The pending deregulation of the power industry has caused PG&E to reevaluate its hydropower assets, including the Battle Creek Hydroelectric Unit. PG&E has shown a willingness to work cooperatively towards a cost effective and equitable resolution for both hydropower and fishery interests, including modification, and in some cases removal, of its existing facilities [1].

The Battle Creek Working Group, a broad-based stakeholder group which includes representatives from state and federal resource agencies as well as from environmental, local, agricultural, power, and urban stakeholder communities, was formed in 1997 to evaluate various alternatives for the development of a final restoration plan. A number of facility modifications are being considered. They include:

- Install fish ladders and fish screens at North Battle Creek Feeder, Eagle Canyon, and Wildcat Diversion Dams on the North Fork.
- Install fish ladders and fish screens at South, Inskip, and Coleman Diversion Dams on the South Fork.
- Remove Eagle Canyon, Wildcat, Coleman, and South Diversion Dams and associated facilities in lieu of installing fish ladders and fish screens.
- Connect the Inskip Powerhouse tailrace with the Coleman Canal (Coleman Tailrace Connector).
- Connect the South Powerhouse tailrace with the Inskip Canal (South Powerhouse Tailrace Bypass Tunnel).
- Construct an Inskip Powerhouse penstock bypass.

This report provides reconnaissance-level designs and cost estimates for removal of Wildcat, Eagle Canyon, and Coleman Diversion Dams and associated facilities, as developed by Reclamation. Reclamation has also prepared reconnaissance-level designs and cost estimates for removal of South Diversion Dam and associated facilities, and for construction of the South Powerhouse Tailrace Bypass Tunnel, which are described in two separate reports by Reclamation. The California Department of Water Resources (DWR) prepared reconnaissance-level designs and cost estimates for the Coleman Tailrace Connector, Inskip Powerhouse Penstock Bypass, and fish ladders and fish screens at North Battle Creek Feeder, Wildcat, South, Inskip, and Coleman Diversion Dams [12]. In addition, DWR has prepared preliminary designs and cost estimates for fish passage facilities at Eagle Canyon Diversion Dam [2].

C. Existing Project Features

The existing project features are described below, with a summary of significant engineering data provided in table 1 (see Project Vicinity Map, Appendix A-2, for dam locations).

1. Eagle Canyon Diversion Dam

Eagle Canyon Diversion Dam is located on the North Fork Battle Creek, about 3 miles west of Manton, and about 1 mile north of Manton Road, on private land. The dam and associated facilities were constructed within a deep gorge where the canyon walls are nearly vertical, rising about 175 feet above the main creek channel. Local geology is dominated by volcanics, consisting predominantly of basalt rock types. The drainage area above the Eagle Canyon damsite is 186 mi^2, and includes the North Battle Creek Feeder, Keswick, and Al Smith Diversion Dams, Macumber Reservoir, and North Battle Creek Reservoir. The diversion dam provides up to 70 ft^3/s to the Eagle Canyon Canal for power generation at the Inskip and Coleman Powerhouses, and was constructed around 1910. Although a minimum streamflow of only 3 ft^3/s is legally required by FERC below Eagle Canyon Diversion Dam, PG&E currently operates the canal system to provide minimum streamflow of 30 ft^3/s (including natural spring flow) below Eagle Canyon Diversion Dam whenever possible, under the terms of an interim agreement with Reclamation [2]. Principal features of the dam are shown in Appendix A (Exhibit L-18) and Appendix B (photographs 1 through 8).

The dam is a masonry gravity structure with a 4-foot crest width at elevation 1412.4, and a total crest length of 66 feet. The dam structure rises about 11 feet above the original streambed surface, with an upstream slope of 0.10H:1.0V, and a downstream slope of 0.25H:1.0V. The dam masonry reportedly consists of local basalt cobbles and boulders generally ranging from 6 inches to 2 feet in diameter, set in concrete. Some concrete repairs have been made to the dam structure over the years, especially near the right abutment (looking downstream). The left half of the dam is believed to be founded on basalt bedrock, while the right half appears to be founded on large, individual basalt blocks up to 15 feet in size. A 4-foot-wide by 10-foot-high radial sluice gate is provided near the center portion of the dam, with a steel cable extending to a hand-operated winch located downstream of the dam's left abutment, for gate operation.

A masonry gravity weir structure extends from just left of the sluice gate to the channel bank upstream of the dam's left abutment, for diversions to the Eagle Canyon Canal above the weir crest at elevation 1409.4. The weir structure has a crest width of 2 feet and a crest length of 37.5 feet, and rises a maximum of 8 feet above the streambed surface, with a vertical upstream slope and a downstream slope of 0.5H:1.0V. An Alaska Steeppass fish ladder is provided on the left abutment of the dam, within the original concrete steppool fish ladder structure, with a total length of 57.2 feet and a design capacity of 7 to 10 ft^3/s. An abandoned tunnel passes through the left canyon wall, with an entrance about 125 feet upstream of the dam, and an outlet just upstream of the diversion gate structure for the Eagle Canyon Canal. The reservoir behind the dam is mostly filled in with sand, gravel, cobbles, boulders, and debris, so that the depth of water averages only three to five feet below the dam crest. The impoundment covers a surface area of about 1/4 acre at the dam crest. Spring flows of up to 10 ft^3/s enter Battle Creek in the vicinity of the dam [3].

Diversions to the Eagle Canyon Canal are controlled by a 3.5-foot-wide by 6-foot-high slide gate on the left abutment with a sill at elevation 1405.9. A second slide gate (3-foot-wide by 6-foot-high) is located about 100 feet downstream, and permits flow return back to the creek, as required. The Eagle Canyon Canal extends over 2.5 miles to its confluence with the Inskip Canal, above the Inskip Powerhouse, and

consists of 1,054 feet of rock tunnel sections 7-feet-wide by 8-feet-high; 3,385 feet of metal flume sections with a 3.5-foot-radius on steel supports (type #132); 181 feet of reinforced concrete bench flume sections; and 9,053 feet of excavated channel sections (7,484 feet unlined and 1,569 feet gunite-lined) with a bottom width of 9 feet, a top width of 14 feet, and a flow depth of 4 feet. Canal flows are supplemented by spring flows to the south of Eagle Canyon through an area known as "Spring Gardens."

The dam is not under the jurisdiction of the DWR Division of Safety of Dams, due to its small size (less than 25 feet in height, and less than 50 acre-feet of storage); however, the physical condition of the dam has been described by DWR as good, considering its age and method of construction. The basalt rocks and cement mortar were reported by DWR to show very few signs of deterioration, and seepage through and beneath the dam did not appear to be critical [2]. FERC has classified the Eagle Canyon Diversion Dam as a low hazard structure, representing no danger to human life in the event of failure. The diversion dam was inspected by FERC in July 1997, and was found to be in good condition, without signs of significant deterioration or structural distress [5]. The facility was visited by Reclamation personnel on June 26, 1998, at which time about 500 ft^3/s was being released over the dam crest and 70 ft^3/s was being diverted into the canal, which prevented a close inspection of the structures.

2. Wildcat Diversion Dam

Wildcat Diversion Dam is located on the North Fork Battle Creek, about 3 miles downstream of Eagle Canyon Diversion Dam, and about 1 mile south of Battle Creek Bottom Road, on PG&E land. The dam and associated facilities were constructed within a deep gorge where the canyon walls rise nearly 100 feet above the main creek channel. The upstream drainage area is 189 mi^2, which includes the Eagle Canyon drainage area. The diversion dam was constructed around 1910 to provide up to 18 ft^3/s to the Wildcat Canal for power generation at the Coleman Powerhouse, via the Coleman Canal. No diversion of flow for power generation has occurred at the site since August 1995, under the terms of an interim agreement with Reclamation. Principal features of the dam are shown in Appendix A (Exhibits L-19 and L-20) and Appendix B (photographs 9 through 14). Exhibit L-19 was superseded by exhibit L-20, but shows some existing details not shown on L-20.

The dam is a masonry gravity structure with a 2-foot crest width and a 27-foot overflow crest length at elevation 1074.7, and an overall structure length of about 55 feet including abutment sections to elevation 1077.5. The dam structure rises about 8 feet above the original streambed surface, with a vertical upstream face and a minimum downstream slope of about 0.5H:1.0V. A sluiceway is provided to the right of the overflow crest, controlled by an upstream 24-inch-diameter slide gate with an invert at elevation 1070.8. A concrete steppool fish ladder structure is provided on the left abutment of the dam, with a total length of 37.5 feet, and contains an Alaska Steeppass fish ladder as shown on Exhibit L-20. The reservoir behind the dam is mostly filled in with sand, gravel, cobbles, boulders, and debris, so that the depth of water averages only a few feet below the dam crest. The impoundment covers a surface area of about 1/4 acre at the dam crest.

Prior to August 1995, diversions to the Wildcat Canal of up to 18 ft^3/s were made through a 30-inch-diameter pipe in the right abutment section, which includes a 6.5-foot-long upstream apron of masonry, a 4-foot-wide sloping metal trashrack with an estimated area of 28 ft^2, and a 36-inch-diameter slide gate with a manually-operated pedestal lift and an intake sill at elevation 1071.0. The Wildcat Canal extends nearly two miles to its confluence with the Coleman Canal, and consists of 5,530 feet of 24-inch-diameter steel pipe with concrete saddles and occasional 3-inch-diameter steel pipe supports where needed, and 4,421 feet of excavated channel sections (3,504 feet unlined and 917 feet lined) with a bottom width of 4 feet, a top width of 6 feet, and a flow depth of 2 feet. In August 1996, a rockfall damaged a section of the 24-inch-diameter pipe about 1,000 feet downstream of the dam. Pipeline repairs would be required to return the Wildcat Canal to service.

The dam is not under the jurisdiction of the DWR Division of Safety of Dams, due to its small size (less than 25 feet in height, and less than 50 acre-feet of storage). FERC has classified the Wildcat Diversion Dam as a low hazard structure. The diversion dam was inspected by FERC in July 1997, and was found to be in good condition, without signs of significant deterioration or structural distress [5]. The facility was visited by Reclamation personnel on July 9, 1998, at which time about 500 ft^3/s was being released over the dam crest, which prevented a close inspection of the dam structure.

3. Coleman Diversion Dam

Coleman Diversion Dam is located on the South Fork Battle Creek, about 6 miles west of Manton, and about 1/4 mile south of Manton Road, on PG&E land. The drainage area above the Coleman damsite is 102 mi^2, and includes the Inskip and South Diversion Dams. The dam and associated facilities were constructed around 1910 for diversion of up to 340 ft^3/s to the Coleman Canal for power generation at the Coleman Powerhouse. Although a minimum streamflow of only 5 ft^3/s is legally required by FERC below Coleman Dam, PG&E currently operates the canal system to provide minimum streamflow of 30 ft^3/s below Coleman Diversion Dam whenever possible, under the terms of an interim agreement with Reclamation. Principal features of the dam are shown in Appendix A (Exhibits L-19 and L-20) and Appendix B (photographs 15 through 21). Exhibit L-19 was superseded by exhibit L-20, but shows some existing details not shown on L-20.

The dam is a masonry gravity structure with a concrete overlay, having a 4-foot crest width at elevation 1003.3 and a crest length of 87.5 feet. The dam structure rises about 13 feet above the original streambed surface, with a near vertical upstream face, and a sloping downstream face and apron providing a maximum base width of about 19 feet. A 14-foot-wide by 8-foot-high radial sluice gate is provided at the right end of the dam, with a hand-operated drum winch located on a hoist deck directly above the gate. The original concrete steppool fish ladder located on the left abutment is 56 feet long and has been abandoned in place, with a concrete head wall placed at the upstream intake. The current fish ladder is located on the right abutment and is of the Alaska Steeppass-type, with a design capacity of 7 to 10 ft^3/s and a total length of about 54 feet, including two baffled flume sections and a 7-foot-long concrete box. A 24-inch-wide slide gate controls releases to the fish ladder, with an intake sill at elevation 1000.68. The reservoir behind the dam is mostly filled in with sand, gravel, cobbles, and debris, so that the depth of water

averages only a few feet below the dam crest. The impoundment covers a surface area of about 1 acre at the dam crest.

Table 1. - Engineering Data for Diversion Dams - Battle Creek Project, California

Feature	Eagle Canyon Dam	Wildcat Dam	Coleman Dam
Structure type	Masonry gravity	Masonry gravity	Masonry gravity
Structure length (ft)	66	55	87.5
Dam crest elevation	1412.4	1074.7	1003.3
Height above orig. streambed (ft)	11	8	13
Fish ladder type	Alaska Steeppass	Alaska Steeppass	Alaska Steeppass
Sluiceway type	4'x10' Radial gate	24" Slide gate	14'x8' Radial gate
Sluiceway invert elevation	1402.4	1070.8	995.3
Sluiceway capacity at dam crest (ft^3/s)	300*	27*	800*
Diversion type	Masonry weir crest	Gated intake pipe	Masonry weir crest
Diversion invert elevation	1409.4	1071.0	1002.3
Diversion capacity in canal (ft^3/s)	70	18	340
Canal length (ft)	13,673	9,951	51,230
(a) unlined tunnel	7' wide, 8' high	N/A	11' wide, 9' high
(b) metal flume	3.5' radius	N/A	N/A
(c) concrete flume	7' wide (est.)	N/A	7’ wide (est.)
(d) unlined channel	8' bottom, 4' deep	4' bottom, 2' deep	15' bottom, 9' deep
(e) lined channel	8' bottom, 4' deep	4' bottom, 2' deep	15' bottom, 9' deep
(f) pipe	N/A	24" diameter	90" diameter
Drainage area (mi^2)	186	189	102

* Note: Sluiceway capacities approximated using available data.

A masonry gravity weir structure extends upstream from the dam on the right abutment to serve as the intake to the Coleman Canal. The weir structure has a crest width of 4 feet and a crest length of 44 feet, with an approximate crest elevation of 1002.3 feet (1 foot below the dam crest). The weir structure rises about 12 feet above the original streambed surface, with a near vertical downstream face and an upstream slope of about 0.33H:1.0V. A masonry gravity retaining wall extends approximately 200 feet downstream from the dam along the Coleman Canal, with a top width of 2 feet, a near vertical downstream face, and an upstream slope of 0.33H:1.0V from the foundation to about 3.5 feet below the top of the wall, where the face becomes vertical.

Diversions to the Coleman Canal are controlled by a series of gate structures located downstream of the dam. The Coleman Canal extends nearly 10 miles to the Coleman Forebay and Powerhouse, and consists of 389 feet of rock tunnel sections 11-feet-wide by 9-feet-high; 83 feet of concrete bench flume, replacing a metal flume section; 46,240 feet of excavated channel sections (30,912 feet unlined and 15,328 feet lined) with a bottom width of 15 feet, a top width of 20 feet, and a flow depth of 9 feet; and 4,518 feet of 90-inch-diameter siphon pipe.

The dam is not under the jurisdiction of the DWR Division of Safety of Dams, due to its small size (less than 25 feet in height, and less than 50 acre-feet of storage). FERC has classified the Coleman Diversion Dam as a low hazard structure. The diversion dam was inspected by FERC in July 1997, and was found to be in good condition, without signs of significant deterioration or structural distress [5]. The facility was visited by Reclamation personnel on June 26, 1998, at which time about 300 ft^3/s was being released over the dam crest and about 300 ft^3/s was being diverted to the canal over the upstream weir, which prevented a close inspection of the structures.

D. Streamflow Diversion Requirements and Construction Sequence

Total streamflow on Battle Creek has been recorded at the Coleman National Fish Hatchery near Cottonwood, California (USGS gauging station No. 11376550) since October 1, 1961. A graphical plot of average daily discharge values from 1961 to 1996 for the 357 mi^2 total drainage area is shown on figure 1. Peak flows recorded on Battle Creek since 1961 have occurred during the months of October through May. Minimum total streamflow is shown to be approximately 250 ft^3/s for the 35 years of record.

Reliable, detailed streamflow data do not currently exist for either North Fork Battle Creek or South Fork Battle Creek. Streamflow gauges currently located on both creeks are used by PG&E to ensure that minimum streamflow requirements are met, and generally do not record higher flows. DWR estimated historic, average daily flows at Eagle Canyon Diversion Dam, having a drainage area of 186 mi^2, by multiplying the recorded average daily flows at the Battle Creek stream gauge by the ratio of the drainage areas (186/357, or 52 percent). This was considered reasonable for higher flows, but was not believed to be accurate for lower flows [2]. The same approach was used by Resource Management International (RMI) to determine median monthly flows for each of the three damsites. Two permanent streamflow gauging stations have been proposed for installation downstream of the Coleman and Wildcat Diversion Dams to provide more reliable data for future studies.