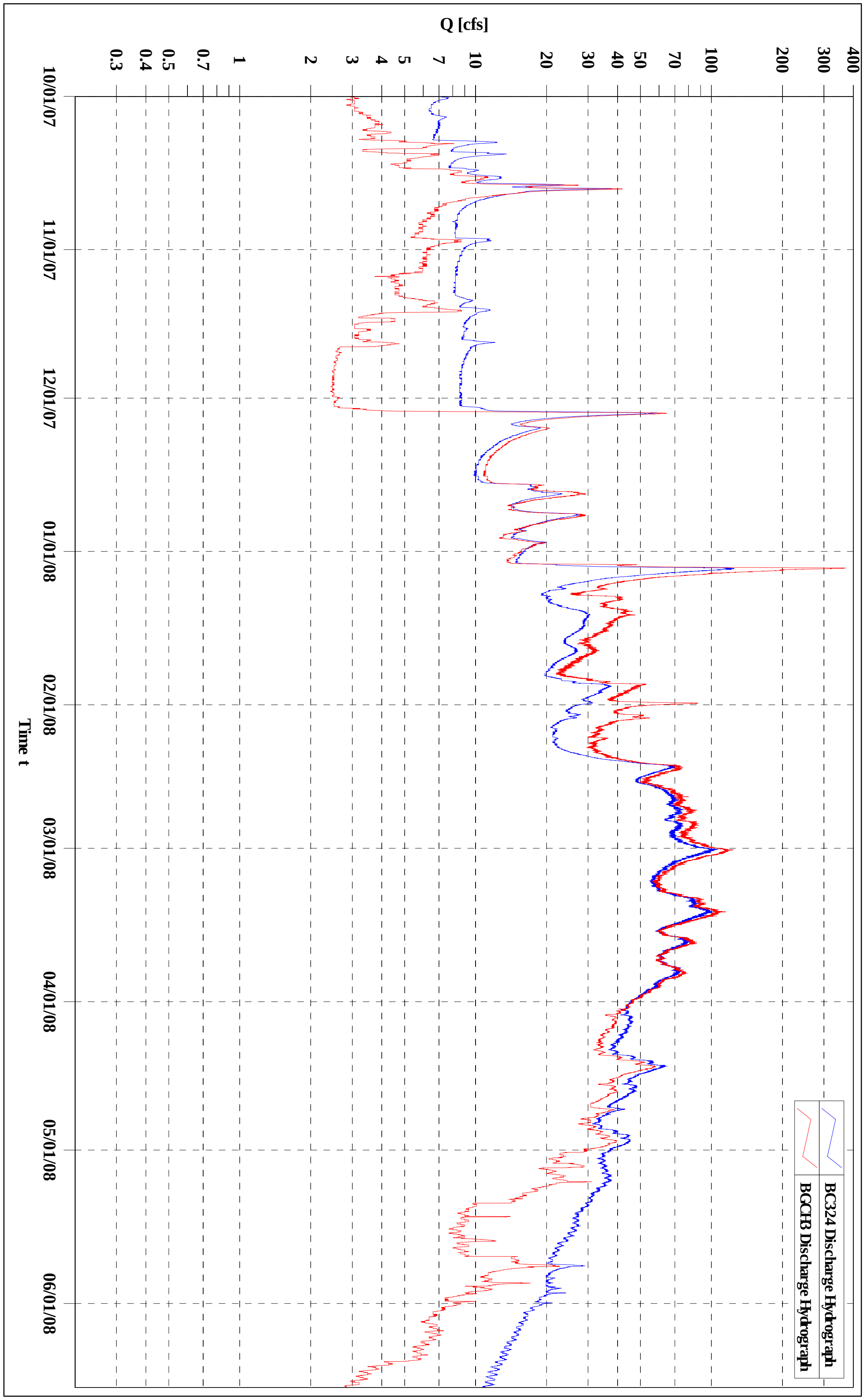


Figure 3. Comparison of Water Year 2008 Discharge Hydrographs -- BC324 11528430 and BGCH3 11528440

4.1.4 Peak Discharges

A summary of the peak discharges during the study period for each of the continuous sites is provided in Table 2. The peak discharges were obtained directly from the appropriate rating tables. Peak discharges were calculated outside of the validated limits of each of the ratings, meaning that the peak discharges were higher than the highest measured discharge used to develop each rating curve. The computed peak values were within the allowable 100% extrapolation limit of each rating.

TABLE 2
BIG CREEK WATERSHED
Summary of Peak Discharge

Site	Date	Discharge (cfs)	Note
Water Year 2007			
BGCH3	February 10, 2007	161	Beyond Validated Limit of Rating but Within Extrapolation Limits
BC324	March 13, 2007	142	Beyond Validated Limit of Rating but Within Extrapolation Limits
Water Year 2008			
BGCH3	January 4, 2008	372	Beyond Validated Limit of Rating but Within Extrapolation Limits
BC324	January 4, 2008	125	Beyond Validated Limit of Rating but Within Extrapolation Limits

4.2 Water Temperature

Water temperature was measured at each of the continuous monitoring sites. Water temperature data presented in this report after May, 2007 were collected using the Design Analysis pressure transducer at BGCH3 and from the DTS-12 turbidity probe at BC324. Gaps in the record at BC324 occurred because the DTS-12 turbidity probe was primarily installed for winter turbidity monitoring. For each of the continuous gaging stations, the data were analyzed and plots of the daily maximum, daily minimum, and the 7-day moving average from the daily max were developed. These plots can be found in the appropriate appendix of this report.

During the first year of the study, the 7-day moving average from the daily maximum at BC324 continued to rise until the sensor was removed in May. At BGCH3, the 7-day moving average continued to rise until late June. Beginning at the end of July, the7-day moving average began to fall and continued to fall through the end of the water year.

From October, 2007 until the end of December, 2007, the 7-day moving average continued to fall at BGCH3. No water temperature data are available at BC324 during the second year of the study until mid-November, at which time the DTS-12 turbidity sensor was re-installed at the site. Between November, 2007 and December, 2007 the 7-day moving average fell at BC324. Between January, 2008 and the end of the study in June, 2008 the 7-day moving average rose at each of the monitoring sites. Figure 4 and Figure 5 are plots of the 7-day moving average from the daily maximum, and the difference between the two for the continuous monitoring sites.

Figure 4 and
Figure 5 indicate that in mid to late March water temperatures at BGCH3 begin to increase more rapidly than at the upstream station, BC324.

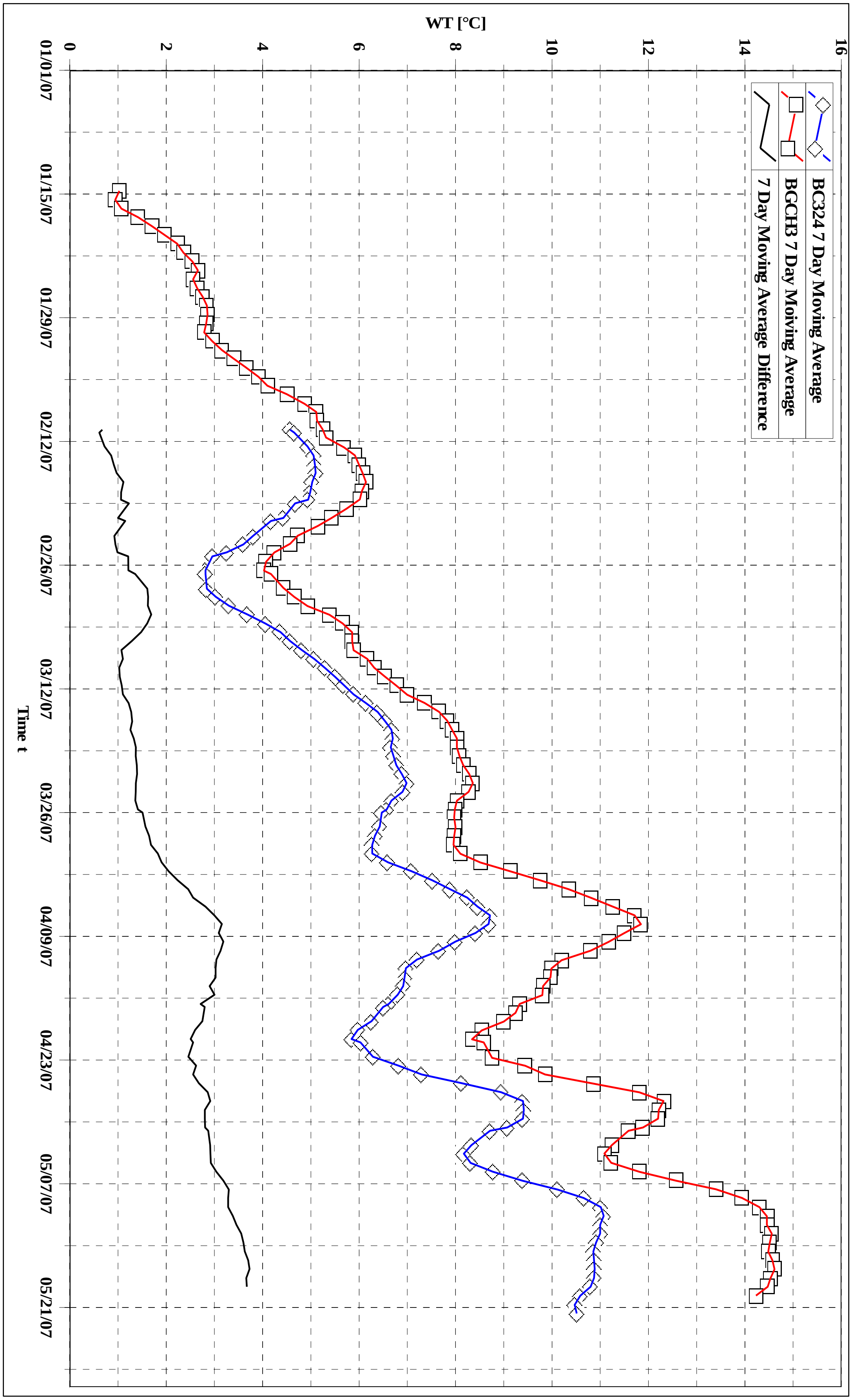


Figure 4. Comparison of Water Year 2007 7-Day Moving Average from Day Max Water Temperature -- BGCH3 11528440 and BC324 11528430

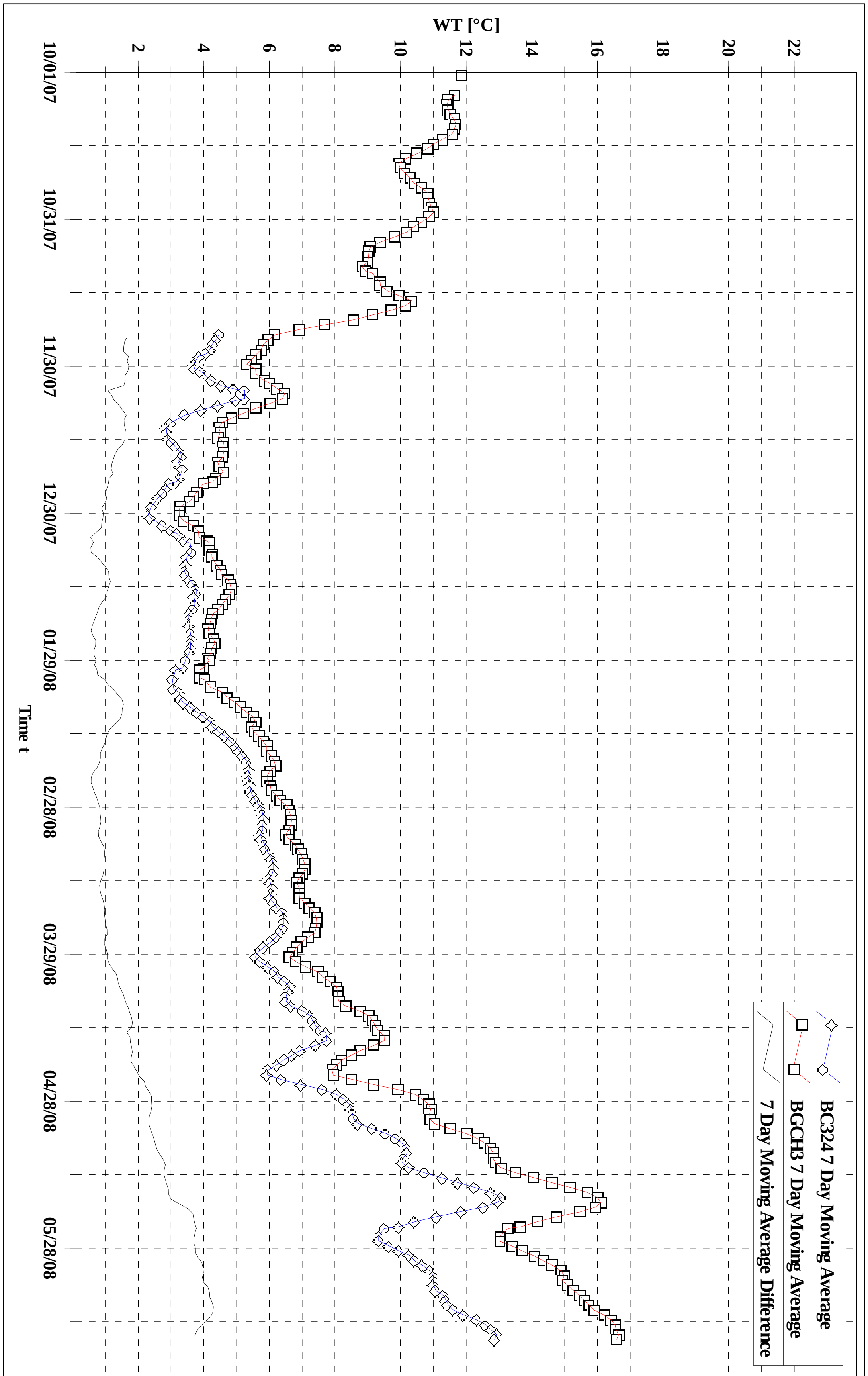


Figure 5. Comparison of Water Year 2008 7-Day Moving Average from Day Max Water Temperature -- BGCH3 11528440 and BC324 11528430

4.3 Sediment Transport

A complete summary of all sediment samples listing the site, date of sample, measurement #, turbidity (NTRU), SSC (mg/l), stage (ft), discharge (cfs), SSD (tons/day), and notes are contained in the appendices of this report.

4.3.1 Turbidity and Suspended-sediment Sampling

A total of 109 sediment measurements, not including replicates, were made during the study period. 38 samples were collected at BC324 and 39 samples were collected at BGCH3. At the manual sediment station anywhere from 1 to 6 samples were collected over the course of the study period. The number and type of samples for each site is listed in Table 3.

TABLE 3
BIG CREEK WATERSHED
Sediment Sample Summary

Site	Total # of Samples Collected	Total # of Depth-Integrated Samples Collected	Total # of Box Samples Collected	Total # of Replicates Collected	Total # of Historical Samples	Total # of Samples
Water Year 2007						
BGCH3	9	5	4	2	30	39
BC324	9	5	4	2	3	12
DC324	5	3	2	0	0	5
T1324	1	0	1	0	0	1
PC324	5	3	2	0	0	5
LC33N47	5	3	2	1	0	5
BC33N47	2	0	2	0	0	2
EFBC	2	0	2	0	0	2
Water Year 2008						
BGCH3	30	16	14	19	39	69
BC324	29	14	15	22	12	41
DC324	6	0	6	0	5	11
T1324	4	0	4	0	1	5
PC324	1	0	1	0	5	6
LC33N47	0	0	0	0	5	5
BC33N47	0	0	0	0	2	2
EFBC	0	0	0	0	2	2
BCBCR	1	1	0	0	0	1

Including replicate samples, 28 correlation samples were collected at BC324 and 25 correlation samples were collected at BGCH3 relating depth-integrated suspended sediment concentration (DIS SSC) and Box SSC. Evaluation of the data pairs indicated that no consistent relationship between DIS SSC and BOX SSC existed at BC324 over the range of concentration sampled. This is likely due to the low concentrations sampled (<0.50 mg/l to 52 mg/l). At BGCH3, evaluation of the data pairs indicated that a fair to good relationship existed between DIS SSC and BOX SSC. The correction coefficient developed between the DIS SSC sample and the Box SSC samples averaged 1, indicating that no correction of Box sampled data is necessary. Future sediment data collection at BGCH3 could be made more efficient and more economical by collecting primarily box samples. If future monitoring were to continue, DIS SSC samples should be collected periodically to verify the relationship and update the correction coefficient, if necessary.

In addition to the correlation samples, 24 replicate samples were collected at BC324 and 18 replicate samples were collected at BGCH3. Replicate samples were collected in the field to evaluate the relative precision or repeatability of sediment measurements. Relative percent difference was calculated for each depth integrated sample (Turbidity and SSC) that had a corresponding replicate. At BHCH3, 31% of the field measurements had corresponding replicates, while at BC324, 39% of the sediment field measurements had corresponding replicates.

At BGCH3, the depth integrated sample turbidity RPD ranged between 0% and 67% and suspended sediment concentration RPD ranged from 0% to 56%. As expected for low turbidities and low suspended sediment concentrations, the RPD was high. As sediment concentration increased, RPD's decreased for both turbidity and suspended sediment concentration. For turbidity values below 5 NTRU, the RPD ranged between 0% and 67% while above 5 NTRU the RPD ranged between 0% and 5%. For suspended sediment concentration values below 10 mg/l the RPD ranged between 5% and 56% while for concentrations above 10 mg/l the RPD ranged between 2% and 6%.

At BC324, the depth integrated sample turbidity RPD ranged between 0% and 150% and suspended sediment concentration RPD ranged from 10% to 87%. Similarly to BGCH3, the RPD decreased as turbidities increased. For turbidity values below 5 NTRU, the RPD ranged between 0% and 150% while above 5 NTRU the RPD ranged between 4% and 24%. Unlike BGCH3, the RPD for suspended sediment concentration did not decrease as the sample concentrations increased. This is likely due to the fact that suspended sediment in not as well mixed at the upper site and that sample concentrations remained low (between <0.50 mg/l and 38 mg/l). For suspended sediment concentration values below 10 mg/l, the RPD ranged between 10% and 87% while for concentrations above 10 mg/l the RPD ranged between 11% and 87%.

4.3.2 Continuous Turbidity Monitoring

Continuous turbidity data were collected at the two continuous stations, BGCH3 and BC324. The continuous turbidity data were plotted along with the discharge hydrographs for each site and show a strong correlation with the discharge when viewed over the entire study period (Figure 6 and Figure 7). Typically, water discharge is not a good predictor of suspended-sediment concentration for streams that transport the bulk of their sediment load as fines, because the delivery of sediment to the channel from hillslopes, roads, and landslides is highly variable (Eads 2002). In contrast, turbidity has been found to be a much better predictor of suspended-sediment concentration than discharge, and a sampling scheme that employs turbidity, which is well correlated to suspended-sediment concentration, can be expected to improve sampling efficiency and load estimation (Eads 2002).

During the first year of the study, turbidity measured by the DTS-12 turbidity sensors appeared accurate and required very little removal of spikes or adjustment due to biofouling. In general, the turbidity record at the upstream site, BC324, contains more noise than the record at the lower site, BGCH3. The noise at the upper site is primarily due to entrained air bubbles that are present in the water column. During the second year of the study, the turbidity probe at BGCH3 experienced numerous periods of poor data due to debris being caught on the probe as well as to biofouling. Any periods of extended poor data were removed from the records. For periods that contained short duration turbidity spikes or drop outs, the erroneous data were removed and the gaps were filled by linear interpolation or eye-fit data points. The turbidity records for each of the sites are provided in the appropriate Appendices at the back of this report.

During the first year of the study, the continuous turbidity records indicate that BC324 reached a peak turbidity of 23.0 FNU on February 10, 2007 at 21:30 hours, while BGCH3 reached a peak turbidity of

75.3 FNU on February 10, 2007 at 15:00 hours. This is an increase of roughly 227% between the upper and lower continuous monitoring sites. The first turbidity event, which peaked on February 8, 2007, showed an increase of turbidity from the upper to the lower site of roughly 1360%. The large increase in turbidity from the upper site to the lower site during these first two storm events indicates that the fine sediment supply was larger in the lower portion of the watershed during this time period. Further, the fact that the turbidity peaked at the downstream station prior to the turbidity peaking at the upstream station indicates that there is a sediment source contributing below the upstream gage.

The continuous turbidity records were also compared for the two storm events that occurred during the first two weeks of March, 2007. The first peak which occurs on March 8, 2007 indicates an increase in turbidity of roughly 100% while the second event, which peaks on March 12, 2007, indicates an increase in turbidity of roughly 65%. Inspection of the continuous turbidity record also indicates that the two sites reach peak turbidity almost simultaneously.

During the first year of the study, turbidity increases from BC324 to BGCH3 are in the range of 65% and 1360%. Figure 6 shows a comparison of the two sites' continuous turbidity record for WY2007.

During the second year of the study, the continuous turbidity records indicate that BC324 reached a peak turbidity of 36.7 FNU on January 4, 2008 at 08:15 hours, while BGCH3 reached a peak turbidity of 299 FNU on January 4, 2008 at 07:45 hours. This is an increase of roughly 714% between the upper and lower continuous monitoring sites. The first turbidity event, which peaked on December 3, 2007, showed an increase of turbidity from the upper to the lower site of roughly 313%. The large increase in turbidity from the upper site to the lower site during these first two storm events further indicates that the fine sediment supply was larger in the lower portion of the watershed during this time period. Once again, during the peak storm of WY08 on January 4, the turbidity peaked at the downstream station prior to the turbidity peaking at the upstream station, indicating a contributing sediment source between the two continuous gages.

It was difficult to compare the continuous turbidity records during spring turbidity peaks because BGCH3 experienced significant biofouling during this time period. A single snowmelt event was compared during the second week of March, 2008. The peak occurs on March 13, 2008 indicates an increase in turbidity of roughly 197%. During this event, turbidity peaked roughly 3 hours early at the upper site. Figure 7 shows a comparison of the two sites' continuous turbidity record for WY2008.

The continuous turbidity records are used as surrogates to estimate suspended sediment discharges in the Big Creek watershed. In order to estimate suspended sediment discharge, a continuous suspended sediment concentration record is developed which is then transformed into continuous suspended sediment discharge. Suspended sediment discharge can then be used to estimate sediment loads. The relationship was developed between continuous turbidity and SSC from depth-integrated samples. Turbidity graphs for each of the continuous sites can be found in the appropriate Appendix of this report.

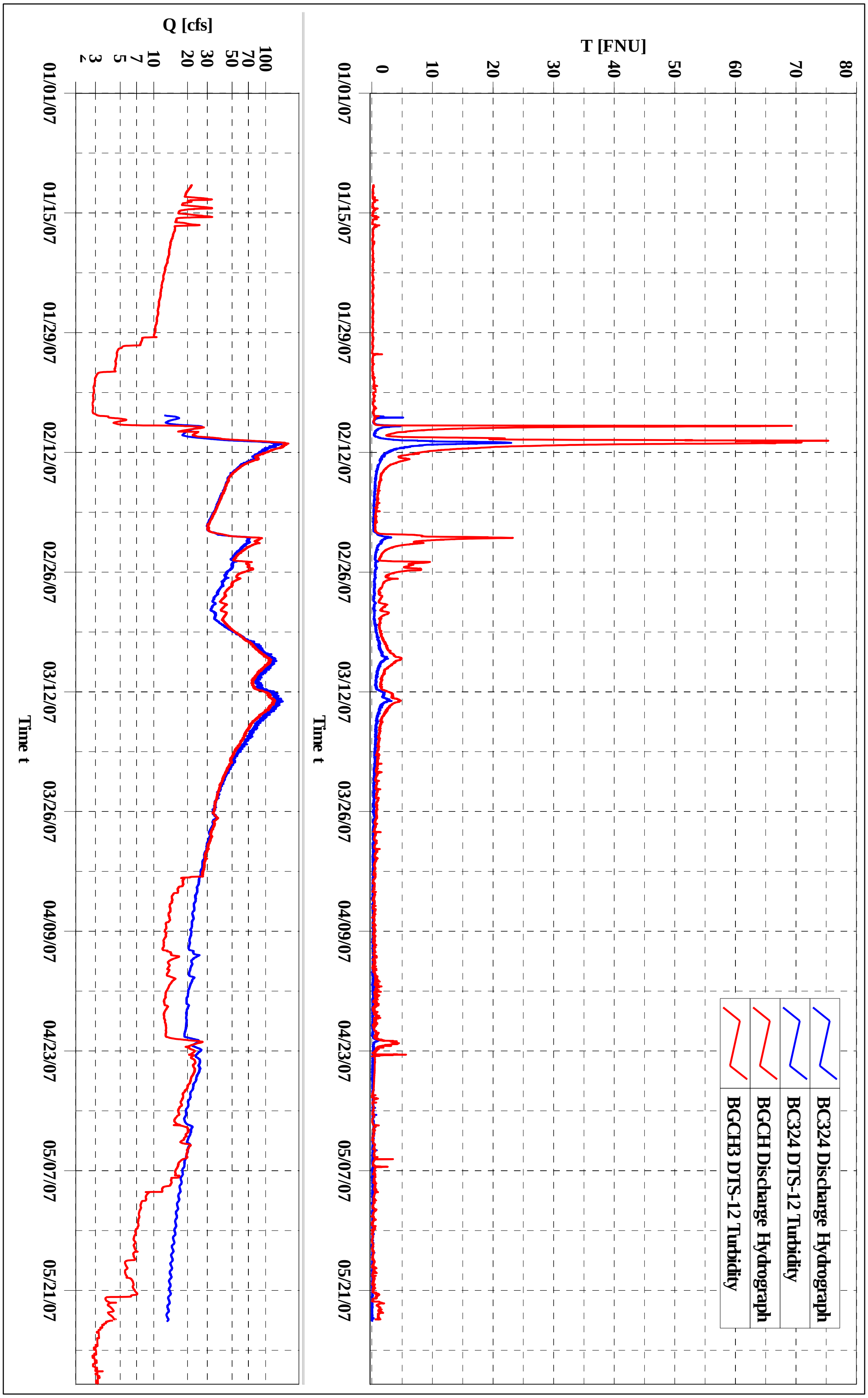


Figure 6. Comparison of Water Year 2007 Continuous Turbidity and Hydrographs -- BGCH3 11528440 and BC324 11528430

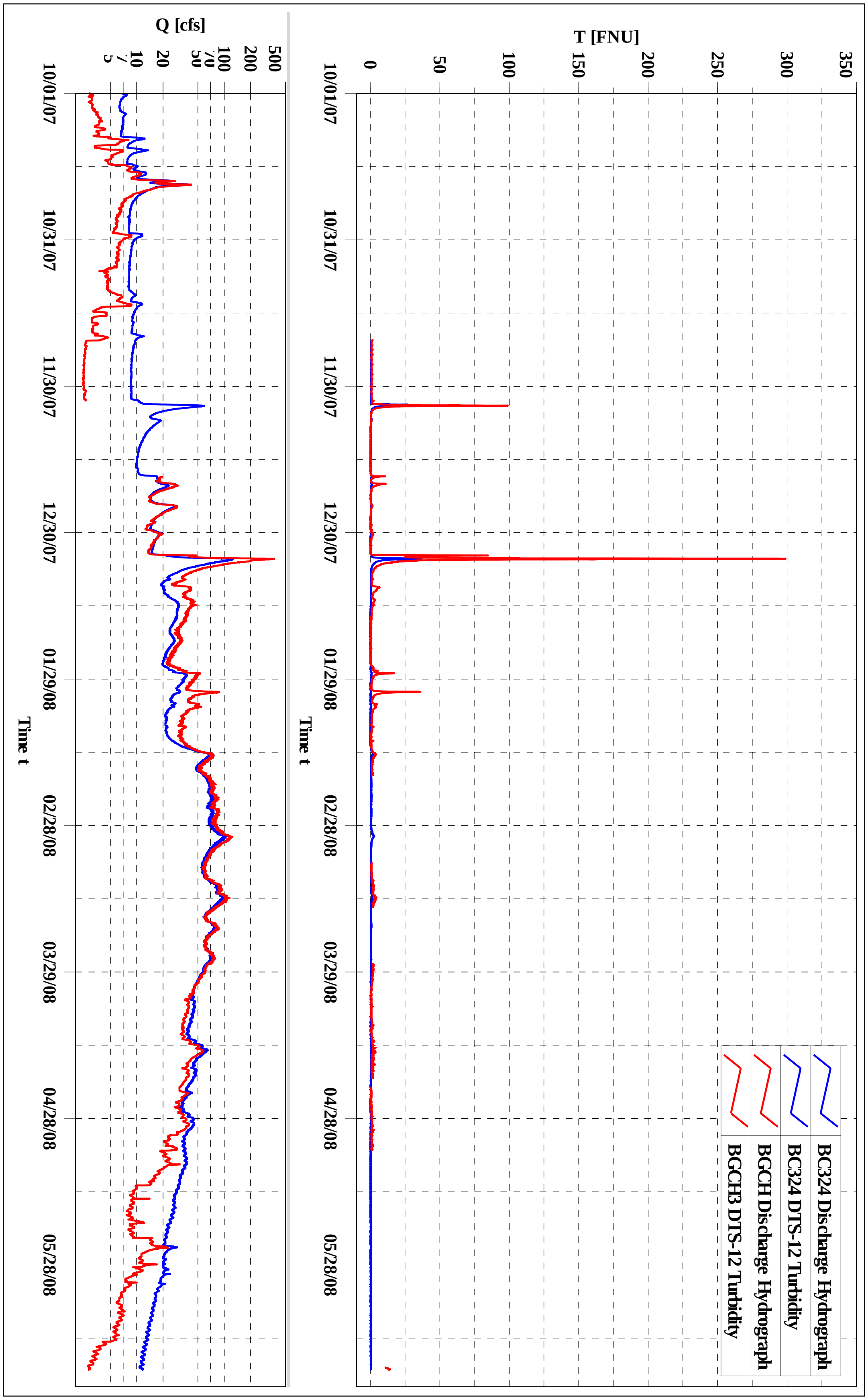


Figure 7. Comparison of Water Year 2008 Continuous Turbidity and Hydrographs -- BGCH3 11528440 and BC324 11528430

4.3.3 Sediment Transport Rates

Suspended-sediment versus turbidity relationships as well as suspended sediment versus discharge relationships, if appropriate, were developed for the two continuous sites. In addition, at BGCH3, lab turbidity values were transformed to equivalent DTS-12 turbidities. It was necessary to transform the lab turbidity data to equivalent DTS-12 values due to the fact that some of the samples were collected during periods of time when the continuous DTS-12 turbidity record was not useable and therefore no turbidity value was available to use in the turbidity/SSC relationship. For periods of time where a good DTS-12 turbidity record was available, the turbidity data were pulled from the continuous turbidity record and paired with the corresponding suspended sediment concentration lab data. The SSC versus turbidity relationship was then applied to the continuous turbidity record in order to estimate suspended sediment discharges and loads over the course of the study.

Below is a list of equations which define the relationships used to estimate suspended sediment discharge for both sites. The graphs of the relationships can be found in the appropriate Appendix of this report.

The DTS-12 turbidity (FNU) versus the LaMotte lab turbidity (NTRU) relationship used to transform lab turbidities at BGCH3 is described by equation (1) below.

$$DTS-12Turb = 1.82473(LaMotteLabTurb)^{0.963197}, R^2 = 0.99 \qquad \text{Eqn. (1)}$$

The suspended sediment versus turbidity relationship developed for BGCH3 is described by equation (2) below.

$$SSC = 1.05683(Turbidity)^{1.08797}, R^2 = 0.99 \qquad \text{Eqn. (2)}$$

The suspended sediment versus discharge relationship developed to estimate suspended sediment concentration at BGCH3 during periods of missing turbidity record is described by equation (3) below.

$$SSC = 6.63015e^{-5}(Discharge)^{2.56004}, R^2 = 0.97 \qquad \text{Eqn. (3)}$$

The suspended-sediment versus turbidity relationship developed for BCH324 is described by equation (4) below.

$$SSC = 1.49425(Turbidity)^{0.938579}, R^2 = 0.96 \qquad \text{Eqn. (4)}$$

Once turbidity/SSC relationships were developed for each of the continuous sites, the relationships were applied to the continuous turbidity record or the discharge record in order to estimate continuous concentration curves and eventually estimate suspended-sediment discharge curves.

4.3.4 Sediment Transport Loads

Total suspended-sediment load was estimated for each of the continuous sites. Suspended sediment load estimates for each year of the study are shown in Table 4. In Water Year 2007, suspended sediment load at the upper site, BC324, was 14.4 tons and at the lower site, BGCH3, the load was estimated at 44.8 tons. This represents a change in load of 30.4 tons between the upper site and the lower site or an increase in load of 211% between the upper site and the lower site.

TABLE 4 BIG CREEK WATERSHED Summary of Suspended Sediment Load		
Site	**Load (tons)**	**Note**
Water Year 2007		
BGCH3	44.8	Discharge Used as Surrogate for SSC for Periods of Missing Turbidity Record
BC324	14.4	
Water Year 2008		
BGCH3	152	Discharge Used as Surrogate for SSC for Periods of Missing Turbidity Record
BC324	18.8	

In Water Year 2008, the estimated suspended sediment load at the upper site was 18.8 tons and was 152 tons at the lower site. This represents a change in load between the upper and lower site of 133 tons or an increase in load of 707%.

Comparing between Water Year 2007 and Water Year 2008, the load at the upper site was 31% greater in Water Year 2008 than WY2007 and was 239% greater at the lower site.

In addition, comparison between the two sites was conducted by looking at the percent of the total load that was transported at each site over different storm events. Figure 8 and Figure 9 show the Water Year 2007 and Water Year 2008 discharge hydrograph for each station along with the cumulative percent of total suspended-sediment load transported.

Inspection of Figure 8 indicates that 65 % of the total estimated load at BGCH3 was transported by the first two sediment transport events (February 8, 2007 through February 16, 2007), whereas at BC324 only 40% of the total estimated load had been transported for the same period. The next event (February 20, 2007 through February 27, 2007) increased the percent of total load transport at BGCH3 by 15%, while at BC324 the percent of total load transported increased by 11%. The final period analyzed was the period between March 2, 2007 and March 26, 2007. Coming into this period BGCH3 had transported 81% of the total estimated load, whereas BC324 had transported only 51% of its total estimated load. From March 2, 2007 to March 26, 2007 the percent of total load transported at BC324 increased by 47% while the percent of total load transported at BGCH3 increased by only 18%. This is likely due to the type of transport event that was occurring. During this period, runoff in the upper basin would have been high due to snowmelt. In Water Year 2007, BC324 transported most of its suspended load during the snowmelt hydrograph whereas the majority of the load at BGCH3 was generated during rain or rain on snow events when overland flow is high.

Inspection of Figure 9 indicates that 75% of the total estimated load at BGCH3 was transported by a single storm event that occurred between January 3, 2008 and January 9, 2008. In contrast, only 27% of the total load estimated for BC324 was transported during the same period. This storm began with snow falling in the upper and lower basin. As the storm progressed, the lower basin began to experience mixed snow and rain and eventually rain, which produced high overland flow rates. Further inspection of Figure 9 indicates that very little load was transported at either of the sites between January 9, 2008 and the beginning of February. Coming into the snow melt period, which begins around February 9, 2008, BGCH3 had transported 82% of its total load for the water year and BC324 had transported only 45% of its total load for the water year. As was seen in Water Year 2007, over half (55%) of the total load for

BC324 was transported during the snow melt period. In contrast, only 18% of the total load transported at BGCH3 occurred during the snowmelt period.

Although the duration of this study was short some insight was gained on the nature of suspended sediment transport in the Big Creek watershed. Figure 8 and Figure 9 clearly indicate that a majority of the material transported in the lower basin, below BC324, occurs early in the year. The figures also indicate that transport in the upper basin, above BC324, occurs primarily during snowmelt. The Appendices in this report include graphs of the discharge hydrographs and the cumulative suspended sediment loads for each of the continuous sites.

5.0 CONCLUSIONS

Two continuous (streamflow and turbidity) and 6 manual (Turbidity/SSC samples) sites were established in the Big Creek watershed during the study period. Adequate stage-discharge relationships were developed at the two continuous monitoring sites so that reasonably accurate streamflow records could be computed. Depth integrated suspended sediment samples and continuous turbidity data were collected and strong relationships were developed between the two data sets. In addition, box samples were collected and evaluated to determine if single point samples collected at each of the monitoring sites would be useful for future monitoring. At BGCH3, there is a strong relationship between box samples and depth integrated cross sectional samples while at BC324 there appears to be no correlation between the two types of samples. Finally, estimates of continuous suspended sediment discharge and computation of total suspended sediment loads were carried out for each of the continuous sites. Suspended sediment was not produced equally at the two continuous sites. Suspended sediment production was highest at the lowest site, BGCH3, during rain or rain on snow events while suspended sediment production at the upper site, BC324, was highest during periods of snowmelt.

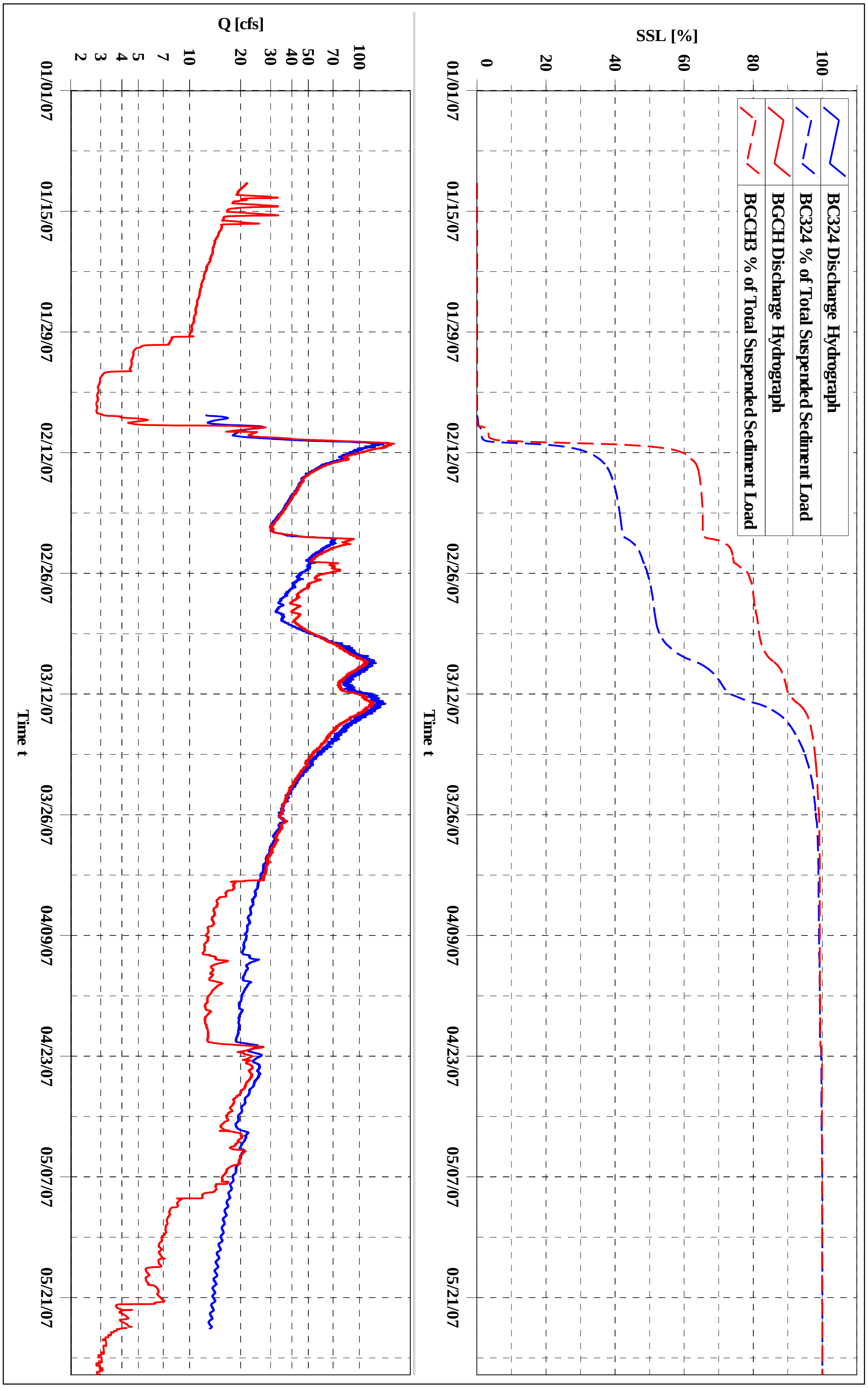


Figure 8. Water Year 2007Cumulative Percent of Total Suspended Sediment Load with Discharge Hydrographs -- BGCH3 11528440 and BC324 11528430

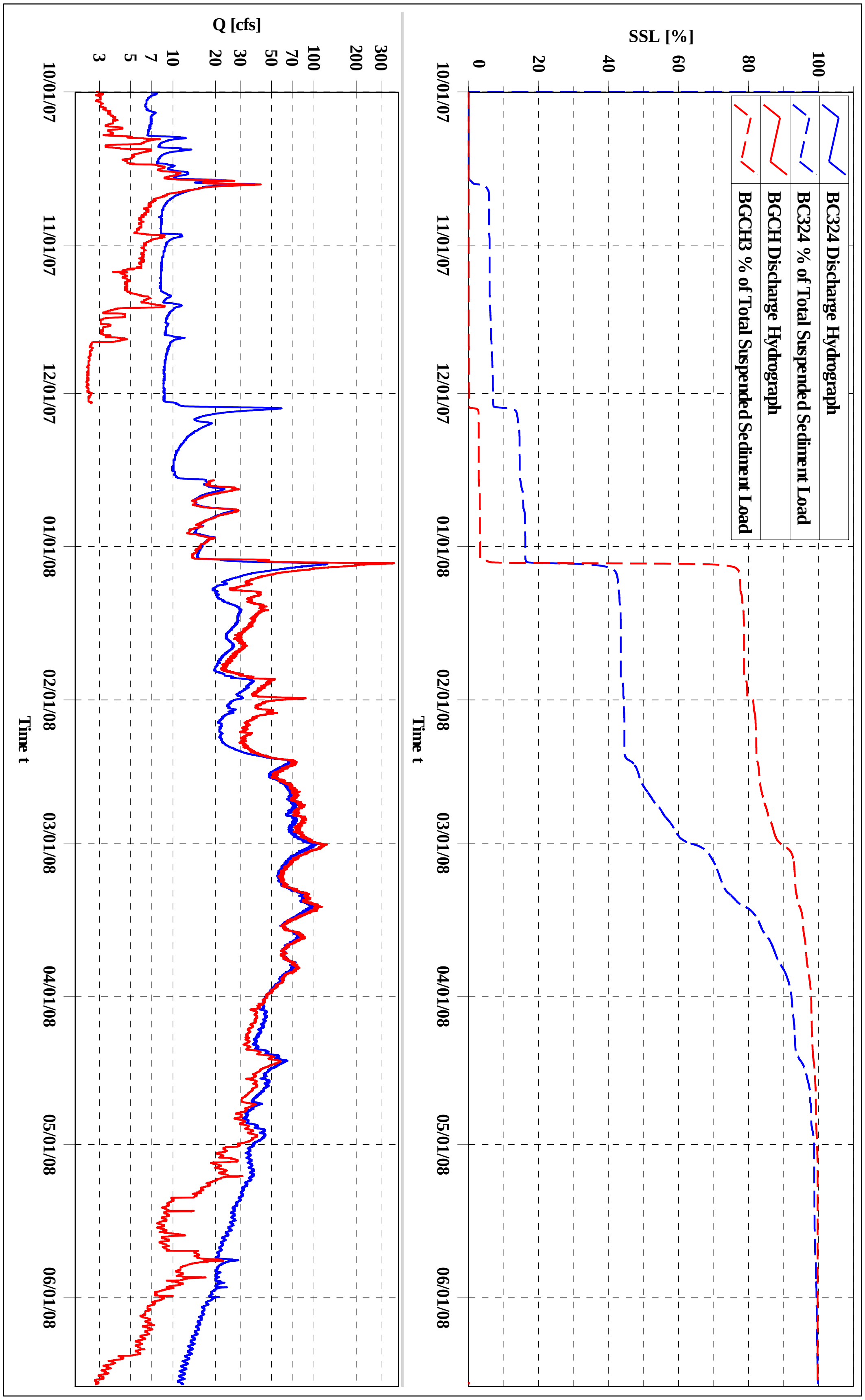


Figure 9. Water Year 2008 Cumulative Percent of Total Suspended Sediment Load with Discharge Hydrographs -- BGCH3 11528440 and BC324 11528430

6.0 REFERENCES

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DISCHARGE SUMMARY SHEET

STATION: Big Creek at Hwy 3 Nr Hayfork, Ca **WATER YEAR:** 2007-2008
STATION NUMBER: 11528440

Measurement Number	WY Msmt #	Date	Made By	Width (feet)	Mean Depth (feet)	Area (ft2)	Mean Velocity (ft/sec)	Staff Height (feet)	Gage Height (feet)	Discharge (cfs)	Rating __3.1___ Comp. Shift (feet)	Used Shift (feet)	% Diff.	Method	Begin Time (hours)	End Time (hours)	Msmt Rating	GZF (feet)	Water Temp (F)	Comments
10	**2007-01**	02/06/2007	J. Huddman	19.0	0.67	12.8	0.24	3.81	3.82	3.11	0.02	0.00	9	Wading	14:00	14:54	Poor	3.41		
11	**2007-02**	02/12/2007	J. Huddman	21.0	1.66	35.0	1.66	4.95	4.97	84.2	0.00	0.00	0	Wading	15:01	15:51	Fair	3.35		GZF Unreliable due to high flow
12	**2007-03**	03/31/2007	L. Cornelius	23.1	0.87	20.1	1.51	4.45	4.45	30.3	0.01	0.00	4	Wading	12:45	13:30	Good	3.40		
13	**2007-04**	05/24/2007	L. Cornelius	17.7	0.49	8.7	0.47	3.91	3.94	4.05	-0.03	0.00	13	Wading	10:25	10:50	Poor	3.41		
14	**2008-01**	12/18/2007	J. Smith	22.8	0.73	16.5	1.12	4.32	4.32	18.5	0.00	0.00	1	Wading	11:19	12:24	Fair	---		
15	**2008-02**	01/04/2008	W. Smith	27.2	2.30	62.4	5.19	6.12	6.04	324	0.00	0.00	0	Wading	10:39	12:03	Fair	---		
16	**2008-03**	02/19/2008	J. Smith	27.5	1.21	33.4	2.28	4.88	4.88	76.2	0.04	0.03	2	Wading	13:57	15:03	Fair	---		
17	**2008-04**	04/03/2008	L. Cornelius	25.0	1.01	25.3	1.64	4.58	4.58	41.6	0.03	0.02	-1	Wading	09:30	10:04	Good	3.28		New Pivot
18	**2008-05**	06/22/2008	L. Cornelius	18.4	0.38	7.03	0.38	3.81	---	2.65	-0.02	0.00	-4	Wading	09:32	09:59	Fair	3.11		

PROJECT:
2007 - 2008 BIG CREEK SEDIMENT SOURCE ANALYSIS
WATER QUANTITY AND QUALITY
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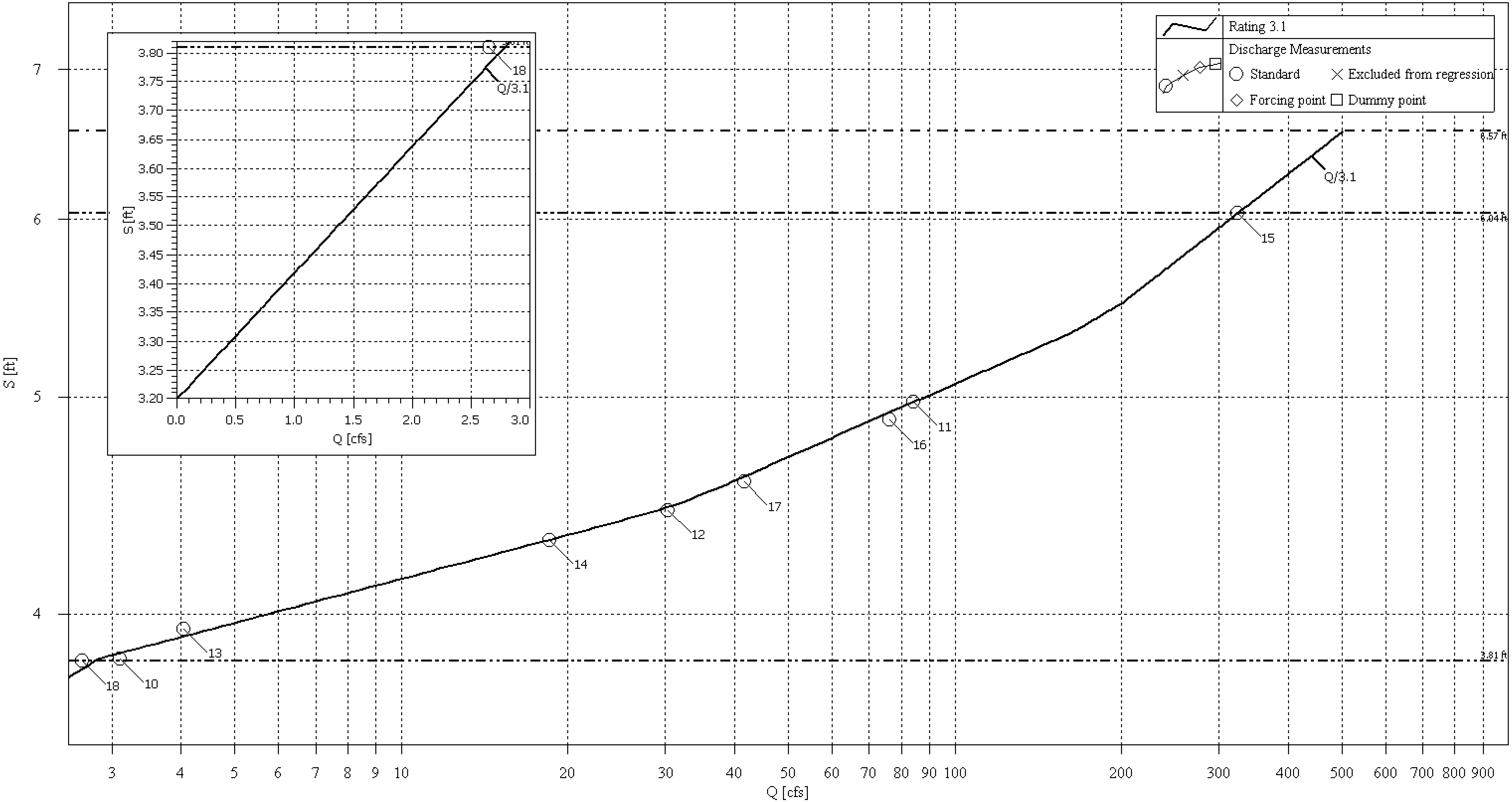
APPENDIX
A-1

BIG CREEK AT HWY 3 NR HAYFORK, CA -- 11528440

Discharge Rating Curve 3.1 – Begin Date 01/11/07



PROJECT:

2007 - 2008 BIG CREEK SEDIMENT SOURCE ANALYSIS
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APPENDIX

A-2

Graham Matthews & Associates

BIG CREEK AT HWY 3 NR HAYFORK, CA -- 11528440

RATING TABLE NO. 3.1 -- Begin Date 1/11/2007

GH	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	1st Diff	2nd Diff
2.4	---	---	---	---	---	---	---	---	---	---	---	---
2.5	---	---	---	---	---	---	---	---	---	---	---	---
2.6	---	---	---	---	---	---	---	---	---	---	---	---
2.7	---	---	---	---	---	---	---	---	---	---	---	---
2.8	---	---	---	---	---	---	---	---	---	---	---	---
2.9	---	---	---	---	---	---	---	---	---	---	---	---
3.0	---	---	---	---	---	---	---	---	---	---	---	---
3.1	---	---	---	---	---	---	---	---	---	---	---	---
3.2	*0.00*	*0.05*	*0.09*	*0.14*	*0.18*	*0.23*	*0.27*	*0.32*	*0.37*	*0.41*	---	---
3.3	*0.46*	*0.50*	*0.55*	*0.59*	*0.64*	*0.69*	*0.73*	*0.78*	*0.82*	*0.87*	0.5	---
3.4	*0.91*	*0.96*	*1.01*	*1.05*	*1.10*	*1.14*	*1.19*	*1.23*	*1.28*	*1.32*	0.5	-0.01
3.5	*1.37*	*1.42*	*1.46*	*1.51*	*1.55*	*1.60*	*1.64*	*1.69*	*1.74*	*1.78*	0.5	0.01
3.6	*1.83*	*1.87*	*1.92*	*1.96*	*2.01*	*2.06*	*2.10*	*2.15*	*2.19*	*2.24*	0.5	0.00
3.7	*2.28*	*2.33*	*2.38*	*2.42*	*2.47*	*2.51*	*2.56*	*2.60*	*2.65*	*2.70*	0.5	0.00
3.8	*2.74*	2.79	2.83	2.95	3.07	3.19	3.32	3.46	3.60	3.74	1.0	0.58
3.9	3.89	4.05	4.21	4.38	4.56	4.74	4.93	5.12	5.32	5.53	1.8	0.75
4.0	5.75	5.97	6.21	6.45	6.70	6.96	7.23	7.50	7.79	8.09	2.6	0.77
4.1	8.40	8.72	9.05	9.40	9.75	10.1	10.5	10.9	11.3	11.7	3.6	1.05
4.2	12.2	12.6	13.1	13.6	14.1	14.6	15.1	15.7	16.3	16.9	5.2	1.59
4.3	17.5	18.1	18.8	19.4	20.1	20.9	21.6	22.3	23.1	23.9	7.0	1.80
4.4	24.8	25.6	26.5	27.3	28.2	29.1	30.0	30.9	31.8	32.5	8.6	1.60
4.5	33.2	34.0	34.7	35.5	36.3	37.1	37.8	38.6	39.5	40.3	7.8	-0.80
4.6	41.1	42.0	42.8	43.7	44.6	45.4	46.4	47.3	48.2	49.2	8.9	1.10
4.7	50.1	51.1	52.1	53.2	54.2	55.3	56.4	57.5	58.6	59.7	10.5	1.60

NOTES: *Values in Italics are beyond the validated range of the rating*

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APPENDIX
A-3a

BIG CREEK AT HWY 3 NR HAYFORK, CA -- 11528440
PROVISIONAL RATING TABLE NO. 3.1 -- Begin Date 1/11/2007

GH	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	1st Diff	2nd Diff
4.8	60.9	62.0	63.2	64.5	65.7	67.0	68.2	69.5	70.9	72.2	12.5	2.00
4.9	73.6	75.0	76.4	77.8	79.3	80.8	82.3	83.8	85.4	87.0	14.8	2.30
5.0	88.6	90.2	91.9	93.6	95.3	97.1	98.9	101	103	104	17.0	2.20
5.1	106	108	110	112	114	116	118	121	123	125	21.0	4.00
5.2	127	129	132	134	136	139	141	144	146	149	24.0	3.00
5.3	151	154	157	159	162	165	167	169	171	173	24.0	0.00
5.4	176	178	180	182	185	187	189	192	194	197	24.0	0.00
5.5	199	201	203	205	207	209	211	213	215	217	20.0	-4.00
5.6	219	221	223	225	227	229	231	234	236	238	21.0	1.00
5.7	240	242	245	247	249	251	254	256	258	260	22.0	1.00
5.8	263	265	268	270	272	275	277	280	282	285	25.0	3.00
5.9	287	290	292	295	297	300	303	305	308	311	26.0	1.00
6.0	313	316	319	322	324	*327*	*330*	*333*	*336*	*339*	28.0	2.00
6.1	*342*	*344*	*347*	*350*	*353*	*356*	*359*	*362*	*365*	*369*	30.0	2.00
6.2	*372*	*375*	*378*	*381*	*384*	*387*	*391*	*394*	*397*	*401*	32.0	2.00
6.3	*404*	*407*	*411*	*414*	*417*	*421*	*424*	*428*	*431*	*435*	34.0	2.00
6.4	*438*	*442*	*445*	*449*	*453*	*456*	*460*	*464*	*467*	*471*	36.0	2.00
6.5	*475*	*479*	*483*	*487*	*490*	*494*	*498*	*502*	---	---	---	---
6.6	---	---	---	---	---	---	---	---	---	---	---	---
6.7	---	---	---	---	---	---	---	---	---	---	---	---
6.8	---	---	---	---	---	---	---	---	---	---	---	---
6.9	---	---	---	---	---	---	---	---	---	---	---	---
7.0	---	---	---	---	---	---	---	---	---	---	---	---

NOTES: *Values in Italics are beyond the validated range of the rating*

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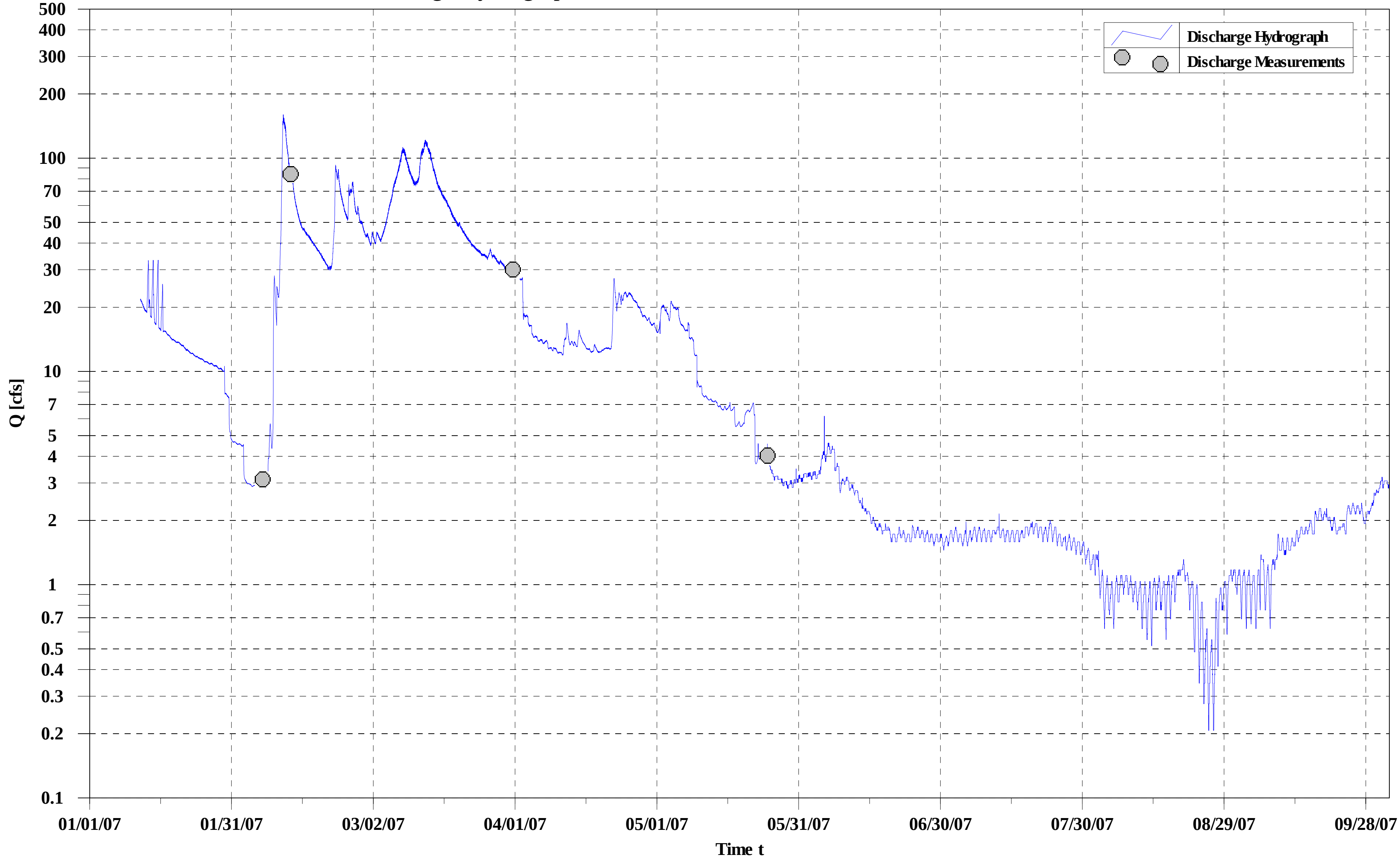
BIG CREEK AT HWY 3 NR HAYFORK, CA – 11528440

Discharge Hydrograph with Measurements – Partial Water Year 2007



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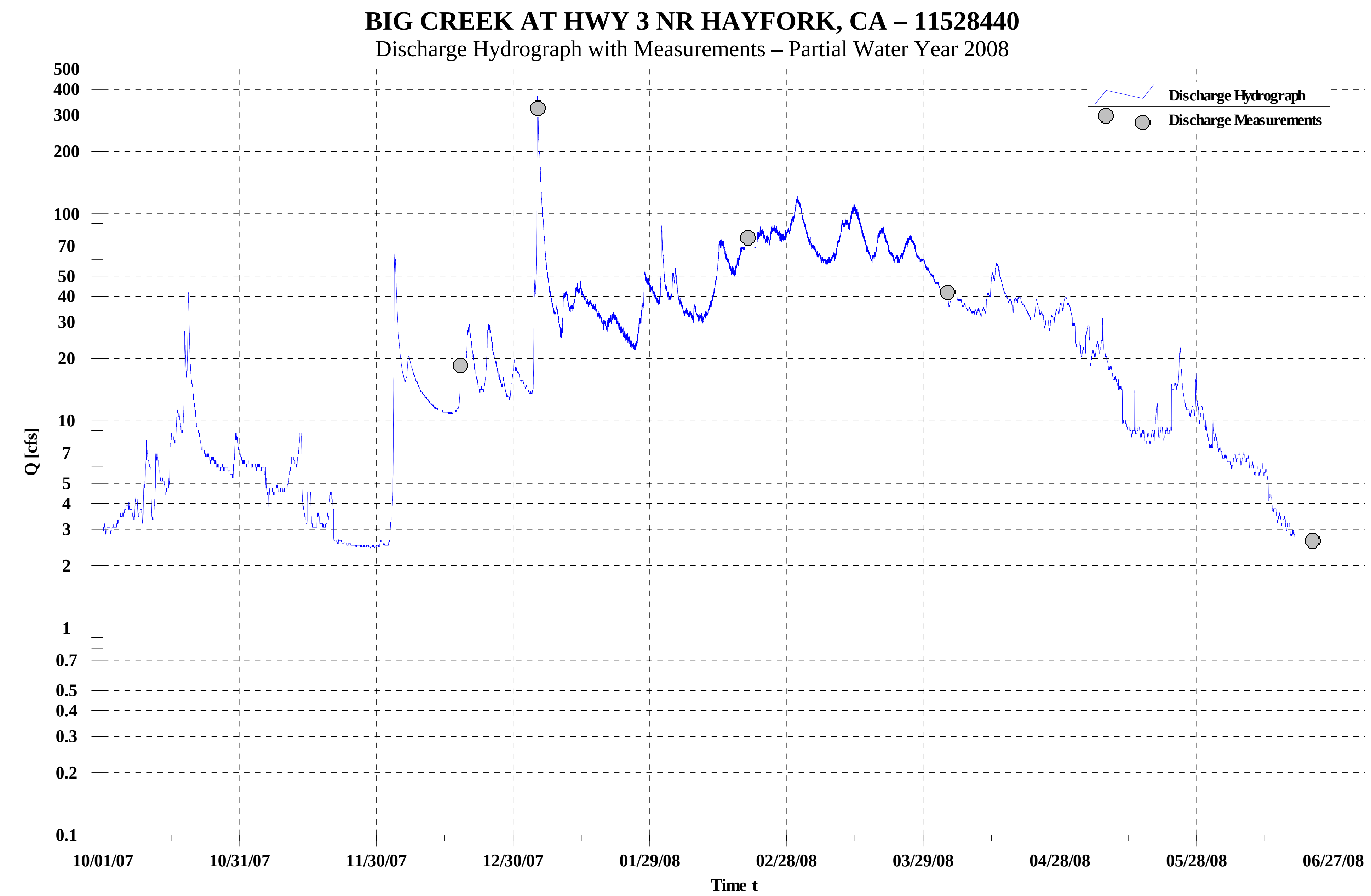

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(530) 623-0520

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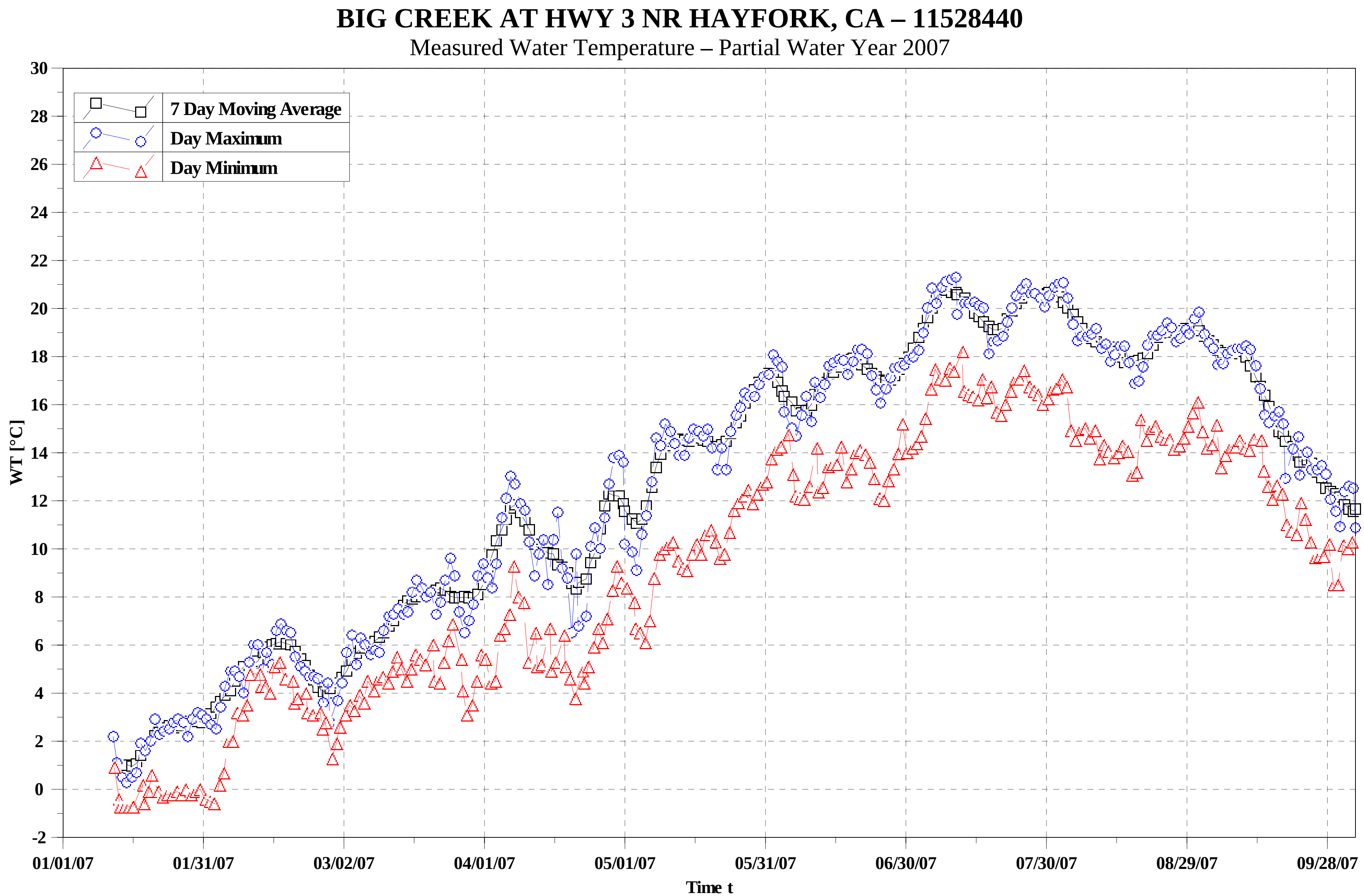

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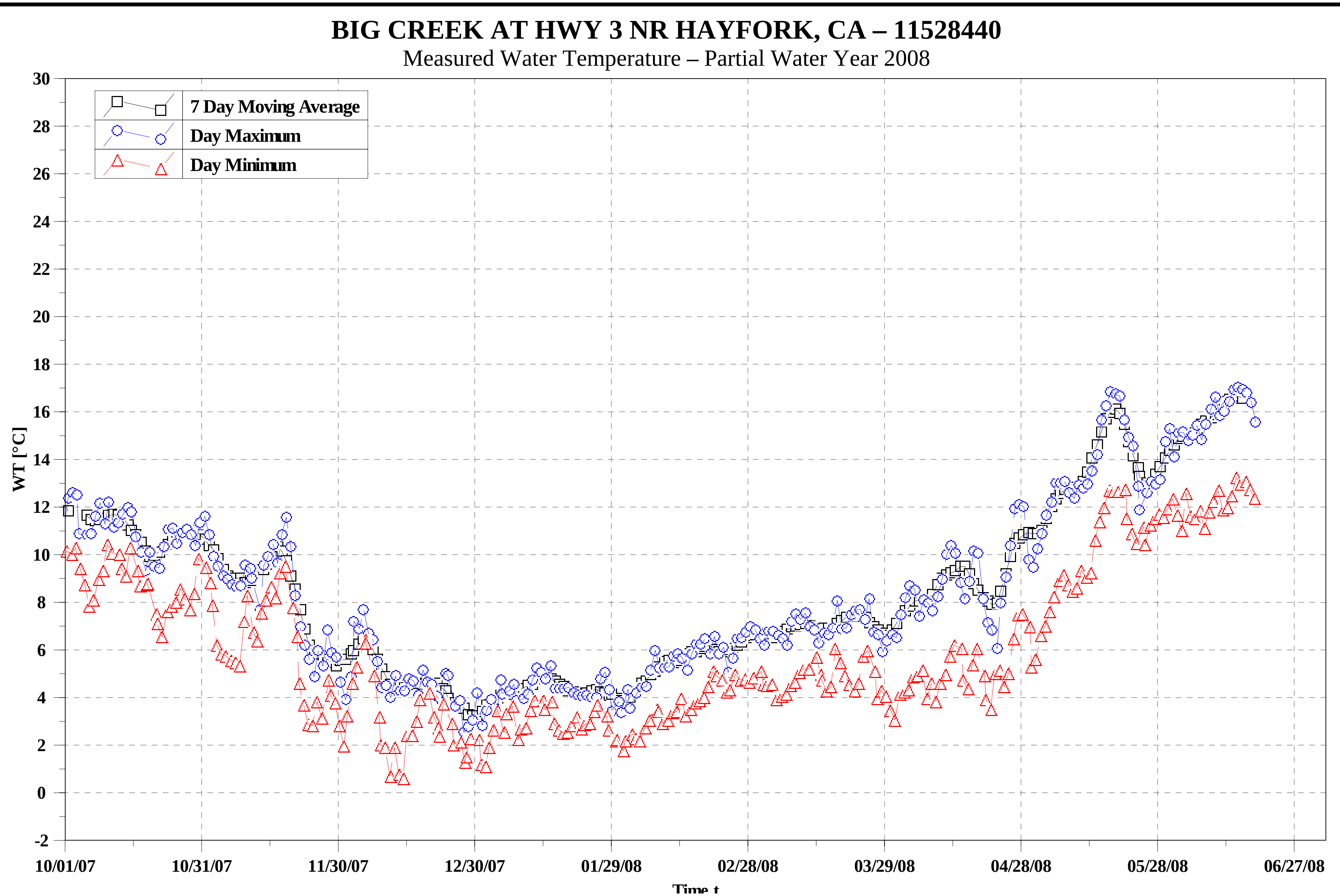

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APPENDIX

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SUSPENDED SEDIMENT MEASUREMENT SUMMARY SHEET

LOCATION: BIG CREEK AT HWY 3 NEAR HAYFORK CA **WATER YEAR 2001-2008**

STATION NUMBER: 11528440

Date Time	Sample Number	Lab Turbidity (NTRU)	SSC (mg/l)	Stage (ft)	Discharge (cfs)	Suspended Sediment Discharge (tons/day)	Type DIS, Grab, Box	Notes
02/20/2001 16:50	BGCH3-SSCT2001-01	10	31	---	---	---	DIS	
02/21/2001 14:35	BGCH3-SSCT2001-02	6.2	---	---	---	---	GRAB	
02/22/2001 13:05	BGCH3-SSCT2001-03	4.9	---	---	---	---	GRAB	
03/04/2001 18:22	BGCH3-SSCT2001-04	4.7	---	---	---	---	GRAB	
03/05/2001 12:03	BGCH3-SSCT2001-05	3.3	---	---	---	---	GRAB	
03/06/2001 11:50	BGCH3-SSCT2001-06	2.1	5	---	---	---	DIS	
03/06/2001 13:51	BGCH3-SSCT2001-07	1.3	4	---	---	---	DIS	
03/07/2001 11:35	BGCH3-SSCT2001-08	1.3	5	---	---	---	DIS	
12/05/2001 20:21	BGCH3-SSCT2002-01	4.3	8	1.55	114	2.5	DIS	
12/05/2001 23:48	BGCH3-SSCT2002-02	5.1	12	1.72	146	4.7	DIS	
12/19/2001 8:08	BGCH3-SSCT2002-03	3.1	5	6.85	171	2.4	DIS	
12/19/2001 12:00	BGCH3-SSCT2002-04	3.5	6	6.95	174	2.6	DIS	
12/19/2001 23:58	BGCH3-SSCT2002-05	13	43	7.10	260	30	DIS	
12/20/2001 15:07	BGCH3-SSCT2002-06	2.8	7	6.98	206	3.6	DIS	
01/01/2002 21:05	BGCH3-SSCT2002-07	65	250	3.20	403	272	DIS	
01/02/2002 12:25	BGCH3-SSCT2002-08	73	375	4.40	804	813	DIS	
01/02/2002 21:30	BGCH3-SSCT2002-09	38	172	3.77	592	275	DIS	
01/03/2002 11:43	BGCH3-SSCT2002-10	10	---	2.64	300	---	GRAB	
01/03/2002 18:14	BGCH3-SSCT2002-11	8	---	2.55	275	---	GRAB	
01/04/2002 13:58	BGCH3-SSCT2002-12	4.1	15	2.11	217	9.01	DIS	
12/14/2002 7:20	BGCH3-SSCT2003-01	22	68	2.07	164	30	DIS	
12/14/2002 12:45	BGCH3-SSCT2003-02	35	159	2.40	237	102	DIS	
12/14/2002 16:00	BGCH3-SSCT2003-03	60	273	3.05	323	238	DIS	
12/14/2002 19:08	BGCH3-SSCT2003-04	34	116	2.85	323	101	DIS	
12/16/2002 7:50	BGCH3-SSCT2003-05	55	240	---	---	---	DIS	
12/16/2002 9:43	BGCH3-SSCT2003-06	40	224	3.50	323	195	DIS	
12/16/2002 16:00	BGCH3-SSCT2003-07	17	93	---	---	---	DIS	Turbidity not measured in 48 hours
12/16/2002 16:02	BGCH3-SSCT2003-08	17	130	---	---	---	DIS	Turbidity not measured in 48 hours
01/20/2003 11:40	BGCH3-SSCT2003-09	1.2	1	1.91	134	0.46	DIS	Turbidity not measured in 48 hours
04/29/2003 11:40	BGCH3-SSCT2003-10	4.8	19	2.20	191	9.8	DIS	Turbidity not measured in 48 hours
02/17/2004 0:00	BGCH3-SSCT2004-01	290	751					Data From USFS
12/26/2006 18:28	BGCH3-SSCT2007-01	31	---	5.03	94.0	---	DIS	Turbidity not measured in 48 hours
12/27/2006 1:06	BGCH3-SSCT2007-02	7.5	---	4.88	71.1	---	DIS	Turbidity not measured in 48 hours
12/27/2006 2:45	BGCH3-SSCT2007-03	6.5	---	5.18	123	---	DIS	Turbidity not measured in 48 hours
02/10/2007 20:30	BGCH3-SSCT2007-04	40	133	5.25	139	50	Box	
02/11/2007 12:09	BGCH3-SSCT2007-05	11	27	5.23	134	9.7	Box	
03/21/2007 12:40	BGCH3-SSCT2007-06	0.20	2	4.63	43.9	0.28	Box	Correlation Sample
03/21/2007 12:43	BGCH3-SSCT2007-07	0.50	2	4.63	43.9	0.20	DIS	
03/21/2007 12:47	BGCH3-SSCT2007-07R	0.25	1	4.63	43.9	0.11	DIS	Replicate
03/21/2007 12:49	BGCH3-SSCT2007-06R	0.10	4	4.63	43.9	0.43	Box	Correlation Sample

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				WY2008				
10/18/2007 08:24	BGCH3-SSCT2008-01	0.35	1	4.13	8.86	0.03	Box	Correlation Sample
10/18/2007 08:28	BGCH3-SSCT2008-02	0.38	2	4.13	8.78	0.04	DIS	
10/18/2007 08:34	BGCH3-SSCT2008-02R	0.67	1	4.13	8.74	0.02	DIS	Replicate
10/18/2007 08:39	BGCH3-SSCT2008-01R	0.10	<0.5	4.13	8.72	---	Box	Correlation Sample, Replicate
12/03/2007 20:10	BGCH3-SSCT2008-03	19.00	44	---	18.0	2.13	Box	Correlation Sample
12/03/2007 20:16	BGCH3-SSCT2008-04	19.00	52	---	19.5	2.75	DIS	
12/03/2007 20:23	BGCH3-SSCT2008-03R	16.00	41	---	19.5	2.14	Box	Correlation Sample, Replicate
12/03/2007 20:27	BGCH3-SSCT2008-04R	18.67	54	---	30.7	4.50	DIS	Replicate
12/18/2007 14:04	BGCH3-SSCT2008-05	3.67	4	4.33	19.5	0.23	DIS	
01/03/2008 14:57	BGCH3-SSCT2008-06	45.00	62	4.60	39.7	6.65	Box	Correlation Sample
01/03/2008 15:00	BGCH3-SSCT2008-07	51.67	66	4.60	40.5	7.17	DIS	
01/03/2008 15:05	BGCH3-SSCT2008-06R	45.00	70	4.60	40.5	7.64	Box	Correlation Sample, Replicate
01/03/2008 15:08	BGCH3-SSCT2008-07R	51.67	69	4.60	40.5	7.58	DIS	Replicate
01/04/2008 09:20	BGCH3-SSCT2008-08	105.00	293	6.18	362	286	DIS	
01/04/2008 09:31	BGCH3-SSCT2008-09	100.00	335	6.18	355	321	Box	Correlation Sample
01/04/2008 09:32	BGCH3-SSCT2008-09R	95.00	288	6.20	354	275	Box	Correlation Sample, Replicate
01/04/2008 09:41	BGCH3-SSCT2008-08R	100.00	288	6.20	364	283	DIS	Replicate
01/04/2008 12:00	BGCH3-SSCT2008-10	45.00	146	6.05	312	123	Box	Correlation Sample
01/04/2008 12:12	BGCH3-SSCT2008-11	50.00	263	6.05	302	214	DIS	
01/04/2008 15:40	BGCH3-SSCT2008-12	24.00	78	5.66	222	46.7	Box	Correlation Sample
01/04/2008 15:53	BGCH3-SSCT2008-13	20.00	60	5.66	216	35.1	DIS	
01/04/2008 17:10	BGCH3-SSCT2008-14	18.00	44	5.40	202	23.9	Box	Correlation Sample
01/04/2008 17:16	BGCH3-SSCT2008-15	17.00	47	5.40	204	25.7	DIS	
02/06/2008 14:17	BGCH3-SSCT2008-16	0.72	1	3.86	31.8	0.07	DIS	
02/06/2008 14:31	BGCH3-SSCT2008-16R	0.50	1	3.87	39.3	0.07	DIS	Replicate
02/21/2008 11:07	BGCH3-SSCT2008-17	1.02	1.5	4.88	74.6	0.30	DIS	
02/21/2008 11:15	BGCH3-SSCT2008-18	1.20	2.7	4.88	74.1	0.54	Box	Correlation Sample
02/21/2008 11:18	BGCH3-SSCT2008-17R	0.75	1.6	4.88	74.1	0.32	DIS	Replicate
02/21/2008 11:22	BGCH3-SSCT2008-18R	1.00	1.7	4.89	74.1	0.34	Box	Correlation Sample; Replicate
02/24/2008 12:46	BGCH3-SSCT2008-19	2.00	4.3	4.94	78.2	0.90	DIS	
02/24/2008 12:58	BGCH3-SSCT2008-20	2.30	4.8	4.94	79.6	1.02	Box	Correlation Sample
02/24/2008 13:00	BGCH3-SSCT2008-19R	3.25	4.7	4.94	79.8	1.02	DIS	Replicate
02/24/2008 13:15	BGCH3-SSCT2008-20R	2.10	4.8	4.94	79.5	1.03	Box	Correlation Sample; Replicate
02/24/2008 17:00	BGCH3-SSCT2008-21	3.55	5.5	5.00	84.7	1.26	DIS	
02/24/2008 17:15	BGCH3-SSCT2008-22	2.60	7.2	5.00	86.2	1.68	Box	Correlation Sample
02/24/2008 17:16	BGCH3-SSCT2008-21R	2.70	5.9	5.00	86.2	1.37	DIS	Replicate
02/24/2008 17:30	BGCH3-SSCT2008-22R	2.60	5.3	5.00	84.4	1.21	Box	Correlation Sample; Replicate
02/25/2008 09:40	BGCH3-SSCT2008-23	1.45	3.2	5.00	84.1	0.72	DIS	
02/25/2008 09:55	BGCH3-SSCT2008-24	1.20	2.7	5.00	82.5	0.60	Box	Correlation Sample
04/02/2008 15:42	BGCH3-SSCT2008-25	0.00	<0.5	4.59	42.2	---	Box	Correlation Sample
04/02/2008 15:47	BGCH3-SSCT2008-26	0.03	<0.5	4.59	42.1	---	DIS	
04/02/2008 15:54	BGCH3-SSCT2008-25R	0.03	0.7	4.59	41.7	0.08	DIS	Replicate
04/02/2008 16:00	BGCH3-SSCT2008-26R	0.10	<0.5	4.59	41.7	---	Box	Correlation Sample; Replicate
04/12/2008 16:30	BGCH3-SSCT2008-27	0.30	<0.5	4.49	39.6	---	Box	Correlation Sample
04/12/2008 16:33	BGCH3-SSCT2008-28	0.22	1.3	4.49	39.6	0.14	DIS	
04/12/2008 16:38	BGCH3-SSCT2008-27R	0.19	1.9	4.49	39.6	0.21	DIS	Replicate
04/12/2008 16:41	BGCH3-SSCT2008-28R	0.25	0.7	4.49	39.8	0.07	Box	Correlation Sample; Replicate
04/22/2008 17:55	BGCH3-SSCT2008-29	0.10	0.6	4.50	37.2	0.06	Box	Correlation Sample
04/22/2008 18:00	BGCH3-SSCT2008-30	0.26	1.4	4.50	37.3	0.14	DIS	

Suspeded Sediment Value Rounding According to Porterfield, 1972
Turbidity Value Rounding According to Anderson, , 2004

BIG CREEK AT HWY 3 NR HAYFORK, CA – 11528440

Continuous Turbidity with Sediment Sample Times and Discharge Hydrograph – Partial Water Year 2007

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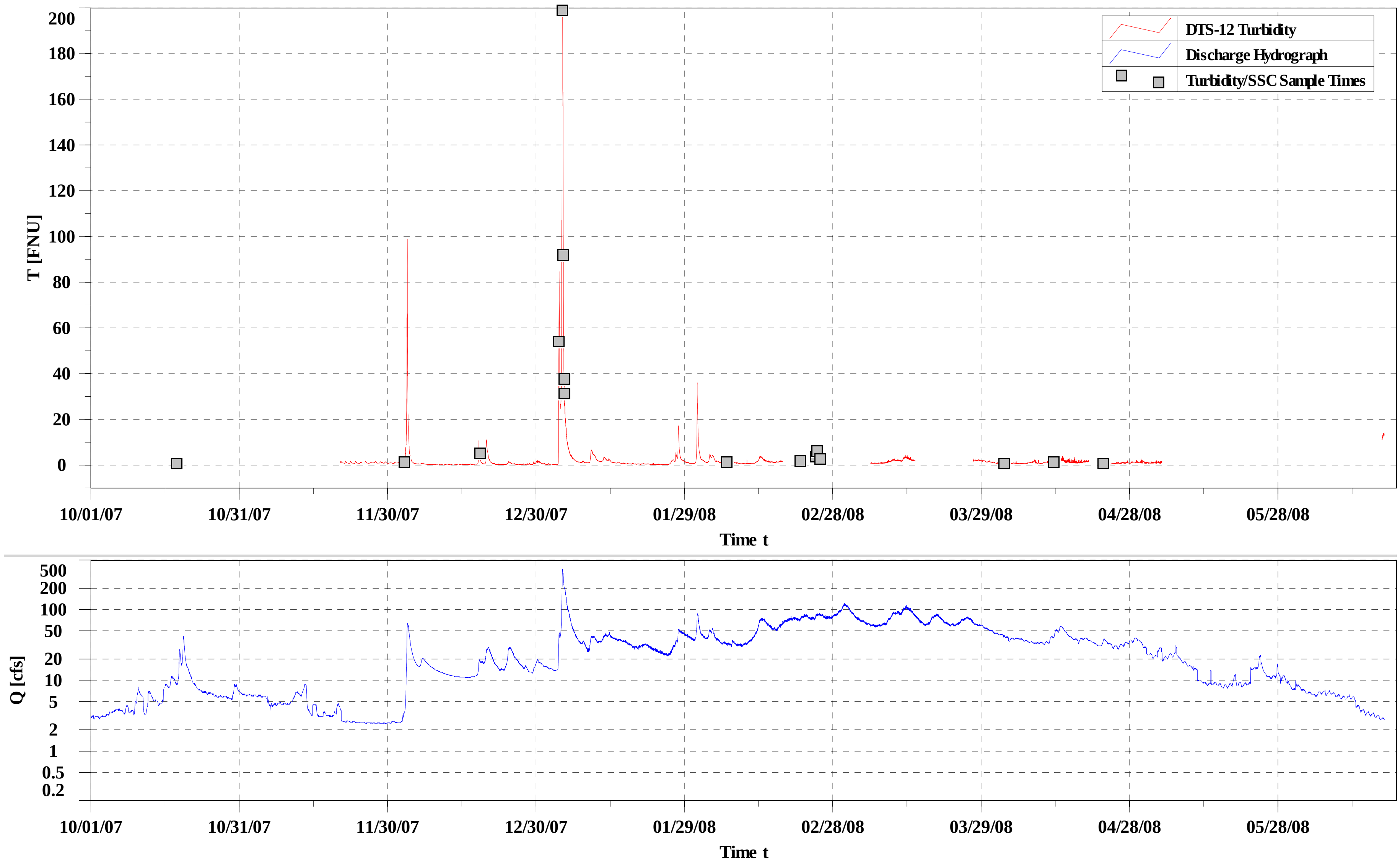
Continuous Turbidity with Sediment Sample Times and Discharge Hydrograph – Partial Water Year 2008



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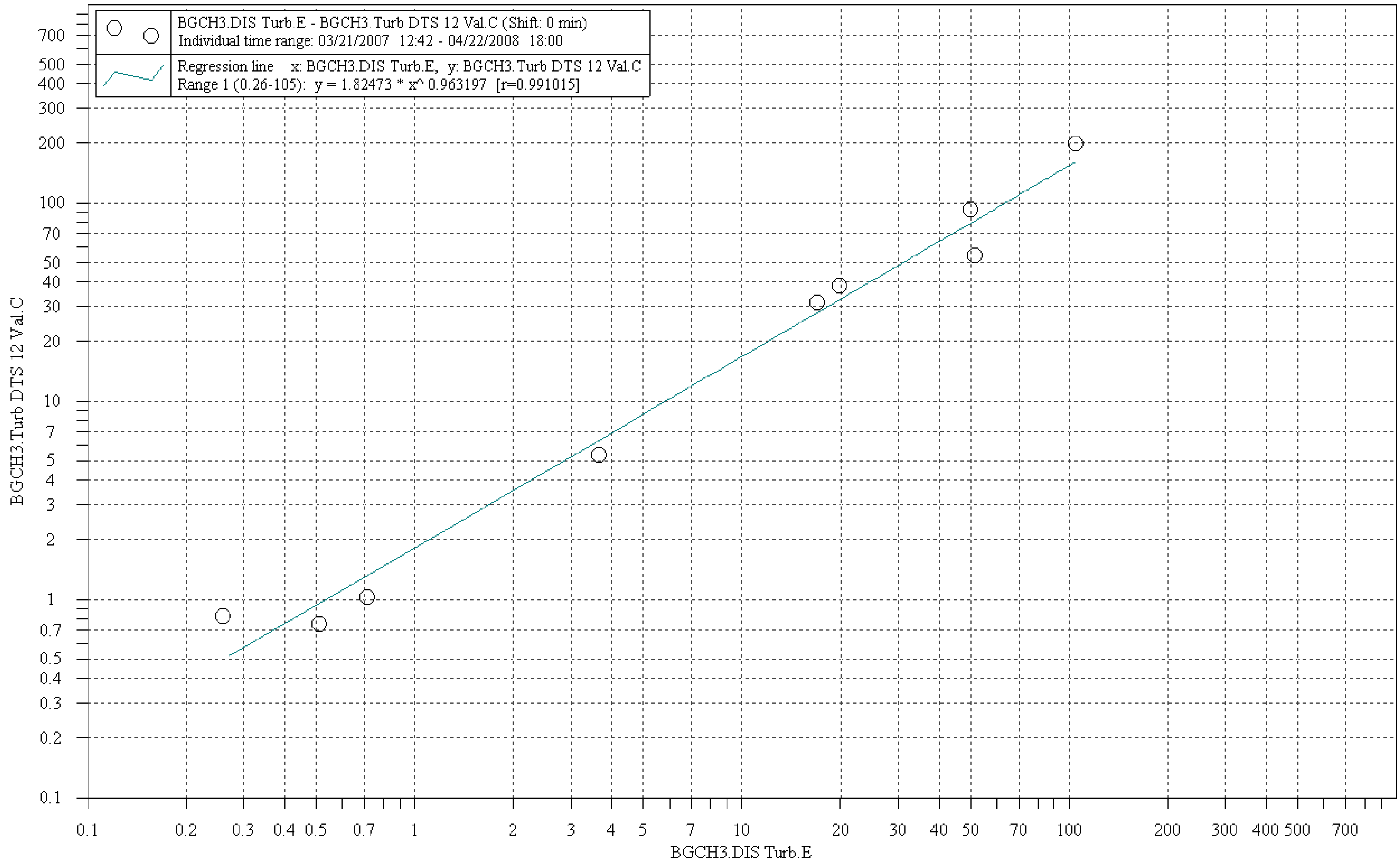
BIG CREEK AT HWY 3 NEAR HAYFORK, CA – 11528440
DTS-12 Turbidity vs. DIS/Box Sample Laboratory Turbidity Transport Curve



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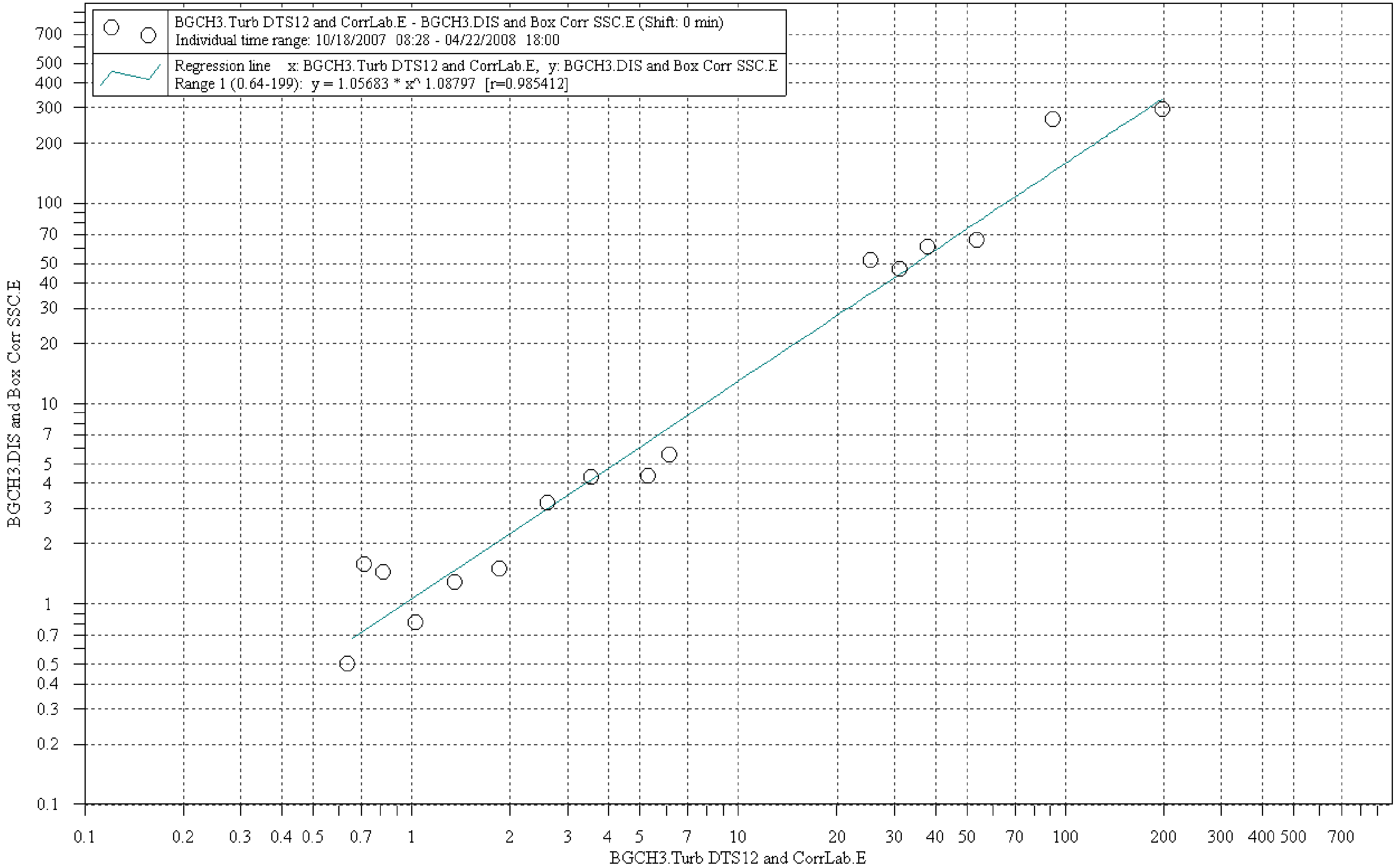
BIG CREEK AT HWY 3 NEAR HAYFORK, CA – 11528440
Suspended Sediment Concentration vs. Turbidity Transport Curve



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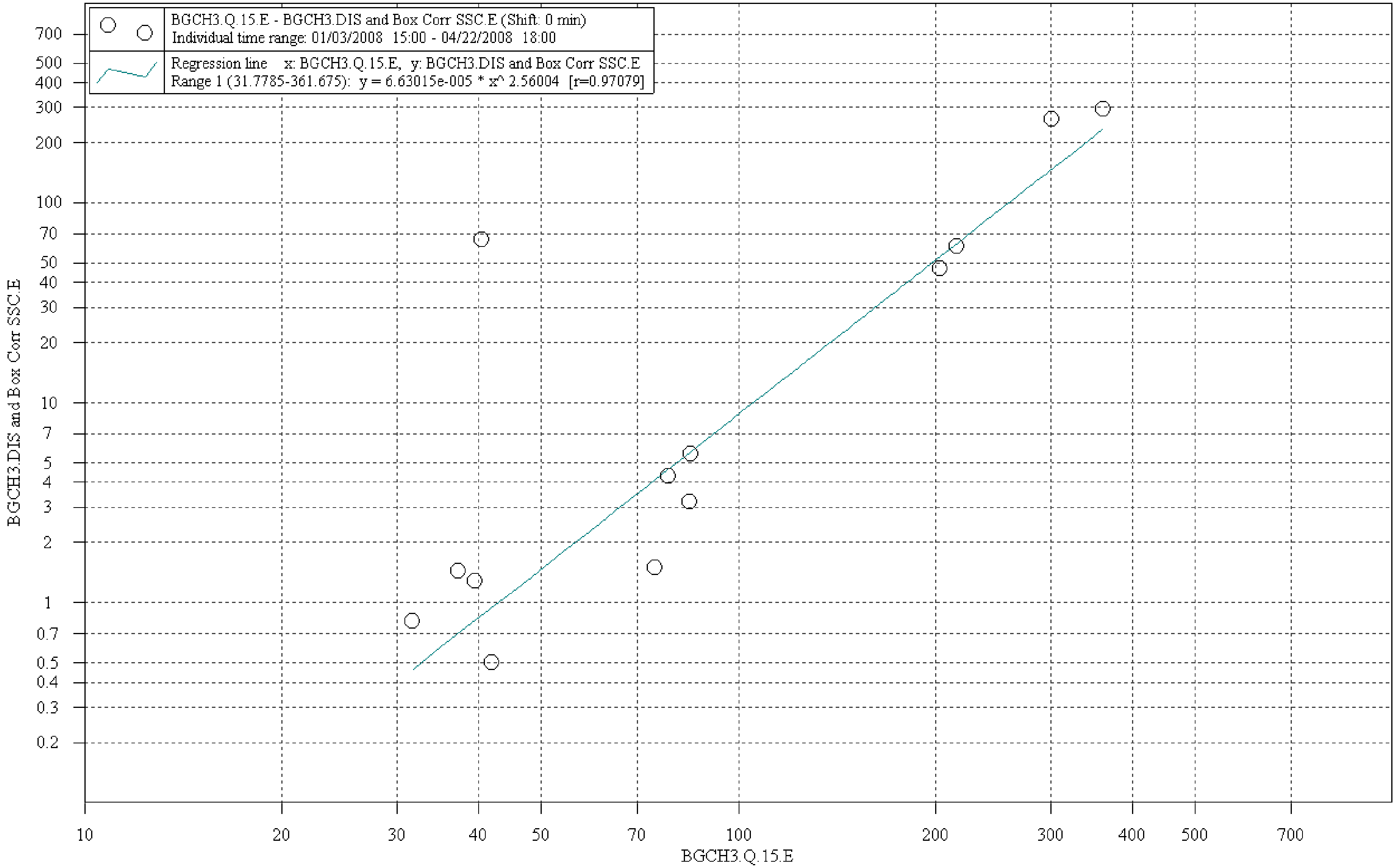
BIG CREEK AT HWY 3 NEAR HAYFORK, CA – 11528440
Suspended Sediment Concentration vs. Discharge Transport Curve



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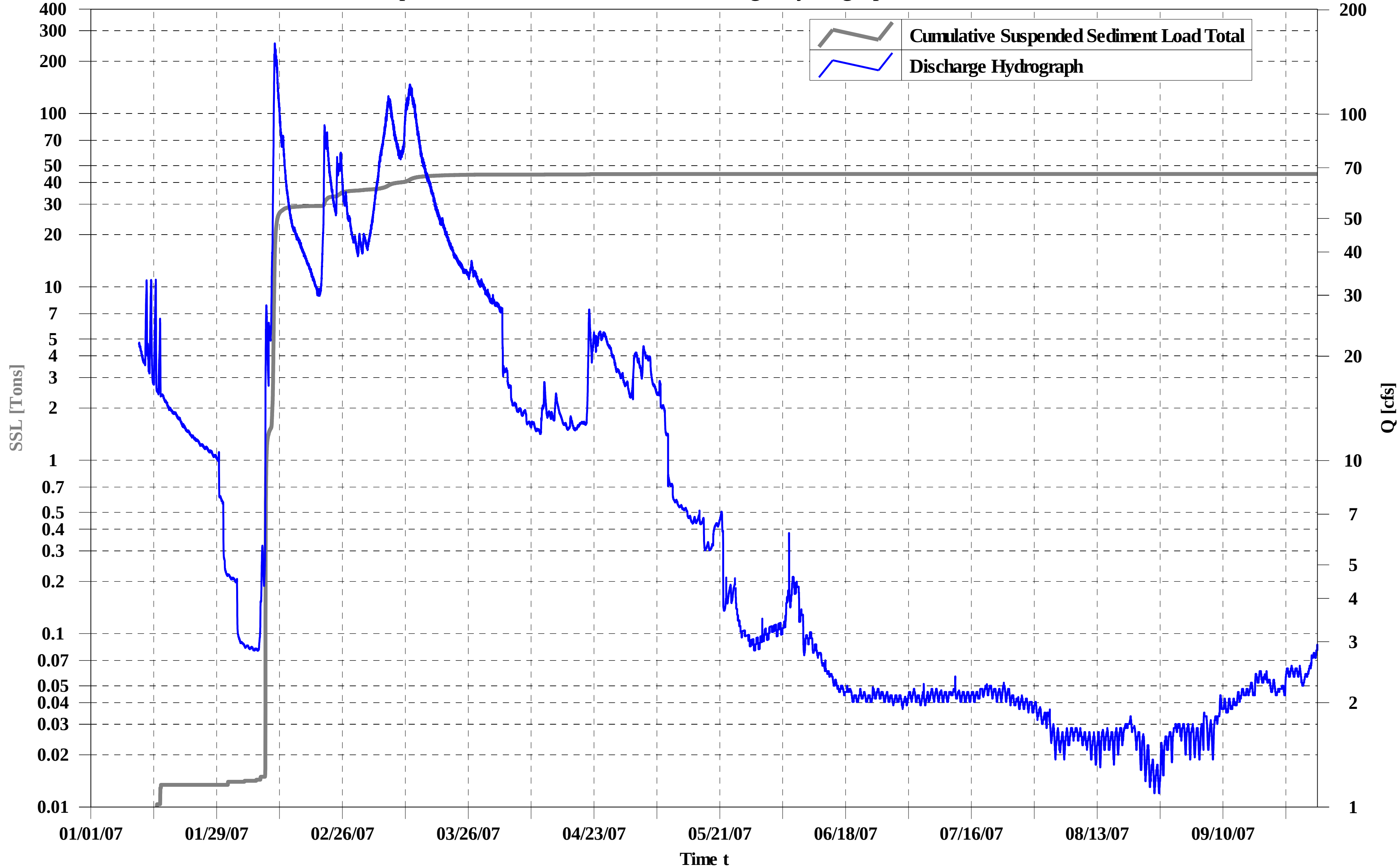
BIG CREEK AT HWY 3 NR HAYFORK, CA – 11528440

Cumulative Suspended Sediment Load and Discharge Hydrograph – Partial Water Year 2007



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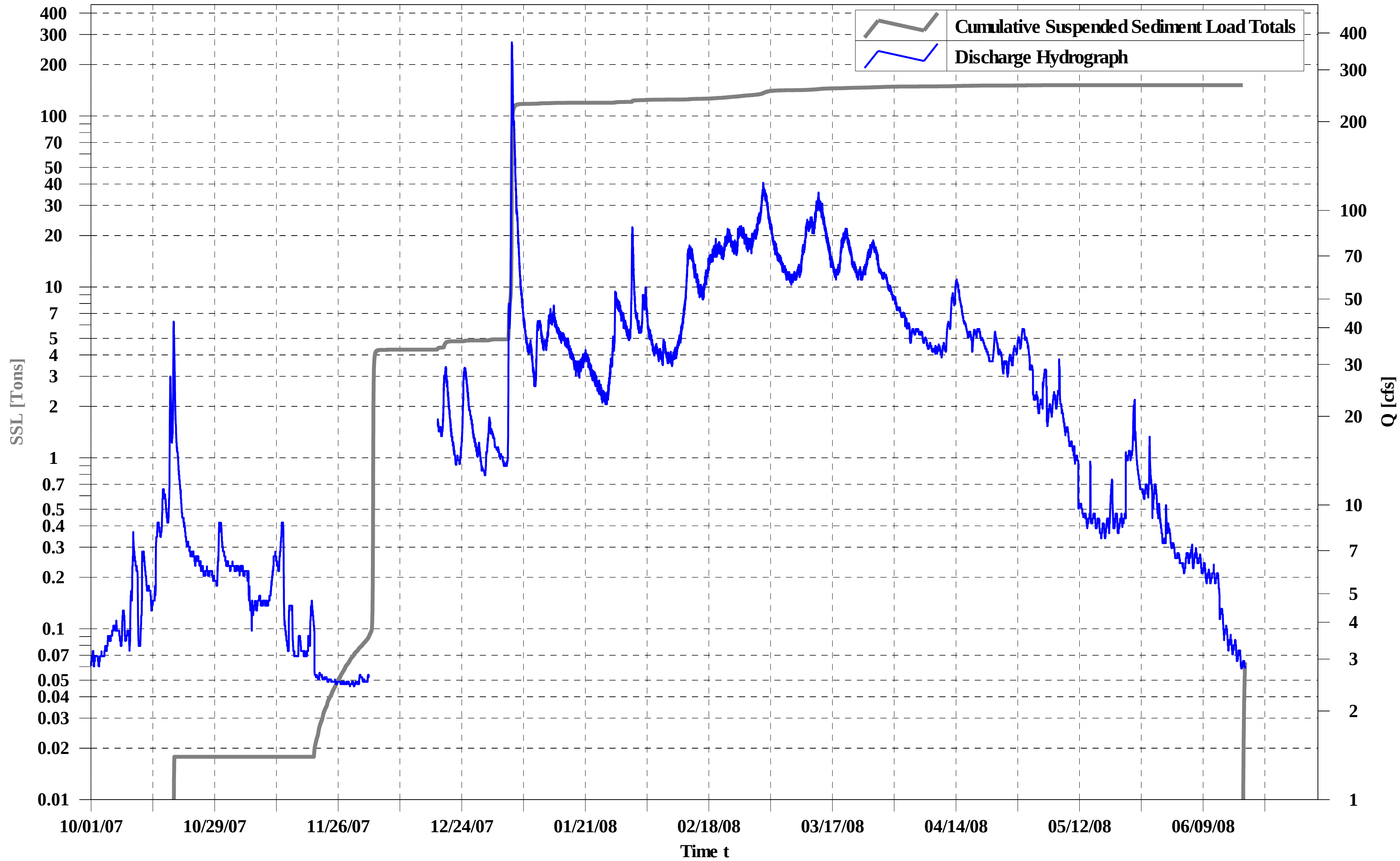
BIG CREEK AT HWY 3 NR HAYFORK, CA – 11528440

Cumulative Suspended Sediment Load and Discharge Hydrograph – Partial Water Year 2008



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5435 Ericson Way Suite 1, Arcata, CA 95521 Phone: (707) 825-6681; Fax (707) 825-6698; email: cort@gmahydrology.com

DISCHARGE SUMMARY SHEET

STATION: Big Creek at TCR 324 Nr Hayfork, Ca **WATER YEAR:** 2007-2008

STATION NUMBER: 11528430

Measurement Number	WY Msmt #	Date	Made By	Width (feet)	Mean Depth (feet)	Area (ft2)	Mean Velocity (ft/sec)	Staff Height (feet)	Gage Height (feet)	Discharge (cfs)	Rating __1.1___ Comp. Shift (feet)	Used Shift (feet)	% Diff.	Method	Begin Time (hours)	End Time (hours)	Msmt Rating	GZF (feet)	Water Temp (F)	Comments
1	**2007-01**	02/07/2007	J. Huddman	18.0	0.60	10.88	1.15	3.54	---	12.6	0.00	0.00	-0.3	Wading	14:36	15:10	Fair	---		
2	**2007-02**	02/12/2007	J. Huddman	26.0	1.17	30.52	2.72	4.69	4.71	82.9	0.00	0.00	0.0	Wading	12:56	14:22	Fair	---		
3	**2007-03**	03/31/2007	L. Cornelius	22.0	0.81	17.73	1.62	3.95	3.98	28.7	0.00	0.00	0.0	Wading	11:17	11:45	Good	,---		
4	**2007-04**	05/24/2007	L. Cornelius	19.0	0.68	12.90	0.91	3.58	3.56	11.7	-0.06	0.00	-12	Wading	15:45	16:09	Poor	1.60		
5	**2007-05**	05/25/2007	L. Cornelius	18.0	0.77	13.80	0.93	3.57	3.55	12.9	0.00	0.00	0.0	Wading	12:45	13:15	Fair	1.60		Msmt made 20 ft dowsntream from usual section
6	**2008-01**	12/18/2007	J. Smith	20.0	0.74	14.87	1.03	3.70	3.70	15.3	-0.06	0.00	-12	Wading	15:19	16:28	Poor			
7	**2008-02**	01/04/2008	W. Smith	35.9	1.32	47.38	2.40	5.17	4.98	113	-0.03	0.00	-4.3	Wading	13:21	13:53	Poor			
8	**2008-03**	02/19/2008	J. Smith	28.0	1.06	29.58	2.58	4.65	4.58	76.3	0.07	0.00	10	Wading	16:42	18:08	Fair			
9	**2008-04**	04/03/2008	L. Cornelius	24.0	0.97	23.30	1.90	4.25	4.25	44.2	0.01	0.00	1.9	Wading	09:34	10:01	Fair	2.15		
10	**2008-05**	06/22/2008	L. Cornelius	18.8	0.61	11.40	0.87	3.57	3.57	9.94	-0.15	-0.12	-5.3	Wading	09:25	09:49	Poor	2.07		
11	**2008-06**	06/22/2008	L. Cornelius	17.8	0.65	11.6	0.95	3.57	3.57	11.0	-0.10	-0.12	4.8	Wading	09:55	10:16	Poor	2.07		

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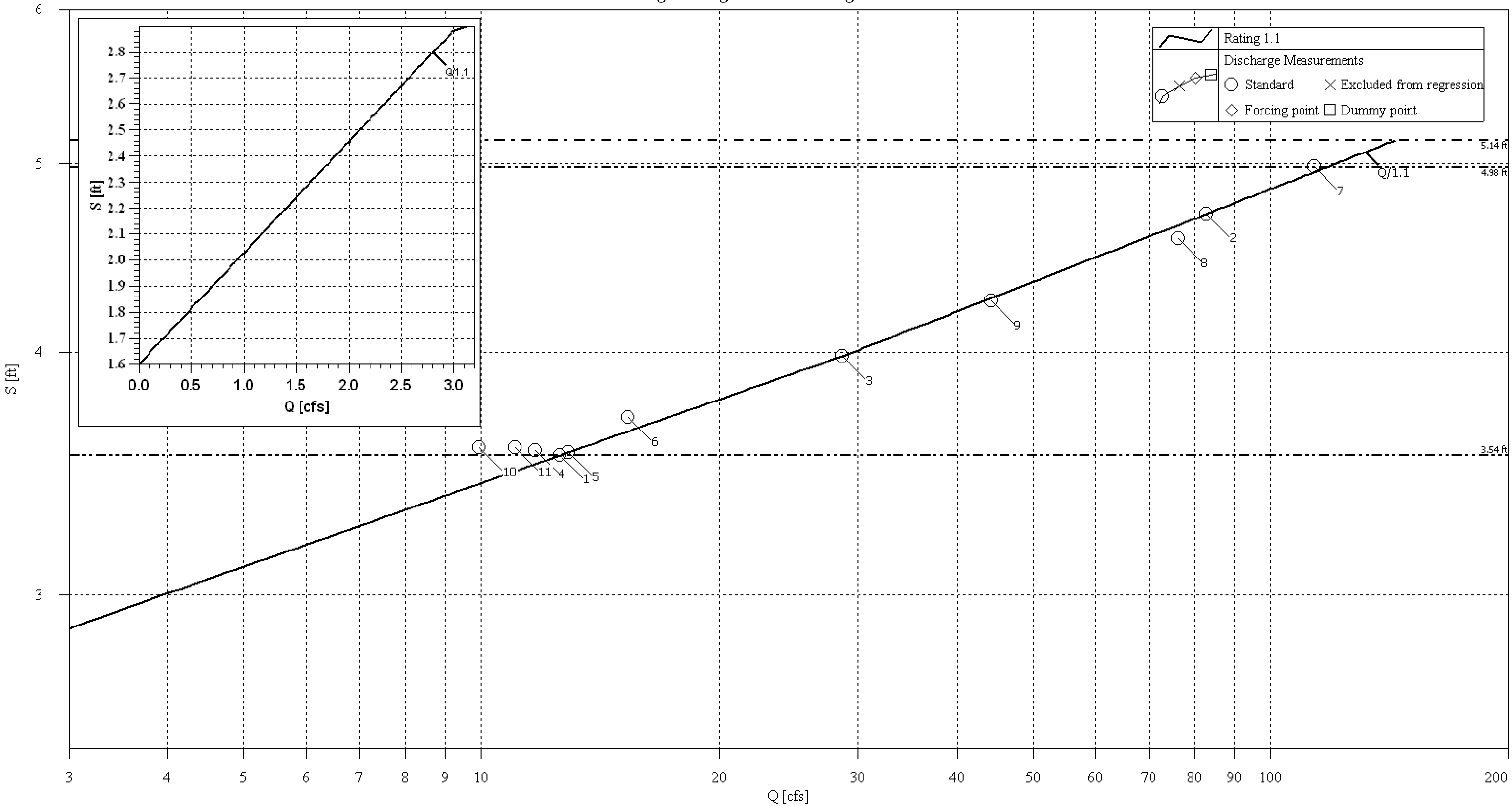
BIG CREEK AT TCR 324 NR HAYFORK, CA -- 11528430

Provisional Discharge Rating Curve 1.1 – Begin Date 02/07/2007



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Graham Matthews & Associates

Big Creek at TCR 324 Nr Hayfork, CA -- 11528430

RATING TABLE NO. 1.1 -- Begin Date 2/1/2007

GH	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	1st Diff	2nd Diff
0.0	---	---	---	---	---	---	---	---	---	---		
0.1	---	---	---	---	---	---	---	---	---	---	---	
0.2	---	---	---	---	---	---	---	---	---	---	---	---
0.3	---	---	---	---	---	---	---	---	---	---	---	---
0.4	---	---	---	---	---	---	---	---	---	---	---	---
0.5	---	---	---	---	---	---	---	---	---	---	---	---
0.6	---	---	---	---	---	---	---	---	---	---	---	---
0.7	---	---	---	---	---	---	---	---	---	---	---	---
0.8	---	---	---	---	---	---	---	---	---	---	---	---
0.9	---	---	---	---	---	---	---	---	---	---	---	---
1.0	---	---	---	---	---	---	---	---	---	---	---	---
1.1	---	---	---	---	---	---	---	---	---	---	---	---
1.2	---	---	---	---	---	---	---	---	---	---	---	---
1.3	---	---	---	---	---	---	---	---	---	---	---	---
1.4	---	---	---	---	---	---	---	---	---	---	---	---
1.5	---	---	---	---	---	---	---	---	---	---	---	---
1.6	---	*0.02*	*0.05*	*0.07*	*0.09*	*0.12*	*0.14*	*0.16*	*0.19*	*0.21*	---	---
1.7	*0.23*	*0.26*	*0.28*	*0.3*	*0.33*	*0.35*	*0.37*	*0.4*	*0.42*	*0.44*	0.2	---
1.8	*0.47*	*0.49*	*0.51*	*0.54*	*0.56*	*0.58*	*0.61*	*0.63*	*0.65*	*0.68*	0.2	0.0
1.9	*0.7*	*0.72*	*0.75*	*0.77*	*0.79*	*0.82*	*0.84*	*0.86*	*0.89*	*0.91*	0.2	0.0
2.0	*0.93*	*0.96*	*0.98*	*1.00*	*1.03*	*1.05*	*1.07*	*1.10*	*1.12*	*1.14*	0.2	0.0
2.1	*1.17*	*1.19*	*1.21*	*1.24*	*1.26*	*1.28*	*1.31*	*1.33*	*1.35*	*1.38*	0.2	0.0
2.2	*1.4*	*1.42*	*1.45*	*1.47*	*1.49*	*1.52*	*1.54*	*1.56*	*1.59*	*1.61*	0.2	0.0
2.3	*1.63*	*1.63*	*1.68*	*1.68*	*1.73*	*1.73*	*1.77*	*1.77*	*1.82*	*1.82*	0.2	0.0

NOTES: *Values in Italics are beyond the validated range of the rating*

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Graham Matthews & Associates

Big Creek at TCR 324 Nr Hayfork, CA -- 11528430

RATING TABLE NO. 1.0 -- Begin Date 2/1/2007

GH	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	1st Diff	2nd Diff
2.4	*1.87*	*1.87*	*1.92*	*1.92*	*1.96*	*1.96*	*2.01*	*2.01*	*2.06*	*2.06*	0.2	0.0
2.5	*2.1*	*2.13*	*2.15*	*2.17*	*2.2*	*2.22*	*2.24*	*2.27*	*2.29*	*2.31*	0.3	0.0
2.6	*2.34*	*2.36*	*2.38*	*2.41*	*2.43*	*2.45*	*2.48*	*2.5*	*2.52*	*2.55*	0.2	0.0
2.7	*2.57*	*2.59*	*2.62*	*2.64*	*2.66*	*2.69*	*2.71*	*2.73*	*2.76*	*2.78*	0.2	0.0
2.8	*2.80*	*2.80*	*2.85*	*2.85*	*2.9*	*2.9*	*2.94*	*2.94*	*2.99*	*2.99*	0.2	0.0
2.9	*3.11*	*3.11*	*3.27*	*3.27*	*3.43*	*3.43*	*3.6*	*3.6*	*3.77*	*3.77*	0.8	0.6
3.0	*3.95*	*4.04*	*4.14*	*4.24*	*4.33*	*4.43*	*4.54*	*4.64*	*4.75*	*4.86*	1.1	0.3
3.1	*4.97*	*5.08*	*5.2*	*5.32*	*5.44*	*5.56*	*5.69*	*5.81*	*5.94*	*6.07*	1.2	0.1
3.2	*6.21*	*6.35*	*6.49*	*6.63*	*6.77*	*6.92*	*7.07*	*7.23*	*7.38*	*7.54*	1.5	0.3
3.3	*7.7*	*7.7*	*8.04*	*8.04*	*8.38*	*8.38*	*8.74*	*8.74*	*9.11*	*9.11*	1.6	0.1
3.4	*9.50*	*9.50*	*9.90*	*9.90*	*10.3*	*10.3*	*10.7*	*10.7*	*11.2*	*11.2*	2.1	0.5
3.5	*11.6*	*11.9*	*12.1*	*12.4*	*12.6*	12.9	13.1	13.4	13.6	13.9	2.7	0.6
3.6	14.2	14.5	14.7	15.0	15.3	15.6	15.9	16.2	16.5	16.9	3.0	0.3
3.7	17.2	17.5	17.8	18.2	18.5	18.9	19.2	19.6	20.0	20.3	3.4	0.4
3.8	20.7	20.7	21.5	21.5	22.3	22.3	23.1	23.1	24.0	24.0	3.7	0.3
3.9	24.8	24.8	25.8	25.8	26.7	26.7	27.7	27.7	28.6	28.6	4.6	0.9
4.0	29.6	30.0	30.5	31.0	31.5	32.0	32.5	33.0	33.5	34.0	5.4	0.8
4.1	34.6	34.6	35.1	36.2	36.7	36.7	37.3	38.4	39.0	39.0	5.0	-0.4
4.2	40.2	40.8	41.4	42.1	42.7	43.3	44.0	44.6	45.3	46.0	7.0	2.0
4.3	46.7	47.3	47.3	48.8	49.5	50.2	50.2	51.7	52.4	53.2	7.2	0.2
4.4	53.9	54.7	55.5	56.3	57.1	57.9	58.8	59.6	60.4	61.3	8.1	0.9
4.5	62.2	63.0	63.9	64.8	65.7	66.6	67.6	68.5	69.5	70.4	9.1	1.0
4.6	71.4	71.4	72.4	74.4	75.4	75.4	76.4	78.5	79.6	79.6	9.2	0.1
4.7	81.8	82.9	84.0	85.1	86.3	87.4	88.6	89.8	91.0	92.2	12.6	3.4

NOTES: *Values in Italics are beyond the validated range of the rating*

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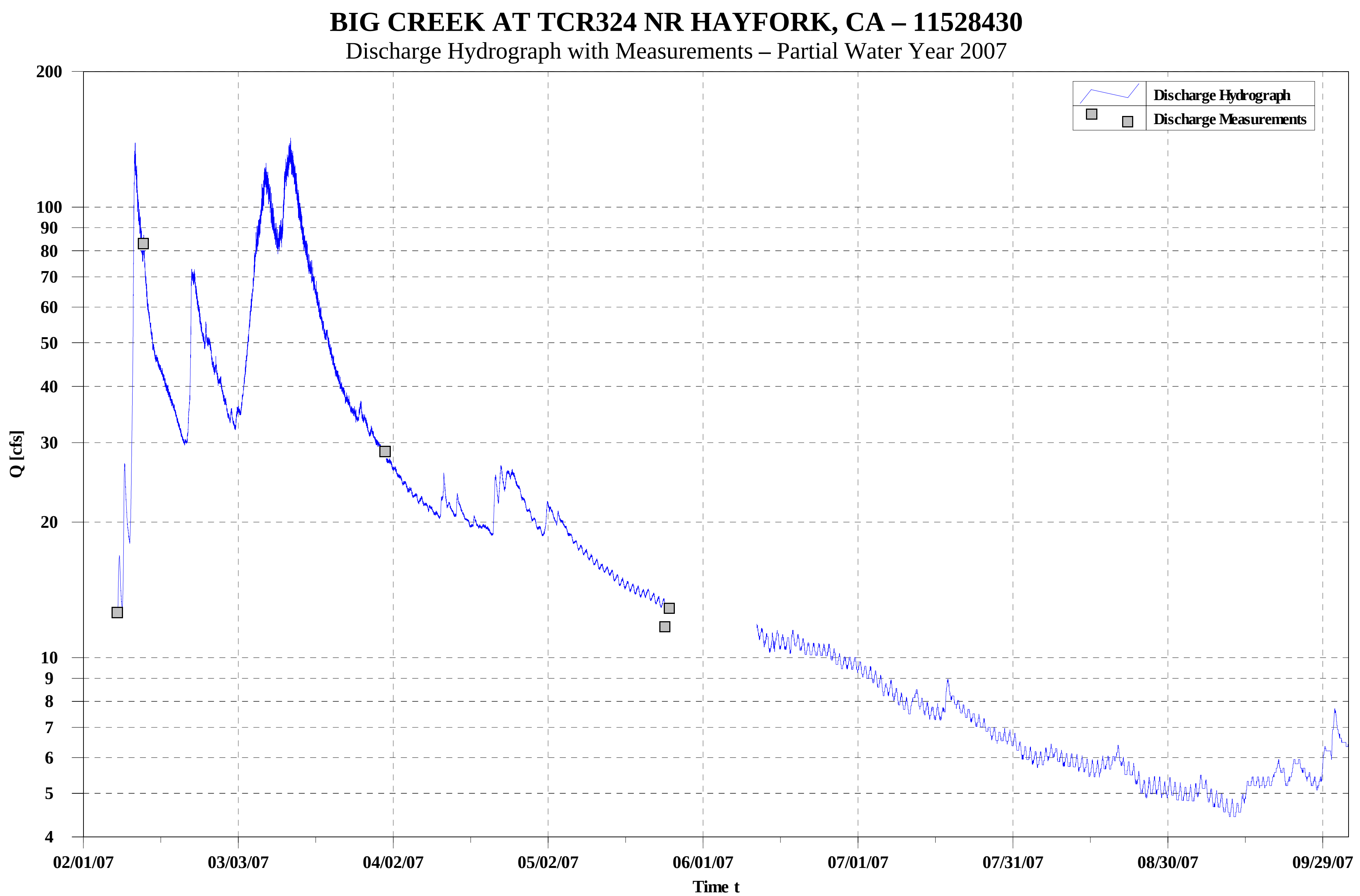

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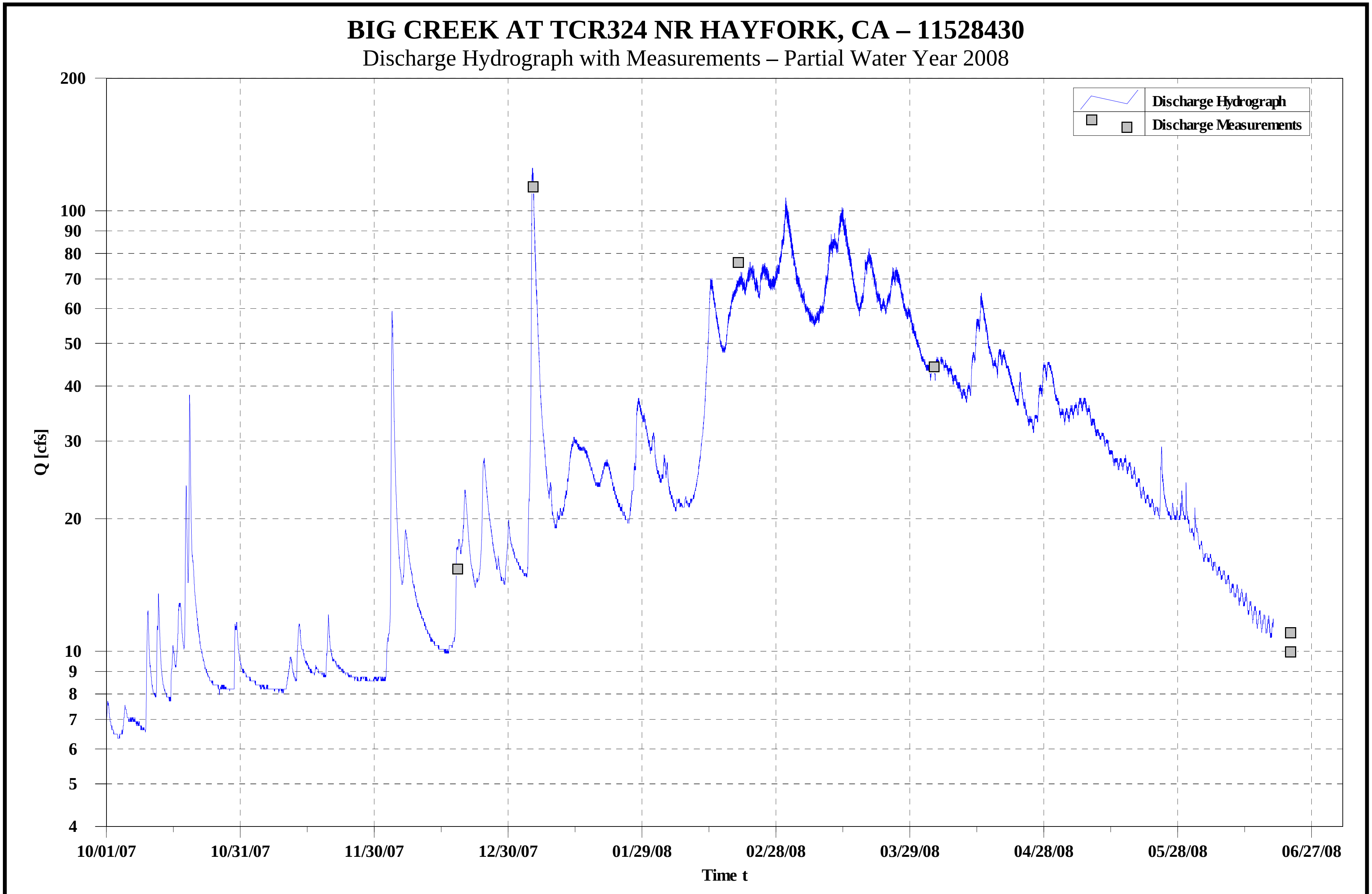

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APPENDIX

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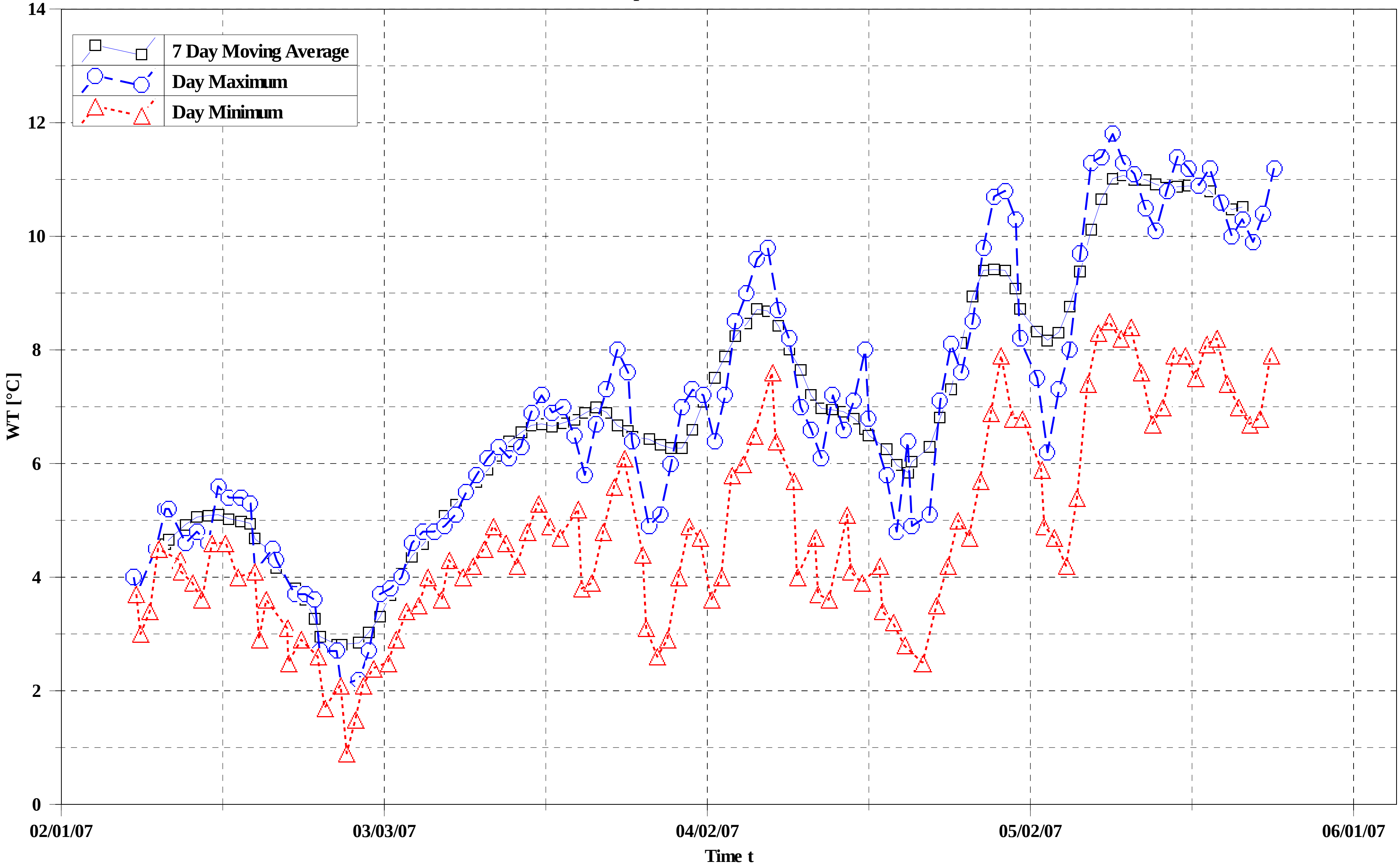
BIG CREEK AT TCR324 NR HAYFORK, CA – 11528430

Measured Water Temperature – Partial Water Year 2007



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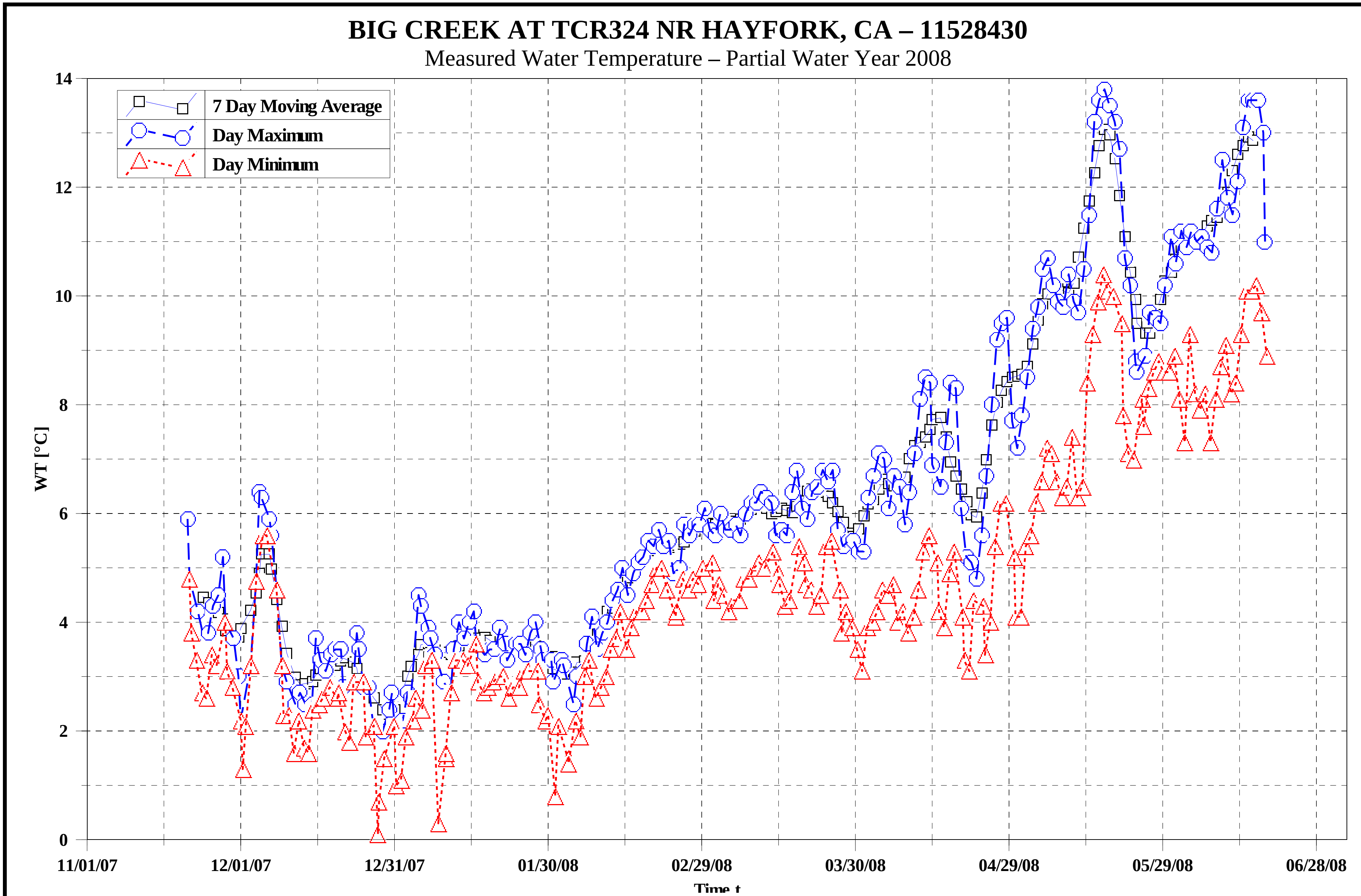

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APPENDIX

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SUSPENDED SEDIMENT MEASUREMENT SUMMARY SHEET

LOCATION: BIG CREEK AT TCR 324 NEAR HAYFORK, CA **WATER YEAR 2001-2008**

STATION NUMBER: 11528430

Date Time	Sample Number	Lab Turbidity (NTRU)	SSC (mg/l)	Stage (ft)	Discharge (cfs)	Suspended Sediment Discharge (tons/day)	Type DIS, Grab, Box	Notes
02/20/01 00:00	BC324-SSCT2001-01	---	28	---	---	---	---	Sampled by USFS
12/14/02 00:00	BC324-SSCT2003-01	30	30	---	---	---	---	Sampled by USFS
02/17/04 00:00	BC324-SSCT2004-01	190	507	---	---	---	---	Sampled by USFS
12/26/06 17:47	BC324-SSCT2007-01	3.7	---	4.29	46.0	---	DIS	Turbidity not measured in 48 hours
12/27/06 01:23	BC324-SSCT2007-02	2.6	---	4.43	56.3	---	DIS	Turbidity not measured in 48 hours
12/27/06 02:32	BC324-SSCT2007-03	2.0	---	4.50	62.2	---	DIS	Turbidity not measured in 48 hours
02/10/2007 20:50	BC324-SSCT2007-04	11	24	5.10	113	7.4	Box	
02/11/2007 12:29	BC324-SSCT2007-05	2.7	2	4.75	106	0.63	Box	
03/21/2007 13:16	BC324-SSCT2007-06	0.05	3	4.23	44.8	0.33	Box	Correlation Sample
03/21/2007 13:20	BC324-SSCT2007-07	0.10	1	4.23	44.8	0.09	DIS	
03/21/2007 13:25	BC324-SSCT2007-06R	0.00	4	4.23	44.8	0.44	Box	Replicate, Correlation Sample
03/21/2007 13:22	BC324-SSCT2007-07R	0.20	2	4.23	44.8	0.24	DIS	Replicate
				WATER YEAR 2008				
10/18/2007 09:05	BC324-SSCT2008-01	0.40	1	3.43	10.1	0.01	Box	Correlation Sample
10/18/2007 09:12	BC324-SSCT2008-02	0.05	<0.5	3.43	10.1		DIS	
10/18/2007 09:17	BC324-SSCT2008-02R	0.05	<0.5	3.43	10.1		DIS	Replicate
10/18/2007 09:22	BC324-SSCT2008-01R	0.05	<0.5	3.44	10.1		Box	Correlation Sample; Replicate
12/03/2007 21:20	BC324-SSCT2008-03	14.00	30	4.28	45.4	3.67	Box	Correlation Sample
12/03/2007 21:25	BC324-SSCT2008-04	14.50	38	4.31	47.4	4.88	DIS	
12/03/2007 21:39	BC324-SSCT2008-03R	15.00	29	4.31	47.4	3.64	Box	Correlation Sample; Replicate
12/03/2007 21:42	BC324-SSCT2008-04R	14.00	32	4.34	49.6	4.27	DIS	Replicate
01/03/2008 15:24	BC324-SSCT2008-05	1.20	<0.5	3.83	21.9		Box	Correlation Sample
01/03/2008 15:27	BC324-SSCT2008-06	0.98	<0.5	3.83	21.9		DIS	
01/03/2008 15:30	BC324-SSCT2008-05R	0.60	<0.5	3.83	21.9		Box	Correlation Sample; Replicate
01/03/2008 15:35	BC324-SSCT2008-06R	1.25	<0.5	3.83	21.9		DIS	Replicate
01/04/2008 07:52	BC324-SSCT2008-07	19.50	52	4.94	111.0	15.46	DIS	
01/04/2008 08:02	BC324-SSCT2008-08	18.00	39	4.94	111.0	11.53	Box	Correlation Sample
01/04/2008 12:00	BC324-SSCT2008-09	16.00	21	5.00	121.0	6.95	Box	Correlation Sample
01/04/2008 12:04	BC324-SSCT2008-10	14.50	36	5.00	121.0	11.85	DIS	
01/04/2008 12:09	BC324-SSCT2008-09R	14.00	45	5.03	121.0	14.59	Box	Correlation Sample; Replicate
01/04/2008 12:13	BC324-SSCT2008-10R	16.00	32	5.03	125.0	10.92	DIS	Replicate
01/04/2008 13:40	BC324-SSCT2008-11	9.50	15	4.98	119.0	4.69	Box	Correlation Sample
01/04/2008 13:45	BC324-SSCT2008-12	8.65	12	4.98	119.0	3.85	DIS	
01/04/2008 13:54	BC324-SSCT2008-11R	9.40	8	4.97	116.0	2.45	Box	Correlation Sample; Replicate
01/04/2008 14:02	BC324-SSCT2008-12R	9.40	7	4.97	116.0	2.25	DIS	Replicate
01/04/2008 15:00	BC324-SSCT2008-13	8.00	25	5.01	122.0	8.32	Box	Correrlation Sample
01/04/2008 15:05	BC324-SSCT2008-14	8.10	13	5.01	122.0	4.15	DIS	
01/04/2008 15:11	BC324-SSCT2008-13R	7.30	8	4.96	115.0	2.39	Box	Correlation Sample; Replicate

01/04/2008 15:15	BC324-SSCT2008-14R	10.35	32	4.96	115.0	9.96	DIS	Replicate
01/04/2008 16:29	BC324-SSCT2008-15	7.10	26	4.93	110.0	7.57	Box	Correlation Sample
01/04/2008 16:37	BC324-SSCT2008-16	6.25	7	4.93	110.0	1.94	DIS	
02/21/2008 15:39	BC324-SSCT2008-17	0.80	<0.5	4.60	71.1		DIS	
02/21/2008 15:45	BC324-SSCT2008-18	0.90	2	4.60	71.1	0.42	Box	Correlation Sample
02/21/2008 15:53	BC324-SSCT2008-17R	0.66	1	4.58	69.7	0.17	DIS	Replicate
02/21/2008 15:58	BC324-SSCT2008-18R	0.95	2	4.58	69.7	0.35	Box	Correlation Sample; Replicate
02/24/2008 12:00	BC324-SSCT2008-19	0.03	1	4.56	67.8	0.10	DIS	
02/24/2008 12:10	BC324-SSCT2008-20	0.15	<0.5	4.55	66.7		Box	Correlation Sample
02/24/2008 12:11	BC324-SSCT2008-19R	0.18	1	4.55	66.7	0.12	DIS	Replicate
02/24/2008 12:20	BC324-SSCT2008-20R	0.10	2	4.55	66.7	0.35	Box	Correlation Sample; Replicate
02/24/2008 16:00	BC324-SSCT2008-20	0.18	1	4.59	70.1	0.21	DIS	
02/24/2008 16:15	BC324-SSCT2008-21	0.80	3	4.60	71.1	0.55	Box	Correlation Sample
02/24/2008 16:16	BC324-SSCT2008-20R	0.40	<.5	4.60	71.7		DIS	Replicate
02/24/2008 16:25	BC324-SSCT2008-21R	0.25	1	4.59	70.7	0.12	Box	Correlation Sample; Replicate
02/25/2008 09:00	BC324-SSCT2008-22	1.20	2	4.63	74.7	0.41	DIS	
02/25/2008 09:15	BC324-SSCT2008-23	0.80	<0.5	4.63	74.7		Box	Correlation Sample
04/02/2008 16:15	BC324-SSCT2008-24	0.05	<0.5	4.93	41.8		Box	Correlation Sample
04/02/2008 16:21	BC324-SSCT2008-25	0.10	<0.5	4.93	41.8		DIS	
04/02/2008 16:26	BC324-SSCT2008-24R	0.05	1	4.93	41.8	0.11	DIS	Replicate
04/02/2008 16:30	BC324-SSCT2008-25R	0.05	<0.5	4.93	41.8		Box	Correlation Sample; Replicate
04/12/2008 17:05	BC324-SSCT2008-26	0.00	1	4.92	47.8	0.06	Box	Correlation Sample
04/12/2008 17:10	BC324-SSCT2008-27	0.28	1	4.92	47.8	0.13	DIS	
04/12/2008 17:18	BC324-SSCT2008-27R	0.24	1	4.92	47.8	0.12	DIS	Replicate
04/12/2008 17:22	BC324-SSCT2008-26R	0.15	1	4.92	47.8	0.19	Box	Correlation Sample; Replicate
04/22/2008 17:20	BC324-SSCT2008-28	0.15	2	4.92	47.8	0.25	Box	Correlation Sample
04/22/2008 17:23	BC324-SSCT2008-29	0.13	1	4.92	47.8	0.14	DIS	

Suspeded Sediment Value Rounding According to Porterfield, 1972

Turbidity Value Rounding According to Anderson, , 2004

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APPENDIX

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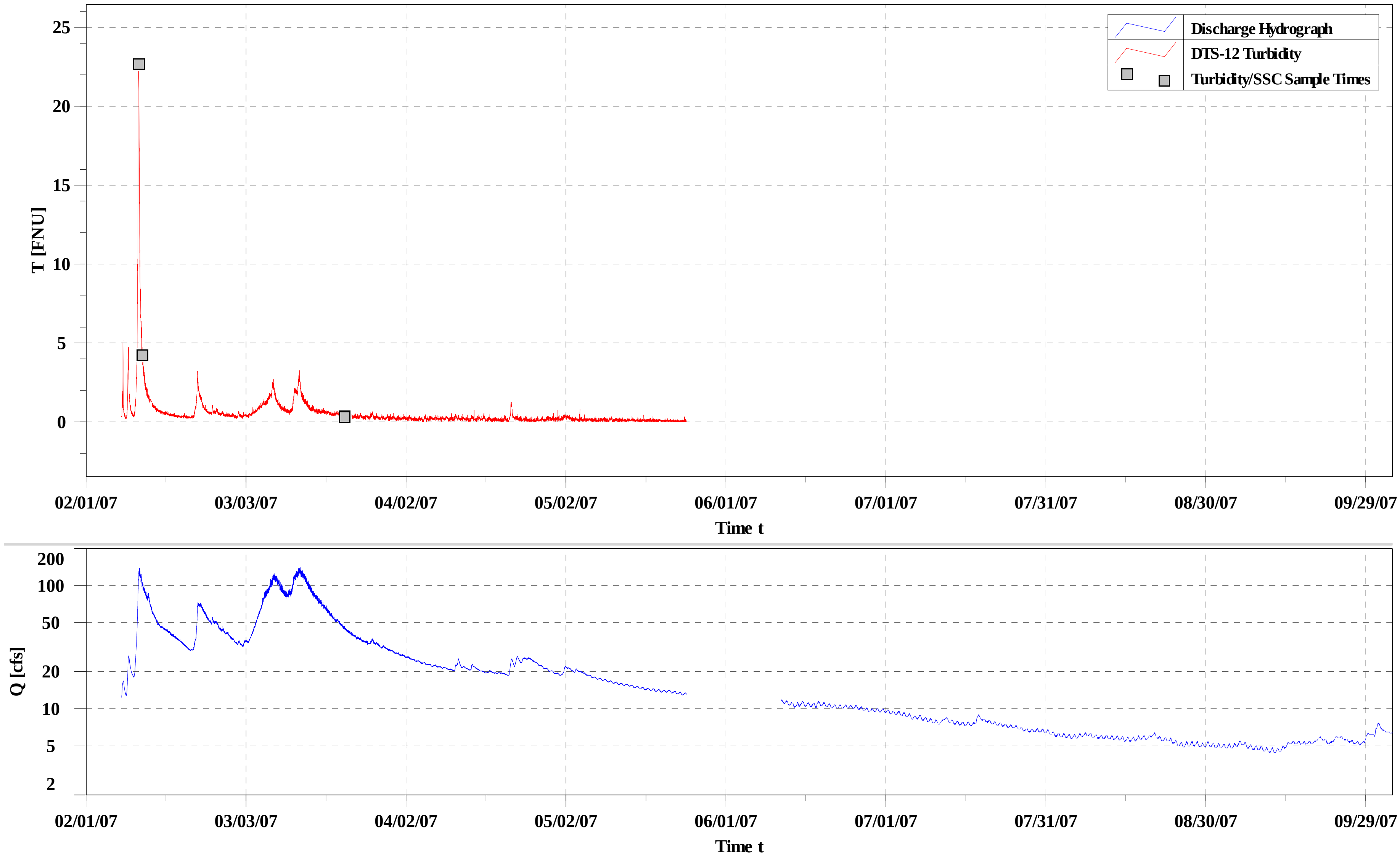
BIG CREEK AT TCR324 NR HAYFORK, CA – 11528430

Continuous Turbidity with Sediment Sample Times and Discharge Hydrograph – Partial Water Year 2007



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APPENDIX

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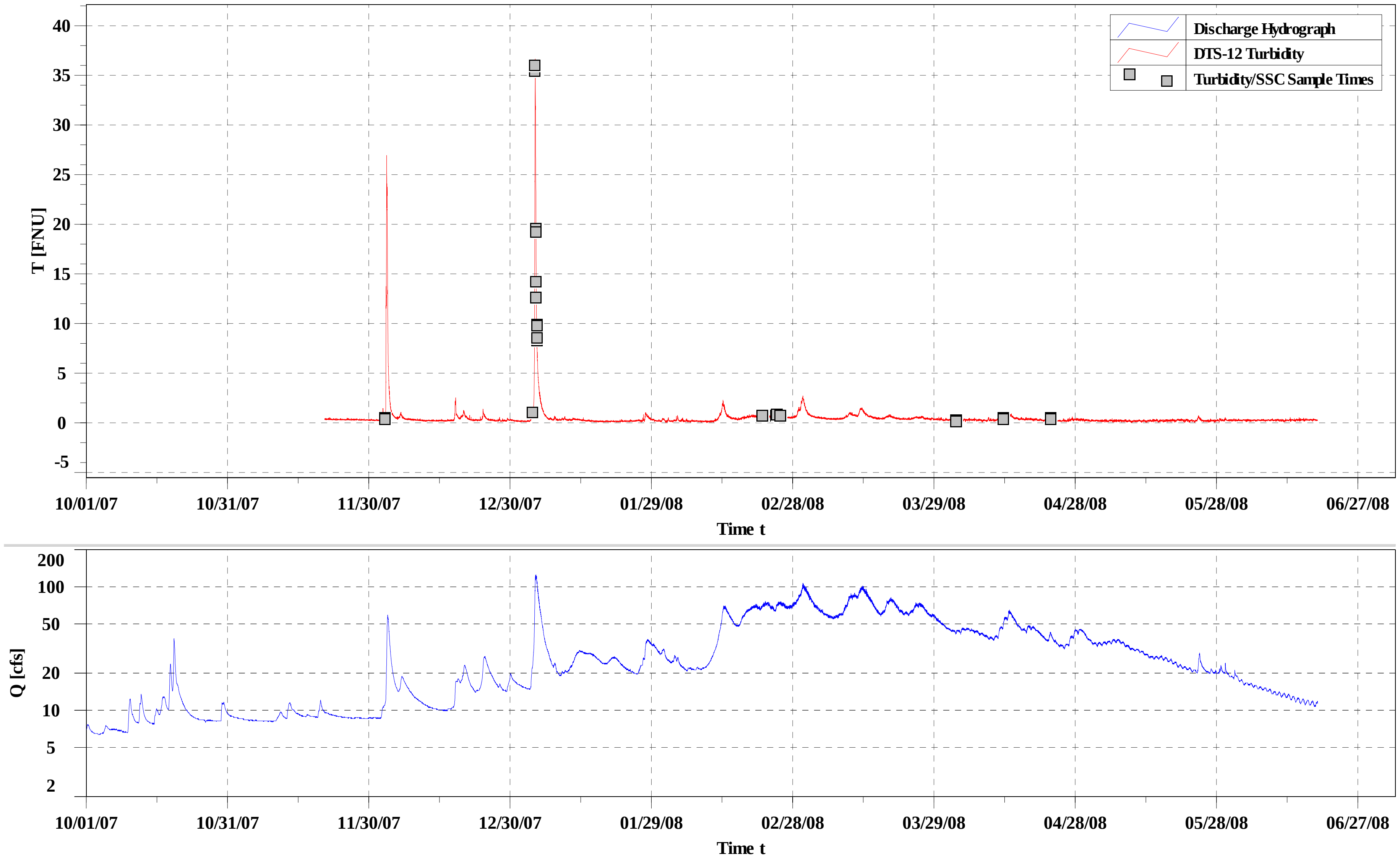
BIG CREEK AT TCR324 NR HAYFORK, CA – 11528430

Continuous Turbidity with Sediment Sample Times and Discharge Hydrograph – Partial Water Year 2008



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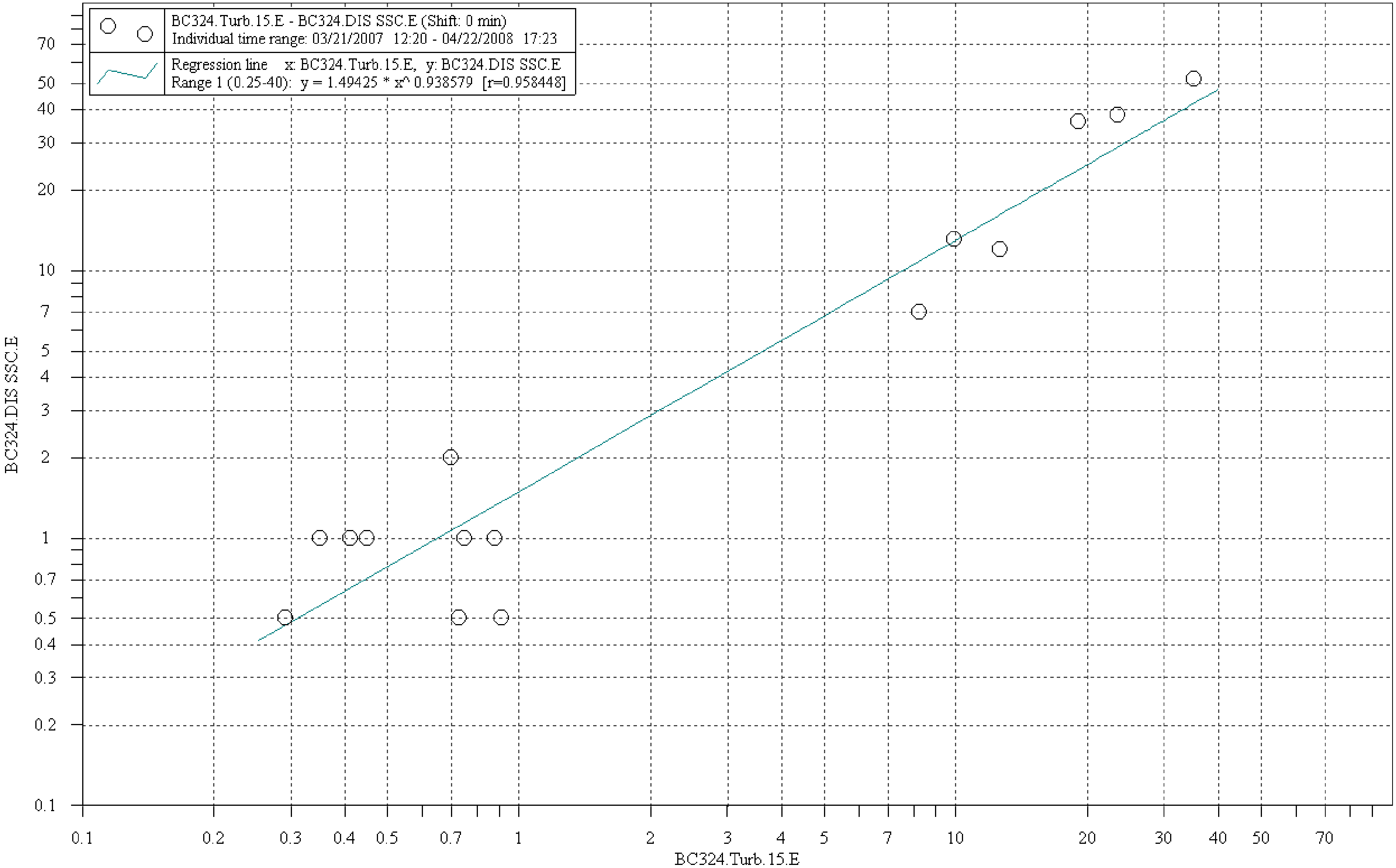
BIG CREEK AT TCR 324 NR HAYFORK, CA – 11528430
Suspended Sediment Concentration vs. Turbidity Transport Curve



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APPENDIX
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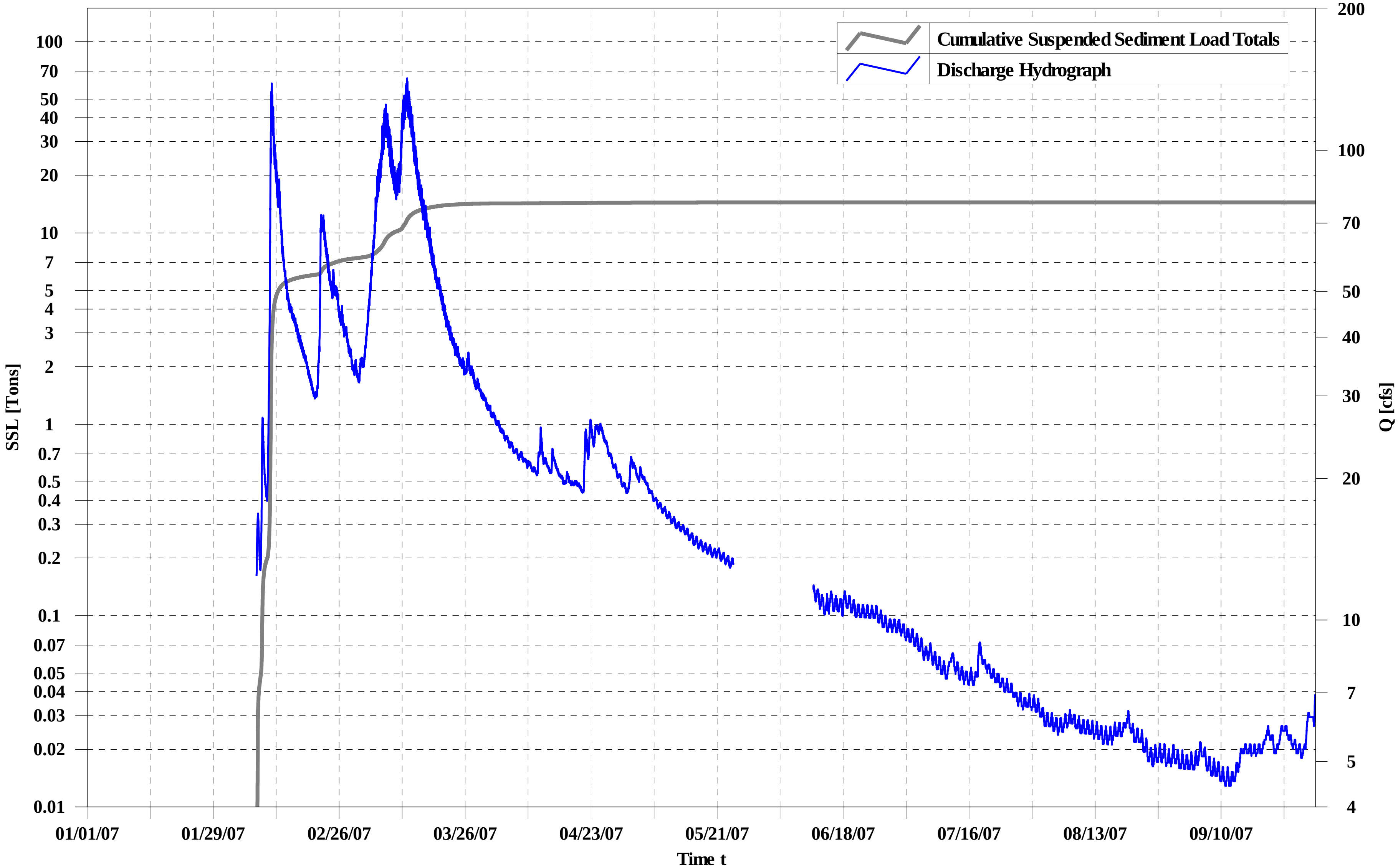
BIG CREEK AT TCR324 NR HAYFORK, CA – 11528430

Cumulative Suspended Sediment Load and Discharge Hydrograph – Partial Water Year 2007



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APPENDIX

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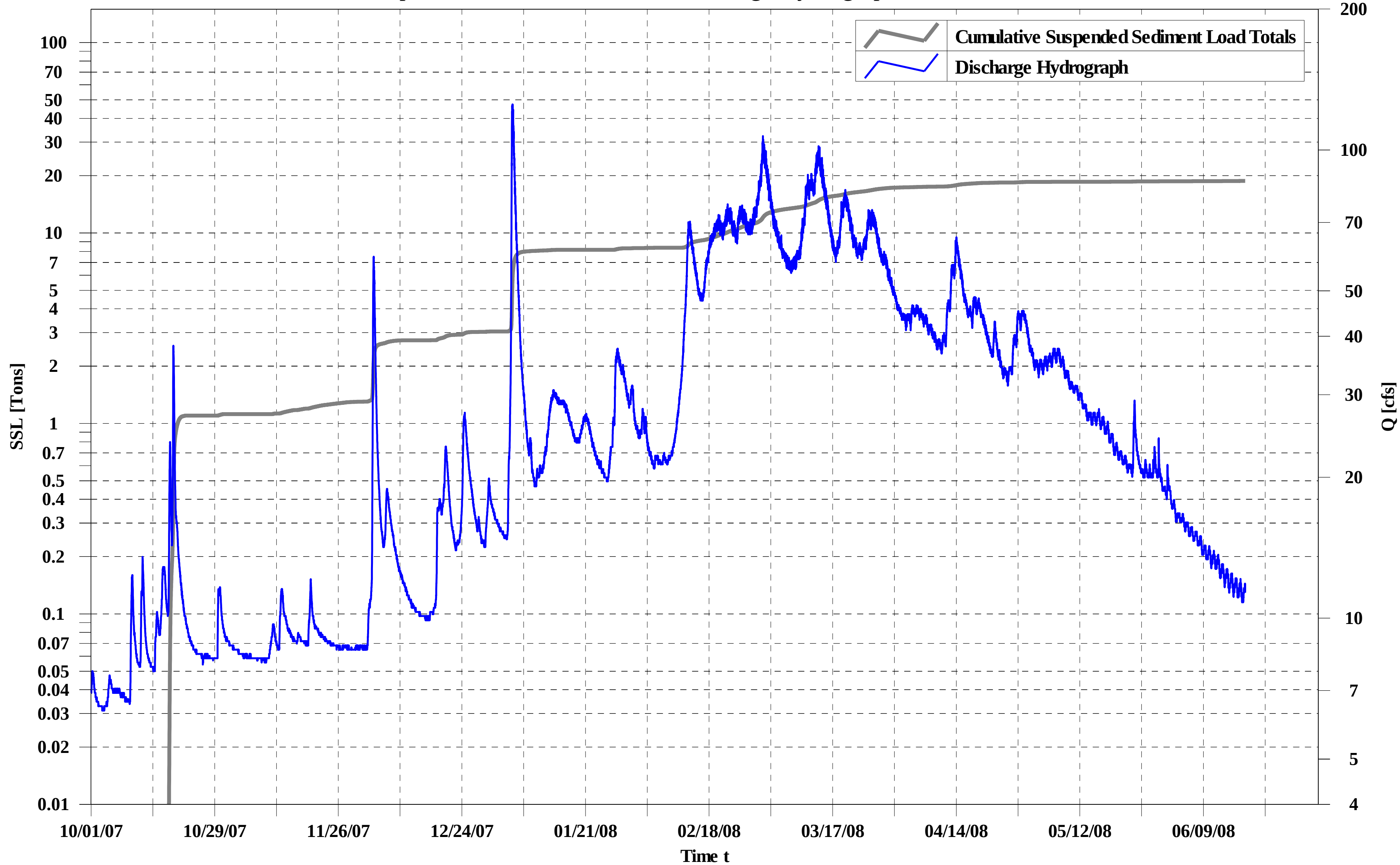
BIG CREEK AT TCR324 NR HAYFORK, CA – 11528430

Cumulative Suspended Sediment Load and Discharge Hydrograph – Partial Water Year 2008



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APPENDIX

B-9b

SUSPENDED SEDIMENT MEASUREMENT SUMMARY SHEET

LOCATION: BIG CREEK MANUAL SAMPLING STATIONS **WATER YEAR 2007 - 2008**

STATION NUMBER: NA

Date Time	Sample Number	Lab Turbidity (NTRU)	SSC (mg/l)	Stage (ft)	Discharge (cfs)	Suspended Sediment Discharge (tons/day)	Type DIS, Grab, Box	Notes
12/26/2006 17:36	DC324-SSCT 2007-01	2.5	---	-4.44	---	---	DIS	Turbidity not measured in 48 hours
12/27/2006 01:35	DC324-SSCT 2007-02	2.5	---	-4.40	---	---	DIS	Turbidity not measured in 48 hours
12/27/2006 02:23	DC324-SSCT 2007-03	1.8	---	-4.42	---	---	DIS	Turbidity not measured in 48 hours
02/11/2007 13:02	DC324-SSCT 2007-04	1.4	---	-4.40	---	---	Box	
03/21/2007 13:41	DC324-SSCT 2007-05	0.10	---	-4.17	---	---	Box	
12/03/2007 10:00	DC324-SSCT 2008-01	9.40	155	---	---	---	Box	
01/03/2008 15:50	DC324-SSCT 2008-02	2.90	2	-4.50	---	---	Box	
01/04/2008 08:20	DC324-SSCT 2008-03	15.0	42	-4.30	---	---	Box	
01/04/2008 14:22	DC324-SSCT 2008-04	7.10	10	-4.30	---	---	Box	
01/04/2008 16:35	DC324-SSCT 2008-05	5.10	9	-4.30	---	---	Box	
04/02/2008 16:00	DC324-SSCT 2008-06	0.00	>0.5	-5.40	---	---	Box	
03/21/2007 13:49	T1324-SSCT 2007-01	0.30	---	-3.94	---	---	DIS	
12/03/2007 10:24	T1324-SSCT 2008-01	4.20	5	---	---	---	Box	
01/04/2008 08:30	T1324-SSCT 2008-02	20.0	25	-4.3	---	---	Box	
01/04/2008 14:30	T1324-SSCT 2008-03	5.50	3	-4.3	---	---	Box	
01/04/2008 16:45	T1324-SSCT 2008-04	5.30	2	-4.3	---	---	Box	
04/02/2008 15:53	T1324-SSCT 2008-05	0.40	3	-5.5	---	---	Box	
12/26/2006 17:21	PC324-SSCT 2007-01	1.7	---	-2.99	---	---	DIS	Turbidity not measured in 48 hours
12/27/2006 01:46	PC324-SSCT 2007-02	7.2	---	-2.90	---	---	DIS	Turbidity not measured in 48 hours
12/27/2006 02:12	PC324-SSCT 2007-03	2.7	---	-2.88	---	---	DIS	Turbidity not measured in 48 hours
02/11/2007 13:18	PC324-SSCT 2007-04	1.7	---	-2.76	---	---	Box	
03/21/2007 13:55	PC324-SSCT 2007-05	0.30	---	-7.65	---	---	Box	
04/02/2008 15:45	PC324-SSCT 2008-01	0.45	>0.5	-7.60	---	---	Box	
12/26/2006 17:09	LC33N47-SSCT 2007-01	4.0	---	-3.86	---	---	DIS	
12/27/2006 01:54	LC33N47-SSCT 2007-02	3.0	---	-3.82	---	---	DIS	
12/27/2006 01:58	LC33N47-SSCT 2007-03	3.6	---	-3.82	---	---	DIS	Replicate
02/11/2007 13:37	LC33N47-SSCT 2007-04	2.9	---	-3.71	---	---	Box	
03/21/2007 14:07	LC33N47-SSCT 2007-05	0.10	---	-10.9	---	---	Box	WSE MSR'D From Crossing
02/11/2007 14:00	BC33N47-SSCT2007-01	3.0	---	NA	---	---	Box	Stake at WSE
03/21/2007 14:17	BC33N47-SSCT2007-02	0.30	---	-5.81	---	---	Box	WSE MSR'D From Crossing
02/11/2007 14:46	EFBC-SSCT 2007-01	2.3	---	NA	---	---	Box	Stake at WSE
03/21/2007 14:23	EFBC-SSCT 2007-02	0.30	---	-4.90	---	---	Box	
04/22/2008 17:41	BCBCR-SSCT 2008-01	0.48	>0.5	-11	---	---	DIS	

Supeded Sediment Value Rounding According to Porterfield, 1972
Turbidity Value Rounding According to Anderson, , 2004

PROJECT:
2007 – 2008 BIG CREEK SEDIMENT SOURCE ANALYSIS
WATER QUANTITY AND QUALITY
The Watershed Research and Training Center

GMA
Hydrology | Geomorphology | Stream Restoration

APPENDIX
C-1

Section 8. Big Creek Sediment Budget

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BIG CREEK DRAFT SEDIMENT BUDGET

1.0 INTRODUCTION

The purpose of this report is to document the results of, as well as the data and methods used for, the Big Creek erosion source inventory and sediment budget. As part of the Big Creek Watershed Resource Inventory, the sediment budget was completed to help identify and prioritize sediment sources within the watershed. The sediment budget is designed to qualify and quantify the relative sediment contribution from different erosion sources, identify which of the Big Creek subwatersheds produce the most suspended sediment, and provide land managers with a tool to develop strategies to prevent and reduce erosion sources created by anthropogenic activities.

2.0 METHODS

This section summarizes the methods, data, and information used to develop the sediment budget.

The sediment budget follows hydrologic and geologic analysis methods outlined in McCammon et al. (1998) and CDC (2001) and sediment budget methods described by Reid and Dunne (1996), Washington Department of Natural Resources (1995), and USDA Forest Service (2004) to identify the controllable sediment sources in the Big Creek watershed. GIS was used to process the data layers, and Excel was used to calculate the amount and probability of sediment delivery. These models were used to estimate the background and management-related sediment delivery from landslide, surface, and fluvial erosion processes.

The sediment budget attempts to account for the short- and long-term input of sediment to the stream network from average and episodic rainfall-runoff and snowmelt-driven flood events. In the sediment budget, sediment yield is expressed as an annual average yield. The analysis compares the background and existing sediment delivery rates for the design flood event (average annual event for the basin).

2.1 Drainage Basin Characteristics

2.1.1 Watershed Stratification

The 11 subwatersheds delineated as part of this sediment budget are listed in Table 1 and shown in Figure 8-1. Land form and land use data are summarized below for each of the subwatersheds.

2.1.2 Watershed Morphometry and Lithotopo Units

The shape, texture, dr**a**inage pattern, and drainage efficiency of the subwatersheds are used to qualify and quantify the frequency and magnitude of upland sediment delivery and instream sediment transport and storage. Watershed morphometry features are measured using NetMap and 10-meter digital elevation models (DEMs), including drainage area, maximum and minimum elevation, basin length, stream network length, and channel type. The NetMap model was used

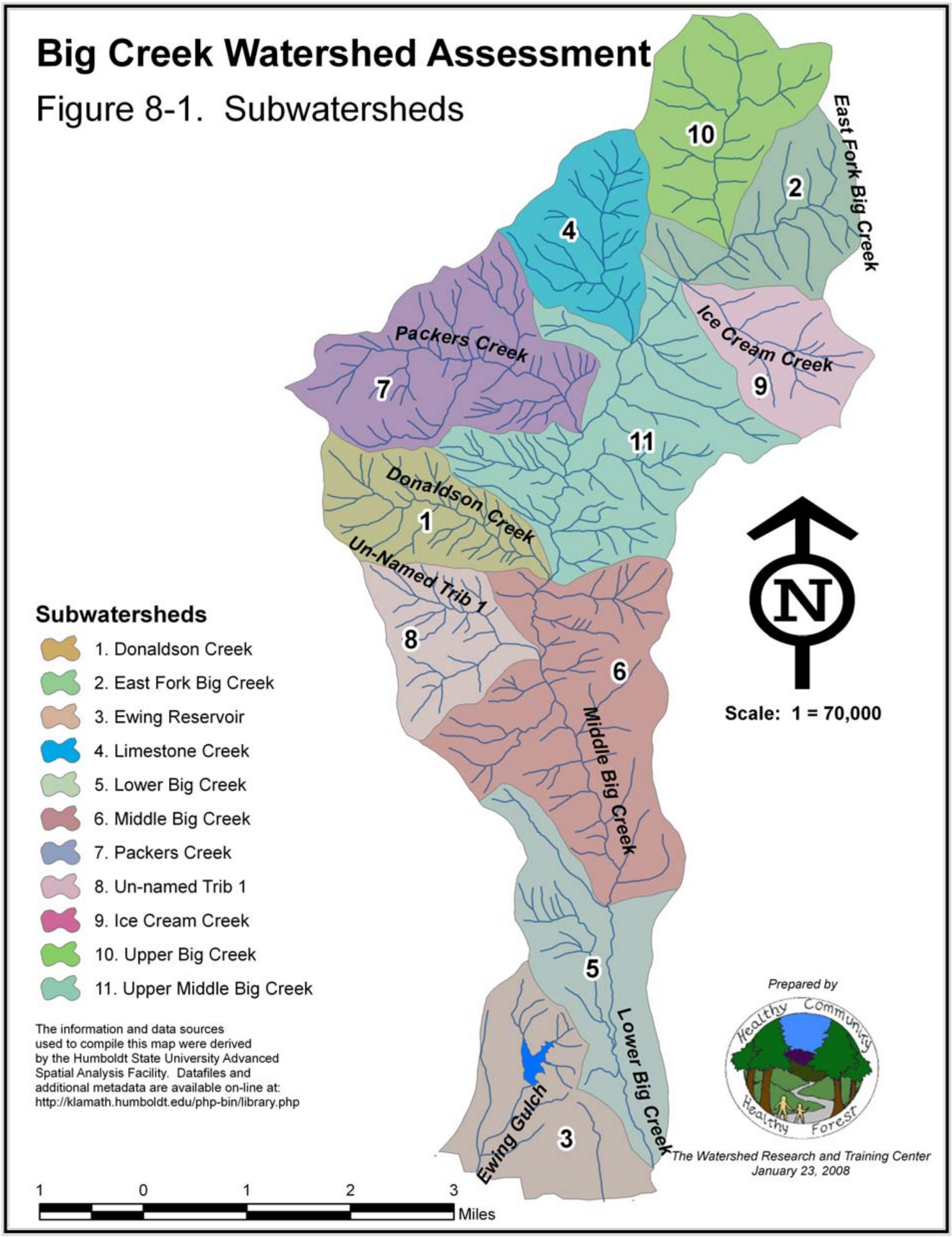

Figure 8-1. Map of the Big Creek subwatersheds and stream layer

to measure the longitudinal profile, distribution of hillslope parameters such as gradient, and drainage efficiency of each subwatershed and the entire basin.

Table 1
Big Creek subwatersheds and corresponding drainage areas

SUBWATERSHED NAME	DRAINAGE AREA (ACRES)
Upper Big Creek	1651
Limestone Creek	1213
Packers Creek	2245
Upper Middle Big Creek	2889
Donaldson Creek	1235
Middle Big Creek	3058
Un-named Trib 1	1075
Lower Big Creek	1765
Un-named Trib 2	1054
East Fork Big Creek	1294
Ewing Reservoir	1606

Lithotopo units are used to classify and analyze natural and human-altered geomorphic processes within the Big Creek watershed using methods described by Montgomery (1999). These units are presumed to be spatially and temporally a function of climate, bedrock geology, tectonic setting, soil type, ground cover, slope stability, slope steepness and convergence, and stream network geometry (Benda et al., 2004). For this analysis, lithotopo units are classified by mapping individual polygons with similar erodibility and topography. Data sources used to stratify the Big Creek watershed into lithotopo units include: 1) bedrock geology (Figure 8-2), 2) dormant and active landslides, and 3) topography generated from a 10-meter DEM. A GIS project was used to generate the lithotopo unit polygons, and sediment source inventory data were used to refine each polygon's erosion rate, sediment delivery rate, and sediment yield (Figure 8-3). The timber harvest data were intersected with the lithotopo unit layer to predict havest related erosion. Each of the resulting timber harvest polygons was assigned an erosion factor. The lithotopo units were not used to modify road erosion rates.

2.2 Landslide Inventory Methods

The landslide inventory was performed in two phases, the first using desktop methods and the second using field methods. The inventory focused on mapping natural and management-related active landslides. Because there were very few active landslides within the Big Creek watershed, dormant and relict landslides were also mapped and included in the lithotopo unit layer.

The first phase of the landslide inventory consisted of examining existing data and landslide maps. Landslide data from the USDA, Forest Service (USDA FS, 2005) and South Fork Trinity River Total Maximum Daily Load (TMDL) (Raines, 1998) were compiled. The USDA FS GIS data are the most comprehensive, with the landslide map covering the entire study area. The map includes data from all of the sources listed above in addition to landslides mapped as part of this study. Active landslides with obvious activity were mapped from the most recent sets of remote sensing data (i.e., 2003 aerial photographs and 2005 digital ortho photographs).

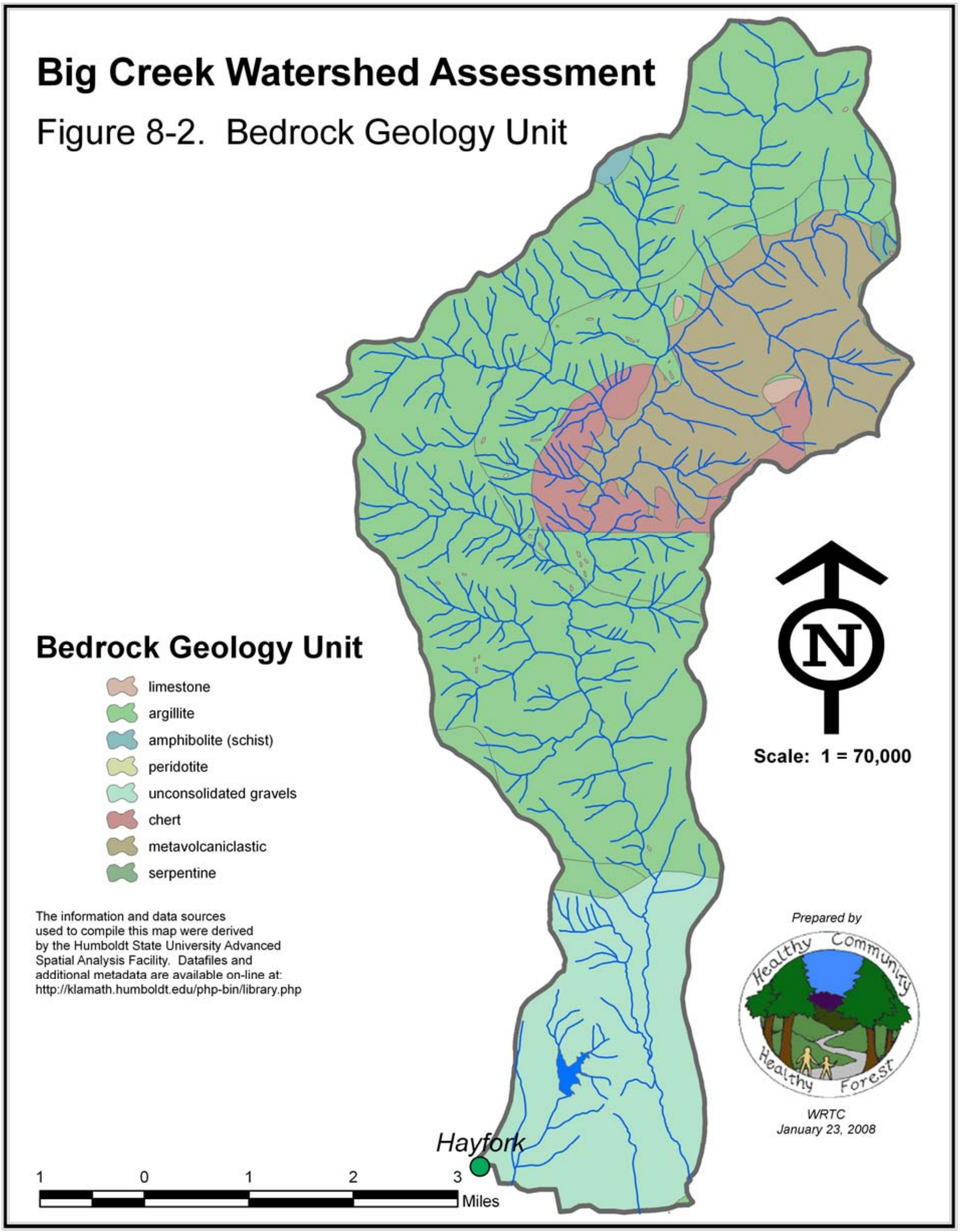

Figure 8-2. Map of Big Creek bedrock geology layer

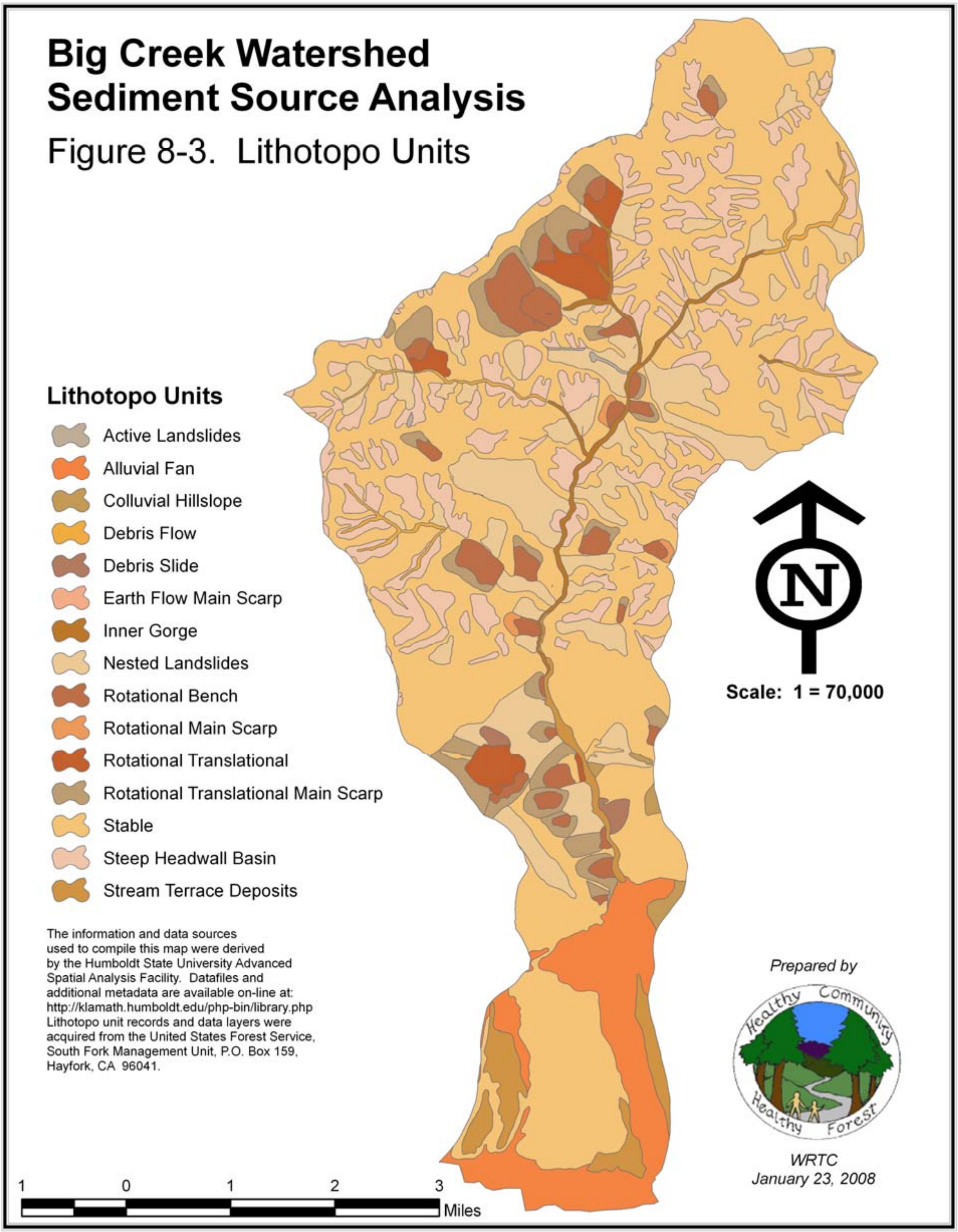

Figure 8-3. Map of the Big Creek lothotopo unit layer

publically available aerial photographs were used; the most recent aerial photos were taken in 2003 and 2005 at a scale of about 1:18,000 (1 inch equals 1,500 feet).

The aerial photo landslide inventory documented the location, type, geometry, and time period of landslides in the watershed. For a given landslide, the dimensions were measured (i.e., length and width), scaled from the photo scale to 1:24,000. The landslide outline was then hand-drawn on an acetate sheet overlaid on the topographic map. After being mapped on the acetate overlay, the landslide was measured a second time to check the scaling. The landslide was then numbered and classified based on attributes visible on the photo. The overlays were then digitized into the GIS project.

For each landslide identified on the aerial photos, the following information was recorded in the landslide database:

- Landslide number.
- Year of the aerial photo on which the landslide first appears.
- Number and flight line of the aerial photo on which the landslide first occurs.
- Landslide classification (described below).
- Certainty of identification: d = definite, p = probable, q = questionable.
- Activity level using the following categories: active, inactive, or relict.
- Landslide width and length.
- Sediment delivery to streams (described below).
- Landslide triggering mechanism (described below).

The second phase of the landslide inventory included conducting a field inventory of a representative sample of the mapped landslides. Data were collected on landslide dimensions and the percentage of sediment entering streams. The results were used to help verify aerial photo measurements and interpretations and to document the size of the landslides that could reasonably be identified on aerial photos.

The fieldwork also included documenting, measuring, and describing smaller landslides that could not be identified with certainty on the aerial photos. Typically, only landslides with areas of 3,000 to 5,000 square feet can be reliably and consistently identified on 1:10,000 to 1:24,000-scale aerial photos in most terrains. The actual size of landslides that can reliably be identified varies with the scale and quality (black and white or color, age and resolution) of the aerial photos.

The landslide triggering mechanism is defined by the process(es) that initiated landslide activity: natural or management-related. Some of the natural triggering mechanisms include reduced soil strength due to slope saturation, removal of lateral support by stream downcutting, and reduced root strength after severe wildland fire. Some of the management-related triggering mechanisms include removal of lateral support above road cuts, increased weight from road fills, reduced soil strength due to slope saturation from road drainage or timber harvest, and reduced root strength after timber harvest (CDC, 1999).

For this analysis, the mechanism that triggered a given landslide is classified into three categories: natural; road-related; and timber harvest. Ground disturbance associated with forest roads and timber harvest activities are commonly landslide-triggering mechanisms; however, other non-forest land uses such as grading associated with urban development also contribute to slope instability (CDC, 1999).

2.3 Surface and Fluvial Erosion

2.3.1 Data Sources

The surface and fluvial erosion analysis relied on road inventory data collected as part of this analysis. The road inventory data are listed in Appendix A and shown in Figure 8-4.

2.3.2 Erosion Source Inventory

A complete road inventory of the Big Creek watershed was completed. Standard USDA FS road inventory protocols were used to collect data on road segments and stream road crossings. Each road segment was split at points where runoff starts and stops: for example, at the top of a ridge and at the bottom of a stream channel. If drainage features were at least 80% effective, the road segment was broken. Hence, each road segment represents runoff patterns and connection to the stream network. Road inventory data are listed in Appendix A. These parameters collected at each road segment include:

- Road surface type
- Road design type
- Road status
- Road gradient
- Road ditch width, depth, and condition (if present)
- Cutbank height, length, slope, exposed soil type, and vegetation cover
- Presence of ruts
- Presence of active rill and gully erosion

Stream road crossings were also inventoried. Measurements at crossings focused on culvert condition and risk of failure. Data on stream road crossings are listed in Appendix A. The parameters collected at each stream road crossing include:

- Stream flow regime
- Diversion potential
- Culvert type, diameter, percent plugged, percent damaged, alignment, and outlet type
- Stream flood prone width and depth, gradient, substrate composition, stability, and debris potential.

2.3.3 Road Surface and Fluvial Erosion Model

The Watershed Erosion and Prediction Model (WEPP) Road Batch (Elliot et. al., 2000) model was used to estimate surface erosion and sediment delivery from roads. Using the road inventory data, the road system was classified into unique road types. This analysis used WEPP to develop an understanding of the relative input of sediment from roads by quantifying the amount of sediment delivered to streams by disturbance type and lithotopo unit.

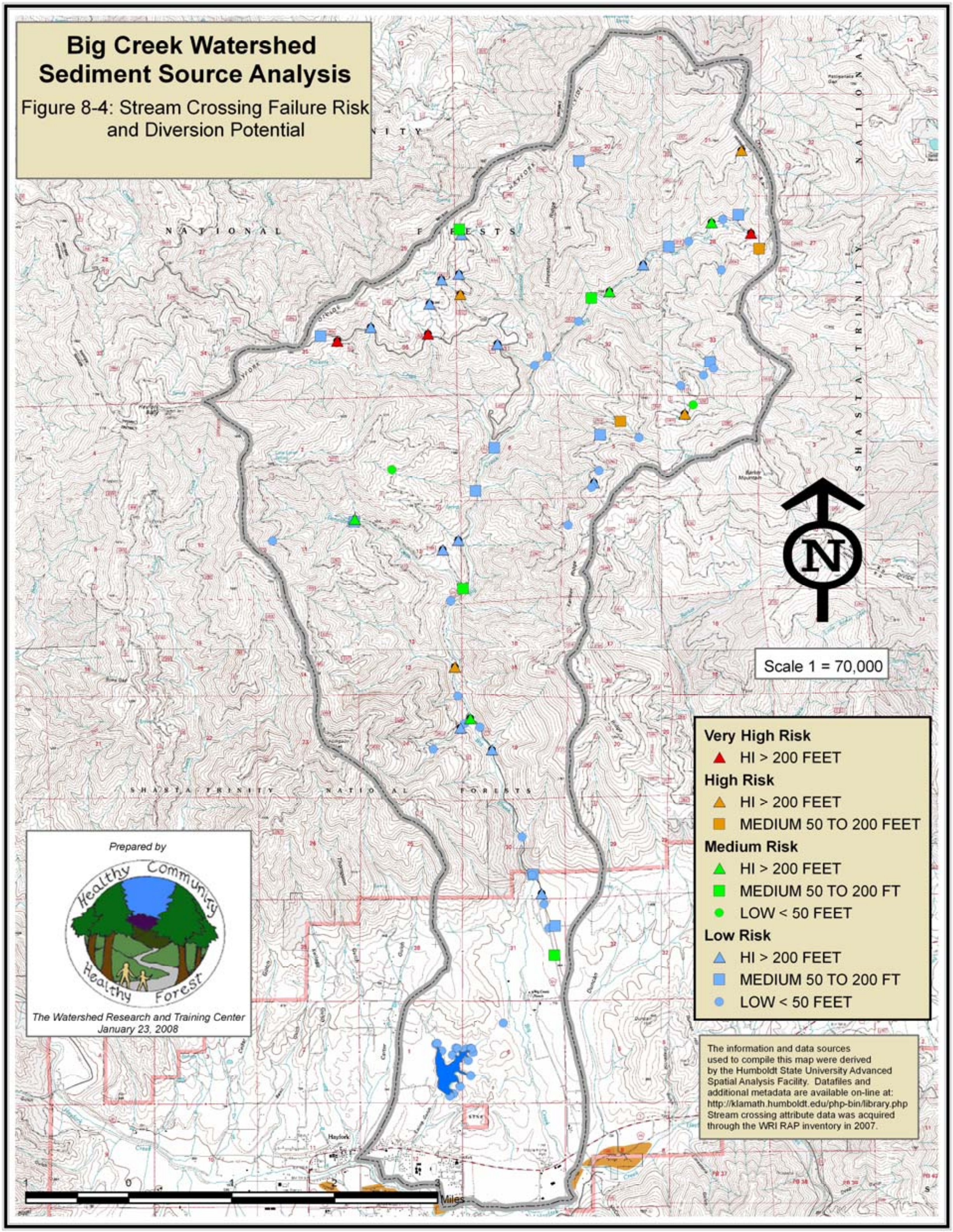

Figure 8-4. Map of the Big Creek road inventory layer displaying stream road crossing failure risk rating.

The WEPP model uses the following physical processes to predict the probability of erosion and sediment delivery: infiltration and runoff, soil detachment, transport, deposition, and revegetation with time. WEPP does not route sediment once the sediment is delivered to the stream network and has an error of plus or minus 50% (Elliot et al., 2000). There are seven input variables: climate, soil texture, type of treatment, gradient, horizontal length, percent cover, and percent rock. Within the model, ground cover is a driving variable where erosion decreases as ground cover increases. Like other erosion models, WEPP is best used as a tool to compare different land disturbances (e.g., background versus existing conditions) and should not be used as an absolute predictor of erosion or sediment delivery. The erosion rates by road type are listed in Appendix B.

The approach used to estimate surface erosion rate for a given type of road was to examine road segments for characteristics of the road prism, drainage system, and traffic as they influence the delivery of sediment to the stream system, and calculate road sediment yield based on these characteristics.

Factors were applied for differing conditions of the road tread, cut-slopes, and traffic use that increase or decrease the estimated sediment delivery of that segment. The result is an estimate of sediment delivery for each road segment. The delivery was further modified according to the estimated sediment yield to the stream network along that segment.

The road inventory data were used to sort roads by sediment delivery potential. This analysis assumed that road drainage points with a buffer greater than 100 feet do not deliver sediment to the stream network. The road database was sorted using this criterion. For road segments with delivery potential, the WEPP model was used to predict total road erosion and sediment delivery potential.

Data were compiled for the following factors and road attributes that influence the amount of sediment delivered to streams from roads:

- The erodibility of the soil/geology the road is built upon
- Precipitation amount, frequency, and intensity (used Forest Glenn weather station)
- Road drainage pattern (insloped/outsloped/crowned)
- Probability that sediment from road reaches stream (depends on distance and slope between road drain and stream, amount of obstructions to trap sediment, and road area that collects water and sediment)
- Length of road that delivers to stream
- Width, surface type and durability, traffic use, and slope of road tread
- Data were not available for road age.

The total amount of erosion from each drainage segment is calculated as the sum of tread erosion, cut-bank erosion, and other sources of erosion using the WEPP model. Total erosion is then divided by the planar road area. Total erosion from each site was then summed for each of the road types and lithotopo units, and the results were then used to develop surface erosion rates (tons/acre/year) which could then be applied to data extracted from the project GIS.

2.3.4 Timber Harvest Surface and Fluvial Erosion

Surface and fluvial erosion from areas disturbed by timber harvest activities is most often related to several different surface disturbance activities, primarily skid trails and harvest operations that result in impervious surfaces and increased rainfall-runoff. The modified Generic Erosion Potential from the NetMap model was used to predict erosion from harvested areas for high, medium, and low disturbance levels. The rate varied by the type of harvest (e.g., clearcut versus thin), the yarding method (e.g., tractor versus cable), and the type of lithotopo unit. Since no active landslides were found within timber harvest areas, this analysis focused on surface and fluvial erosion and assumes that the units are fully recovered within 15 years of harvest.

2.4 Sediment Budget

2.4.1 Data Sources

The NetMap model uses the 10-meter DEMs to measure hillslope and stream channel parameters and to predict local sediment delivery and watershed-wide sediment yield. The hillslope and stream channel data are synthesized and refined using the stream, erosion source, and landslide field data collected as part of this analysis. The geology, landslide, and land use GIS layers were used to refine the NetMap sediment budget. The intersected layer is called the litho disturbance layer. The Big Creek subwatersheds (Table 1 and Figure 8-1) were used to stratify the analysis area and summarize the sediment budget results. All of the GIS and Excel files are stored electronically in the project file and are available on DVD.

2.4.2 NetMap Model

The NetMap model, developed by the Earth Systems Institute (ESI), was used to develop the Big Creek watershed sediment budget. This model was run using the best available data and information. New information can be used to further inform this model and improve the overall accuracy of sediment yield predictions in the future. A watershed analysis system (NetMap) is used to increase the spatial resolution of erosion sources to better identify upland areas with high sediment delivery potential. Results are tabulated and displayed in map form.

NetMap generates a parameter referred to as generic erosion potential (GEP), an erosion index that is based on slope gradient and slope curvature. GEP is calculated as:

$$GEP = (A_L * S)/b$$

where

A_L = measure of local contributing area (within one pixel length)

S = slope gradient (Miller and Burnett 2007)

b = a measure of local topographic convergence

For this equation, b is the length of an elevation contour crossed by flow out of the pixel; values less than one pixel length indicate convergent topography. GEP is similar in form to other models that predict shallow failures based on some measure of slope gradient and curvature (i.e., Shaw and

Johnson 1995, Montgomery and Dietrich 1994, Pack et al. 1998). GEP is applicable to many landscapes since steep, convergent areas are preferential locations for erosion in the form of shallow failures, gullies, and even surface erosion (following fires). However, predicted erosion potential (such as GEP) should be considered only in the context of additional information on geology, climate, and vegetation, among other factors. For example, steep and convergent areas in humid landscapes are more susceptible to shallow landslides and debris flows due to heavy rain and rain-on-snow compared to similar landforms in semi-arid landscapes where they may pose a lower erosion hazard because spring snowmelt runoff is gradual, except in areas of post-fire gullying. Importantly, GEP does not address erosion sources such as large debris flows and slides, deep-seated slides, and earthflows.

In NetMap, GEP can be converted to annual sediment yield by directly scaling GEP values to known (or estimated) erosion rates or basin sediment yield (information often collected while developing a sediment budget). Predicted sediment yield values are reported for hillslopes and channels, and predicted values are accumulated downstream and scaled by drainage area. GEP in NetMap can apply to surface erosion mechanisms on landslide-prone terrain, since hillslope gradient and surface topography should govern shallow failures and surface erosion.

To convert the GEP to hillslope sediment yield, polygons are draped onto the predicted GEP maps for the Big Creek watershed. NetMap downgraded the GEP values and reported the results in terms of pixel-scale sediment yield. Alternatively, in areas of rock with high erosion potential (reflected by slope and convergence - shallow failure, gullying, surface erosion post fire), the GEP values were increased or were transformed into relatively high sediment yield values.

The GEP is used to predict the probability of surface and fluvial erosion for landforms that are stable or have shallow debris flow potential. For locations on the landscape where surface and fluvial erosion are the dominant erosional processes, the GEP is modified using results from the WEPP road erosion model. The factors and sediment delivery rates calculated for each geologic, landslide, and land use disturbance type are summarized in Appendix B.

The predicted basin average sediment yield ($Q_{SL(Basin)}$) for the Big Creek watershed is the sum of sediment delivery road sediment delivery ($Q_{SD(Road)}$) (sediment delivery Method 1) and GEP terrain ($Q_{SD(GEP)}$) (sediment delivery Method 2). The sediment yield is calculated using the following equation:

$$Q_{SL(Basin)} = Q_{SD(Road)} + Q_{SD(GEP)}$$

To calculate surface and fluvial erosion ($Q_{SD(GEP)}$), the GEP is adjusted using an erosion potential factor (F). This factor is calculated by dividing the average sediment delivery for a given lithotopo unit ($Q_{SD(unit)}$) by the measured or estimated basin average sediment yield $Q_{SLM(basin)}$ where:

$$F = Q_{SD(unit)} / Q_{SLM(basin)}$$

The existing sediment yield was estimated at 7 tons/acre/year as part of this analysis. These values are the basis used to scale the basin sediment delivery ratio and convert GEP to units of sediment delivery. The $Q_{SD(unit)}$ is calculated for each lithotopo unit and is varied depending on surface and fluvial erosion potential. On natural or disturbed erodible hillslopes (e.g., convergent slopes in metasediment) with no landslide activity, the GEP is adjusted using the factor (F>1) to account for the erodibility of different rock types. For litholtopo units with a $Q_{SD(unit)} < Q_{SLM(basin)}$, F =1.

The GEP of each lithotopo unit is then converted into sediment delivery units using the following scaling factor:

$$Q_{SD(GEP)} = Q_{SLM(basin)}/GEP_{(basin)}, \text{ where}$$

$$GEP_{(basin)} = \text{basin average GEP}$$

For roads, the GEP is not used to predict erosion and sediment delivery. The average measured estimated road sediment delivery rate ($Q_{SDR(Landslide)}$) (from WEPP Appendix A) by road type, bedrock geology, and disturbance type is used to develop the non-GEP portion of the sediment budget (Method 1). The sediment delivery rate was held constant for each type of road and lithotopo unit. The sediment delivery from each road was calculated using the following equation:

$$Q_{SD(Road)} = Q_{SDR(Road)} * A_{(Road)}, \text{ where}$$

$$A_{(Road)} = \text{mapped landslide area.}$$

NetMap takes the predicted sediment delivery from Methods 1 and 2 and delivers sediment to the channel network. It then routes the delivered sediment through the network to the basin outlet. NetMap does not predict sediment storage within the network; rather, it assumes equilibrium conditions between sediment supply and storage. As stated above, for stable terrain, slope steepness and convergence are used with the measured basin sediment yield to predict erosion potential and sediment delivery to the stream network (Benda et al., 2007). NetMap aggregates sediment delivery rates downstream to the basin outlet. The total cumulative sediment yield is estimated at the basin outlet and for each of the subwatersheds and erosion source type.

3.0 SEDIMENT BUDGET RESULTS

3.1 Erosion Source Inventory

3.1.1 Landslide Inventory Results

Landslide field-verification surveys were performed to assess whether the features observed were actually slides, evaluate the state of activity, establish thickness by landslide type, validate the size of landslides mapped from aerial photography, and validate the trigger mechanism assigned to each landslide. The landslide map created from existing USDA FS landslide data and aerial photo mapping were given a certainty of recognition rating.

All of the mapped active landslides were visited in the field, and about 10% of the dormant landslides were visited. Results from landslide field verification helped substantiate that there are very few active landslides within the Big Creek watershed. Most of the landslides are dormant or relict, and the active slides occur within the inner gorge or on steep upslope areas.

The landslide inventory layer (i.e., lithotopo layer) created for this analysis covers the entire watershed and includes stable and unstable hillslopes. This layer was intersected with the delineated subwatersheds (Figure 8-1) and Forest Service bedrock geology layer (Figure 8-2), creating the lithotopo unit layer (Figure 8-3). The lithotopo unit layer was then intersected with the land use layers to include roads, timber harvest, and irrigated agriculture. Data summary tables were prepared to perform sediment delivery and yield calculations and to help interpret the data (Table 2 and Table 3).

Table 2
Landslide activity by lithotopo unit sorted by spatial area covered in descending order followed by average annual sediment yield.

LITHOTOPO UNIT	AREA (ACRES)	PERCENT OF TOTAL	SEDIMENT YIELD (TONS/YR)	PERCENT OF TOTAL
Stable	9482	50%	5080	31%
Dormant	7194	38%	5647	34%
Alluvial	1552	8%	4927	30%
Terrace	518	3%	623	4%
Active landslide	224	1%	273	2%
Colluvial	129	1%	50	0%

Table 3
Bedrock geology versus lithotopo unit sorted by spatial area (in acres) covered in descending order.

LITHOTOPO UNIT	E3	E4	E7	E8	TW	W2	W4	W6	TOTAL	PER-CENT OF TOTAL
Stable	62	6125	14	1	1204	351	1693	31	9482	50%
Steep headwall basin	2	1828				113	610	2	2554	13%
Nested landslides	3	1431		1		357	538	21	2351	12%
Alluvial fan		23			1529				1552	8%
Translational scarp	2	786	34		2	20	21	0	865	5%
Rotational	0	693	3		2	21	22		741	4%
Stream terrace deposits	0	98			420				518	3%
Rotational translational		392							392	2%
Inner gorge		102				18	87		207	1%
Colluvial hillslope		49			80				129	1%
Debris flow		99					29		128	1%
Debris slide		64							64	0%
Rotational bench		37				5	14		56	0%
Rotational main scarp		23				15	1		38	0%
Active landslide		17							17	0%
Earth flow lateral scarp						1	0	2	2	0%
Earth flow main scarp							0	0	0	0%
Percent of Total	0%	62%	0%	0%	17%	5%	16%	0%		

For the Big Creek watershed, about 1% of the mapped landslides are active (Table 1). Current landslide activity is limited to shallow debris flows on steep upland slopes and inner gorge failures and accounts for less than 2% of the average annual sediment yield. Stable hillslopes cover about half of the watershed and produce about 31% of the average annual sediment yield. Alluvial material, mainly present in Lower Big Creek (Figure 8-3), covers about 8% of the watershed and produces about 30% of the annual sediment yield (Table 1).

Most of the stable hillslopes are underlain by metasediment (E4) and metavolcanic - andesite (W4) (Table 2). Alluvial material is present on stable hillslopes and on alluvial fans. The alluvial lithotopo type and alluvial geology type are mapped in the same area where most of the alluvial material occurs on the mapped alluvial fans and terraces. All of the mapped active debris flows occur in metasediment (E4), and inner gorge slides occur in E4 and metavolcanic (W4) (Table 2).

3.1.2 Surface and Fluvial Erosion Inventory Results

The surface and fluvial erosion inventory focused on erosion from roads. The inventory measured and categorized erosion potential from road surfaces and stream road crossings. The Watershed Center completed a comprehensive road inventory of the entire road system within the Big Creek watershed to include 96.3 miles of road and 82 stream road crossings (Figure 8-4). The road inventory data are listed in Appendix A. About 15% of the sites were checked for quality assurance, and corrections were made as found. Differences were found mainly at stream road crossings, and sites with anomalous values were re-inventoried and corrected. For example, the flood prone width was corrected at several sites.

Several GPS and GIS problems were encountered after data collection that caused topology and attribute table errors. The final road version may still have unknown topology errors; the attribute table was corrected. Topology errors will cause differences between actual versus mapped road length and area. As a result, there is a 14% difference between road erosion predicted using WEPP versus NetMap. If the road topology differences did not occur, the NetMap model would not under-predict road erosion.

The measured road length and density for the Big Creek watershed is 91.2 mi and 3.1 mi/mi^2, respectively. The road density varies by subwatershed, with several greater than 3.5 mi/ mi^2 (Table 4). For the entire watershed, 71% of the road surfaces are native, 18% are rocked, and 11% are paved, and about 75% of the roads have an outslope shape. Road gradient ranges from less than 1% to greater than 15% with 1% between 1 and 3%, 20% between 3 and 5%, 34% between 5 and 10%, 33% between 10 and 15%, and 12% > 15%. The average road cutbank height is 11 ft, with a maximum of 50 ft, and most of the cutbanks are steep (>50% slope). About 7% of the cutbanks expose bedrock, 17% clay loam, 41% gravelly loam, and 34% silt loam. Most of the cutbanks (66%) have more than 50% vegetative cover, and 12% have less than 10% cover. Over half of the unvegetated cutbanks expose gravelly loam followed by silt loam and clay loam.

Rutting caused from vehicle traffic occurs on 16% of the road systems, mainly on native surface roads (66%) with most of the remainder (33%) on gravel surface roads. Ruts and road surface rill and gully erosion occurred together for 99% of the measurements taken. Gullies are present on 6% of the road system, and rills are present on 10%. Most of the rill and gully erosion occurs on roads that are cut into stable metasediment and alluvial hillslopes.

Using the road buffer length and gradient as an indicator of sediment delivery, road inventory data show that about 33% of the road system is hydrologically connected to the stream network. Roads in the upper portions of the watershed do not tend to deliver sediment to ephemeral, intermittent, and perennial streams. About 78% of the drainage points measured have a buffer distance greater than 100 ft, and about 26% of the points have a buffer gradient less than 35%. About 35% of the points are steeper than 65%, and 91% of the >65% points have a buffer distance greater than 100 ft.

Table 4
Road length by subwatershed and road surface type with road density listed in the last column.

SUBWATERSHED NAME	DRAINAGE AREA (MI2)	NATIVE LENGTH (MI)	GRAVEL LENGTH (MI)	PAVED LENGTH (MI)	TOTAL LENGTH (MI)	ROAD DENSITY (MI/MI2)
Ewing Reservoir	2.5	2.6			2.6	1.0
Lower Big Creek	2.8	2.5	1.3	2.8	6.7	2.4
Middle Big Creek	4.8	10.9	1.5	2.3	14.7	3.1
Un-named Trib 1	1.7	3.3	1.7		5.1	3.0
Donaldson Creek	1.9	5.7	2.7		8.4	4.3
Upper Middle Big Creek	4.5	11.3	3.9	1.8	17.0	3.8
Packers Creek	3.5	7.7	0.0	2.6	10.3	2.9
Limestone Creek	1.9	6.1	0.0	0.8	6.9	3.6
Un-named Trib 2	1.6	4.9	1.0		5.9	3.6
Upper Big Creek	2.6	5.7			5.7	2.2
East Fork Big Creek	2.0	3.9	4.2		8.1	4.0
Total		64.7	16.4	10.2	91.2	3.1
Percent of Total		71%	18%	11%		

3.1.3 Stream Road Crossing Inventory Results

The drainage inventory measured road and stream channel characteristics where roads cross ephemeral, intermittent, and perennial streams. About 43% of the inventoried sites cross perennial streams, 35% cross intermittent streams, and 22% cross ephemeral streams. Most of the stream channels are steep with slope gradients greater than 12%. Slopes at only two of the sites are less than 3.5%. The channel substrate tends to be coarse gravel and cobble or boulder bedrock. Ephemeral channels tend to have cobble substrate, and the substrate composition does not depend on channel slope.

Stream channel measurements were taken at each crossing. Perennial streams have an average flood prone width of 7 ft, intermittent streams 4 ft, and ephemeral streams 3 ft. The average flood prone depth is 1 ft with a maximum of 4 ft in the mainstem of Big Creek. There is a linear relationship between drainage area and flood prone width:

$$W_{fp} = 1.4882*A + 4.1319$$

$$R^2 = 0.85$$

W_{fp} = flood prone width (ft)

A = drainage area above stream-road crossing (mi2)

The stream channel stability above the crossing was evaluated and classified, and 34% of the sites are stable with bedrock or boulder channel substrate, 62% are moderately stable, and 4% are unstable.

Road inventory data are used to analyze the risk of stream road crossing failure. Data show that there is low diversion potential for half of the stream road crossings. Diversion potential is highest for perennial stream crossings, followed by intermittent and ephemeral streams. Most of the culverts are properly aligned, and 17% are poorly aligned. The culvert outlet measurements indicate that 39% of the culverts are shotgun with no energy dissipater.

Six variables are used to evaluate the risk of culvert failure: diversion potential, channel slope, flood prone width versus culvert width, debris potential, outlet type, and fill volume. These variables are combined to quantify the relative risk of culvert failure; however, they can be used independently as well. For example, the ratio between flood prone width and culvert diameter is used to help determine if the culverts are sized for the Q_{100} flood event.

Results show that three of the 82 culverts inventoried have a very high risk of failure. These culverts have diversion potential and are likely undersized for the Q_{100} flood event (Table 5). There are six other culverts, mainly on intermittent and perennial stream channels, with a high risk of failure. Figure 4 shows the location of the stream road crossings and their risk rating.

Table 5
Count of stream road crossings culvert by risk of culvert failure and streamflow regime.

CULVERT FAILURE RISK	EPHEMERAL	INTERMITTENT	PERENNIAL	GRAND TOTAL
Low	16	22	25	63
Medium	1	3	6	10
High	1	2	3	6
Very high		2	1	3
Grand Total	18	29	35	82

WEPP Model Surface Erosion Results

Road type and condition data collected as part of the road inventory were used as input to the WEPP model (Figure 8-4). All of the WEPP input and output data are listed in Appendix B. Each road segment was classified using road design, surface type, and road gradient. Data collected to measure the cutslope characteristics were used to classify the condition of the inboard ditch since this is a driving variable in the WEPP model. Tall cutslopes (i.e., > 11 ft) that expose loam material with less than 50% vegetative cover were given an inboard unvegetated (i.e., ib) road design class. Nearly 71% of the road segments were classified as inboard vegetated and outboard unrutted (see Appendix B). Fewer than 10% of the roads were given an inboard bare or design class.

The average erosion rate from road surface erosion predicted by the WEPP model is 71 tons/acre/year, the maximum is 247 tons/acre/year, and the minimum is 3 tons/acre/year. The highest erosion rates were predicted for inboard unvegetated and outboard rutted native surface roads with greater than 10% gradient. The majority of the road system was assigned an erosion rate of less than 21 tons/acre/year. These results were input directly into the sediment budget model discussed below.

3.2 Sediment Budget Results

The NetMap model was used to develop a sediment budget for landslide, surface, and fluvial erosion processes within the Big Creek watershed. The adjusted GEP was used to predict surface and fluvial erosion from stable hillslopes and shallow debris flow potential. The GEP was not used to predict sediment delivery from roads. The model output is summarized to help quantify the relative types, importance, and sources of erosion. The sediment yield by lithotopo unit was distributed to the upland sources creating a polygon layer of background and management related erosion sources (Figure 8-5). The final sediment source map displays the sediment yield by lithotopo unit and disturbance type.

The sediment yield estimates generated using NetMap indicate that the average background and existing unit sediment yield of the Big Creek watershed are 0.5 and 0.9 tons/acre/year, respectively (Table 6). The total average annual sediment yield predicted using NetMap is 16,600 tons/year. About 57% of the existing sediment yield is attributable to background erosion sources, 11% from roads, 2% from timber harvest, and 30% from irrigated agriculture (Table 7). The predicted erosion rates and sediment yield are low relative to other tributaries of Hayfork Creek (Trinity County Resource Conservation District, 2003).

Table 6
NetMap model sediment budget results by subwatershed and unit sediment yield.

SUBWATERSHED	DRAINAGE AREA (ACRES)	BACK-GROUND (TONS/ACRE/ YEAR)	ROAD (TONS/ACRE/ YEAR)	TIMBER HARVEST (TONS/ACRE/ YEAR)	IRRIGATED AGRICULTURE (TONS/ACRE/ YEAR)
Ewing Reservoir	1606	0.20	0.04	0.00	0.00
Lower Big Creek	1765	0.17	0.17	0.14	2.83
Middle Big Creek	3058	0.55	0.10	0.00	0.00
Un-named Trib 1	1075	0.52	0.11	0.00	0.00
Donaldson Creek	1235	0.57	0.20	0.01	0.00
Upper Middle Big Creek	2889	0.58	0.08	0.00	0.00
Packers Creek	2245	0.54	0.07	0.00	0.00
Limestone Creek	1213	0.57	0.07	0.02	0.00
Un-named Trib 2	1054	0.59	0.08	0.00	0.00
Upper Big Creek	1651	0.58	0.04	0.00	0.00
East Fork Big Creek	1294	0.57	0.16	0.00	0.00

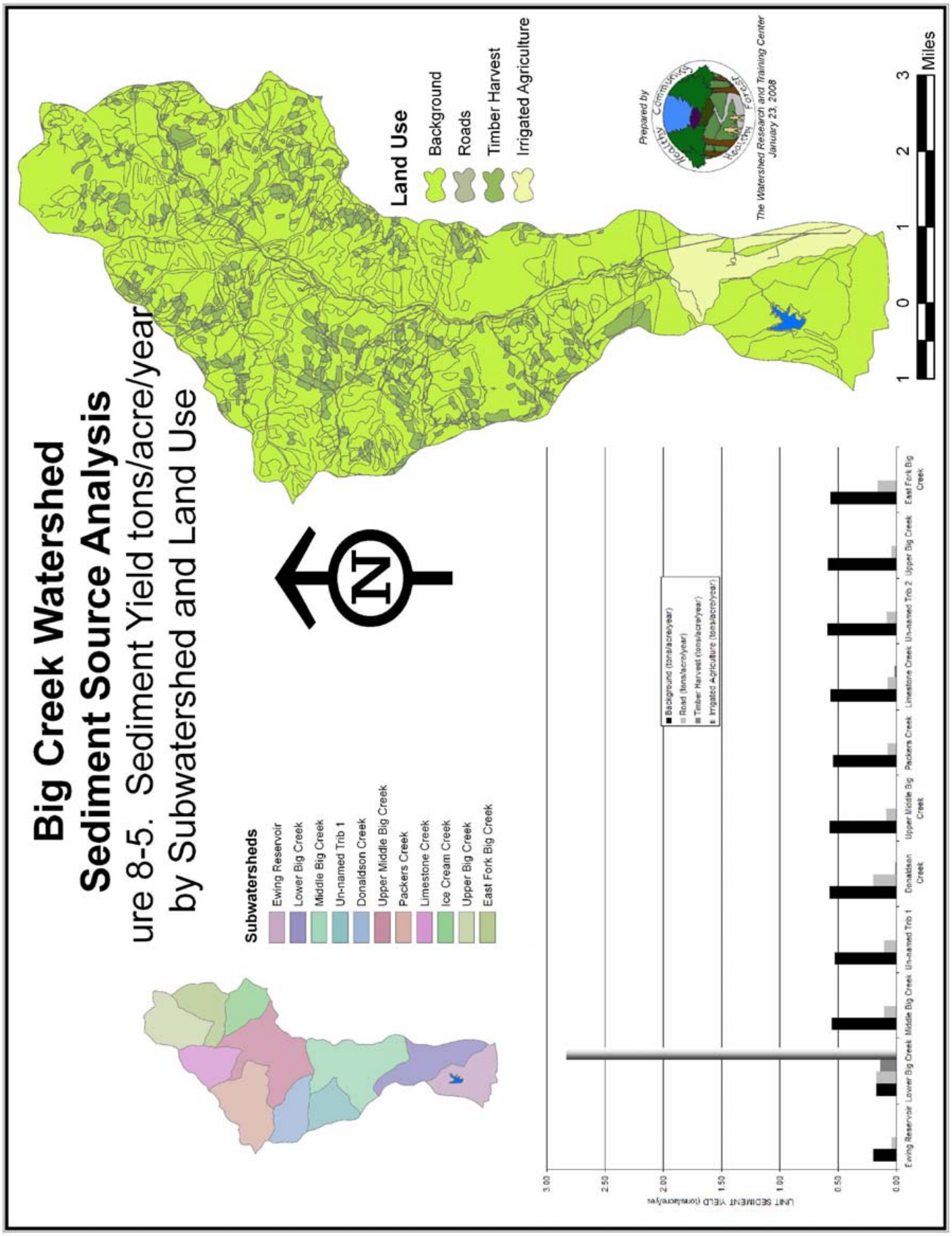

Figure 8-5. Map of the Big Creek NetMap model sediment budget results displaying sediment yield by lithotopo unit and disturbance type

Table 7
NetMap model sediment budget results by subwatershed and erosion source category.

SUBWATERSHED	DRAIN-AGE AREA (ACRES)	BACKGROUND (TONS/YR)	ROAD (TONS/YR)	TIMBER HARVEST (TONS/YR)	IRRI-GATED AGRICUL-TURE (TONS/YR)	TOTAL (TONS/YR)	PERCENT BY SUBWA-TERSHED
Ewing Reservoir	1606	315	63			377	2%
Lower Big Creek	1765	303	298	244	4,988	5,834	35%
Middle Big Creek	3058	1,691	320	0		2,012	12%
Un-named Trib 1	1075	563	115	0		678	4%
Donaldson Creek	1235	705	247	7		959	6%
Upper Middle Big Creek	2889	1,662	238	0		1,900	11%
Packers Creek	2245	1,214	163	0		1,377	8%
Limestone Creek	1213	687	89	20		795	5%
Un-named Trib 2	1054	621	81	0		702	4%
Upper Big Creek	1651	964	61	0		1,025	6%
East Fork Big Creek	1294	735	206	0		941	6%
Total	19084	9,460	1,881	271	4,988	16,600	
Percent by Land Use			11%	2%	30%		

The average background sediment yield is about 0.5 tons/acre/year for steep convergent topography and about 0.2 tons/acre/year for gentle slopes with trellis drainage patterns (Figure 8-4). The gently sloped topography in the lower watershed has a lower GEP than the middle and upper subwatersheds. As a result the Ewing Reservoir and Lower Big Creek subwatersheds have the lowest GEP (Table 6 and Figure 8-4).

Sediment yield from roads, estimated using the road inventory data and WEPP, is highest in the Donaldson Creek, Lower Big Creek, East Fork Big Creek, Un-named Trib 1, and Middle Big Creek (Table 6 and Figure 8-5). Lower Big Creek also has the highest timber harvest related sediment yield and all of the irrigated agriculture yield (Table 6).

Even though the Lower Big Creek subwatershed has one of the lowest background unit sediment yields (Table 5), it has the highest management related yield and produces about 35% of the average annual sediment yield of the Big Creek watershed (Table 7). Most of the sediment delivery within the Lower Big Creek subwatershed is from irrigated agriculture with a sediment yield of about 4,988 tons/year and a unit sediment yield of about 2.8 tons/acre per year. The unit sediment yield from irrigated agriculture is greater than background sources by a factor of 5 and other management sources by a factor between 10.

The Middle Big Creek, Upper Middle Big Creek, and Packers Creek subwatersheds have the highest background sediment yields within the Big Creek watershed. Including road and timber harvest erosion, these three subwatersheds represent 31% of the average annual sediment yield of the Big Creek watershed (Table 7).

3.2.1 Confidence in Analysis

The confidence in this analysis is medium to high. The main sources of uncertainty arise from the topology problems with the road data. There is a 14% difference between the road erosion calculations using the linear stream distance versus the road area used in NetMap.

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