Chapter 2

Geology, Basin Morphology, and Hydrologic System

Introduction

The Butte Creek Watershed is characterized by a unique geologic and hydrologic setting that has influenced the stream morphology and current land uses of the watershed. The steep canyon sections provide opportunity to harness the creek for hydroelectric power production. The relatively flat and open valley section of the creek, with extensive clay soils, provides an ideal setting for rice production. The inclusion of intrusive and metamorphic geologic structures in the upper portions of the watershed produced gold bearing deposits that attracted miners as early as the mid 1800s. All of these land uses have modified the environment and the hydrologic regime of the watershed. The following section describes the hydrologic system of Butte Creek including diversions, surface water and groundwater augmentations from a variety of sources, and the structures involved. It profiles the geology and basic basin morphology of the watershed. This description starts at the upper elevations in the watershed, and proceeds downstream, incorporating diversions, feeder streams and structures as they are encountered. It also profiles and explains the geology of the watershed as the description runs through it. It has been designed to be used in conjunction with USGS quadrangles, geologic maps, or the Butte Creek Watershed Project's Hydrology map (see Map Appendix). The geologic descriptions correspond to the geology encountered at creek level, as this is where changes in geology are most visible, and the effects on stream morphology are immediately evident. The breaking of the watershed into component parts such as "Upper Watershed" and "Lower Watershed," with further subdivisions, was done merely to provide the reader a way to easily find descriptions of certain sections of the creek.

Upper Watershed: Butte Meadows

Beginning at an elevation of over 7000 feet near the Butte Meadows area, Butte Creek is fed by numerous source streams such as Scotts John, Jones, Colby, and Bolt Creeks, two separate Willow Creeks, and several smaller un-named tributaries. These are perennial streams, with base flows supplemented by numerous springs, particularly in the area of the more northern Willow Creek. Most of these streams begin on the flanks of steeper slopes such as Colby Mountain, Humboldt Peak, or Snow Mountain.

The geology of this headwaters area is composed of volcanic rocks, associated with the Pliocene volcano Mt. Yana. The area contains andesitic rocks, with flows light to dark gray in color, medium to coarse grained in texture, and composed of hornblende, pyroxene, and ferromagnesium-poor andesites; basaltic rocks, black to gray flows of aphanitic to medium-grained olovine basalts, along with andesitic basalts, pyroxene basalt and local, thin interbedded mudflows; and pyroclastic formations (Tuscan Formation) composed of basaltic and andesitic volcanic breccia, mudflow, tuff, tuff-breccia, and thin interbedded sediments and basalt flows (Lydon et al., 1960 Division of Mines and Geology, Westwood sheet). The Tuscan Formation, a major geologic feature in the watershed, is described in further detail later in this section.

These creeks drain into a relatively flat area between the settlements of Jonesville and Butte Meadows, communities comprised mostly of vacation homes and cabins. Flowing through the Butte Meadows area, the creek is essentially in its first flood plain. As the Butte Meadows area is surrounded by uplands at elevations that hold a significant amount of snow during the winter and spring months, the area is subject to flooding during high intensity, warm precipitation events on top of snow, such as the early 1997 event.

Upper Watershed: Upper Butte Creek Canyon

As the creek leaves the Butte Meadows area, it begins to incise into the Pre-Cretaceous metavolcanic and (older) Paleozoic marine sedimentary and metasedimentary geologic structures. Known as the Sierra Nevada Basement Series or Basement Complex, these rocks underlie the volcanic structures that dominate the drainage basin. This formation is composed of massive greenstones, tuffaceous schists, dark schistose metasedimentary and metavolcanic rocks of the “Calaveras Formation,” slates, dark phyllite, quartzite, serpentine, and graywacke (Lydon et al., 1960; Harwood, Helley, and Doukas, 1981).

Approximately two miles into the canyon, the first of many unnamed tributaries enters Butte Creek from the east. The creek averages a drop of over 100 feet per mile in this section (USGS Provisional “Butte Meadows” 7.5’ quadrangle, 1991) and canyon walls can average 40-60% gradient (Andrew Conlin, 1997 Pers. Com, NRCS). Over the next two miles, two more unnamed tributaries enter from east, each spaced approximately a mile apart. Almost three and one-half miles downstream, the first major named tributary enters from the east. Bull Creek is joined by Bottle Creek about one and one-half miles above the Butte Creek confluence, and joins Secret Creek about three-quarters of a mile above the Butte Creek confluence.

It is in this area that the interface between the Tuscan (mudflow) Formation and the underlying Basement Series geology, in part containing the "Tertiary Auriferous gravels", begins to become exposed (USGS, 1894). The Tertiary Auriferous gravels are ancient, gold-bearing (auriferous) stream deposits, with their deposition occurring in the Tertiary period of the geologic time scale.

Below the Bull Creek confluence, it is approximately one and one half miles before another tributary enters from the east. It is followed about one half mile later by another small tributary coming in from the east, and less than a quarter of a mile after this, the first major diversion structure on Butte Creek, the Butte Creek Diversion Dam, is found.

The Butte Creek Diversion Dam (also known as the Butte Creek Head Dam) was constructed in its current configuration in 1917. Most likely it existed in another smaller form since the days of the gold rush and surely since 1903, when Eugene J. DeSabla Jr. began to operate the DeSabla/Centerville hydroelectric system. As the dam stands today, it is a 95 foot long, concrete arch structure, with a spillway crest elevation of 2884 feet, and stands 42 feet above the streambed (Flint and Meyer, 1977). The area behind the dam is completely filled with sediment, although it still functions to divert water into the canal.

Water diverted by the dam is directed along the canyon wall through a series of canals, flumes and tunnels known as the Butte Creek Canal. The 11.53 mile-long Butte Canal has a capacity of 91 cfs (Flint and Meyer, 1977), is joined by the Toadtown Canal (described later in this text), and enters the DeSabla Reservoir, PG&E's forebay for its DeSabla/Centerville Hydroelectric System.

Haw Creek, the first tributary to enter the canyon from the west, drains the middle portion of Carpenter Ridge, dropping off the plateau and entering the creek just below the Butte Creek Diversion Dam and just above the Inskip Creek confluence. Inskip Creek enters from the east, just downstream from Haw Creek, and drains an area smaller in size than the Bull Creek drainage.

Continuing downstream 3/4 of a mile, Cape Horn, a geologic feature that dominates the canyon landscape, is visible. This outcropping of more resistant metavolcanic material has forced Butte Creek to flow around the rock outcrop, while the Butte Creek Canal, some 180 feet above the creek, enters a tunnel through the rock itself.

In the next 1.5 miles, several small, unnamed tributaries enter Butte Creek from the east and west. Coming in soon after, on the east, is Clear Creek. Clear Creek is joined by Kanaka Creek about one mile before its confluence with Butte Creek. Downstream of the confluence with Clear Creek, numerous small tributaries, many of them spring fed, begin to enter from both sides of the creek.

Upper Watershed: Middle Butte Creek Canyon

Looking again at the creek and its associated landscape in the area below Clear Creek, the increasing amounts of mining debris, broken equipment, and old homesites bear evidence of past Euro-American habitation. Extensive faulting of the Basement Series in this area intrusion of the interface between the Tertiary stream gravels and the overlying Tuscan Formation mentioned earlier are probably what account for the concentration of mining activity and settlement in this area in the days of the Gold Rush. There are many mines in the area, several indentified on USGS 7.5' quadrangles (Dix, Royal Drift, Black Diamond, etc.). The natural topography of the inner gorge of Butte Creek Canyon in the area around the Forks of Butte (the confluence with the West Branch of Butte Creek) has been modified by the mining of the stream and terrace gravel in the area of the confluence itself. Tailing piles and old sluice channels are scattered along the banks. The interface between the Tuscan and Basement Series rocks was exploited extensively on the Platte Ravine, off the West Branch of Butte Creek, accounting for headcuts and some hardrock tunneling in this area. Although many of the cutbanks in the area now have 100+ year old trees growing out of them, the landscape is still visibly altered.

Less than 1 mile downstream from the Forks of Butte is Doe Mill Road Bridge (also known as Ponderosa Way or Garland Rd.), which crosses Butte Creek. About the same distance below the bridge is the intake structure for the Forks of the Butte Hydroelectric Project, operated by Energy Growth Partnership I. This intake takes water through the dam and into the east canyon wall where an 11 foot diameter, 11,000 foot long tunnel and penstock system drops the water to produce electricity at the Forks of Butte Powerhouse, located just upstream from PG&E's DeSabla Powerhouse. During the 1993 wy, Energy Growth Partnership I diverted 80,370 acre-feet of water at the Forks of Butte diversion site for power generation. In the 1994 wy, 17,070 acre-feet was diverted, and for the 1995 wy, 79,852 acre-feet of water was diverted (USGS California Hydrologic Data Reports, 1993, 1994, 1995). Just across from the dam, a large serpentine belt is visible as it runs through the canyon wall. This feature is large enough to be identified easily on aerial photographs and geologic maps.

In the next 3.5 miles of creek from the Forks of the Butte intake structure down to the Forks of Butte and DeSabla Powerhouses, Butte Creek drops an average 215 feet per mile (USGS Paradise West and Cohasset 7.5’ Quadrangles). This section of the creek is punctuated by several large waterfalls, has primarily bedrock substrate and banks, and is "pool-drop" in nature. The 1998 report by Johnson and Kier provides heights and locations of the numerous natural and anthropogenic barriers located within this reach. The Forks of Butte Powerhouse, and, just downstream, the DeSabla Powerhouse, lie at the bottom of a 5-mile road coming down from PG&E's DeSabla Reservoir (shown as Lake DeSabla on many maps). The reservoir, which is located in Magalia, is the terminus of the Butte Creek Canal and has a capacity of 188 acre-feet, covering 14.9 acres (Flint and Meyer, 1977). The Toadtown Canal, as mentioned earlier, ties into the Butte Creek Canal just upstream of where the Butte Creek Canal passes below Understock Road. The Toadtown Canal, built in the gold rush era of the late 1800's, transfers water from the Hendricks Head Dam (elevation 3256') on the West Branch of the Feather River across the watershed divide into the Butte Creek Watershed by way of a series of tunnels, flumes, and canals. The system also provides water for Stirling City's Breedlove Reservoir, the city's water supply. The rated capacity of this canal is 125 cfs (Flint and Meyer, 1977). According to USGS records, the average flow of the Toadtown Canal has been 65.8 cfs for a period of record spanning wy 1987 to wy 1996, and the maximum daily discharge was 127 cfs on both February 12 and May 20, 1995 (*USGS California Hydrologic Data Reports*, 1996). Spanning the period of record of wys 1931 to 1993, the average annual flow, in acre-feet, for the Toadtown Canal is 46,727 cfs (Hillaire, 1993). It should be noted that the canal is often without flow during late summer and fall, and due to the nature of the landscape that the canal runs through, it is often shut down for cleaning and maintenance after large precipitation events. All the data mentioned above was taken at a station 600 feet upstream of the confluence with the Butte Creek Canal, a point which is below Breedlove Reservoir; therefore, consumptive use by Stirling City does not affect the recorded data.

Water from the West Branch of the Feather River is commingled with Butte Creek water in DeSabla Reservoir and enters Butte Creek through the DeSabla Powerhouse, changing its hydrogeochemical composition from this point downstream. The powerhouse operates with water dropped over 1,400 feet through penstocks. The

DeSabla Powerhouse discharged 93,330 acre-feet in 1993, 77,670 acre-feet in 1994, 88,310 acre-feet for 1995, and 86,700 acre-feet for 1996 (USGS California Hydrologic Data Reports, 1993, 1994, 1995, and 1996).

Downstream from DeSabla Powerhouse, 0.2 miles, the waters of Butte Creek are diverted again by PG&E at the Centerville Diversion Dam. The Centerville Diversion Dam is considered the upper limit for anadromous fish migration, although anecdotal evidence suggest that some fish may have cleared this barrier at higher flows (Holtgrieve and Holtgrieve, 1995). In the 1993 wy, the Centerville Diversion Dam diverted 93,690 acre-feet of water into the Lower Centerville Canal, conveying it to the Centerville Powerhouse. In 1994, 74,870 acre-feet of water was diverted, and in 1995, 75,450 acre-feet (USGS California Hydrologic Data Reports, 1993, 1994, and 1995). The 7.97 mile-long Lower Centerville Canal is rated at 180 cfs above Helltown Ravine, and 192 cfs below (Flint and Meyer, 1977).

Water diverted from Butte Creek at the Centerville Diversion Dam is supplemented by DeSabla Reservoir water conveyed through the 5.1 mile-long Upper Centerville Canal dropping into the lower canal by way of Helltown Ravine. This upper ditch, with a capacity of 35 cfs, supplies a number of properties on the Nimshew Ridge and in Butte Creek Canyon (Flint and Meyer, 1977).

Upper Watershed: Lower Butte Creek Canyon

In this section, below Centerville Head Dam, the canyon has similar characteristics until the creek flows into valley sediments below the Skyway. This section is visually dominated by the towering canyon walls, composed of the Tuscan Formation, rising over 1500 feet above creek level in some places. The predominant geologic unit in the watershed, the Tuscan Formation covers all other geologic formations in the mid-section of the watershed and effectively "caps" the landscape. Its estimated 300 cubic miles of material are spread out over a range of 2,000 square miles, covering an area from Oroville to Red Bluff. This formation was created by a mudflow deposit of late Pliocene age and is composed of angular to subrounded volcanic and metamorphic fragments, up to 3 meters in diameter, in a matrix of gray-tan volcanic mudstone. This mudflow, is theorized to have been mobilized by a lahar from magmatic or meteoric water, and has a maximum thickness of about 1700 feet (Harwood, Helley, and Doukas, 1981; Lydon, 1968).

Continuing downstream from the Centerville Diversion Dam, the stream is entrenched in the metamorphic and igneous rocks that comprise the Basement complex of the Sierra Nevada (shown in white, with cross hatching, on the Geology Map). The sides of the creek show signs of past mining by way of tailings piles and tunnels through bedrock banks. More, small, unnamed tributaries enter the creek through this section.

The creek changes its character markedly about 1.25 miles above the Helltown Bridge. This is the point where the Sierran Basement geology is covered by the Chico Formation (see formation indicated with purple on Geology map). The Chico Formation, a unit of Cretaceous age associated with the inland seas of the Sacramento Valley, is composed of fossiliferous marine sandstone, tan, yellowish-brown to light-gray in color (Harwood, Helley, and Doukas, 1981). Gravel bars begin to form on the insides of meander bends, and the banks are covered with vegetation as roots more easily penetrate the softer sandstone. Homes begin to appear on the terraces of the creek beginning at the Helltown Bridge.

Due to a large landslide sometime within the last 11,000 years, the creek is forced up against the west side of the canyon just below the bridge, cutting deeply into the Chico Formation, leaving well-exposed tan sandstone cliffs. Directly below this landslide area begins a unit known as the Modesto Formation (shown in bright yellow on Geology Map). It is composed of gravel, sand, silt and clay derived from the Tuscan and Chico Formations, and is thought to have been deposited by the same stream system as today, as the formation tends to border existing channels. The unit is perched atop the Chico Formation all along the creek, and is prevalent along the canyon bottom, leading through to the Sacramento Valley. There is an excellent example of this formation exposed on the left bank of the creek about one quarter mile below the Centerville Powerhouse.

Down the creek below the Helltown landslide area is the Centerville Powerhouse. Construction began in 1898, and the powerhouse was operational in 1900. It is now PG&E's oldest operational powerhouse. Just upstream from the powerhouse, below the overflow channel for the penstocks, are the remnants of a CDFG fish barrier dam, constructed in 1969. This dam was formerly used to keep spring run chinook salmon from entering the low-flow zone created by the diversion of water at the Centerville Diversion Dam. The powerhouse itself discharges into a shaded holding pool, and the comparatively cooler, and substantially larger flows of water attract up-migrating chinook salmon.

Although mining debris and cobbles from are visible along the creek around the Forks of Butte, this area in particular reveals the first obvious signs of dredge tailings. These tailings, consisting of cobble-sized and larger rocks, sit in piles where they were left after being sluiced through by miners looking for gold. The tailings continue down the canyon along the creek, and are visible on the Geology Map.

From the Centerville facility down to the Parrott-Phelan Diversion Dam, the creek flows through the highest concentration of homes lining its banks. The creek passes under a Bailey Bridge which replaced the Steel Bridge in January of 1997, three private bridges, the Honey Run Road Bridge, and the historic Honey Run Covered Bridge on its way to the Parrot-Phelan Diversion Dam. Within this section, numerous federal and private bank stabilization projects (rip-rap) were constructed after the high flow event of early 1997.

Less than one half mile above the Covered Bridge, Little Butte Creek enters on Butte Creek's left bank. Little Butte Creek drains the ridge and plateau-like area of Paradise, and the regions that extend further up this ridge area to the north. The creek has two water storage reservoirs located on it: Magalia Reservoir (usable capacity 796 acre-feet), and upstream, Paradise Lake (usable capacity 11,500 acre-feet). The two reservoirs serve as water supply for the Paradise Irrigation District, which supplies water to the town of Paradise. The two reservoirs do not function as flood control facilities. The use of water for domestic use by PID diminish the base flow of Little Butte Creek during the summer and fall months. Paradise Irrigation District is required to release 5 cfs down Little Butte Creek as a minimum base flow per an agreement with CDFG.

The USGS maintains a surface water gauging station just below the Covered Bridge, known as "Butte Creek near Chico, #11390000." Foreign water from the West Branch of the North Fork of the Feather River is included in this gauge reading, raising the flow, on average, by 65 cfs. In the summer, this rate of augmentation is approximately 110 cfs. Despite the fact that foreign water is included in its assessment of streamflow, this gauge is the best source of data for finding quantities and rates of water coming out of the upper, primary water-generating part of the watershed. Below this area, much of the creek down to and below Highway 99, has been mined for gold using dredging techniques and later gravel mining.

Lower Watershed: Valley Section and Butte Basin

Parrott-Phelan Diversion Dam

The Parrott-Phelan Dam is the upper-most agricultural and wildlife enhancement diversion on the creek. This diversion is also the beginning of California Department of Water Resources' (DWR) Butte Creek Watermaster Service Area (see Appendix B), with the diversion itself being Diversion No. 50.

Diversion No. 50 feeds into a ditch that goes by many names: Edgar Slough, Crouch Ditch, and Comanche Creek. The discrepancy comes from the fact that Comanche Creek is an intermittent stream that drains lower Doe Mill Ridge, and crosses under Honey Run Road approximately three-quarters of a mile above the Skyway. Under natural conditions, the stream functioned as an overflow of Butte Creek during peak flow conditions. In essence, Comanche Creek was a distributary or natural bypass of Butte Creek floodwaters. However, this did not occur at the present site of diversion, as evidenced by the very unnatural low-gradient canal that cuts across slopes coming from the dam. Most likely, Butte Creek had a series of sloughs created through channel abandonment and avulsion. One or more of these sloughs connected into what is now known as Comanche Creek or Edgar Slough, as it is known in its valley reach. Although no record of exactly where Butte Creek waters flowed into the lower portions of Comanche Creek exist, evidence from the mapping of soils and old channels show that it most likely occurred between the Skyway and Highway 99. This area was dredged for gold in the early part of this century, then leveled for aggregate processing and residential and commercial development. These anthropomorphic alterations make it difficult to determine the exact site of the confluence of the two waterways.

After widespread agricultural development in the valley in the early part of the 20th Century, the need for irrigation water increased, and the Parrott-Phelan Diversion Dam was constructed and a low-gradient channel was dug to carry water over into Chico and out into the agricultural region beyond. The bypass channel is relatively straight with steep banks 6 feet high. It flows through low-density residential areas before meeting Comanche Creek, just below Honey Run Road. There is a weir with a gauge approximately 0.25 mile below the dam.

The following section describes the Comanche Creek/Crouch Ditch delivery system. Approximately 1.5 miles from the Butte Creek diversion, Comanche Creek enters a siphon with a spillway to the Little Chico Creek bypass (described later in this report), which diverts storm flow from Little Chico Creek to Butte Creek. Some water from the Crouch Ditch at this point is spilled into the diversion channel to be pumped out by Diversion No. 53, for use in the USDA Forest Service Genetic Tree Improvement Center. Below the siphon, Comanche Creek flows through part of the Chico urban area. Storm water from large commercial developments to the north flows through constructed and natural drainages into Comanche Creek. The channel is broader in this section with a 2-foot, incised, low-flow channel, meanders, and small vegetated islands and bars. Residents along the south bank have modified the creek by constructing pools, additional channels, and other features in the creek. As the creek enters the City of Chico, its channel is more constrained and more incised (Ayers & Associates, 1996).

West of Chico near Dayton Road (approximately 6.5 miles from the Butte Creek diversion), Comanche Creek is straight and incised between 10-15 feet with nearly vertical banks. This area is predominately agricultural but has some residential areas. South of Edgar Road, the channel has some meanders and is broader and less incised with three to five foot banks. Clay hardpan soils in this area may be preventing further deepening of the channel. There is a stage gauge in this area to measure water delivered to consumers (see Appendix B). Dayton Mutual Water Company has three points of diversion on the south bank not far below the weir. The north bank is part of M&T and water can be diverted from the creek to irrigate the ranch. The creek reaches the Parrrott-Phelan Canal approximately 2 miles past Crouch Avenue. At the intersection of Comanche Creek and this canal, water can be diverted south through the Parrott Canal (on to Llano Seco Rancho), north to M&T, or continue west in Edgar Slough. There is a surge pond at the intersection to provide temporary storage of water.

The system provides drainage for stormwater runoff from the area north of the channel. During winter storms, runoff from urban and range lands around Comanche Creek can produce high flows in the creek. During large storm events, diversions from Butte Creek are curtailed to prevent flooding in Comanche Creek. Diversions from Butte Creek are also reported to be curtailed from November through March because of a lack of demand and to allow for channel maintenance. In April, May, and June, large quantities of water (up to 10,950 acre ft/month) are diverted from Butte Creek into Comanche Creek to flood rice fields and wetlands, irrigate pasture for cattle, and irrigate nut/fruit trees and other crops. Bank storage and seepage may be significant with losses of 20-30% of the flow diverted from Butte Creek. When residents along Comanche Creek pump water, the loss is higher. Most of these conveyance losses recharge the groundwater and support riparian vegetation. These losses are to be expected, as the channel is traversing the edge of an alluvial fan. Other creeks in the Chico area exhibit this sort of reduction in streamflow. Big and Little Chico Creeks lose much of their flow as they travel across the fan.

As natural flows in Butte Creek drop, the availability of appropriated Butte Creek water utilized by M&T and Parrott Investment Corporation decreases. Dayton Mutual has a senior right to the natural flows of Butte Creek (see Appendix C) and can use water during periods when M&T, Llano Seco Rancho, and the Llano Seco wildlife refuges cannot. During summer, when flows in Butte Creek are low, Dayton Mutual may continue to receive water via Comanche Creek when deliveries to M&T, Llano Seco Rancho, and the Llano Seco wildlife refuges may be limited. This is because of limited flows from the West Branch of the Feather River or because of the inferior right to the natural flow of Butte Creek.

When water demand at M&T and Llano Seco Rancho exceeds available supply through Edgar Slough and Comanche Creek, water is pumped from the Sacramento River at the M&T pumps to supply water to the Phelan Canal. This pump is also necessary as certain portions of the M&T Ranch can only be serviced by Butte Creek water, and other portions of the ranch can only be serviced by Sacramento River water. Water in the canal can be delivered to M&T, Llano Seco Rancho, and the Llano Seco wildlife refuges. The ranches prefer to divert from Butte Creek because the system operates by gravity and the pumps on the Sacramento are expensive to operate; consequently, diversions generally decline in the late summer and increase again in early fall as fields are flooded for waterfowl habitat.

Parrott-Phelan Dam: Diversions and Issues

The Parrott-Phelan diversion has taken an average 27,274 acre-feet of water each year, calculated during the "watermaster period" (April to September), from a period of record running from the 1968 to the 1993 (Hillaire, 1993). It is important to point out that this average is only during the watermaster period, and the diversion does, and has operated during every month of the year. Until recently, with the addition of real-time telemetered gauging, good records for the full years diversion rates and volumes were unavailable. Summer diversions from Butte Creek to Comanche Creek range from 15-163 cfs; however average summer flows for the period 1968 through 1992 were approximately 88 cfs (USDI, USFWS et al., 1996). The diversion has been fitted with a high-flow fish ladder and self-cleaning fish screen that sends entrained juveniles back to the creek, or can be set to keep them in a holding tank for analysis and tagging by CDF&G personnel. During the high water event of early 1997, Butte Creek changed its course in the area of the Parrott-Phelan Diversion. Details regarding this avulsion and the subsequent channel modifications are contained in the Fluvial Geomorphology chapter of this document.

Thus far, diversions from Butte Creek may have created low-flow zones as water has been diverted around sections of the creek for hydroelectric generation, but they have, by definition, been non-consumptive because the flow is returned to the creek downstream. The Parrott-Phelan diversion is the first major diversion for agricultural irrigation, a consumptive use.

The Irrigation Season is defined by DWR to be the period starting in April and continuing through September. This also happens to correspond to the period of low precipitation, and resulting decline in natural flows as the season progresses. The Parrott-Phelan diversion takes 25.4% of Butte Creek flows during the Irrigation Season, averaged over the span of records from the 1968 wy to the 1993 wy. The majority of this diverted water is actually the West Branch of the North Fork of the Feather River import water that arrived in Butte Creek via the Toadtown Canal.

A more recent agreement that affects the diversions at Diversion No. 50 is the agreement between M&T Chico Ranch, Parrott Investment Company, CDF&G, and the USFWS. The *Agreement For Relocation Of M&T/Parrott Pumping Plant Providing For Bypass Of Flows In Butte Creek* relocates the M&T/Parrott pumps on Big Chico Creek to a location on the Sacramento River. This diversion has been granted the right to divert water that would normally be taken from Butte Creek Diversion No. 50. The water not diverted from Butte Creek is to be left in the stream for enhancement of instream flows, and is referred to as "Bypass Waters" in the aforementioned agreement. Bypass Waters are to be provided during the "Bypass Period," which is October 1 through June 30. Bypass Waters are to be "...the total amount of the flow of [the Butte Creek waters to which M&T and PIC have rights] or 40 cfs, which ever is the lesser" However, "the parties acknowledge that consummation of the exchange will depend upon assurance by the USBR and others that Bypass Waters in Butte Creek in fact returns to the Sacramento River (as they will be required to do in order to improve in-stream habitat for chinook salmon and steelhead. The DWR Watermaster Service Area can police diversions down to just above the Western Canal Siphon crossing, but cannot enforce against illegal diversions below that point (see Issues and Concerns chapter, #2).

Increased real-time telemetered streamflow gauges may be a solution. Even with increased gauging, it may be difficult or impossible to keep track of quantities of water being left in the stream for the fishery. Most conventional gauging techniques are difficult as low gradients, backwater effects, and the dynamic nature of agricultural returns and withdrawls interferes with normal operation.

Lower Watershed: Valley Diversions, Canals and Sloughs

Continuing downstream from the Parrott-Phelan Diversion, the creek passes under the Skyway, and just more than a quarter mile downstream of these bridges is the Durham Mutual Dam. This diversion, No. 56, takes water from Butte Creek on the left bank into the Durham Mutual Water Company (DMWC) Ditch, stretching down into their Durham service area. This ditch branches off into Robber's Gulch, which eventually ties into Hamlin Slough just below the upper Rancho Esquon Partners' Dam on Hamlin Slough. Before Robber's Gulch, the DMWC ditch supplies twelve small diverters and the Butte Creek Country Club's golf course. Recent funding from the Central Valley Project Improvement Act (CVPIA) Unscreened Diversions Program and DWR's Four Pumps fund has been approved to install a fish ladder and screening system similar to the one at the Parrott-Phelan Dam upstream.

A smaller, unscreened diversion on the right (north) bank of the dam sends water to several users on the west side of Highway 99. Deemed to be Diversion Nos. 54 and 55 of the Watermaster Service Area, the control valve for the screw gate on this northern diversion has been disabled. Plans to fix this valve or to screen this diversion are awaiting a decision on transfer of a water right.

Just downstream from this diversion, on the north bank, the Little Chico Creek Diversion Channel enters. In 1959 the Army Corps of Engineers installed a flood control structure on Little Chico Creek to limit flows through the City of Chico. (US Army Corp of Engineers, 1957) The flow of Little Chico Creek through Chico is limited to 1,200 cfs. The rest of the flow is diverted into diversion channel and on to Butte Creek. The Corp Design Memorandum details the levee system that begins at this point continuing downstream on both sides for 14.5 miles.

The creek then flows under the Highway 99 bridges, passing a short stretch of creek that was protected with rip-rap in the fall of 1997. About a mile below Highway 99, the Oro-Chico Highway Bridge crosses the creek, and DWR's "Butte Creek near Durham" stream gauge is located on the east bank, just below the bridge. Located near this gauge are the two pumps making up Diversion No. 58, with allowable diversions totaling 0.61 cfs.

Butte Creek then flows between the levees for almost 4 miles, past Durham, on its way to Diversion No. 60, the Rancho Esquon Dam. This large diversion is slated for an improved fish ladder and screening system funded by Proposition 204, Ducks Unlimited and the CVPIA Unscreened Diversions Program. This diversion provides water for to their farming operations. They also diverts from Hamlin Slough (Diversion No. 64, upper Rancho Esquon diversion on Hamlin Slough), which receives additional water from the Durham Mutual Water Company ditch,and at Diversion No. 65, about 1.25 miles downstream on Hamlin Slough.

Just above the Rancho Esquon Dam, an overflow channel branches off to the right of Butte Creek, running parallel for nearly 2 miles. Diversion No. 60A, a pump that is not in use at this time, is just above the Midway. Directly below the Midway is Diversion No. 61, the Gorrill Dam. Diversion No. 61 supplies water to the Gorrill ranch and Western Canal Water District (WCWD). It is currently being fitted with a screening system and new summer and winter fish ladders. Funding for this Project was provided by the same agencies involved in the Rancho Esquon Dam upgrade. Water ponds up for some distance above the Midway when the dam is operational. The Gorrill Ranch also diverts water from Hamlin Slough just below the Midway (Diversion No. 66).

Prior to the removal of the Western Canal Dam in the fall of 1997, water conveyed from Thermalito Afterbay crossed Butte Creek on its way to WCWD customers on the west side of the creek. An island in the middle of Butte Creek, splitting the creek into two channels for a short distance, served as an ideal spot to transfer water across the creek. Dams were placed on both channels, with Western Canal entering the creek just upstream of the eastern dam. Just above the western dam, there was a set of gates that let water back into the Western Canal on the west side of the creek. Water backed up behind the dams and flowed out through the gates into the canal. At this point, Butte Creek water was mixed with Thermalito water from the Feather River. WCWD personnel were responsible for gauging how much water was coming across the creek from the canal, how much was coming down the creek, and how much water they were allowed to divert at that time from the creek under their 8th priority water right (see Appendix C). Unneeded water spilled over the west dam back into Butte Creek.

The dams not only helped get canal water across the creek, they backed up Butte Creek into Hamlin Slough, a distance of over 1 mile. This allowed the pumps in Hamlin Slough (1048) at Diversion No. 62 to draw water. The elevated water level also allowed for the use of the Highline Ditch, a canal that directs water to some of the higher elevation lands in the northern part of the district.

Ladders on the Western Canal Dam in the past helped migrating fish clear this obstacle, but often times more water was coming across the creek from the canal than was coming down the creek from above. Fish could be confused into heading up the swift water Western Canal instead of the relatively stagnant Butte Creek, essentially a pond for over 2 miles.

In the fall of 1997, after completion of the siphon the two dams were removed. A new ditch leading off of the Western Canal, the Durnel Ditch, was constructed with a reverse gradient. It is now, under some conditions, filled with Western Canal water, with the pumps at Diversion No. 62 drawing out of this ditch. It also feeds the east side 1048 pumps, now called the 870 pumps, of the WCWD through pipelines. In another configuration, the Durnel Ditch can be used to take Butte Creek waters to the Western Canal. Water diverted at the Gorrill Dam under WCWD's water right to Butte Creek, can be run through Hamlin Slough, the Durnel Ditch and into the Canal.

On the west side of Butte Creek, the siphon feeds the Highline Ditch with a newly constructed extension. The Highline in turn spills water into the 1048 West Slough which has a newly constructed check dam on it that allows the pumps up in the 1048 West Slough to draw water. Just after the outlet structure of the siphon on the west side of the creek, there is a glory hole structure that allows WCWD to spill water back into Butte Creek for delivery of water to the duck and gun clubs of the Butte Sink area. Up to 200 cfs of Feather River water, by way of the Western Canal is conveyed for this purpose (Pers. com., Ted Trimble, 1997, WCWD).

Below the Western Canal Siphon crossing, lies the "Butte Creek below Western Canal" DWR stream gauge. Once a PG&E gauging station, it was reactivated in October of 1991 to monitor releases from WCWD for the duck clubs.

Butte Creek flows for approximately 7 miles until it reaches the McGowan Dam now operated by CDFG. The McGowan Dam, located approximately 1 mile upstream of Highway 162, will be removed under the current WCWD improvement plans. Instead, water will be conveyed to lands currently serviced by the McGowan Dam through a system that is, for the most part, currently in place.

Western Canal travels west from the siphon into a wetland area that is composed of many merging and then diverging channels. This is known as the WCWD Reservoir Area. In this area, a series of check dams and weirs disperse water into Little Butte Creek, the Main Canal, and the Ward Canal, all water conveyance structures for the WCWD. Little Butte Creek will be extended approximately 9,000 feet and connected to the Main Drain, which joins Butte Creek just above the McGowan Dam. Check dam structures will be placed on both Little Butte Creek and the Main Drain near their confluence with Butte Creek, eliminating flows into the creek that may mislead salmon into straying up these agricultural ditches. Howard Slough, located just above the McPherrin Dam will have a similar structure blocking flows from Butte Creek from entering the slough, as water will be provided via the Main Drain from above.

On the other side of the creek, Little Dry Creek will carry Western Canal water south from the point where it crosses the canal near Nelson Road, down to a point where it will be diverted into a drainage ditch on the Harris property. This ditch, to be enlarged and lengthened, will transfer water down to a point where it can be distributed onto the McPherrin Ranch. A check structure on the Little Dry Creek Overflow channel will keep flows in the Harris Ditch, and out of Butte Creek. The work on this eastern side of the creek will allow for the removal of the McPherrin Dam, located about 2 miles below Highway 162, and just below the upper confluence of Butte Creek with Howard Slough.

Below the McPherrin diversion site, Howard Slough, essentially a side channel, drains into Butte Creek. Campbell Slough empties into Howard Slough above this confluence. There are no fish screens or ladders below the McPherrin diversion site. About 3.5 miles downstream, Butte Creek reaches what is known as the Sanborn Slough Bifurcation, a point where the Butte Creek channel takes a hard right hand turn, and the slough opens up straight ahead. Much of Butte Creek's flow is taken straight down this channel into a series of water conveyance ditches that service the waterfowl clubs of the Butte Sink. Angel Slough enters Butte Creek a short distance downstream after taking a hard turn to the right. The creek at this point is flowing through the Butte Sink itself, and about 0.5 miles downstream the White Mallard Dam is reached. This structure diverts water into what is known as the White Mallard Canal. This canal sends water down to a place called "Five Points", where five water conveyance structures come together. It is at this point that water from Drumheller Slough containing water pumped from the Sacramento River is mixed with Butte Creek water and either redistributed to areas west of the creek, or is dropped into the creek through one of the five channels. Right below this outlet channel, the Cherokee Canal/Biggs-West Gridley Main Drain enters the creek on the east, after flowing through the Butte Sink.

The Colusa Bypass of the Sacramento River feeds into this lower portion of the Butte Basin just south of Laux Road. This break in the levees along the Sacramento River provides a point for flood flows to escape the river and flow into the Butte Basin, Butte Creek, then into Butte Slough, and eventually the Sutter Bypass system. Moulton Weir, located further upstream on the Sacramento River, is described later in this text.

Approximately seven miles after the confluence with the Cherokee Main Drain outlet from the Butte Sink, Butte Creek empties into Butte Slough. The slough, which originally was one of the major distributary points of the Sacramento River, used to accept a fairly large portion of the Sacramento River. The water flowed out into the Sutter Basin, creating a shallow inland sea. Now, the Sutter Bypass system, composed of two levees, their associated borrow pits, and the floodway in-between them sends flood waters on through to the confluence of the Feather and Sacramento Rivers near Verona.

Butte Slough now has a structure placed at its confluence with the Sacramento River, known as the Butte Slough Outfall Gates. This area is also known as Ward's Landing. No longer is the slough a place where the flood waters of the Sacramento River are slacked off before the river continues downstream. The gates, which regulate the water levels in Butte Slough, have a maximum outlet capacity of 3,500 cfs. This system keeps most of the flow of Butte Creek from going into the Sacramento River. It is instead diverted through the Butte Slough and eventually through either the east or west borrow pits of the Sutter Bypass, depending on the configuration of the East-West Diversion structure, a low weir located at the top of the east borrow.

Other Streams, Waterways, and Diversions

The following section describes waterways, some natural and others human-made, that affect flows in the Butte Creek Watershed. As many of them do not physically connect with Butte Creek, they are being discussed in a separate format:

Hamlin Slough, Nance Canyon, and Little Dry, Dry, Cottonwood, Gold Run, and Clear Creeks

These tributary streams to Butte Creek originate in the area south of Paradise and have the beginnings of their watersheds at less than 1700 feet elevation. They are all intermittent drainages in the lower reaches. The importance of these watersheds as recharge areas for the Butte Basin Aquifer, although considered important, has not been extensively evaluated. Little Dry Creek and Hamlin Slough are both used for water conveyance in their valley reaches. Cottonwood Creek, Clear Creek, Gold Run Creek and Dry Creek are consolidated into what is known as the Cherokee Canal. Gold Run Creek receives water from the Lower Miocene Canal, which originates at a dam on the West Branch of the Feather River below Magalia. Gold Run and Cottonwood Creeks also have on-stream storage in the form of irrigation ponds, regulating flows on these streams.

Cherokee Canal

This structure was originally constructed to protect agricultural lands and the towns of Richvale, Nelson and Biggs from mining debris created by mines in the Cherokee area (Carpenter et al., 1926). In that role, it was significantly larger than its present configuration, as evidenced by nearly 30 feet of accumulated debris through sections of the canal that lie in southern Butte County (Pers. com., Dean Burkett, NRCS, 1998). The canal is now used for irrigation, drainage, and to protect approximately 35,000 acres of agricultural lands, related buildings, and homes from flooding. It ties into Butte Creek after flowing through the Butte Sink. The canal is gauged by DWR's "Cherokee Canal near Richvale" gauge.

Western Canal

This canal begins at the northwest corner of the Thermalito Afterbay. Fourteen miles in length, the canal siphons under the Cherokee Canal and Butte Creek on its way to a sink area near Seven Mile Lane, known as the Western Canal Reservoir area, and referred to earlier in this text. From here, water is directed to the western areas of the district through three separate canals/ditches. "Average water year delivery to Western Canal from Thermalito Afterbay is 226,500 acre-feet for the period 1968 through 1992" (Hillaire, 1993). This figure does not include the average flow of 3,441 acre-feet coming from the PG&E Lateral (also known as the Western Canal Lateral), computed over the period 1968 through 1993

Richvale Canal

This canal services the eastern portion of the Richvale Irrigation District. The Richvale Canal Outlet, located adjacent to the Western Canal Outlet, recorded an average water year delivery from Thermalito Afterbay of 80,700 acre-feet during the period 1968 through 1992 (Hillaire, 1993). Drainage water from the district enters Butte Creek, Little Dry Creek, and the Cherokee Canal.

Main Canal Outlet

This convergence is the only outlet from Thermalito Afterbay that is on the south side. It has an average water year delivery of 459,900 acre-feet for the period 1968 through 1992 (Hillaire, 1993). The Main Canal becomes the Sutter-Butte Canal 12 miles below the outlet, near the town of Gridley. The Main Canal has several laterals that are major water delivery structures, with their tailwaters reaching Butte Creek: Belding Lateral, Biggs Extension Canal, Deitzler Lateral, and Lateral Eight. There are many laterals and diversions from the Sutter-Butte Canal to water districts outside the watershed boundary, in Sutter County. As a portion of the Main Canal Outlet water goes to these users, and much of the water used within the watershed goes to crop production with its associated losses from evapotranspiration, runoff and deep percolation, the vast majority of the 459,900 acre-feet does not end up in Butte Creek.

Biggs-West Gridley Main Drain

This drain also known as the R.D. 833 Drain, drains a large portion of the watershed south of the Thermalito Afterbay. This drain services the Biggs-West Gridley Irrigation District as well as the Gray Lodge Wildlife Management Area. It ties into the Cherokee Canal just above its confluence with Sanborn Slough.

M&T Chico Ranch Sacramento River Diversion

Recently moved from its location on Big Chico Creek, this diversion has, during the period 1970 through 1992, taken an average 20,345 acre-feet per year from a combined source of Big Chico Creek and the Sacramento River. The diversion has been relocated to a site on the Sacramento River. It is tied into the M&T Canal by a new pipeline. The M&T Canal becomes the Parrott Lateral below the confluence of the M&T Canal and Edgar Slough.

Edgar Slough

Also known as Crouch Ditch or Comanche Creek, this slough carries foreign (West Branch of the North Fork of the Feather River) water and Butte Creek water from Butte Creek Diversion No. 50 to Dayton Mutual Water Company, M&T Chico Ranch, and Parrott Ranch (Rancho Llano Seco).

Angel Slough

This slough is used as a drain by M&T Chico Ranch in the more northern portions of their property, but then appears to have been connected to Little Chico Creek, to function as a drain through the lower, more southern portions of the property. Angel Slough appears again separate from Little Chico Creek, outside the M&T Chico Ranch boundary, along River Road.

Little Chico Creek

This creek drains into the Llano Seco Rancho, and appears to be ponded in the USFWS easement along the east side of the Rancho. Angel Slough meander through the Rancho in a channel that appears to be unaltered. It then flows through agricultural lands, some reaches channelized, others in a more natural state, on its way to its confluence with Butte Creek in the lower Butte Basin.

Little Butte Creek

This creek forms in the area south of the terminus of Little Chico Creek. It still shows signs of the braided channel topography, formed from the Sacramento River overflowing this area. The flood waters were carried toward Butte Creek and the center of the Butte Basin by way of the numerous distributary sloughs, many still visible today. The sloughs flow away from the river in a south-easterly direction, indicative of the direction they took as they flowed out from the higher river flood terrace.

Moulton Weir

This structure is located on the east bank of the Sacramento River, about five miles below the town of Princeton, mimics this spilling of the Sacramento River to the Butte Basin in a controlled fashion. Essentially, at a low spot in the levees along the river the weir allows for water to enter the Butte Basin, but it does so over a weir surface that keeps the levees from being eroded as the water spills down into the Butte Basin.

Other controlled floodwater spill locations into the Butte Basin from the Sacramento River

Floodwater spillage occurs at three places along the Sacramento River between Chico Landing and Moulten Weir. According to Les Herringer, Manager of the M&T Chico Ranch, there are three flood relief structures on the Sacramento River in this area. The M&T weir is a spillway with an approximately eight inch concrete cap. Its waters spill into Angel Slough and continue down to meet Butte Creek. There is another spill area, known as the "Three B's" that is just downstream of M&T's property. It is earthen and is subject to erosion. Another area of spill is located on the Llano Seco Rancho. Concern by residents on the west side of Butte Creek, below Nelson Road and West of Little Butte Creek is for their property and agricultural lands as the water from the Sacramento River, during higher flows, is spilling through these three structures and flooding their lands. Herringer mentioned that these three structures are state designed, controlled, and mandated, and they were originally (30 to 40 years ago) to be the basis for a bypass structure similar to the Sutter Bypass. The construction of the three structures brought about the formation of Reclamation District 2106, but the state never continued with plans to complete the bypass structure.

Stream Flows

In terms of a long-term period of record, the most reliable stream gauging station for Butte Creek flows is the USGS gage 0.7 mile downstream of the confluence with Little Butte Creek, and upstream of the Parrott-Phelan Diversion Dam. This station, known as "Butte Creek near Chico” is USGS Gauge #11390000. From October 1931 through the present, stream stage heights (later converted to streamflows) have been recorded. Below are some of the statistics useful in examining the outflow from the upper watershed. Foreign water from the West Branch of the North Fork of the Feather River is included in this summary. For an indepth graphical representation and discussion of diversions and imports within the Butte Creek Watershed (see Appendix D).

Table 2.1
General Statistics for Butte Creek near Chico, CA; USGS Gauge # 11390000
Water Years October 1931 to September 1997

Statistic	Unit of Measurement	Time Period for Computation/ Date of Occurrence
Annual mean	409 cfs	1931 wy-1997 wy
Highest Annual Mean	834 cfs	1995
Lowest Annual Mean	94.0 cfs	1977
Highest Daily Mean	26,600 cfs	January 1, 1997
Lowest Daily Mean	44 cfs	August 23, 1931
Annual Seven-Day Minimum	44 cfs	August 23, 1931
Instantaneous Peak Flow	35,600	January 1, 1997
Annual Runoff	295,300 acre-feet	1931 wy-1997 wy
10 Percent Exceeds	842 cfs	1931 wy-1997 wy
50 Percent Exceeds	206 cfs	1931 wy-1997 wy
90 Percent Exceeds	100 cfs	1931 wy-1997 wy

Data taken from the USGS Hydrologic Data Report for the 1997 Water Year (Provisional).

The data above was provided to the Project by USGS personnel at the Water Resources Division Redding Field Office, and is considered provisional until published in their annual report due out this year (see Tables 2.1 and 2.2). However, the data has been computed and checked, and is not expected to result in any major changes that would influence the statistics to any measurable degree. Table 2.1 shows general flow statistics from the 1931 wy through the 1997 wy. The 1998 wy, with record rainfalls during some winter months, will almost certainly set new maximum mean monthly values for certain months in Table 2.1 and Table 2.2.

Table 2.2
Summary Statistics of Mean Monthly Data: Butte Creek near Chico, CA. USGS Gauge # 11390000.
Water Years October 1931 to September 1997

Month	Mean (cfs)	Minimum (cfs)	Water Year	Maximum (cfs)	Water Year
October	138	65.8	1992	775	1963
November	224	77.8	1992	1269	1974
December	463	89.5	1991	2061	1956
January	691	91.0	1991	2847	1997
February	788	114	1977	2925	1986
March	761	123	1977	2601	1995
April	679	114	1977	1848	1982
May	498	134	1977	1314	1995
June	280	79.4	1977	667	1983
July	163	54.4	1977	321	1983
August	131	46.1	1931	223	1975
September	118	51.9	1992	175	1967

Data taken from the USGS Hydrologic Data Report for the 1997 Water Year (Provisional).

Surface Water - Water Flow/Stage Measurements

The Surface Water Flow Stations Map (see Map Appendix) indicates that there are 22 flow or stage measuring stations in the Upper Butte Creek basin still in operation. Pertinent data collected for each station (such as parameters, locations, and periods of record) are summarized in the Gauge Information Table (see Appendix E). The Diversions Map (also in the Map Appendix) shows numerous bypasses and diversions. The period of record for the flow/stage measurements varies from 1 to 73 years. Of the 22 stations still operating, nine have a period of record of 30 years or more and five have a period of record greater than 10 years (DWR, EarthInfo, 1998).

Climate, Precipitation and the Relation to Streamflow

Table 2.1 shows the mean monthly flows for the "Butte Creek near Chico Station". The variance in these flows follow a pattern that is in direct response to precipitation within the watershed, and characteristic of a Mediterranean climate. The four months having the highest average daily flows are December, January, February, and March. For comparative purposes, precipitation records for five different recording stations, increasing with elevation are included as Tables 2.3 – 2.7.

Table 2.3

Average Monthly Rainfall for Chico Experimental Station Period of Record: 1870-1989

Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Year**
4.9	4.0	3.3	1.8	0.9	0.4	0.0	0.1	0.5	1.4	3.0	4.4	24.8

Approx. 200 ft. above mean sea level (MSL)
Precipitation measured in inches

Table 2.4

Average Monthly Rainfall for Centerville Powerhouse Period of Record: 1931-1971

Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Year**
9.0	7.3	5.6	3.7	1.5	0.6	0.0	0.1	0.4	2.6	4.9	8.1	43.7

Approx. 520 ft. above MSL
Precipitation measured in inches

Table 2.5

Average Monthly Rainfall for Paradise Period of Record: 1957-1995

Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Year**
10.8	8.1	8.9	3.8	1.4	0.7	0.1	0.2	1.0	2.8	7.6	8.6	54.1

Approx. 1750 ft. above MSL
Precipitation measured in inches

Table 2.6

Average Monthly Rainfall for De Sabla (measured at Camp 1, near Magalia, not at Powerhouse) Period of Record: 1931-1995

Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Year**
12.0	10.5	9.4	5.1	2.2	1.0	0.1	0.2	1.0	3.8	7.8	10.9	64.0

Approx. 2700 ft. above MSL
Precipitation measured in inches

Table 2.7

Average Monthly Rainfall for Stirling City Period of Record: 1939-1966

Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Year**
10.5	16.6	10.2	5.9	4.9	0.8	0.0	0.0	0.6	5.8	9.6	10.2	75.1

Approx. 3500 ft. above MSL
Precipitation measured in inches

Information for the preceding tables was taken from the “World Climate” Internet site: [www.worldclimate.com]. The World Climate website assimilates climate data for over 85,000 sites in the United States and worldwide. Their data comes from the National Climate Data Center and the Global Historical Climatology Network, which is a part of NCDC and the Carbon Dioxide Information Analysis Center at Oak Ridge National Laboratory.

Measurable rainfall within the Butte Creek Basin increases with a corresponding increase in station elevation. This phenomena, known as orographic lift is caused by the forced ascent of air over high ground or mountains. Uplift of the air leads to cooling which, if the air is moist, may lead to condensation and eventually precipitation.

Data Gaps

While conducting research for this Project a large amount of information was amassed. However, the more that was learned, the more it was realized that there is much more to examine and study. The following are summaries of data gaps for Butte Creek in the areas of hydrology, geology, and overall stream morphology.

The lack of detailed geologic and soil maps during the preparation of this report was a hindrance. Geologic maps for the upper watershed are over 30 years old. General formations are fairly well understood, but more detailed mapping is still lacking. Geology, among many factors, influences soil types, their development and characteristics. Soils for Butte County were first mapped in 1926 and then only in a cursory fashion (Carpenter et al., 1926). There is currently an extensive soil survey being undertaken by the NRCS. The mapping that they are in the process of preparing can and should be incorporated into the planned roads survey (a future study to examine accelerated sediment transport due to roads), as well as the following proposed study.

A detailed stream-reach classification should be conducted, identifying stream orders, profiling geology, soils, streamside slopes, stream gradient and the characterization of the stream itself (composition of pools, nick points, etc.). The necessity for this type of information is determined by the canyon's unique geology, gradient, and other factors mentioned above which change as the creek flows from the mountains to the valley. Management practices in one section (or reach) of the canyon will not be the same as in another. Delineation or classification of these separate reaches should be undertaken in order to have a more detailed understanding of the current conditions so as to establish management strategies that will be site specific and ultimately the most effective.

A comprehensive survey for sediment transport corridors (areas that sediment, from a variety of sources, travels through on its way to waterways) could be incorporated into the detailed stream-reach classification. Such a survey will be conducted as a component of the road survey, but only for the sub-watersheds of Bull, Varey, and Scotts John Creeks (see Issues and Concerns chapter, #5).

In-stream Flow Inventory Modeling (IFIM) is a way to look at specific pools, rapids and runs and evaluate the aquatic habitat of these features at various water levels. Such a study would go beyond the temperature studies undertaken by PG&E by examining what the optimum flow needs for migration, spawning, holding and rearing would be for specific areas of the creek. While this method examines what is best for specific areas, it lacks the holistic approach to stream management that is needed to maintain species diversity and integrity, and as a tool, should be used with respect to this fact (see Issues and Concerns chapter, #2).

Additional stream-flow monitoring stations would greatly aid in understanding to what extent certain sub-watersheds contribute in terms of stream-flow to the main stem of Butte Creek. A station below Butte Meadows as well as several others through the canyon above the current USGS “Butte Creek near Chico” gauge would help to further characterize the watershed. This data could be used to assist in the analysis of runoff processes from certain sub-watersheds, ultimately leading to a better understanding of flooding and sediment contribution to Butte Creek (see Issues and Concerns chapter, #9).

A gap in climatological monitoring exists spatially in the area of the Stirling City/Inskip area, as well as for the Carpenter Ridge area in the north-western portion of the watershed. Although past measurements were made in some of these areas, valuable data is missing for drought periods and the recent periods of high rainfall. Although these temporal gaps (data for times past) cannot be filled, future monitoring could increase the understanding of these areas as source areas for runoff.

A complete analysis of the inflow and outflow of water to Butte Creek, from the Gorrill Dam to the mouth of Butte Creek, would improve understanding of problem areas in the section of the creek that is not adjudicated.