

**UNITED WATER CONSERVATION DISTRICT**



**A PLAN FOR THE EMPIRICAL DETERMINATION OF THE  
RELATIONSHIP BETWEEN DISCHARGE, DEPTH, AND VELOCITY IN  
LOWER PIRU CREEK, VENTURA COUNTY, CALIFORNIA**

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Santa Felicia Project FERC P-2153

August 2011

## **Introduction**

United Water Conservation District (United) owns and operates the Santa Felicia Project (Project) on Piru Creek in Ventura County, California. The Federal Energy Regulatory Commission (FERC) issued a new license to United for the operations of the Project on September 12, 2008 (FERC Project No. 2153-012). This license incorporates numerous requirements set by National Marine Fisheries Service (NMFS) in its biological opinion (BO) for addressing affects of the Project on the federally endangered southern California steelhead. This plan has been prepared to comply with Article 401(a) of the license and term and condition 1(B) for reasonable and prudent measure 1 in the BO.

The primary function of the Project is to hold back winter flows in Piru Creek and make controlled releases in a manner which enhances recharge of stored waters into the aquifers managed by United. These controlled releases require that changes in flow in Piru Creek below Santa Felicia Dam occur in time. Changing flow in time create conditions that allow aquatic species to disperse to areas they otherwise couldn't access, in the case of increasing flows, and that may result in stranding of these animals, in the case of decreasing flows. Accordingly, it is important to design the time changes in flow (ramping rates) to minimize these effects. This plan addresses the design of these ramping rates.

Reasonable and prudent measure 1 requires that United "implement a water-release ramping rate for the purpose of minimizing steelhead stranding in Piru Creek downstream of Santa Felicia Dam." The BO provides term and condition 1(A) and 1(B) to guide implementation of the measure.

Term and condition 1(A) requires that United "implement a water-release ramping rate of 2inches/hour to guide increases and decreases of water releases from Santa Felicia Dam to Piru Creek for the purpose of minimizing the likelihood of displacing and stranding steelhead in Piru Creek downstream of Santa Felicia Dam."

Term and condition 1(B) requires that "the water-release ramping rate specified in term and condition 1A shall be based on an empirical relationship between discharge and water depth and velocity representing Piru Creek downstream of Santa Felicia Dam." It goes on to require United to prepare a plan for developing this empirical relationship for Piru Creek. The plan must contain the following:

1. A description of the field sampling methods that will be used to collect the necessary field data for developing the discharge depth (and water velocity) relationship,
2. The number of sampling locations and number of samples representing each location in Piru Creek, and the different magnitudes of creek discharge the collected data will represent,
3. The requirement that the sampling locations will be selected randomly,
4. A description of the sampling schedule,
5. A description of the analytical methods that will be used to develop the discharge-depth relationship, and
6. A requirement that the findings obtained from implementation of the plan that is required of this term and condition shall be provided to NMFS.

The license and BO require that United obtain the agreement of NMFS and approval of FERC on the content of the plan.

### **Brief History**

On July 24, 2009, United submitted a draft plan to NMFS for review. In a letter dated October 02, 2009, NMFS provided comments to United on the plan. The letter consisted of four comments. The first three comments focused on incorporating a one-dimensional flow model such as HEC-RAS to evaluate the reduction on the falling limb of the hydrograph. The fourth comment requested information on the vertical resolution of the level loggers.

Following the receipt of this comment letter along with comment letters on several other draft plans, United and NMFS had a series of meetings to address this situation. Reporting on the outcome of the first meeting on November 16, 2009, NMFS reported in a letter to FERC, dated November 24, 2009, that the “draft water-release plan is of primary interest to United and NMFS”. United and NMFS then focused attention on developing the water release plan. On September 27, 2010, NMFS agreed to the water release plan that United submitted. United filed this plan with FERC on November 29, 2010.

The Water Release Plan contains ramping rates for both increasing and decreasing flows. They are as follows.

#### 1) Habitat Flows

Between January 1 and June 1 when either increases or decreases in habitat flows are triggered, the Licensee will ramp discharge up or down at the rate of 2.0 cfs every 30 minutes until the new target habitat flow is reached.

#### 2) Migration and Water Conservation Flows

Increasing flows: The Licensee will increase discharge such that flows no more than double in any two hour period.

Decreasing flows: The Licensee will reduce discharge no faster than 50% in any 24-hour period. The downward ramping shall stop, and discharges fixed, at flows no less than the appropriate habitat flow.

Changes in the water depths in Lower Piru Creek during ramped flow reductions shall be measured in accordance with the Water Release and Ramping Rate Effectiveness Monitoring Plan for Lower Piru Creek. Should the proposed ramping rates yield a decreasing depth of more than 2-inches/hour, modification to the rates shall be implemented following consultation with NMFS and FERC.

It should be noted that this ramping rate plan deviates from what is called for in the BO. Term and condition 1(A) states that both increasing and decreasing flows must meet the 2 inches/hour

requirement. However, the Water Release Plan agreed to by NMFS only applies this requirement to decreasing flows. In conference calls between FERC, NMFS, and United on July 7, 2011, and NMFS and United on July 13, 2011, FERC stated they are fine with the deviation from the BO as long as the deviation is acceptable to NMFS. NMFS stated that the ramping rates as described in the Water Release Plan are acceptable and that meeting the 2 inches/hour requirement is not necessary for increasing releases.

With work on the water release plan concluding, on August 9, 2010, United and NMFS met to review the status of United’s compliance with the BO, including the ramping plan. NMFS stated during the meeting that the method proposed in the original draft ramping rate plan was acceptable and that the plan did not need to incorporate a one-dimensional model requested in the October 2, 2009, comment letter on the original plan.

Meanwhile, United began to collect the data described in the original draft ramping rate plan. During United’s conservation release in the fall of 2009, eight transducers were deployed in lower Piru Creek to establish a relationship between the change of discharge to the change in water levels. This information was then used in the 2010 conservation release. The transducers were again placed in the creek to measure changes in the water levels and to verify that the ramping rates achieved the 2 inches/hour. Appendix A describes this work in more detail.

The plan that follows reflects the guidance United received from NMFS on August 9, 2010, the water release plan, and the data obtained in 2009 and 2010.

**Initial Ramping Rates**

United has proposed initial ramping rates as follows:

<b>Regime</b>	<b>Possible bio-effect</b>	<b>Initial Rule</b>	<b>T (Q7cfs - Q400cfs)</b>
Ramp-Up (Increased discharge)	Displacement	< doubled each 2 Hours	12 Hrs.
Ramp-Down (Decreased discharge)	Stranding	<halved each 24 Hours	6 days

These ramping rates were determined by a statistical review of pre-dam natural runoff events (Unimpaired Ramping Rate Analysis in Piru Creek, Murray McEachron, United, 4/29/09).

**Streamflow Response Measurement**

United shall measure changes to streamflow depth at various locations in Lower Piru Creek throughout an annual conservation release, including the ramp-up and ramp-down of releases. The information will be gathered to; 1) determine whether the initial ramping rates for decreasing flows satisfy the maximum 2 inches/hour threshold, or 2) provide data for the determination of an empirical relationship between stage, discharge and velocity.

The depth monitoring shall be conducted at eight stations along lower Piru Creek. Five stations shall be at locations selected randomly by placing instruments at each river mile below the outlet

works (see Appendix A). The instruments shall be anchored in the creek bed where GPS indicates a mile point. In the case where cultural structures are affecting the water surface at the mile point, the station shall be moved to the nearest representative location. Additionally, three stations shall be set at one of three randomly selected mesohabitat types. One shall be placed in a run, one in a riffle and one in a pool. At each of the three mesohabitat stations, three transects (instrument site plus one upstream and one downstream) will be surveyed to provide local channel geometry.

Water levels at each station are to be measured at a maximum 15-minute interval with logging transducers manufactured by Solinst, Inc. United intends to utilize the Levellogger Gold model 3001 – F100, which have absolute elevation accuracy of 1.5 cm and significantly higher sensitivity to changes in water level.

Following ramp-down at the end of the release, the loggers shall be retrieved and the data downloaded.

### **Data Compilation and Analyses**

The raw depth data shall be compiled during periods of changing flows as follows. The hydrographs for the five random stations shall be plotted in real time along with the instantaneous discharge measured at the USGS gauge below Santa Felicia. Additionally, the running one-hour time derivative of the random stations shall be calculated and presented in a second set of graphs. The mesohabitat station hydrographs will be displayed on three independent graphs, both as raw depth and as time derivative.

Data from the three mesohabitat stations shall be subjected to further analyses. Specifically, the station cross sections shall be plotted at a minimum of three discharges (say 50, 100 and 200 cfs) and the area, wetted perimeter and velocity shall be calculated and provided for each station and each discharge. This information shall then be analyzed using Manning's equation (either directly or using HEC-RAS) to determine a value for manning's "n" at each of the three stations.

### **Information Uses**

The information obtained from the implementation of this study plan shall be used to optimize the ramping rates of releases from Santa Felicia Dam to minimize stranding and displacing of steelhead in lower Piru Creek. United will determine the effectiveness of the ramping rates by implementing the "Water Release Schedule and Ramping Rate Effectiveness Monitoring Plan For Lower Piru Creek" This plan is currently under development. .

Using the hydrographic information alone, ramping rates could be adjusted up or down to keep changes in depth to less than the required 2 inches/hour. However, if significant stranding or displacement is observed at this threshold rate, a different threshold may need to be developed. This process for making adjustments will be guided by the adaptive management plan for water releases that is currently under development.

## **Schedules**

If acceptable to NMFS, the data that have already been collected will be compiled and analyzed in a report. The report shall include all raw data as well as the exact methods and results of the proposed analyses and shall be submitted in draft form for review by NMFS no later than 90 days after the approved ramping plan has approved by FERC.

## Appendix A - Initial Findings for the Ramping Rate Plan

During the 2009 conservation release, United proceeded with the collection of data as described in the initial ramping rate plan submitted to NMFS on July 24, 2009. As the plan detailed, a total of eight transducers were placed along the six mile portion of Piru Creek below Santa Felicia Dam. Three of the transducers were placed in a survey site representing a pool, run and a riffle. The remaining transducers were located at each mile marker downstream of the dam. Surveyed cross sections of the bed profile were done at the three habitat types before and after the release (figure 7). The conservation release ramp down was done in accordance with the water rights license and was consistent with the method described in the biological assessment.



**Figure 1** Location of the three habitat types surveyed

The transducers provided a relationship between decreases of flows at various magnitudes with the associated decrease of the water levels at each monitoring point. Below is a graph showing the 15 minute data of the discharge from Santa Felicia Dam (green line) and the water levels in Piru Creek (Blue line) at the pool survey site. The discharge was measured at the USGS gage 11109800 Piru Creek below Santa Felicia Dam. Figure 2 shows that when the discharge of the

creek is at an average of 169 cfs, the water levels drop 0.76 Ft (9.1 inches) when flows are decreased by 117 cfs. This equates to 0.0065 foot drop for every cfs drop in this flow range.

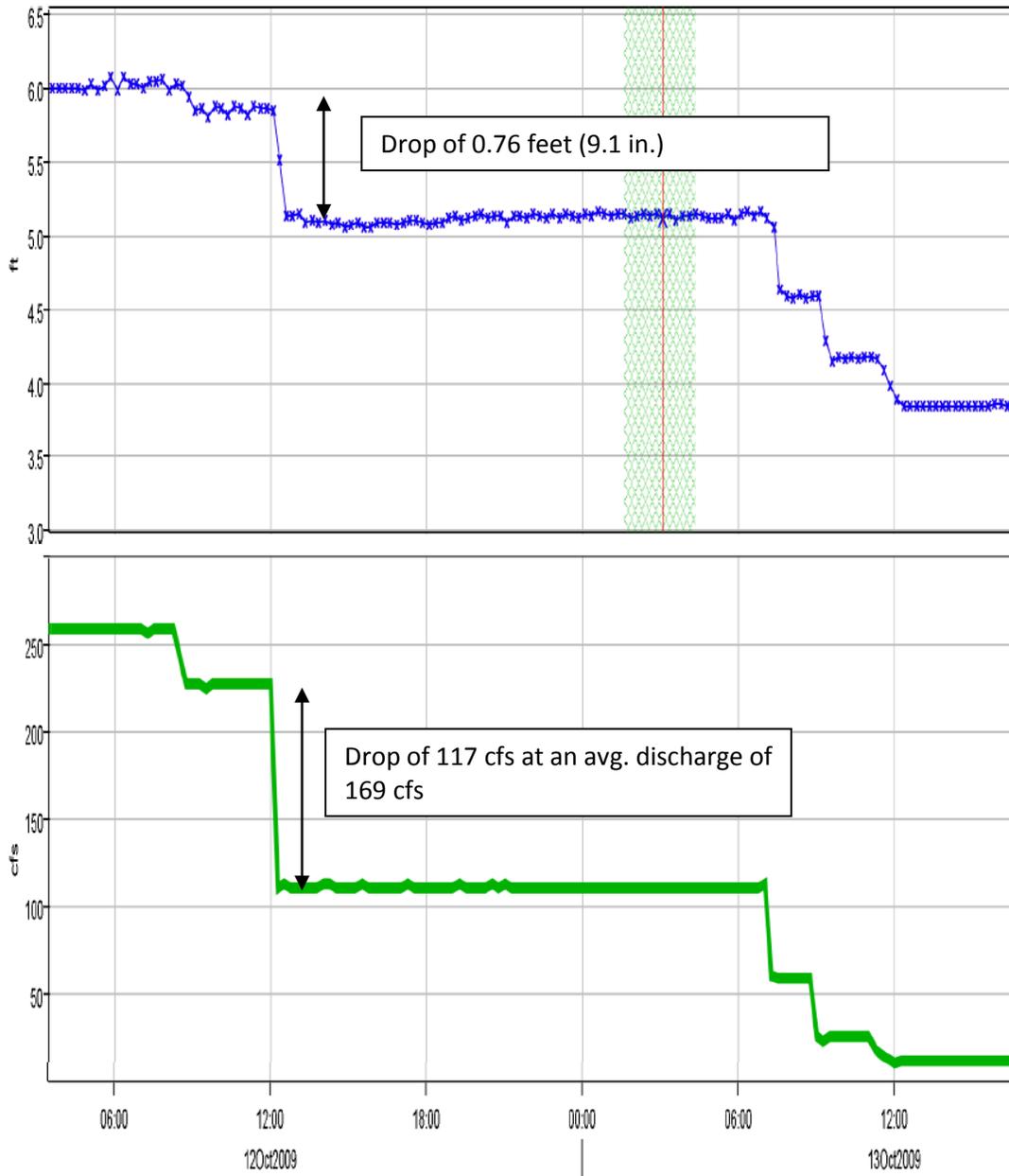


Figure 2 Drop in water surface associated with the drop in flow at the pool survey site during the 2009 release

The data from all of the transducers were plotted showing the change in depth for every cfs drop associated with the average flow during the ramp down. Figure 3 shows the relationship of the three survey sites and an average of the other sites further downstream.

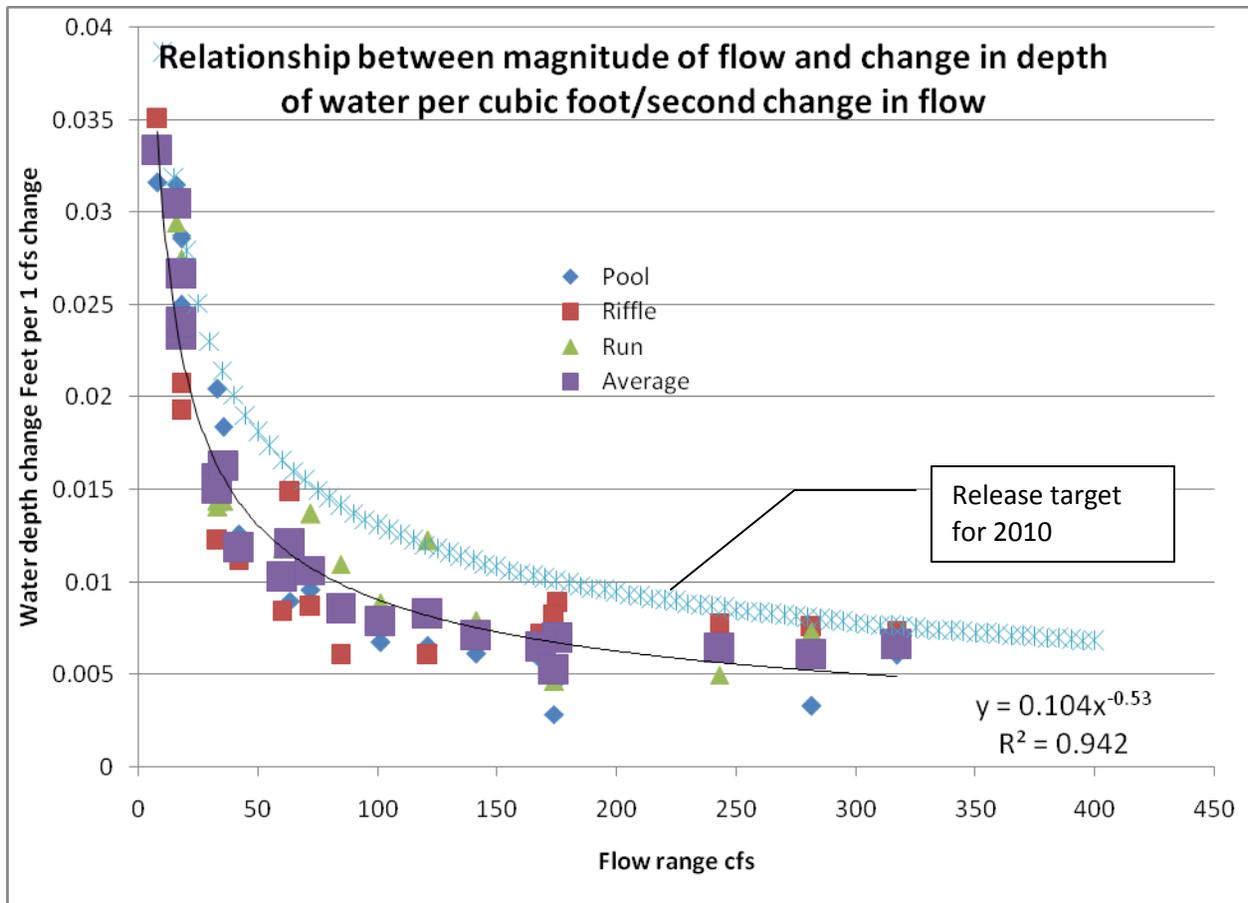


Figure 3

As expected the graph shows that water levels are much more responsive to change in flows when the discharges are smaller. This would indicate that as the magnitude of the release decreases, the change in magnitude of the release must also decrease to meet the 2 inches per hour criteria. The blue line labeled “Release target for 2010” was calculated to encompass or exceed all of the rates of changes found in the data obtained in 2009. The release for 2010 was designed around this new conservative rate of change.

Figure 4 shows an example of how the 2010 release was designed. The blue line shows the new conservative rate of change (labeled Release target for 2010 in figure 3). When flows are at 200 cfs the change in water depth of the creek could be as much as 0.0095 Feet (0.114 in) for every cubic foot of discharge changed in the river. At a limit of 2 inches per hour, that would allow  $2''/0.114'' = 17.6$  cfs/hour. So when flows were at 200 cfs the release may be decrease by 17.6 cfs down to 182.4 cfs. The next adjustment would be calculated in the same way using the initial flow of 182.4 cfs.

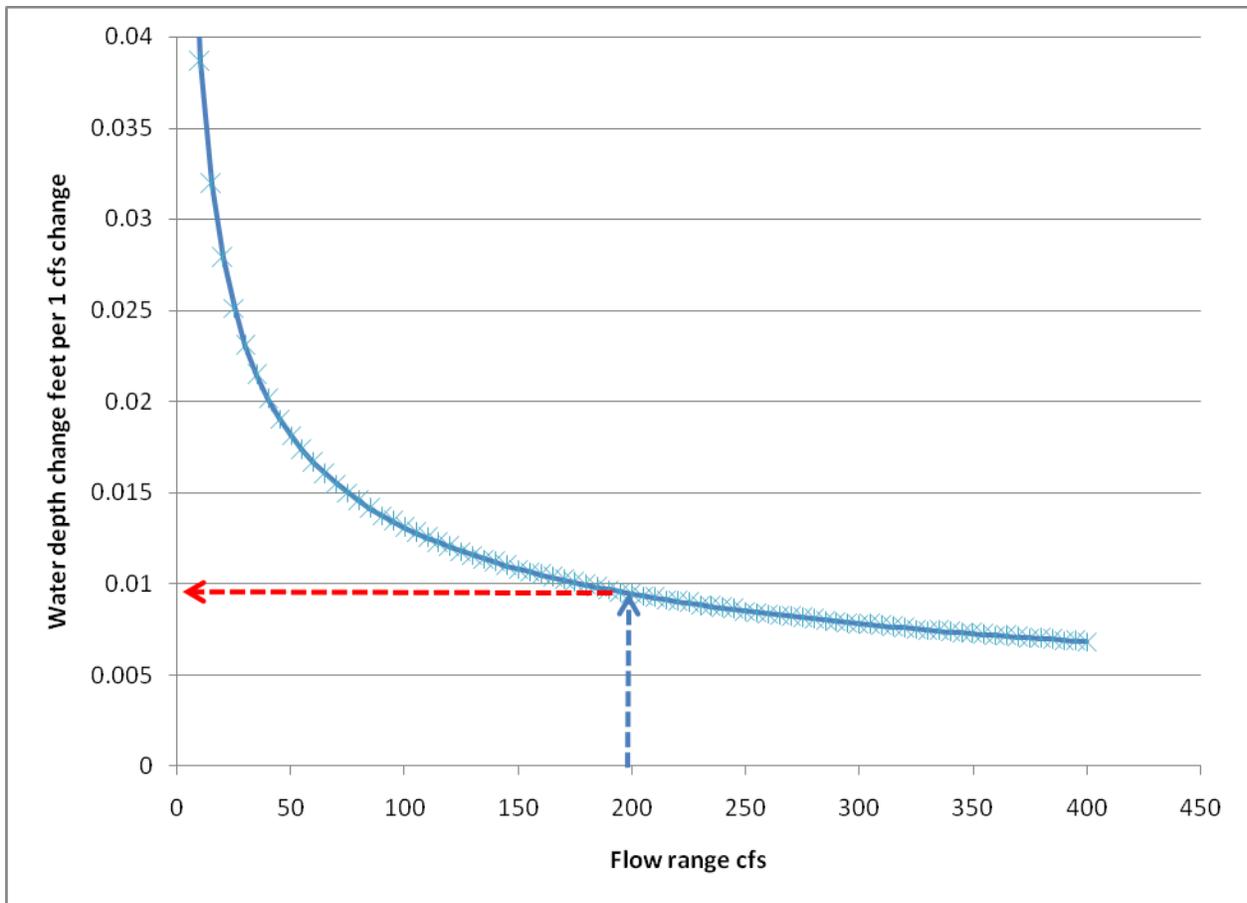


Figure 4 Associated change in water depth to total flow

The new ramping rates for the 2010 release were implemented and the transducers were deployed in the same locations to verify that the ramping rates were meeting the required water level change. Below is a graph showing the ramp down of the release with the associated water levels at the various locations of the remaining five working transducers. During the release, one transducer was lost, and another two transducers did not produce data that reflected water levels. (Transducers are made to monitor groundwater and not surface flows that carry suspended solids.)

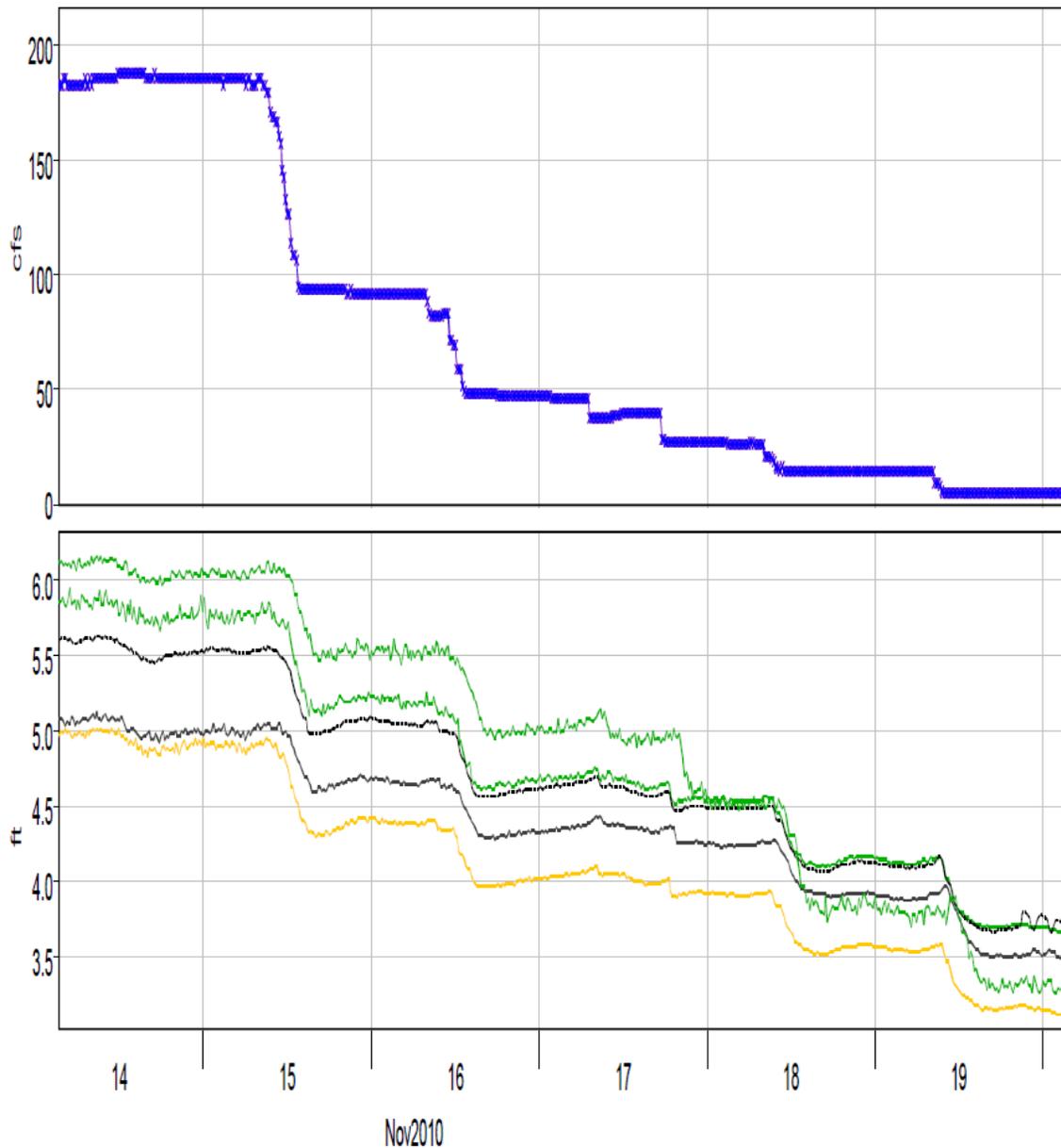


Figure 5 Drop in water level associated with drop in flows for all sites during 2010 release (see legend in Figure 6)

To better visualize the rate of change in water surface elevation with each associated ramp down, a running total of water level change for one hour was calculated from the 15 min. data for each station. This information would give the sum of the prior hours change in flows every 15 minutes. The graph below shows the rate of change per hour in inches associated with the flows during the ramp down. In order to meet the 2 inches per hour criteria and average of 5 to 8 adjustments were made to the release every day. Additionally the number of adjustments per day was limited by the ramp down criteria established in the flow plan of not decreasing the flows by more than 50% in one day.

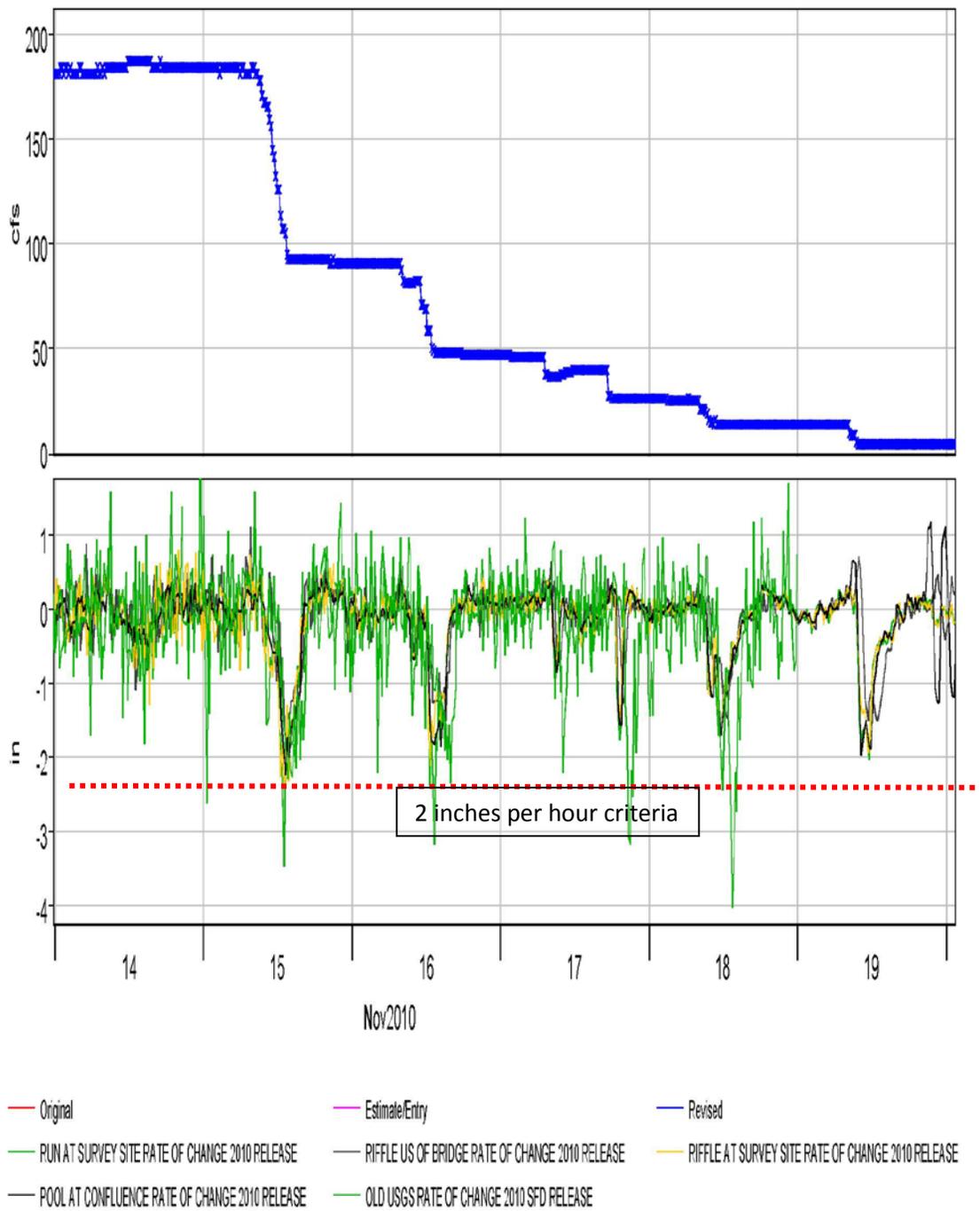


Figure 6 Hourly changes in water levels during the 2010 conservation release ramp down

The ramping rates met the required water level change of 2 inches/hour in all but one site. The site that did not meet the standards is the one called upstream of the Old USGS. At this point it is not clear if the effects of the old weir at the USGS station is causing an unnatural elevation in the creek bed or if this portion of the river naturally elevates more during high flows due to channel constrictions. The release in 2011 will again monitor this site to see if stranding will be an issue.

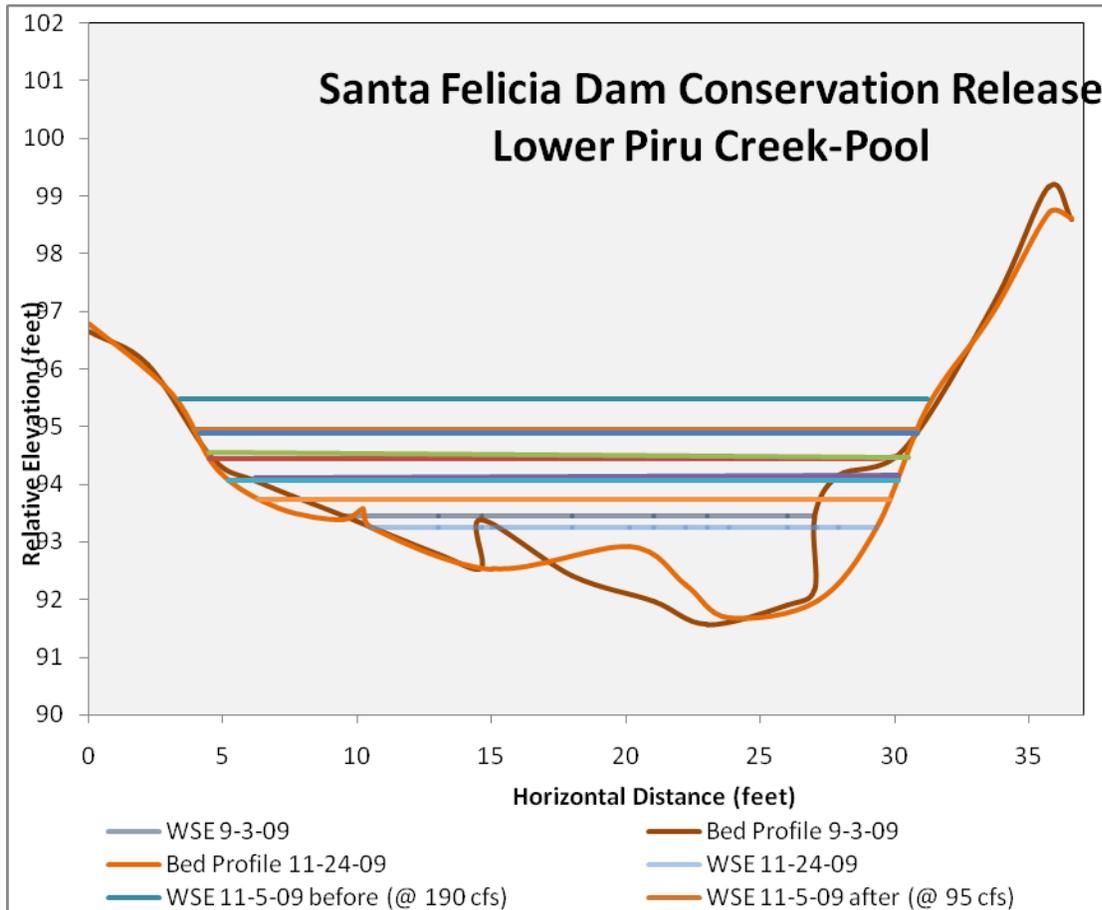


Figure 7