San Francisco Public Utilities Commission
Water Quality Bureau
Sunol, CA

TECHNICAL MEMORANDUM NO. 2-04-005
16 September 2005

Accessibility of Calaveras Reservoir Fishes, Especially Rainbow Trout (*Oncorhynchus mykiss*), to Arroyo Hondo During Low Water Conditions

In 2001 the San Francisco Public Utilities Commission (SFPUC) received a letter from California Department of Water Resources' Division of Safety of Dams (DSOD) asking that Calaveras Reservoir water levels be maintained at an elevation not greater than 705.5-feet (USGS datum) until seismic stability issues related to the dam have been addressed. After the SFPUC expressed concerns about meeting the DSOD requirement subsequent to relatively large winter storm events, an agreement between the two parties was reached allowing Calaveras Reservoir water levels to exceed 705.5-feet following excessive runoff as long as the SFPUC made good faith efforts to bring the reservoir back down. The SFPUC lowered Calaveras Reservoir to 705.5-feet, or less, in January 2002 and has been successful at keeping water levels below the DSOD required maximum elevation with the exception of during relatively wet winter and spring months (Figure 1).

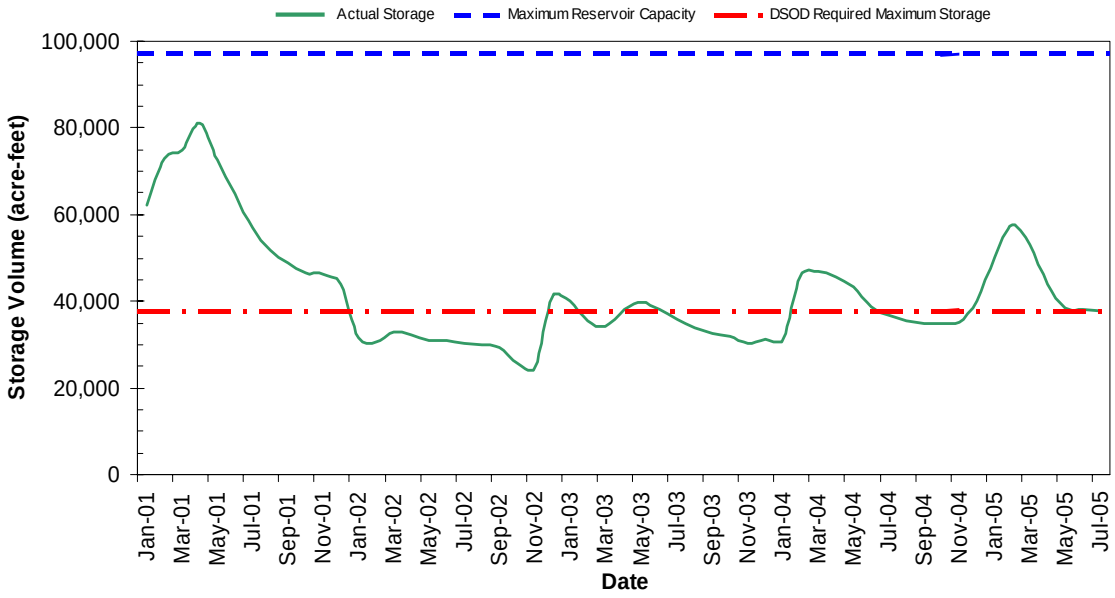

Figure 1. *Average monthly storage at Calaveras Reservoir, with the maximum reservoir capacity and the DSOD requirement equivalent superimposed.*

On August 17, 2004, biologists representing the California Department of Fish and Game (CDFG), the National Marine Fisheries Service (NMFS) branch of the National Oceanic and Atmospheric Administration, and the SFPUC visited the lower portion of Arroyo Hondo. The group hiked from Marsh Road Bridge upstream to a large natural rockslide and downstream to Calaveras Reservoir. Following the trip state and federal agency biologists expressed concerns over the effect of lower reservoir water levels on the ability of resident rainbow trout (*Oncorhynchus mykiss*) to move between the reservoir and Arroyo Hondo during both winter and spring.

The San Francisco City Attorney's Office received a letter from CDFG on October 14, 2004, formalizing their concern about the ability of rainbow trout to move between Calaveras Reservoir and Arroyo Hondo. The CDFG letter advised that the SFPUC assess fish passage conditions in Arroyo Hondo, just upstream of the reservoir, under a variety of flow regimes. The letter also brought up the idea of excavating a low-flow channel at the mouth of Arroyo Hondo if the conditions were found to be unsatisfactory for rainbow trout passage.

In response to the concerns of CDFG and NMFS, SFPUC biologists conducted a stream survey in Arroyo Hondo between its current confluence with Calaveras Reservoir and where the confluence would be if the reservoir were at capacity following the first major rain event of the 2004-2005 wet weather season (SFPUC 2004a). During this survey every individual habitat was classified (riffle, run, pool, etc.) and photographed, while its length and minimum and maximum depths were measured along the thalweg. The dominant depth range (the depths encountered along 80 percent, or more, of the habitat's thalweg) was also estimated for each habitat. Biologists were constantly on the lookout for signs of rainbow trout activity during the survey.

The SFPUC's 2004 survey concluded that, under what should be considered worst-case conditions, most of the Arroyo Hondo was passable for the upstream and downstream migrating adult rainbow trout typically found in the system. There were, however, some relatively shallow high-gradient riffles and short sections of low-gradient riffles, runs and glides that were classified as "difficult" for upstream moving adult trout to get through. Although the questionable sections in lower Arroyo Hondo would probably have posed problems for migrating rainbow trout at the time of the survey (October 28, 2004), the SFPUC's hydrologist and biologists predicted that additional rains would continue to create a defined channel, rendering the entire reach suitable for fish passage by the time that trout have been documented to move in the system (January through June (SFPUC 2004b, SFPUC *In prep. a*, SFPUC *In prep. b*)).

The 2004 survey technical report made supplemental monitoring recommendations based on CDFG and NMFS concerns, the survey's findings and the dynamic nature of the newly exposed reach of the Arroyo Hondo (SFPUC 2004a). Key suggestions included tying additional seasonal monitoring (spawning surveys) to the ongoing fish trapping study being conducted further upstream and the continuation and support of other ongoing SFPUC fisheries-related studies in the Arroyo Hondo area.

The SFPUC met with CDFG and NMFS representatives on December 13, 2004 to discuss, in part, the late October survey (Technical Memo No. 2-04-003) and Calaveras Reservoir/Arroyo Hondo connectivity issues. During that meeting both state and federal agency biologists expressed their continued concern regarding the ability of rainbow trout to move between Calaveras Reservoir and Arroyo Hondo, despite the findings and

conclusions made by SFPUC biologists in the technical memo. Although the agencies were supportive of doing spawning surveys and continuing ongoing projects, they felt that the SFPUC should spend time monitoring the physical characteristics of the Arroyo Hondo at a handful of select critical-passage sites. The CDFG also questioned the surface flow relationship between the USGS gauging station near the Marsh Road Bridge and the newly exposed portion of Arroyo Hondo just upstream of the reservoir that SFPUC biologists assumed near equal in the technical memo.

This technical memo (No. 2-04-005) reports on six additional Arroyo Hondo stream surveys conducted by SFPUC biologists (two prior to the CDFG/NMFS/SFPUC meeting and four following the meeting). The goal of these surveys, conducted between late November 2004 and early June 2005, was to further address the rainbow trout passage concerns of CDFG and NMFS at Calaveras Reservoir.

PROCEDURE

The additional monitoring of the newly exposed reach of Arroyo Hondo, between its current confluence with Calaveras Reservoir and its historical confluence when the reservoir was at capacity, was broken up into three components. Spawning surveys, conducted between Calaveras Reservoir and the SFPUC's trap site near Marsh Road Bridge, were used to determine whether or not adult rainbow trout successfully migrated from the reservoir to Arroyo Hondo. Critical riffles (the shallowest riffles found closest to the reservoir) were mapped (lengths, widths and depths) to determine their suitability for fish passage. Arroyo Hondo surface flows were measured as close to Calaveras Reservoir as feasible and compared to flows measured by the upstream USGS gauging station.

FINDINGS

Due to an extremely wet winter and relatively high, sustained flows in Arroyo Hondo, the SFPUC was not able to conduct as many supplemental surveys as it had planned. A total of five spawning surveys, two critical riffle mappings, and three downstream flow measurements were performed (Table 1).

Table 1. *Supplimental surveys conducted in Arroyo Hondo by SFPUC biologists.*

	Type of Survey Conducted		
Survey Date	**Spawning**	**Critical Riffle Mapping**	**Downstream Flow Measurement**
11/29/2004	✔		
1/4/2005	✔		
1/25/2005	✔		✔
2/8/2005	✔	✔	✔
6/2/2005	✔	✔	✔

Spawning Surveys – Five spawning surveys were conducted between November 29, 2004 and June 2, 2005 (Table 1). The survey conducted in November and the two surveys conducted in January covered about 2 ¼ miles of Arroyo Hondo, from Calaveras Reservoir to the SFPUC's trap site located just downstream of the USGS gauging station. The February and June surveys only covered the newly exposed reach of Arroyo Hondo, from its current confluence with Calaveras Reservoir to where the confluence would be if the reservoir were at capacity.

There were no signs of fishes, including rainbow trout and trout redds, during the November 29th and January 4th surveys. It should be noted, however, that the water in Arroyo Hondo was very turbid (visibility about 12 inches) during the early January survey, and the likelihood of observing fishes was low. Two adult rainbow trout were spotted in a pool during the January 25th survey, while a single trout redd was observed at the tail of a glide just downstream of the pool that had the adult fish. Biologists also documented groups of ten to 20 adult Sacramento sucker in three relatively deep pools during the late January survey. There were no trout or trout redds observed during the February 8th survey, although there were Sacramento sucker holding in several pools (Figure 2). During the June 2nd survey there were no adult rainbow trout, trout redds, or Sacramento sucker spotted, although there were numerous young-of-year trout at the upstream end of the reach examined.

Figure 2. *SFPUC biologists saw Sacramento sucker in several relatively deep pools during the January and February spawning surveys.*

Critical Riffle Mapping – There was a single critical riffle, just upstream of Calaveras Reservoir, mapped during the February 8th and June 2nd surveys. Due to changes in the reservoir elevation and stream morphology, however, it was not possible to map the same riffle during each survey. The key features mapped were riffle length, width and depth.

The early February survey found a sandbar forming at the Arroyo Hondo's confluence with Calaveras Reservoir, where the channel was slightly braided with depths averaging about 10 inches. Upon examination, biologists determined that the first riffle upstream of this braided section was the most difficult for fish passage, and thus selected it for monitoring. The riffle measured 210-feet in length, and had a broad gravel bar and narrow side-channel to the right. Widths ranged from 18-feet at the riffle's head to 22-

feet at its tail. Minimum and maximum depths at the thalweg were seven and 13 inches, respectively, averaging about nine inches.

Biologists again found a plume of fine sediment deposited at the confluence of Arroyo Hondo and Calaveras Reservoir during the early June survey (Figure 3), although they were not able to measure water depths there due to the soft nature of the substrate. It was noted, however, that a relatively narrow, defined single channel had formed through the sediment. The third riffle upstream of the reservoir, being determined the most difficult for fishes to pass through, was monitored. This reach of stream was a low-gradient riffle flowing into a high-gradient riffle, with each section being measured individually. The low-gradient riffle measured 316-feet long, with the upstream end narrower than the downstream end. Widths along the narrow portion ranged from 15 ½- to 20 ½-feet (averaging just under 18-feet), while the wide portion ranged from 19 ½- to 47 ½-feet (averaging 35 ½-feet). Minimum and maximum depths along the thalweg in the narrow section were 6 ½ and 7 inches, respectively, while the average depth of the entire channel was 3 ½ inches. The depths along the thalweg of the wide portion ranged from 5 to 7 ½ inches, with an average channel depth of 3 inches. The high-gradient riffle was 42-feet in length, with widths ranging from 19 ½-feet at the upstream end to 37-feet at the downstream end. Minimum and maximum depths along the thalweg were 5 and 8 ½ inches, respectively, averaging slightly greater than 7 inches. The average depth of the entire high-gradient riffle section of channel was about 4 inches.

Figure 3. *Fine sediments are deposited at the confluence of Arroyo Hondo and Calaveras Reservoir.*

Downstream Flow Measurements – Surface flows were measured in Arroyo Hondo just upstream of its confluence with Calaveras Reservoir on three occasions and compared to flows reported by United States Geological Survey gauging station 11173200, located further upstream near Marsh Road. In all three cases, the flow near the reservoir was slightly greater than the flow near Marsh Road (Table 2, Figures 4 and 5), never differing by more than 4.4 cubic feet per second (cfs).

Table 2. *Surface flows measured in Arroyo Hondo by the USGS and the SFPUC.*

Survey Date	Stream Surface Flow (cfs)	
	USGS Gauging Station 11173200	Manually by SFPUC Upstream of Reservoir
1/25/2005	26	30.4
2/8/2005	27	28.1
6/2/2005	11	11.9

DISCUSSION

Following the original intensive survey conducted on October 28, 2004, and discussions with CDFG and NMFS, the SFPUC agreed to routinely monitor fish passage conditions in the lower reach of Arroyo Hondo during the coming wet weather season. It was anticipated that spawning surveys, critical riffle evaluations and flow measurements would be performed on a monthly basis, at minimum. The above average precipitation experienced between late December and mid-April and the resultant high flows (Figure 4) in Arroyo Hondo, however, limited the number of times that biologists were able to get into the field to conduct surveys. As a result of the unworkable conditions, only four additional trips were made following the SFPUC's meeting with CDFG and NMFS.

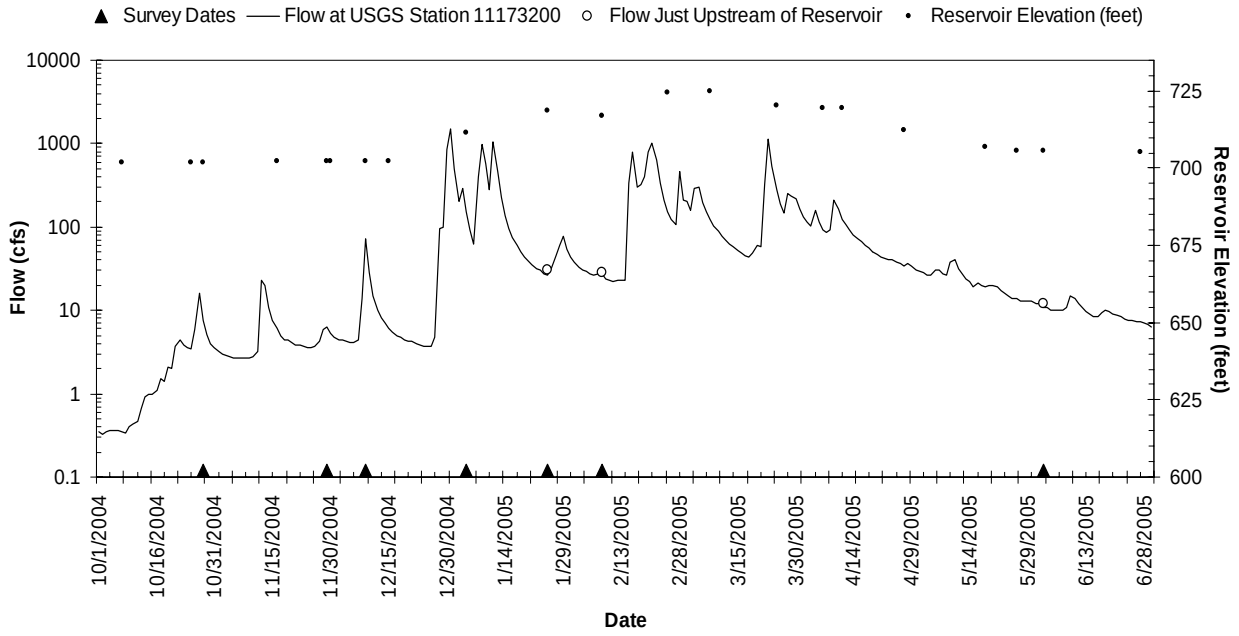

Figure 4. *Arroyo Hondo surface flows at USGS gauging station 11173200 near Marsh Road, flows just upstream of Calaveras Reservoir and reservoir elevations.*

During the few spawning surveys that were conducted, there were two adult rainbow trout and one redd observed on a single occasion. Several young-of-year trout were also documented in the newly exposed reach of Arroyo Hondo during a June trip. Even with the telltale signs of successful rainbow trout spawning, however, the small numbers of fish observed does not provide a means of knowing whether they made it upstream from Calaveras Reservoir or were stream residents. The ability of fishes to move between the reservoir and Arroyo Hondo is, on the other hand, supported by the presence of relatively large schools of adult Sacramento sucker, that have not been found during summer snorkel surveys, in the stream's deeper pools.

Although the fish passage conditions encountered during the late October survey were considered worst-case due to the time of year and the minimal amount of rainfall prior to the trip, SFPUC biologists felt that fishes could successfully move between Calaveras Reservoir and Arroyo Hondo (SFPUC 2004a). In addition, the SFPUC

expressed to CDFG and NMFS at their meeting that they were cautiously confident that the conditions, especially those areas called marginal during the original survey, would improve with more precipitation. Subsequent surveys confirmed their beliefs, as the Arroyo Hondo's banks became better-defined and overall water depths increased. Even in early June, with the cessation of storms and a reduction in stream flows, the shallowest portion of the thalweg in the critical riffles monitored met or exceeded the minimum depth criteria (5 inches) set by Bjornn and Reiser (1991) for non-anadromous trout.

Although it will take additional data to define a statistical relationship, the surface flows measured by the USGS near Marsh Road do appear to closely approximate the

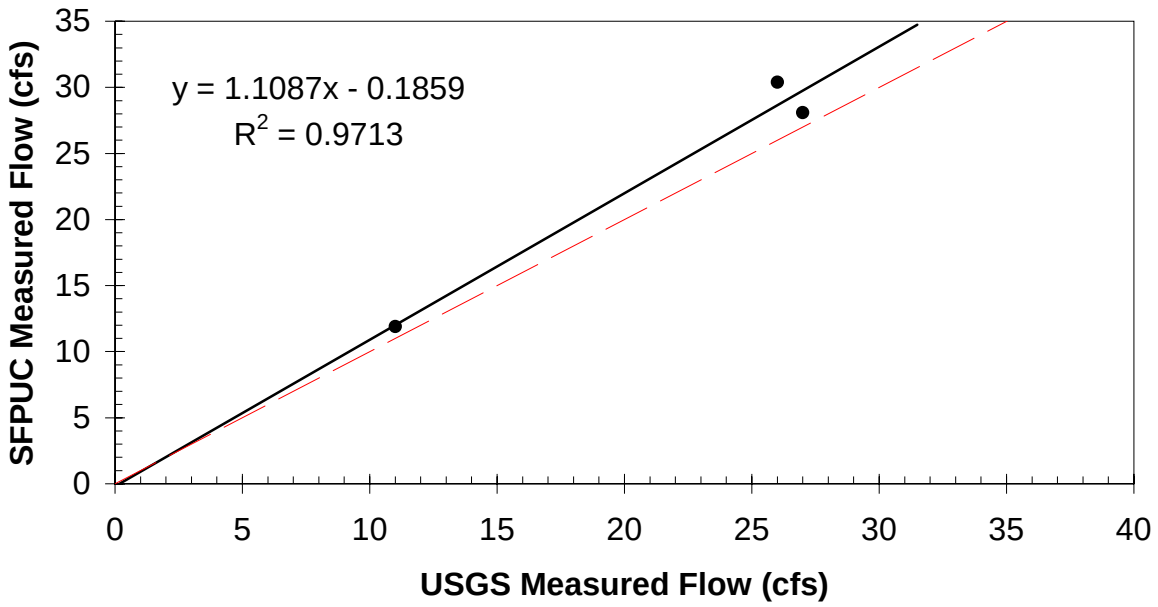

Figure 5. *Relationship between Arroyo Hondo surface flows at USGS gauging station 11173200 near Marsh Road and SFPUC-measured flows just upstream of Calaveras Reservoir (solid black line). The red dashed line represents what a 1:1 relationship would look like.*

Arroyo Hondo flows just upstream of its confluence with Calaveras Reservoir (Figure 5). The slightly higher flows observed at the monitoring location closest to the reservoir is probably a function of additional storm-event runoff, natural springs and input from small drainages downstream of the USGS gauging station.

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Stream Surveys

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