FINDINGS ON THE EMPIRICAL DETERMINATION OF THE RELATIONSHIP BETWEEN DISCHARGE, DEPTH, AND VELOCITY IN LOWER PIRU CREEK, VENTURA COUNTY, CALIFORNIA

Santa Felicia Project FERC P-2153-031

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Table of Contents

Table of Figures

1.0 BACKGROUND

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 federally listed endangered southern California steelhead (*Oncorhynchus mykiss*).

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 2-inches per 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." It should be noted that the Water Release Schedule (September 2010) contains a schedule for ramping rates that was agreed to by NMFS. That schedule only applies the 2-inches per hour requirement to decreasing flows. In an order issued by FERC on November 22, 2011, FERC modified the license such that term and condition 1(A) only applies to decreasing flows. Based on this, the Plan and this findings report only address decreasing flows. Term and condition 1(B) requires that "the water-release ramping rate specified in term and condition 1(A) shall be based on an empirical relationship between discharge, water depth and velocity representing Piru Creek downstream of Santa Felicia Dam."

In compliance with Article 401(a) of the license and term and condition 1(B) for reasonable and prudent measure 1 in the BO, United developed "A Plan for the Empirical Determination of the Relationship between Discharge, Depth, and Velocity in Lower Piru Creek, Ventura County, California" (Plan). NMFS submitted a letter of agreement of the Plan on October 14, 2011, and FERC issued an order approving the Plan on November 22, 2011. United implemented the Plan during its annual conservation releases between 2009 and 2011 and has evaluated the data collected. The Plan and FERC's order require United to file the findings with NMFS and FERC within 90 days of receiving FERC's approval of the Plan. United has prepared this report to fulfill this requirement.

2.0 INTRODUCTION

The relationship between discharge and depth in lower Piru Creek was empirically derived by measuring changes in surface water depth at various locations (study sites) in lower Piru Creek during annual conservation releases[1] and correlating those changes to fluctuations in discharges released through the Santa Felicia Dam outlet works. Changes in water surface elevation (WSEL) were measured using transducer dataloggers, and flows discharged from the Santa

[1] The purpose of the project is to store water during wet periods and release water during dry periods to replenish downstream groundwater basins. Water is typically released during the fall of each year. This release event is referred to as a conservation release.

Felicia Dam were measured at the USGS Gaging Station #11109800 located below the Santa Felicia Dam outlet works.

Initial study sites (2009) were located at mile intervals below the Santa Felicia Dam. As required in the Plan, a set of mesohabitat study sites was also monitored. The mesohabitat study sites consisted of a delineated pool, riffle, and run in a representative reach located in the vicinity of the confluence of the spillway and release channel. Results obtained from 2009 monitoring activities were evaluated to determine the relationship between discharge from the outlet works and associated changes to WSEL at the study sites. The derived relationship was used to establish a ramping protocol that was implemented during the 2010 and 2011 conservation releases. Monitoring activities continued at various locations in lower Piru Creek during the 2010 and 2011 conservation releases to verify the efficiency of the established ramping protocol and inform refinement strategies.

3.0 METHODS

3.1 2009 DATA COLLECTION

A total of 10 study sites, including three mesohabitat sites, were assessed in 2009. Their locations were determined using a Google Earth aerial map. The furthest upstream study site was selected in a reach just below the outlet works and additional study sites were positioned at approximate one mile intervals in a downstream direction. Coordinates for the 2009 study sites are presented in Table 1, and an aerial map showing the location of the study sites is included in Figure 1. Technicians located the designated sites using GPS coordinates obtained from Google Earth. Fence posts were installed within the stream channel at each location to anchor the transducer dataloggers (Levelogger Gold model 3001 – F100, manufactured by Solinst Inc.). Fence posts were positioned so that the top of each post was as close to the streambed as possible to avoid catching suspended and floating debris that could influence results. Transducer dataloggers were programmed to collect data at 15 minute intervals and attached to the base of each fence post.

Transducer dataloggers were installed prior to the conservation release and retrieved after termination of the conservation release. Transducers positioned in the mesohabitat riffle and Sites 6 and 7 malfunctioned and did not produce usable data (the transducer dataloggers are intended to measure groundwater levels in wells). Bed profiles were surveyed at the mesohabitat sites (presented in Appendix A). The 2009 conservation release began on September 10th, and ended on October 15th. Flow increases were consistent with the Ramping Rate Plan submitted to NMFS on July 24, 2009. Flow decreases were conducted in accordance with United's water rights license and consistent with the methods described in the BO.

Table 1 - 2009 Site locations and characteristics

Site #	Location Coordinate	Location Description	Hydraulic Unit
1	N34° 27' 31.03" W118° 45' 4.29"	Release channel below outlet works	Pool
2	N34° 27' 4.86" W118° 45' 14.88"	Confluence of spillway and release channel	Pool
3	N34° 26' 36.70" W118° 45' 28.29"	Upstream of 1st bridge below Santa Felicia Dam	Run
4	N34° 26' 0.73" W118° 45' 40.97"	Upstream of 2nd bridge below Santa Felicia Dam	Riffle
5	N34° 25' 22.65" W118° 46' 15.41"	Below old USGS gaging station	Pool
6*	N34° 25' 13.28" W118° 47' 13.85"	Upstream of town/bank stabilization project	Pool
7*	N34° 24' 44.94" W118° 47' 11.60"	Between Piru Diversion and 126 Hwy	Run
Mesohabitat Sites			
A	N34° 27' 9.16" W118° 45' 9.34"	Release channel upstream of confluence with spillway channel	Pool
B	N34° 27' 8.53" W118° 45' 9.34"	Release channel upstream of confluence with spillway channel	Riffle
C	N34° 27' 8.84" W118° 45' 9.38"	Release channel upstream of confluence with spillway channel	Run

*Transducer dataloggers at these sites did not produce usable data (the intended use for dataloggers is to measure groundwater levels in wells).

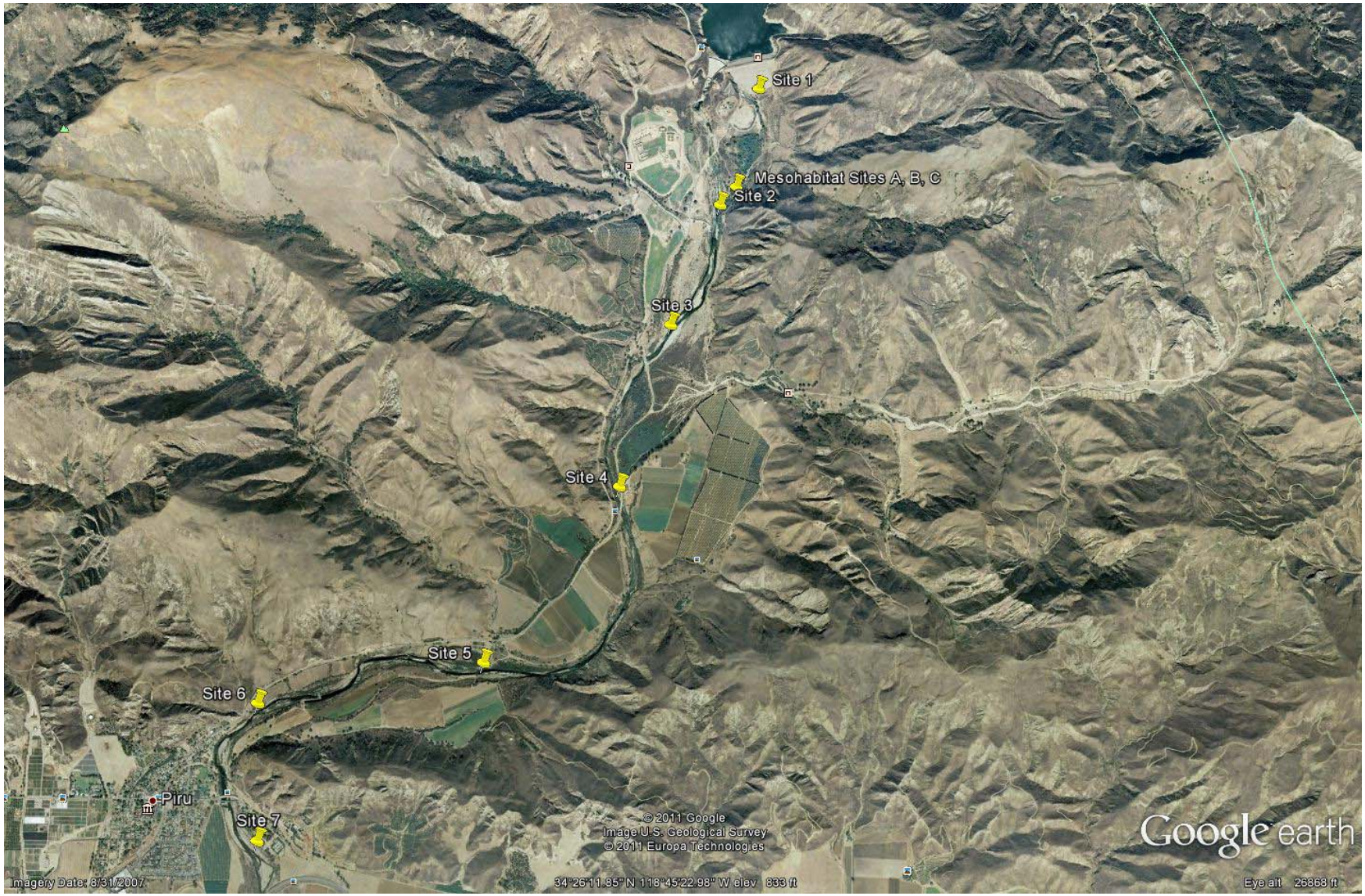


Figure 1 - 2009 Site map

3.2 2010 DATA COLLECTION

Data collected during the 2009 conservation release was evaluated to derive a relationship between depth of water column at the study sites and discharge released from the Santa Felicia Dam (analytical details are presented in the results section). United used this derived relationship to establish a ramp-down schedule for the 2010 conservation release. The 2010 data was collected to verify that this schedule would meet the goal of 2-inches per hour. It also supplemented data collected in 2009. The suite of study sites assessed during 2010 varied slightly from those assessed during 2009. Fewer study sites were assessed during 2010 due to availability of transducer dataloggers. Study sites consisted of the three mesohabitat sites, four of the original study sites (Sites 1-3 and 6), and a study site slightly upstream of Site 5 (referred to below as Site 5A). In the case of Site 5A, the technician performing installations of the transducer dataloggers misunderstood directions and installed the datalogger in an unintended location. At Site 5A, the transducer datalogger was attached to a pipe located within the concrete channel of the old USGS gaging station. With the exception of Site 5A, installation and retrieval methods were consistent with methods implemented in 2009. The 2010 study sites are described in Table 2 and shown on an aerial map in Figure 2. Transducer dataloggers positioned at Sites 1, 2, and 6 did not produce usable data. The 2010 conservation release began on September 17th and ended on November 20th. As in 2009, flow increases were consistent with the Ramping Rate Plan submitted to NMFS on July 24, 2009 (included in Appendix B). Flow decreases were conducted in accordance with United's water rights license, consistent with the methods described in the BO, and according the formula developed from the analysis of the 2009 data.

Table 2 - 2010 Site locations and characteristics

Site #	Location Coordinate	Location Description	Hydraulic Unit
1*	N34° 27' 31.03" W118° 45' 4.29"	Release channel below outlet works	Pool
2*	N34° 27' 4.86" W118° 45' 14.88"	Confluence of spillway and release channel	Pool
3	N34° 26' 36.70" W118° 45' 28.29"	Upstream of 1st bridge below Santa Felicia Dam	Riffle
5A	N34° 25' 22.65" W118° 46' 15.41"	Old USGS gaging station	Weir
6*	N34° 25' 13.28" W118° 47' 13.85"	Upstream of town/bank stabilization project	Pool
Mesohabitat Sites			
A	N34° 27' 9.16" W118° 45' 9.34"	Release channel upstream of confluence with spillway channel	Pool
B	N34° 27' 8.53" W118° 45' 9.34"	Release channel upstream of confluence with spillway channel	Riffle
C	N34° 27' 8.84" W118° 45' 9.38"	Release channel upstream of confluence with spillway channel	Run

*Transducer dataloggers at these sites did not produce usable data (the intended use for dataloggers is to measure groundwater levels in wells).

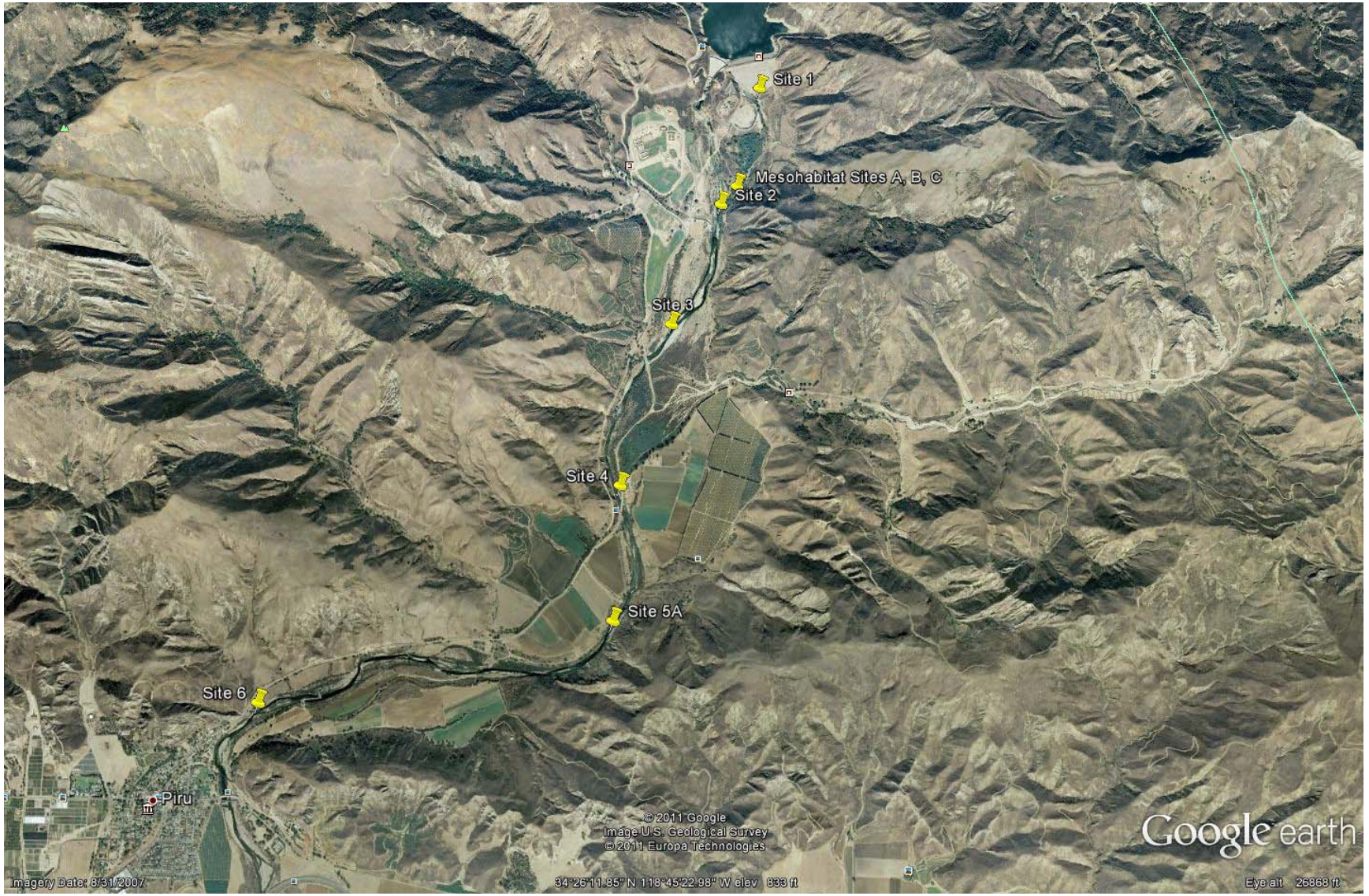


Figure 2 - 2010 Site map

3.3 2011 DATA COLLECTION

Five sites were monitored during the 2011 conservation release. Sites were selected based on availability of transducer dataloggers, coordinated efforts with a tandem study, and the desire to retest at a site that exhibited excessive declines during 2010 monitoring activities. Three of the sites were located in the vicinity of prior sites. Sites 1 and 2 were changed to coincide with data collection for the "Study Plan to Characterize Geomorphic Effects of Santa Felicia Dam on Lower Piru Creek Geomorphology" (the revised sites are identified in Table 3 as Sites 1A and 2A). Results from the 2010 monitoring activities indicated that the change in WSEL measured at Site 5A (where the transducer datalogger was installed within the weir at the old USGS gaging station) exceeded the 2-inch per hour criterion. To capture additional data representing the localized area adjacent to the weir, a transducer datalogger was positioned upstream of the old USGS gaging station weir (identified in Table 3 as Site 5B). Additional transducer dataloggers were positioned at Sites 3 and 7. Study sites for 2011 monitoring activities are described in Table 3 and shown on an aerial map in Figure 3. Installation and retrieval methods were consistent with methods implemented in 2009. The 2011 conservation release began on September 13th and was ramped down to minimum flows at the end of October. In support of the geomorphic effects study, water releases were then ramped up to a maximum flow of approximately 600 cfs on November 3rd. This release ended on November 10th. Flow increases and decreases were done in accordance with the Water Release Schedule (September 2010) and the formula developed from the analysis of the 2009 data.

Table 3 - 2011 Site location and characteristics

Site #	Location Coordinate	Location Description	Habitat Type
1A	N34° 27' 31.03" W118° 45' 4.29"	Release channel below outlet works	Riffle
2A	N34° 27' 0.15" W118° 45' 15.57"	Confluence of spillway and release channel	Pool
3	N34° 26' 36.70" W118° 45' 28.29"	Upstream of 1st bridge below Santa Felicia Dam	Run
5B	N34° 25' 33.99" W118° 45' 39.03"	Upstream of old USGS gaging station	Run
7	N34° 24' 44.94" W118° 47' 11.60"	Between Piru Diversion and 126 Hwy	Run

Figure 3 - 2011 Site map

4.0 DATA ANALYSIS AND RESULTS

4.1 2009 RESULTS

Data downloaded from the transducer dataloggers and measured flow from the USGS gaging station downstream of the Santa Felicia Dam outlet works were assessed to determine the relationship between discharge from the outlet works and WSEL at study site locations in lower Piru Creek. The data retrieved from the transducer dataloggers showed changes in WSEL (in feet) at 15 minute intervals. Hydrographs for the period of the 2009 conservation release showing WSELs at the study sites and discharge measured at the USGS gaging station located below the outlet works are presented in Figure 4. WSELs presented throughout this study are relative to a preset value at the time of installation and not actual elevations.

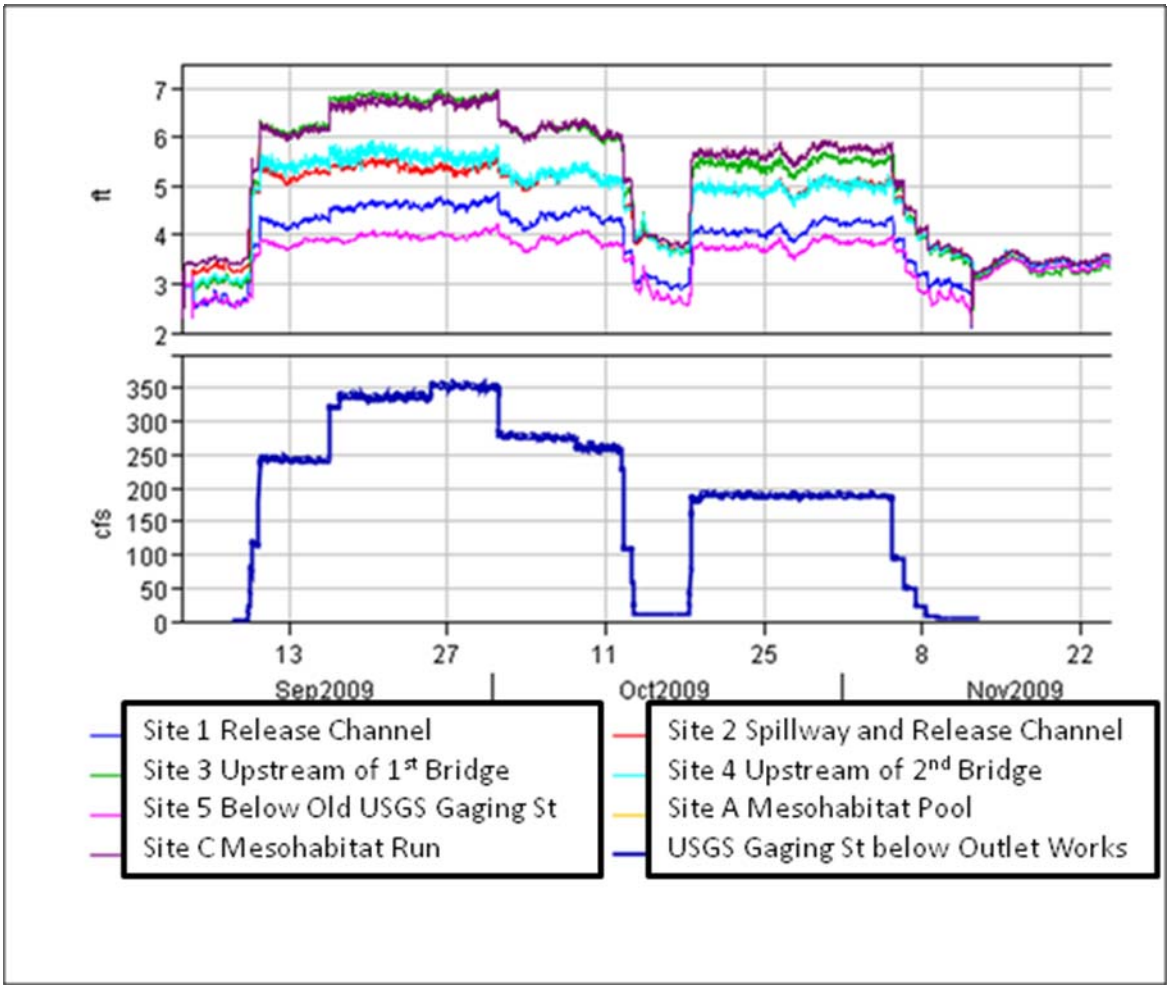


Figure 4 - Hydrographs of relative WSEL at study sites and discharge measured at the USGS gaging station during the 2009 conservation release

The goal of evaluating the relationship between discharge from the outlet works and WSEL in lower Piru Creek was to develop protocol for achieving ramping rates that would not exceed a reduction of WSEL greater than 2-inches per hour; therefore, records were assessed for periods of receding flows. Figure 5 is presented to illustrate the method used to evaluate decreases of flow and associated changes in WSEL. The data presented in the example were collected at the

pool "mesohabitat" study site. In the example, a flow decrease of 117 cfs resulted in a decrease of WSEL in the pool of 0.76 feet. For purposes of the analysis, the magnitude of flow (169 cfs) was calculated by averaging the flow measured before the decrease occurred with the stabilized flow following the change. In this example, for a flow range approximated at 169 cfs, each reduction of one cubic foot per second (1 cfs) produced a decrease in WSEL of approximately 0.0065 feet.

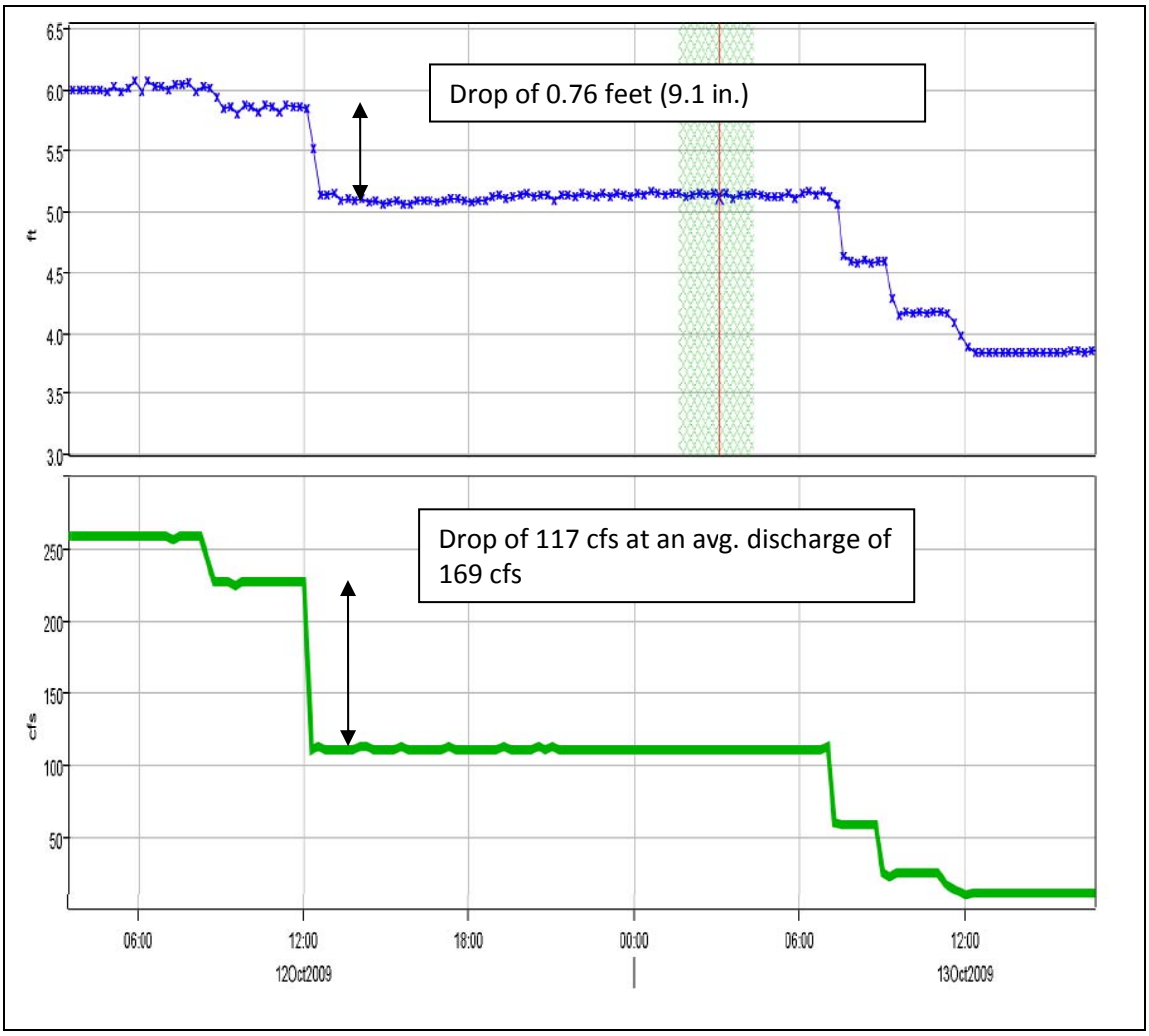


Figure 5 - Reduction of discharge and resultant decrease in WSEL at an example study site

Top graph shows a decrease in WSEL at the pool "mesohabitat" study site. Bottom graph presents the associated decrease in flow measured at the USGS gaging station downstream of the Santa Felicia Dam outlet works.

Identified changes in WSEL at the "mesohabitat" sites were evaluated individually and changes in WSEL at the study sites located at mile intervals (Sites 1-5) were averaged. Data were plotted on a graph and a curve was identified that was intended to conservatively estimate the effect of flow reductions on WSEL in lower Piru Creek. The graph presented in Figure 6 indicates that WSEL is most responsive to changes in flow at smaller magnitude discharges. Conversely, water levels are least responsive to changes in flow during larger magnitude discharges. This

inverse relationship necessitates that in order to avoid exceeding the 2-inch per hour criterion during receding flows, the magnitude of adjustments to flows must decrease as discharges become smaller.

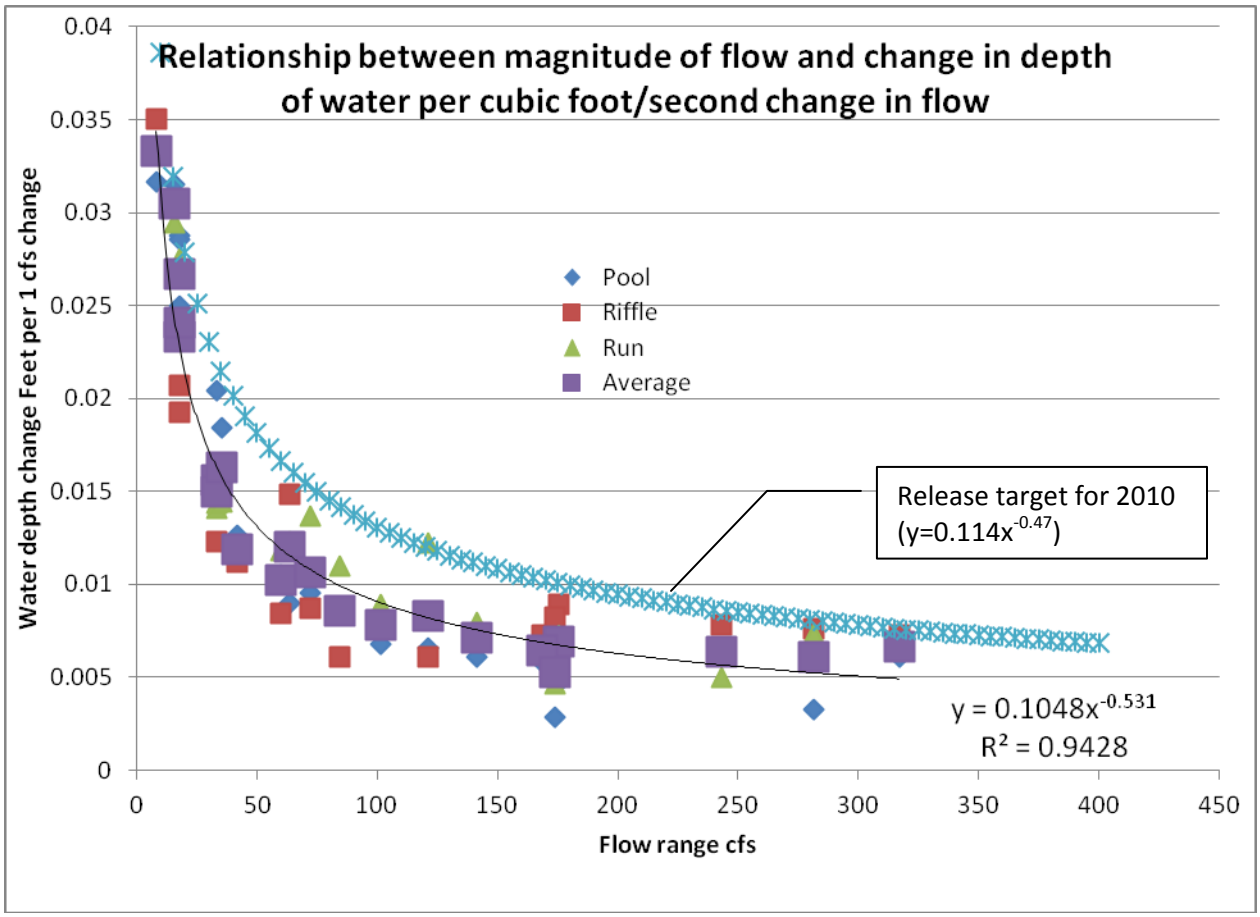


Figure 6 - Relationship between discharge and WSEL

The blue curve in Figure 6 (labeled "Release target for 2010") was calculated to encompass or exceed all evaluated data points. The curve is duplicated in Figure 7. The example presented in Figure 7 indicates that when discharges are in the range of 200 cfs, WSEL in lower Piru Creek is not expected to decrease by more than 0.0095 feet (0.114 inch) for every cubic foot per second decrease in discharge. In order to avoid exceeding the 2-inch per hour criterion, the maximum reduction in flow beginning at a discharge of 200 cfs would be calculated as follows: 2"/hour ÷ 0.114"/cfs = 17.6 cfs/hour. Using this method, a 200 cfs discharge could be decreased by a maximum of 17.6 cfs per hour. Theoretically, a second decrease could be implemented an hour later with a beginning discharge of 182.4 cfs and a total decrease of no more than 16.9 cfs.

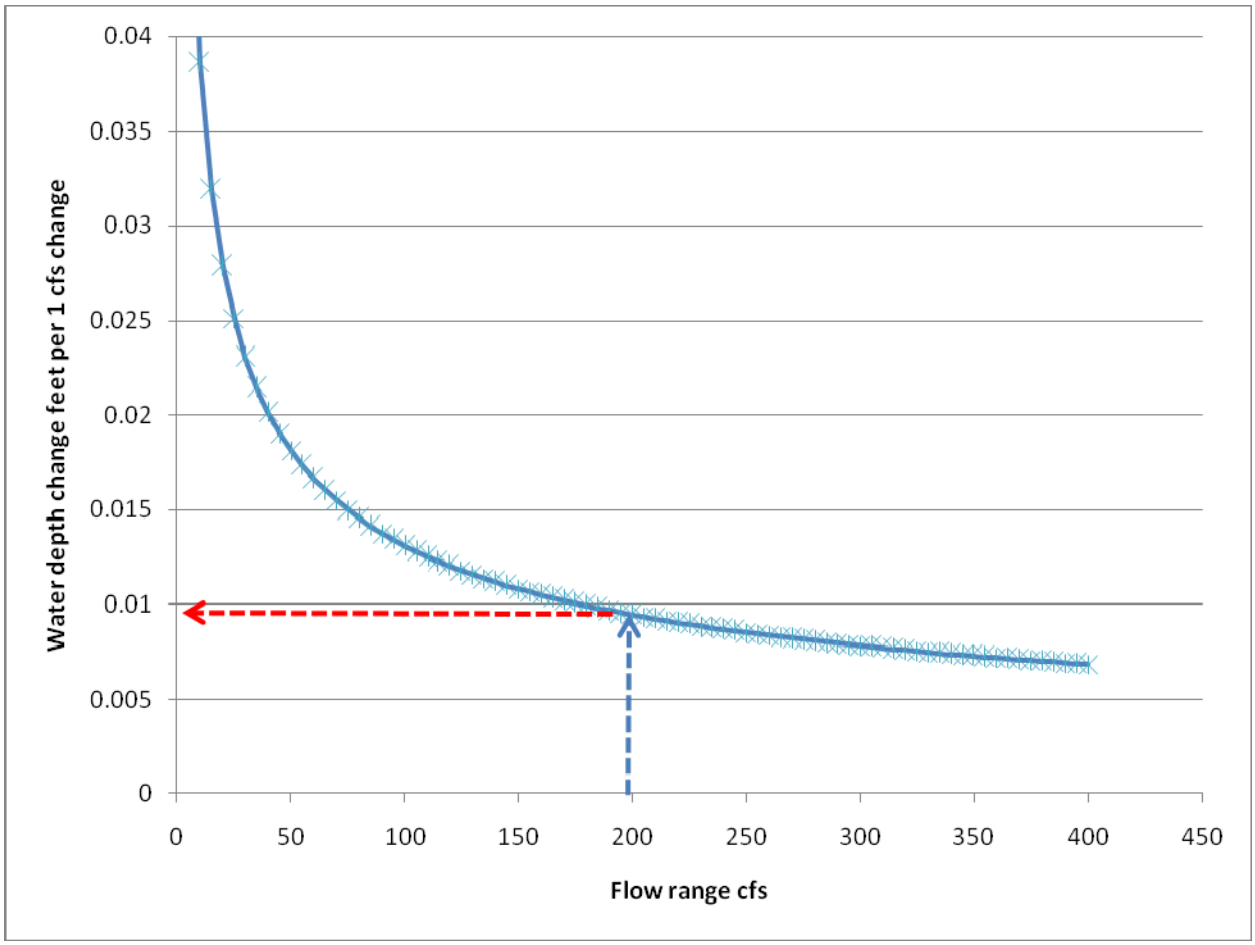


Figure 7 – Ramping rate curve designed to avoid exceeding a decrease of WSEL of more than 2-inches per hour. Curve equation ($y=0.114x^{-0.47}$)

The curve presented in Figures 6 and 7 was used to develop the ramping rate schedule for decreases to migration and conservation releases presented in Table 4. The ramping rate schedule also incorporates the requirement that flow decreases by no more than fifty-percent in a 24 hour period.

Table 4 - Ramping schedule used during the 2010 and 2011 conservation releases

Migration and Conservation Release Ramp-down Schedule				
Steps (no more than 1 per hour)	Beginning Discharge (cfs)	Maximum Target Reduction (cfs)	Target Ending Discharge (cfs)	Reduce by no more than fifty-percent per day
1	400	24	376	Day 1
2	376	24	352	
3	352	23	329	
4	329	22	307	
5	307	22	285	
6	285	21	265	
7	265	20	244	
8	244	19	225	
9	225	19	206	
10	206	18	189	Day 2
11	189	17	171	
12	171	16	155	
13	155	16	139	
14	139	15	124	
15	124	14	110	
16	110	13	97	Day 3
17	97	13	84	
18	84	12	73	
19	73	11	62	
20	62	10	52	Day 4
21	52	9	42	
22	42	8	34	
23	34	8	26	Day 5
24	26	7	19	
25	19	6	13	Day 6
26	13	4	10	
27	10	3	7	Day 7

The Plan intended for additional work to occur at the mesohabitat sites. Much of the work outlined in the Plan was conducted in 2009 prior to approval of the Plan in 2011. Although the majority of activities were implemented, data collection was not sufficient to appropriately calculate velocities or determine Manning's "n" at the mesohabitat sites, and United does not have access to the sites to retrieve additional data. The data that was collected is represented in the bed profiles that are shown in Appendix A. Velocities will be measured in lower Piru Creek

during implementation of the monitoring and adaptive management plans for the Water Release Schedule.

4.2 2010 RESULTS

The ramping rate schedule in Table 4 was implemented during the 2010 and 2011 conservation releases. The 2010 conservation release had one ramp-down period that occurred between November 15th and November 19th and hydrographs for the event are presented in Figure 8. Figure 9 shows a running rate of change per hour for WSEL at the monitored sites. The hourly rate of change was obtained by calculating the change in WSEL at each site for each 15 minute interval, and summing the changes that occurred during the prior hour (4 data points) for each 15 minute interval.

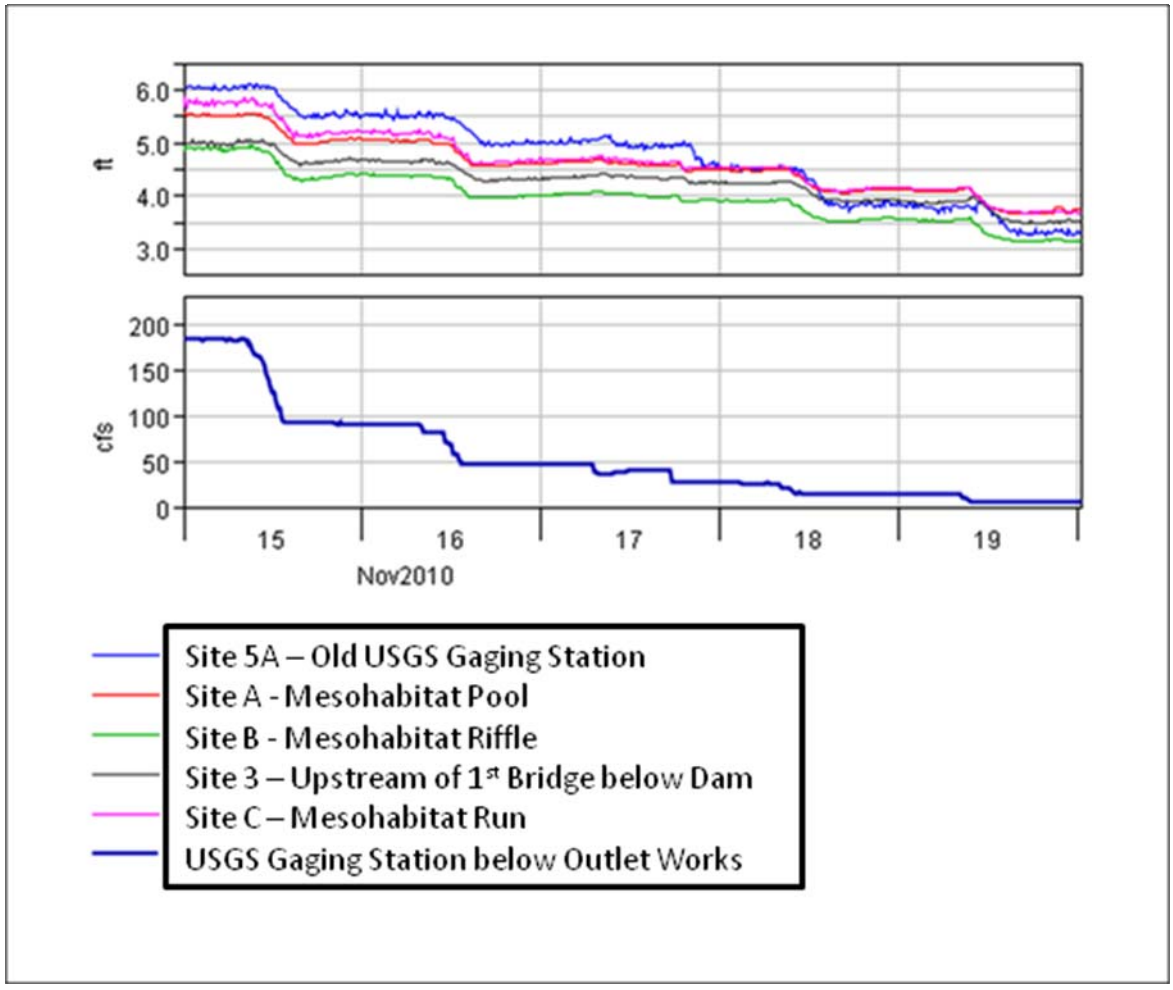


Figure 8 - Hydrographs of relative WSEL at study sites and discharge measured at the USGS gaging during the 2010 conservation release (Nov 15 - 19)

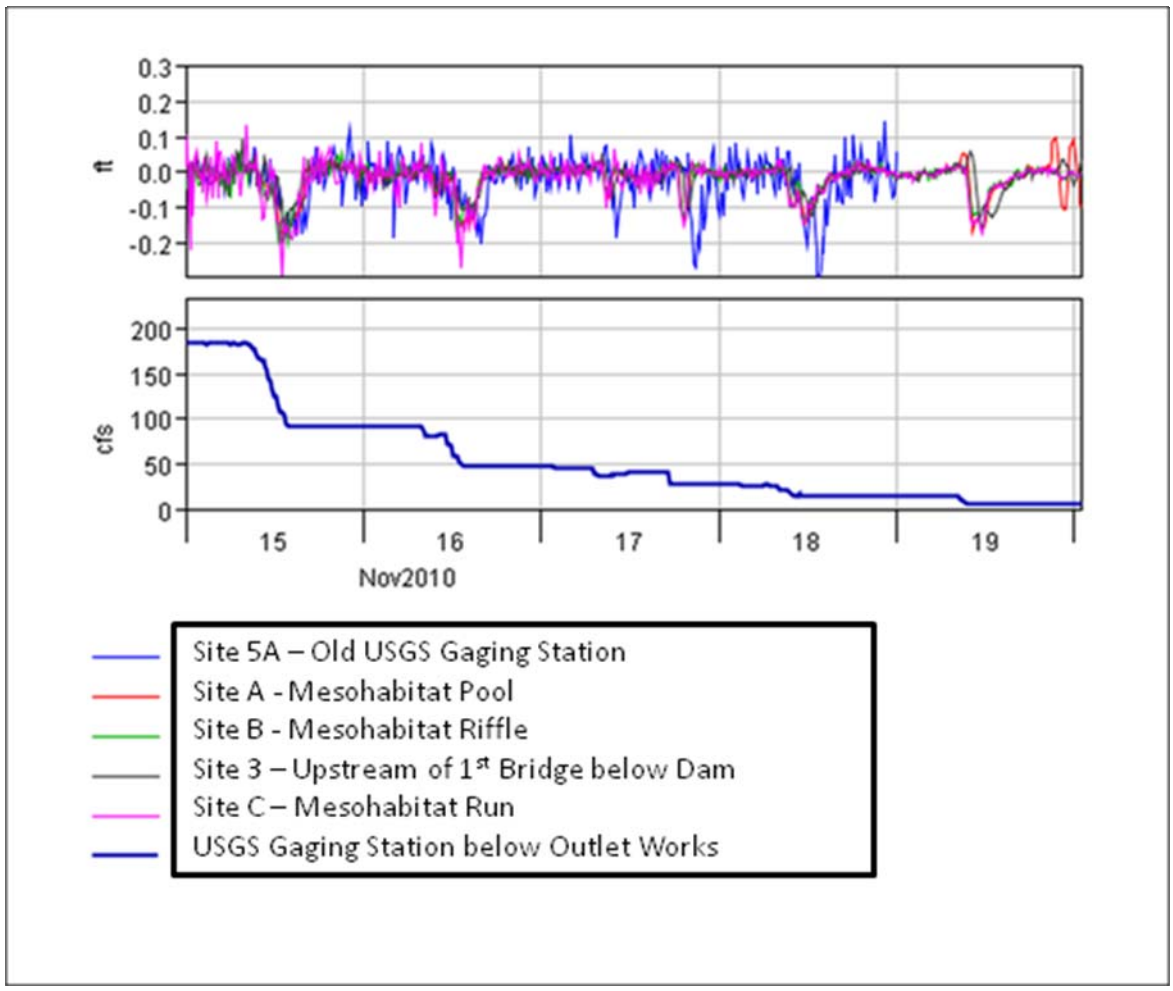


Figure 9 - Hydrographs of hourly rate of change in WSEL at study sites and discharge measured at the USGS gaging during the 2010 conservation release (Nov 15 - 19)

4.3 2011 RESULTS

The 2011 conservation release incorporated unique flow scenarios for a coinciding geomorphology study and involved three separate ramp-down periods. Discharge measurements for 2011 are preliminary and have not yet been reviewed or verified by the USGS as of the date of this report. Results from monitoring activities conducted in 2011 are presented in Figures 10 through 15. Figures 10 and 11 present a small ramp-down performed to prevent loss of water resources due to a forecasted storm event. Figure 10 shows hydrographs of the relative change in WSEL and associated discharge from the Santa Felicia Dam measured at the USGS gaging station located below the outlet works. Figure 11 includes the running rate of change per hour for WSEL at the monitored sites and the associated discharge measured at the gaging station. The same format is duplicated in Figures 12 and 13, and 14 and 15. Figures 12 and 13 represent conditions present during the ramp-down to minimum flows at the end of October and Figures 14 and 15 represent conditions present during a ramp-up to 600 cfs followed by the termination of the conservation release in early November. The discharge hydrographs in Figures 14 and 15 falsely indicate that there was a sharp increase in discharge on November 4th. This false indication is attributed to maintenance that was conducted at the gaging station to clear sediment from the orifice line.

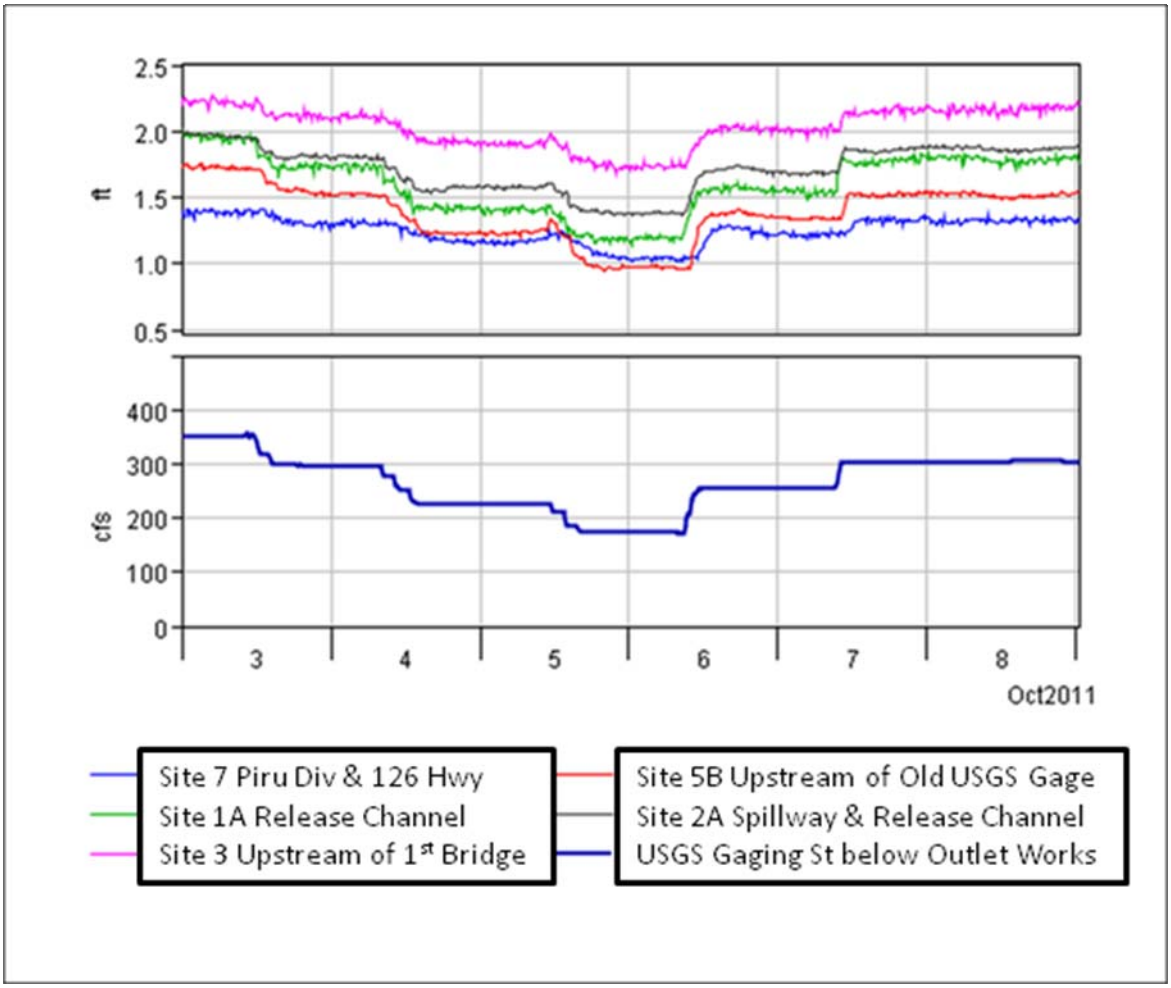


Figure 10 - Hydrographs of relative WSEL at study sites and discharge measured at the USGS gaging during the 2011 conservation release (Oct 3 – 8)

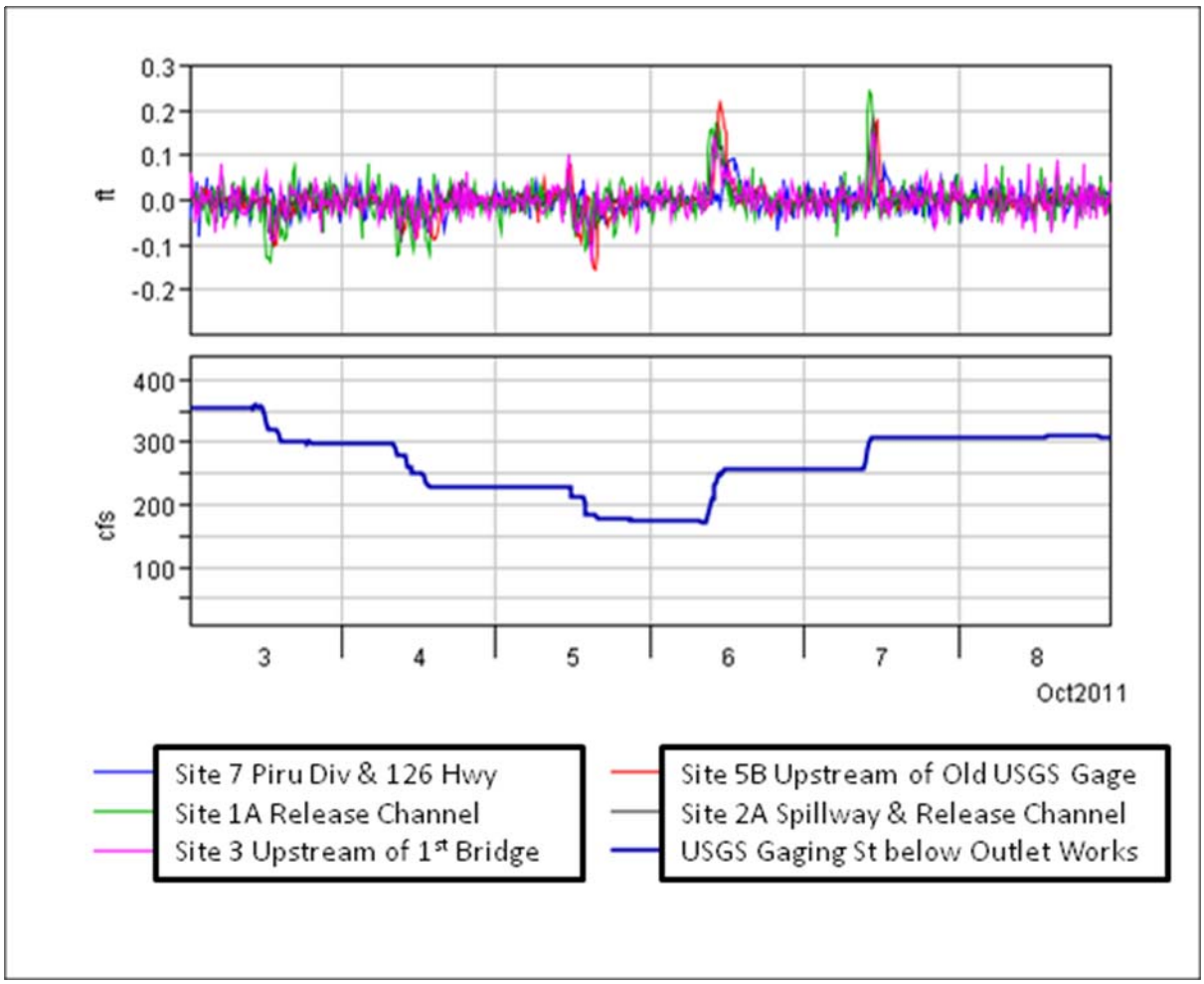


Figure 11 - Hydrographs of hourly rate of change in WSEL at study sites and discharge measured at the USGS gaging during the 2011 conservation release (Oct 3 – 8)

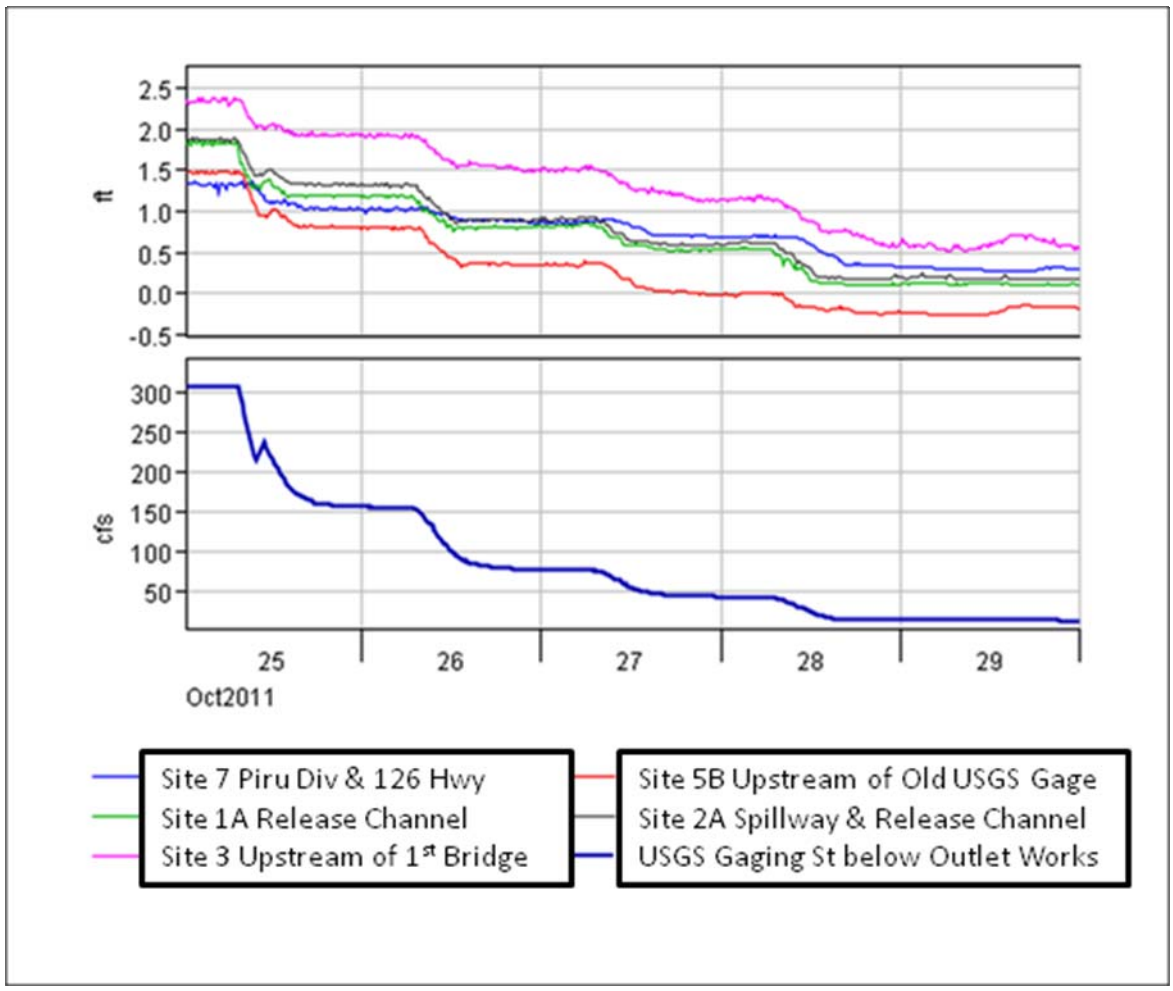


Figure 12 - Hydrographs of relative WSEL at study sites and discharge measured at the USGS gaging during the 2011 conservation release (Oct 25 - 29)

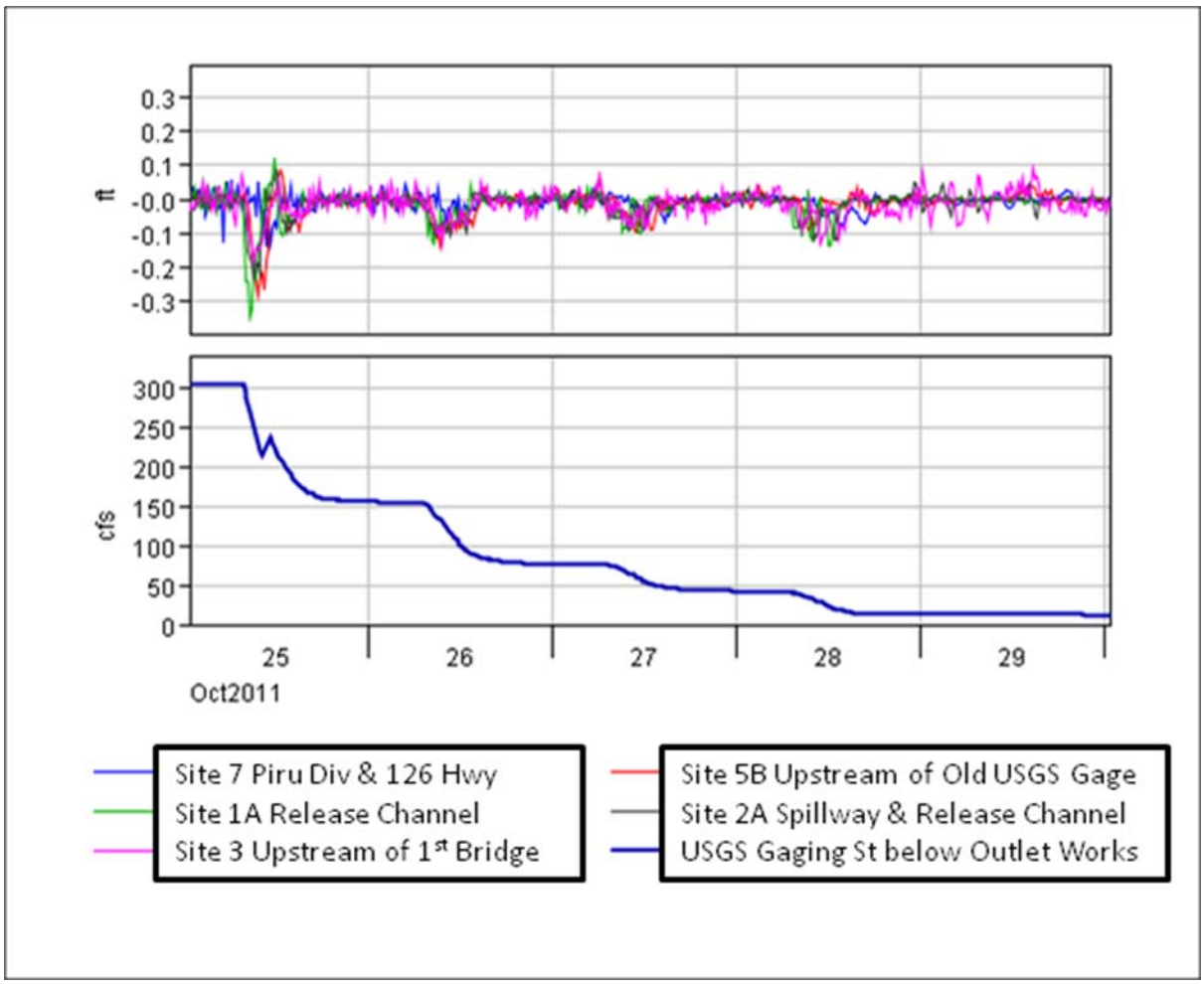


Figure 13 - Hydrographs of hourly rate of change in WSEL at study sites and discharge measured at the USGS gaging during the 2011 conservation release (Oct 25 - 29)

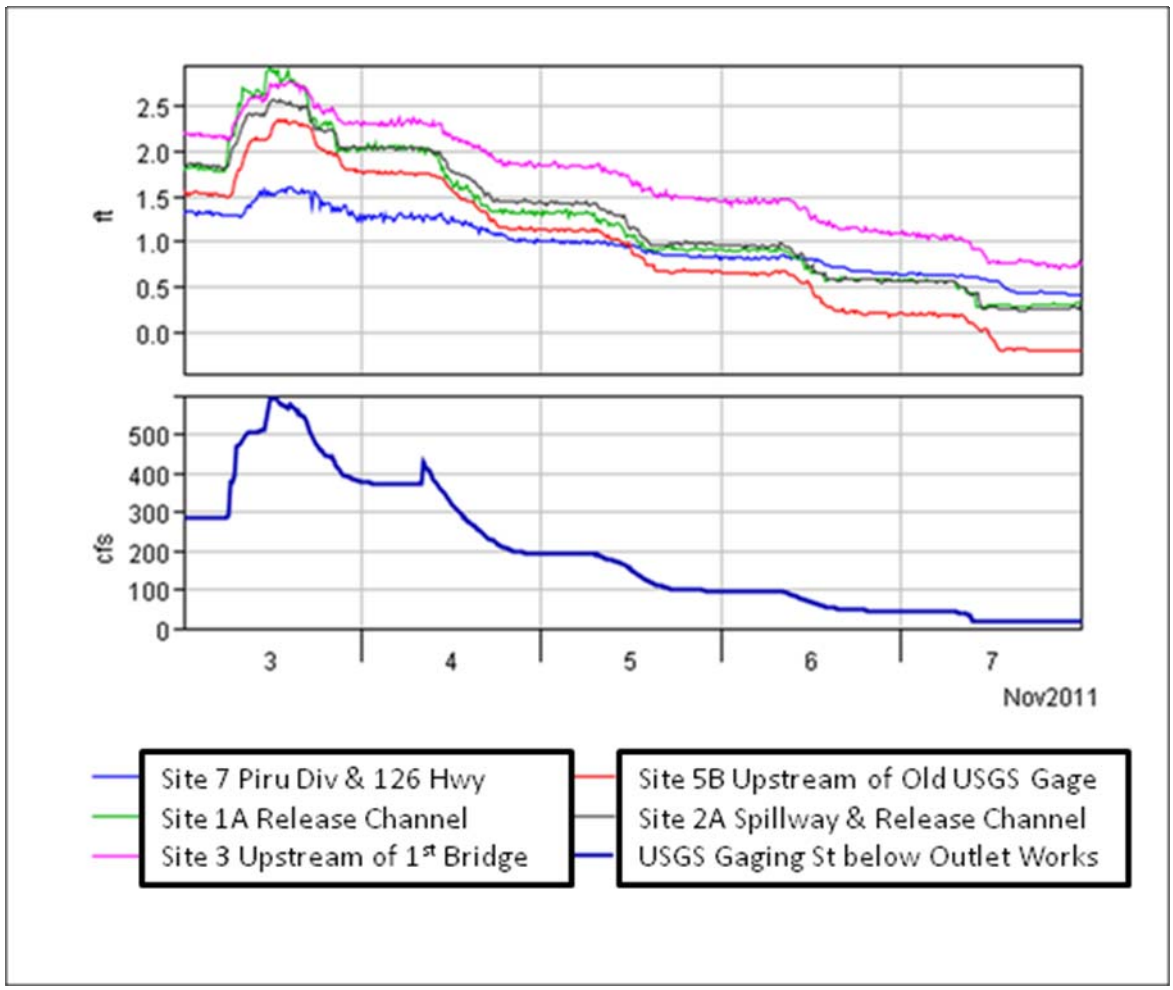


Figure 14 - Hydrographs of relative WSEL at study sites and discharge measured at the USGS gaging during the 2011 conservation release (Nov 3 - 7)

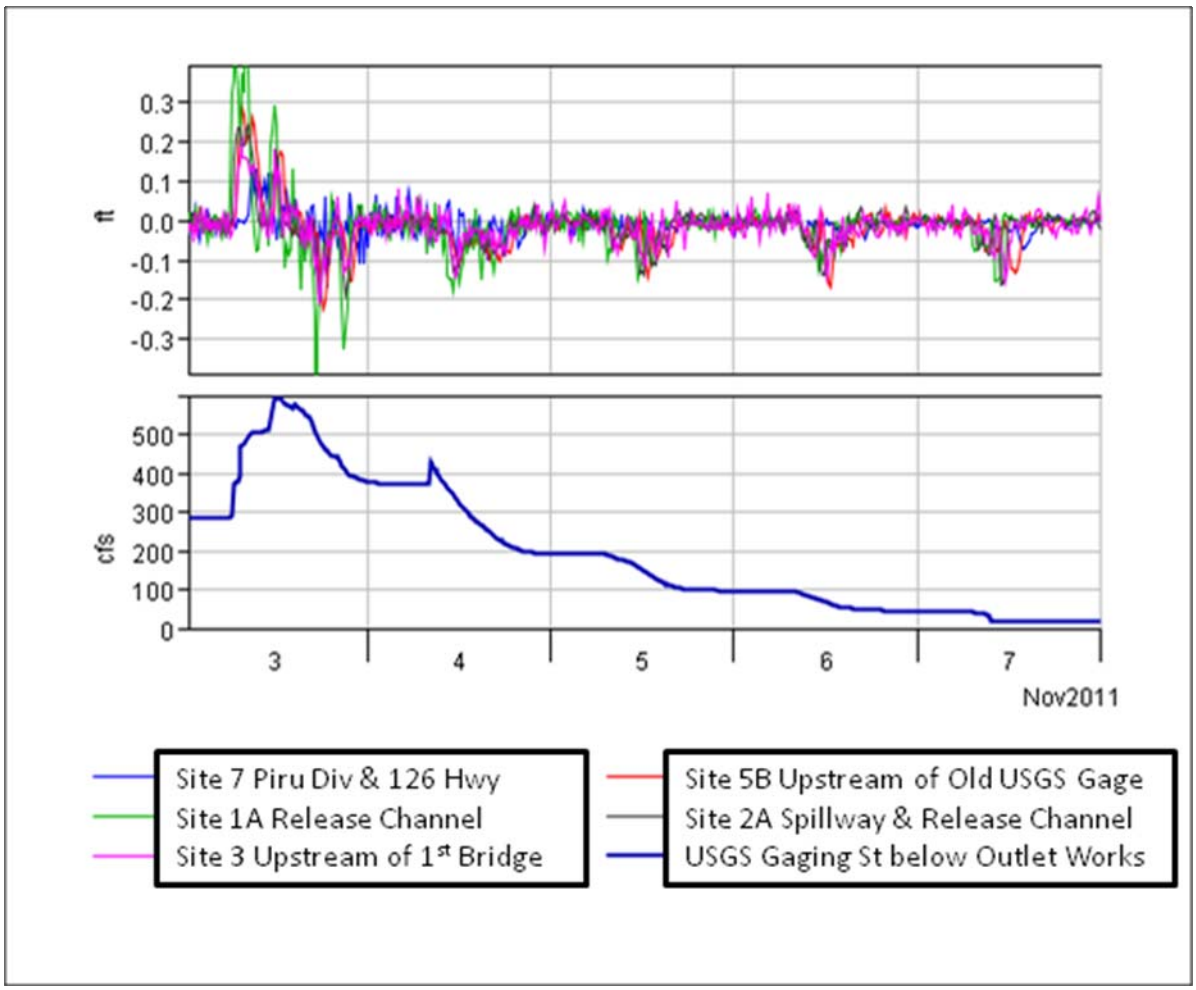


Figure 15 - Hydrographs of hourly rate of change in WSEL at study sites and discharge measured at the USGS gaging during the 2011 conservation release (Nov 3 - 7)

5.0 DISCUSSION

5.1 CONSIDERATIONS

Results collected during 2010 and 2011 conservation releases indicate that the ramping rate schedule developed from the 2009 data meets the objectives. However, there are two factors that warrant consideration when evaluating the findings resulting from implementation of the Plan that may influence whether the 2-inches per hour goal is actually attained.

First, the derived relationship between discharge and depth of WSEL assumes a degree of operational precision that may not be realistically achievable. Flows are adjusted using actuator switches to open or close two 36-inch cone valves. Each actuator switch has three positions, open, close, and neutral. Timing is essential in the procedure and is a skill learned over years with hands-on experience. The rate of change during an adjustment is dependent on WSEL in the lake, ambient air temperature, and the current magnitude of release. To reduce flows, the operator puts the switch in the "close" position and relies on experience to estimate when to stop closing the valve and return it to a neutral position. In situations when flows are greater than 150 cfs, the operator must leave the outlet works and travel to the USGS gaging station to read the

flow measurement. If the targeted flow is not achieved, the operator returns to the outlet works and makes another adjustment. It is an iterative process that lacks precision. A flow meter with a maximum gaging capacity of 150 cfs is present in the building where the actuator switch is located, and therefore, targeted adjustments to smaller magnitude flows are easier to achieve. Clearly, implementation of the targeted flow reductions is an operational challenge. United's operations staff will continue to practice and refine their skills to improve the frequency of achieving the ramping rate goal.

The second factor warranting consideration is the complexity of quantifying changes in WSEL in a system that fluctuates naturally. The 2-inch criterion falls within the range of natural variability during periods of constant flow. This is demonstrated in the hydrographs showing the hourly rates of changes to WSEL at study sites (e.g. October 8, 2011 shown in Figure 11, and October 29, 2011 shown in Figure 13). This variability cannot be accurately factored into the formula for calculating ramping rate.

5.2 INTERPRETATION OF RESULTS

Results collected during 2010 and 2011 conservation releases indicate that the ramping rate schedule developed from the 2009 data meets the 2-inches per hour objective. Data presented in the results section indicate that the 2-inch per hour criterion was achieved with more regularity during the second trial year (2011) and at lower magnitude flows. The first trial year (2010) was the first year that United's operations staff attempted to make the concise adjustments outlined in the ramping rate schedule presented in Table 4. During the 2010 conservation release, the 2-inches-per-hour criterion was met at three of the five monitored sites (Figure 9). As mentioned earlier, a transducer datalogger was installed within the weir at the old USGS gaging station (Site 5A). Results from this site showed multiple exceedences per day during the ramp-down event. Because of the unnatural characteristics of the incised, concrete, vertical-sided channel, the site exhibits limited stranding potential. If this type of channel configuration is present at other locations within lower Piru Creek it would be highly unlikely for stranding to occur under these conditions. The other site where exceedences were observed was in the mesohabitat run, where stranding concerns are appropriate and relevant. A cross-section profile of the site is presented in Appendix A. The measured exceedences occurred during higher magnitude flows and decreases in WSEL were less than 2-inches per hour during lower flow periods.

During the second trial year (2011), the 2-inch per hour criterion was not exceeded at any monitored site during the first ramp-down period that occurred between October 3rd and 5th (Figure 11). The second ramp-down period occurred between October 25th and 29th. Figure 13 shows an example of an over-adjustment by United's operations staff that occurred on October 25th. A distinctive "v" is present in the discharge hydrograph showing where the operator made a correction for the over-adjustment. In this situation, the study site located in the release channel experienced the largest drop in WSEL which was measured at approximately 4-inches in an hour. The 2-inch per hour criterion was met for the remainder of the October 25th to 29th ramp-down event.

The final ramp-down terminating the 2011 conservation release is shown in Figure 15. Typical conservation releases have maximum flows in the range between 300 and 400 cfs. The 600 cfs release was a unique situation, and flows of this magnitude were not included in evaluating the

relationship between discharge and WSEL in lower Piru Creek. In this extreme flow range, reductions resulted in a decrease of WSEL in the release channel of 0.39-feet per hour (4.68-inches). Once flows receded below 400 cfs, changes to WSEL at the monitored sites remained close to or within the 2-inch per hour criterion. As stated above, the indicated increase in discharge that occurred on November 4th was due to maintenance at the gaging station and not indicative of an actual change in flow.

6.0 CONCLUSION

Numerous conclusions can be reached from the findings reported here. Below we have highlighted what we consider to be the most important. As appropriate, United intends to integrate these conclusions into its implementation, monitoring, and adaptive management plans for the Water Release Schedule.

Perhaps the most important conclusion is that the relationship between discharge from the Santa Felicia Dam outlet works and depth of WSEL in lower Piru Creek that was derived through implementation of the Plan achieves the goal of 2-inches per hour for flow ranges that are expected to occur during conservation and migration releases. Migration releases are required to be a minimum of 200 cfs and typical conservation releases are between 300 and 400 cfs. It should be noted that data obtained during the 2011 conservation release will need to be evaluated to determine the relationship between discharge and WSEL for flows that exceed 400 cfs prior to another event of that magnitude.

The findings also demonstrate that, while theoretically the ramping schedule will attain the goal, practically operational limitations pose certain challenges. This is particularly true for flow regimes above 150 cfs. United is considering multiple strategies that could be employed to improve the level of confidence for complying with the 2-inch per hour criterion. The following strategies are designed to decrease the magnitude of flow reductions during higher flow regimes and still meet project objectives.

The ramp-down schedule presented in Table 4 calls for nine reduction steps in the first 24 hours. In situations where it is desirable to obtain the first fifty-percent reduction in 24 hours, the magnitude of reductions could be decreased if the number of reduction steps is increased. The approach is labor intensive but achievable. This could be accomplished by reducing targeted releases and having staff on site to make two or three additional adjustments on the first day of the ramp-down; or, by reducing targeted releases by half and implementing the adjustments at 30 minute intervals rather than hour intervals. In this scenario, implementation errors should theoretically be smaller (relative to the schedule presented in Table 4) and could be accommodated in the next reduction step.

United's water management strategies are constantly evolving and will vary from year to year. In situations other than conservation releases, the first fifty-percent reduction is the most crucial for conserving water resources. During typical conservation releases, however, the first fifty-percent reduction is not as critical. In order to comply with the 2-inch per hour criterion during a ramp-down at the end of a typical conservation release, the first fifty-percent reduction could be split over a period of two days. This would allow for an increase in the number of reduction

steps and a decrease in the magnitude of reductions per step during initiation of the ramp-down, when flows are greatest. In this case, the ramp-down could be started a day earlier without having a substantial impact on water resources. An example of the described ramping strategy is presented in Table 5.

Finally, in the case of migration releases, the ramp-down would begin at a minimum of 200 cfs. The ramping rate schedule presented in Table 4 outlines six steps to achieve a fifty-percent reduction in the first 24-hours. If an additional step were added on the first day, the magnitude of reductions on that day could be reduced. An example of this ramping strategy for migration releases is presented in Table 6.

Table 5 - Example of the discussed ramp-down strategy for typical conservation releases (all future ramp-downs would end at appropriate designated habitat flow)

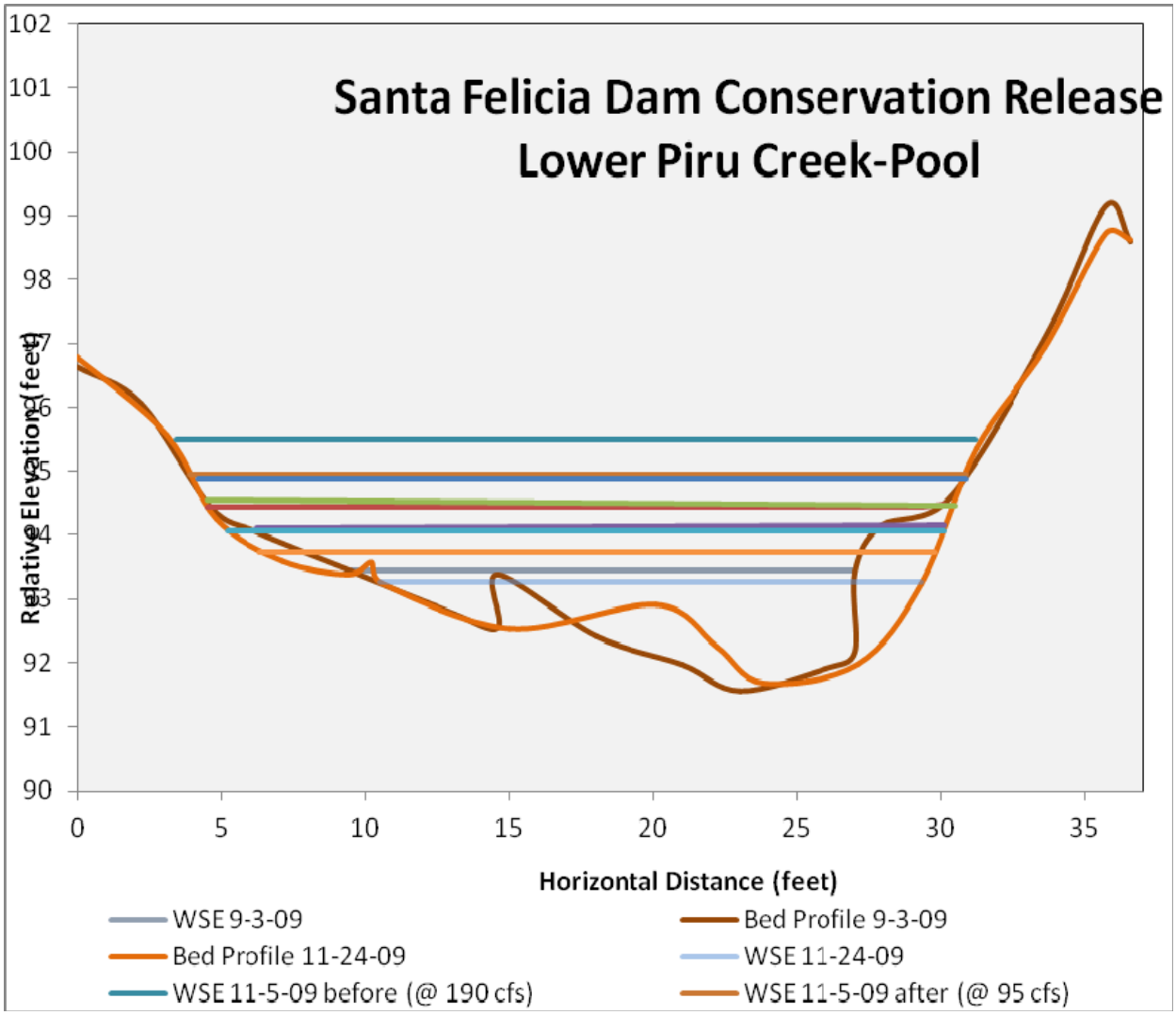
Example of a Conservation Flow Ramping Strategy				
Steps (no more than 1 per hour)	Beginning Discharge (cfs)	Maximum Target Reduction (cfs)	Target Ending Discharge (cfs)	Reduce by no more than fifty-percent per day
1	400	20	380	Day 1
2	380	20	360	
3	360	20	340	
4	340	20	320	
5	320	20	300	
6	300	20	280	
7	280	20	260	
8	260	15	245	Day 2
9	245	15	230	
10	230	15	215	
11	215	15	200	
12	200	15	185	
13	185	15	170	
14	170	15	155	
15	155	16	139	Day 3
16	139	15	124	
17	124	14	110	
18	110	13	97	
19	97	13	84	
20	84	12	73	Day 4
21	73	11	62	
22	62	10	52	
23	52	9	42	
24	42	7	35	Day 5
25	35	7	28	
26	28	7	21	
27	21	6	15	Day 6
28	15	5	10	
29	10	3	7	Day 7

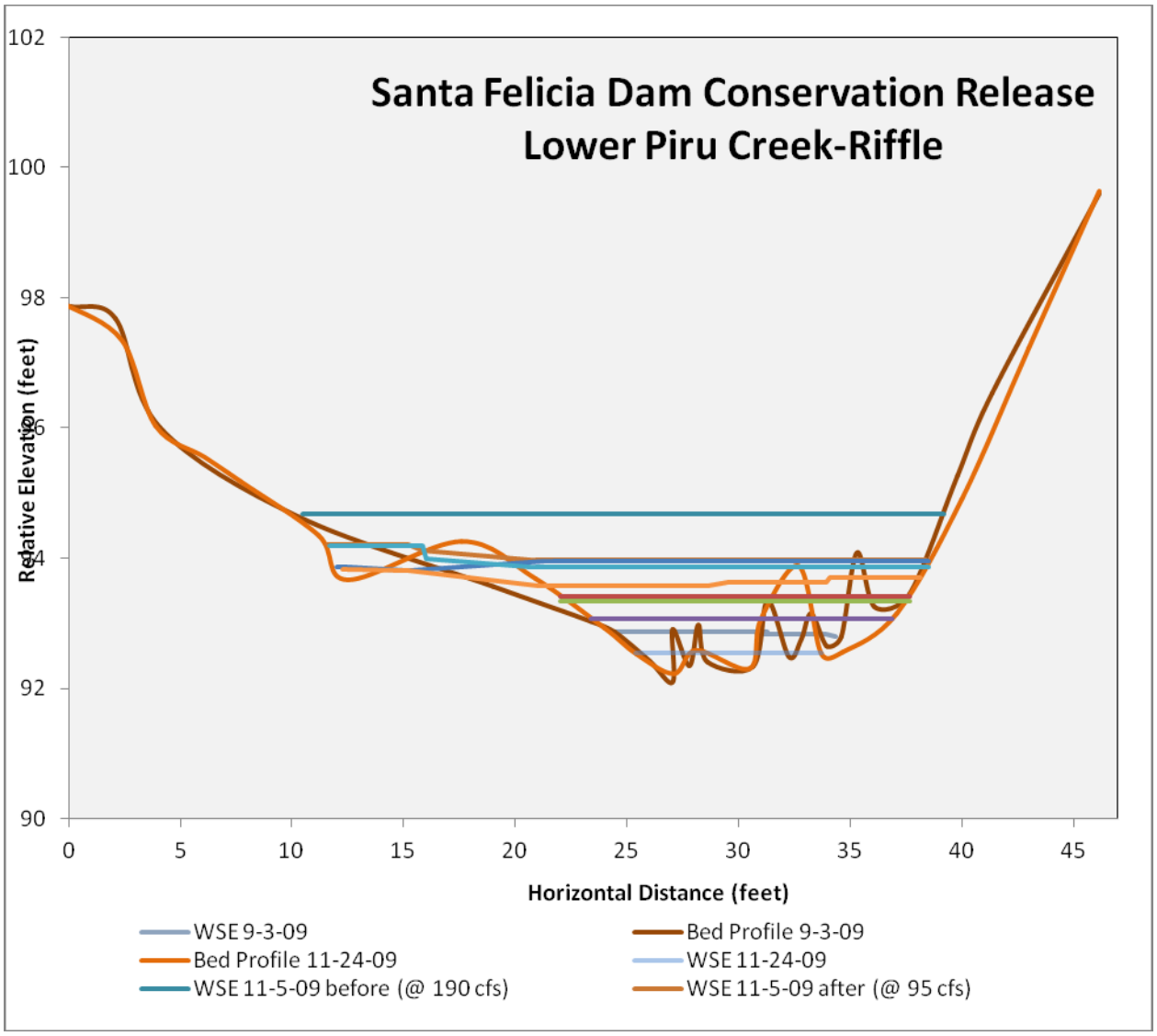
Table 6 - Example of the discussed ramp-down strategy for migration releases (all future ramp-downs would end at appropriate designated habitat flow)

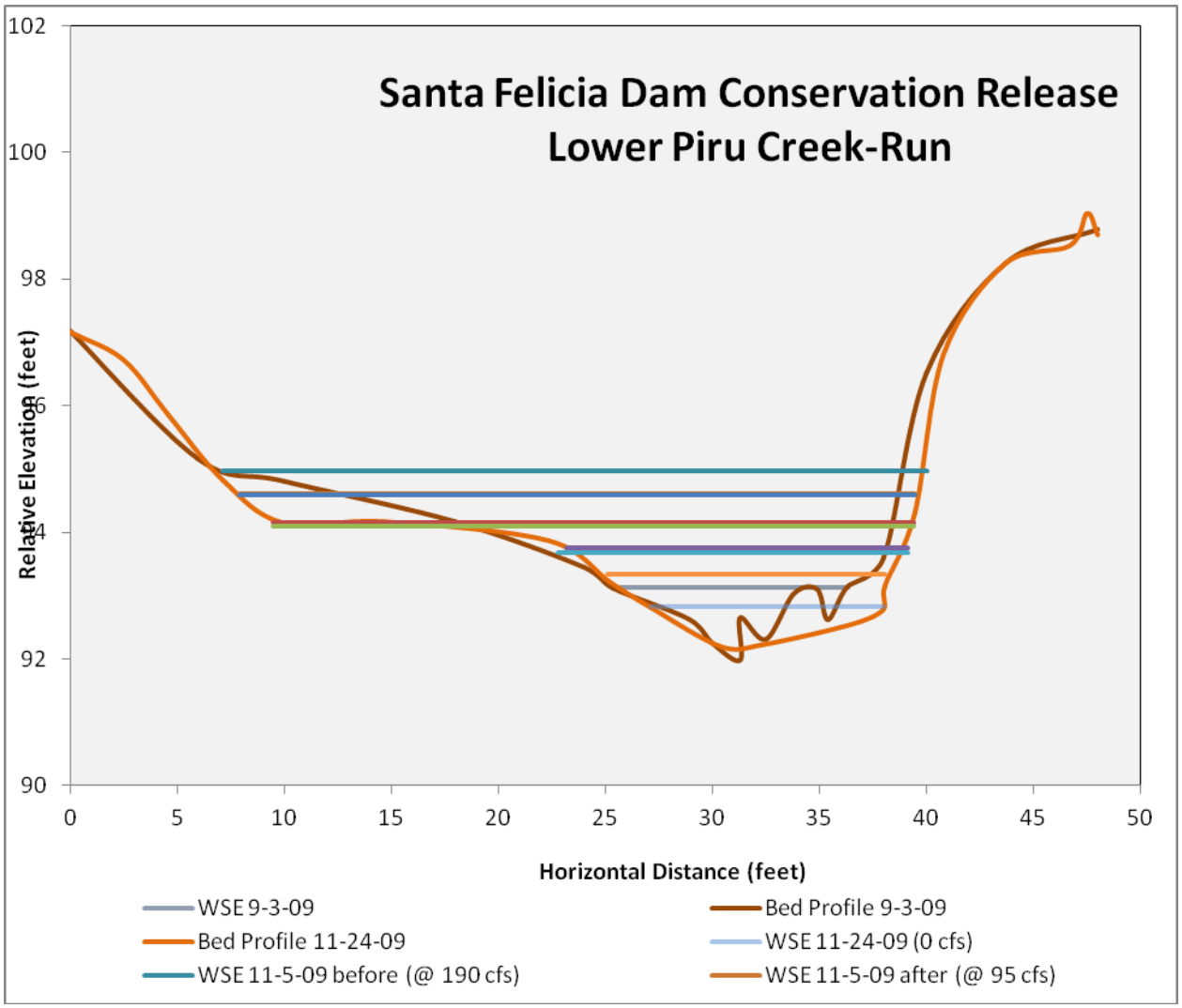
Example of a Migration Flow Ramping Strategy				
Steps (no more than 1 per hour)	Beginning Discharge (cfs)	Maximum Target Reduction (cfs)	Target Ending Discharge (cfs)	Reduce by no more than fifty-percent per day
1	200	15	185	Day 1
2	185	15	170	
3	170	14	156	
4	156	14	142	
5	142	14	128	
6	128	14	114	
	114	14	100	
7	100	13	87	Day 2
8	87	12	75	
9	75	11	64	
10	64	10	54	
11	54	10	44	Day 3
12	44	9	36	
13	36	8	28	
14	28	7	21	Day 4
15	21	6	15	
16	15	4	11	Day 5
17	11	4	7	

APPENDIX A

Mesohabitat Bed Profiles
2009


Santa Felicia Dam Conservation Release
Lower Piru Creek-Pool
Relative Elevation (feet)
102
101
100
99
98
97
96
95
94
93
92
91
90
0
5
10
15
20
25
30
35
Horizontal Distance (feet)
WSE 9-3-09
Bed Profile 9-3-09
Bed Profile 11-24-09
WSE 11-24-09
WSE 11-5-09 before (@ 190 cfs)
WSE 11-5-09 after (@ 95 cfs)


Santa Felicia Dam Conservation Release
Lower Piru Creek-Riffle
Relative Elevation (feet)
102
100
98
96
94
92
90
0
5
10
15
20
25
30
35
40
45
Horizontal Distance (feet)
WSE 9-3-09
Bed Profile 9-3-09
Bed Profile 11-24-09
WSE 11-24-09
WSE 11-5-09 before (@ 190 cfs)
WSE 11-5-09 after (@ 95 cfs)


Santa Felicia Dam Conservation Release
Lower Piru Creek-Run
Relative Elevation (feet)
102
100
98
96
94
92
90
0
5
10
15
20
25
30
35
40
45
50
Horizontal Distance (feet)
WSE 9-3-09
Bed Profile 9-3-09
Bed Profile 11-24-09
WSE 11-24-09 (0 cfs)
WSE 11-5-09 before (@ 190 cfs)
WSE 11-5-09 after (@ 95 cfs)