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	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2005 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2005-7

Bobcat Flat/River Mile 43:
Phase I Project Completion Report

Prepared by

McBain and Trush
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March 2006

Bobcat Flat RM 43 - Phase I As-Built Monitoring Final Report

March 29, 2006

Cover Photo: Construction of point bar at Patch 5.
Photo courtesy of Friends of the Tuolumne.

Bobcat Flat RM 43 Phase I
As-Built Monitoring Final Report

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1 INTRODUCTION AND BACKGROUND

Bobcat Flat is a 303-acre parcel adjacent to 1.6 miles of the Tuolumne River, located approximately 10 miles east of Waterford, California (Figure 1). In 2001, with funding from CALFED, the Friends of the Tuolumne (FOT) purchased Bobcat Flat for the purpose of long-term restoration and preservation. Restoration funds were provided by grants from CALFED to FOT and the California Department of Water Resources to Turlock Irrigation District. Bobcat Flat (RM43) Phase I included excavating 10.5 acres of remnant dredger tailings, sorting excavated tailings, and placing approximately 12,000 yd^3 of coarse sediment from these tailings into the river channel as constructed riffles and bars (Appendix A, Sheet 3). The design for the Phase I restoration (McBain & Trush 2004a) is presented in Appendix A. The Phase I project monitoring plan (McBain & Trush 2004b) is presented in Appendix B.

This report documents construction methods and as-built monitoring for the Phase I project. Objectives of the as-built monitoring were to:

- Document as-built topography, bathymetry, bed texture, and Chinook spawning, rearing, and holding habitat areas to provide baseline conditions for future project monitoring;
- Compare as-built topography, bathymetry, and bed texture to the project design; and
- Identify lessons learned that can be applied to future projects to be implemented as part of the Tuolumne River Coarse Sediment Management Plan.

2 CONSTRUCTION METHODS

2.1 Construction Overview

Bobcat Flat Phase I was constructed from August 22 to September 21, 2005. To place the coarse sediment into the river efficiently and with minimal hazard, flow releases from La Grange Dam were reduced from 1,000 cubic feet per second (cfs) on August 20 to 330 cfs on August 25 and were maintained at 330 to 375 cfs through the construction period. All construction activities were performed by:

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2.2 Dredger Tailing Excavation

Dredge tailing excavation began on August 23 and was completed on September 9, 2005. Two Caterpillar 627G scrapers (each with 22 yd^3 capacity) operating in tandem were used to excavate dredger tailings from the floodplain restoration area and transport excavated material to stockpiles (Figure 2). After the scrapers removed the tailings and achieved rough grade, a Caterpillar 14H motor grader bladed the ground to finished elevations (Figure 3). While grading, the grader transmitted to a grade laser receiver mounted on the back of a work truck to confirm finished elevations. McBain & Trush, Inc. also spot checked floodplain elevations using a total station during construction.

2.3 Sieving and Washing

Stockpiled material tailings were transported to the sieving and washing plant by a Caterpillar 980G front-end loader (Figure 4). The sieving and washing plant consisted of a diesel-powered Construction Equipment Co. (CEC) Screen-It, retrofitted with a washing system that sprayed water through three fire nozzles aimed at the screen (Figure 5). The loader filled the sieving plant hopper with raw excavated tailings. From the hopper, tailings were conveyed on a belt to a 5-inch screen to remove larger clasts. Material passing through the 5-inch screen was then passed over a ¼-inch screen to remove sand and silt (Figure 6).

The majority of the sieved and washed coarse sediment placed into the channel was comprised of dredger tailings that passed a 5-inch square screen and was retained by a ¼-inch square screen. Prior to processing the ¼-inch to 5-inch material, 800 yd^3 of tailings ranging in size from ¼ to ¾-inch was sieved, washed, and set aside to be mixed into the ¼ to 5-inch material, as needed to meet coarse sediment gradation targets.

2.4 In-Channel Construction

In-channel construction began on August 23, 2005 and was completed on September 19, 2005. Screened and washed coarse sediment was loaded into a Caterpillar D350E articulated truck (22 yd^3 capacity), hauled to the river, and stockpiled within the augmentation patch boundaries (Figure 7). Stockpiled coarse sediment was placed in the river using a Hyundai 770-7 front end loader (Figure 8). The loader was also used to rework the placed sediment to the desired finished surface. Coarse sediment was placed under the supervision of FOT. During construction, McBain & Trush, Inc. checked riffle (hydraulic control) elevations and slopes to assist FOT in maintaining consistency with the design (Figure 9), with the acknowledgement that some field adjustments would likely occur.

3 AS-BUILT MONITORING METHODS

As-built monitoring was conducted between September 21, 2005 and December 17, 2005 by McBain & Trush, Inc. and FOT. The as-built monitoring builds on pre-project monitoring and provides baseline conditions for future project monitoring. Project effectiveness monitoring will continue through approximately 2009, depending on funding. Monitoring parameters and methods are summarized in Table 1 and are discussed below.

3.1 Channel Morphology

Pre-project channel morphology was surveyed May 22–23 and November 10-11, 2003 (Table 2). Total station surveys documented channel conditions in 1,500 feet of the 2,000-foot project reach. Surveys included the active channel, extending from top of the banks that confine approximately 1,000 cfs to the wetted channel thalweg. The lower (Patches 5 and 6) and upper (Patch 1) portions of the project reach were not included in the area surveyed. Depth soundings were used to construct a channel profile in these portions of the project area. In addition to the total station bathymetry survey, seven monitoring cross sections were installed and surveyed in the project reach (Table 2, Figure 3). All cross section endpoints were monumented with ½-inch rebar and surveyed with a total station. Additional cross sections were surveyed, but not monumented, for hydraulic modeling.

As-built channel morphology was documented using cross section surveys, total station surveys, and Real-Time Kinematics (RTK) Global Positioning System (GPS) surveys. Where appropriate, pre-project cross sections were resurveyed in October 2005 to document as-built channel morphology (Table 3, Figure 10). Where pre-project cross sections were not established at locations appropriate for as-built and post-project monitoring, new cross sections were established and surveyed. Cross sections are identified by river station (feet upstream from the San Joaquin River) and entered into the Tuolumne River Geographic Information System (GIS). Cross section endpoints were monumented with ½-inch rebar and surveyed with a total station. All cross sections are referenced to NGVD 29, ft vertical datum.

The as-built channel profile was compiled from the GPS and total station surveys. For portions of the project reach outside of the augmentation patches (i.e., where no coarse sediment was placed in the channel), the channel profile was extracted from the acoustic bathymetry survey conducted in July 2005. At each sediment augmentation patch, the channel profile was extracted from the total station surveys conducted in October 2005. All survey data coordinates are oriented to the NAD 83, California State Plane, Zone III, ft coordinate system and NGVD 29, ft vertical datum. All topographic survey data were combined in AutoCAD Land Development Desktop 2005, where final editing was accomplished by building a digital terrain model (DTM), creating contours, and inspecting for horizontal and vertical errors. Bathymetry surveys were combined with topographic surveys in AutoCAD.

3.2 Floodplain Topography

Pre-project floodplain topography was surveyed on November 10-11, 2003 using a total station. Topographic surveys included the entire right bank floodplain along the 2,000-foot project reach. A DTM of existing conditions constructed from the survey provided the basis for the project design (Appendix A: Sheet 2). In additional to the DTM, three of the seven channel pre-project cross sections were extended across the floodplain to document floodplain conditions (Appendix A: Sheet 4).

As-built floodplain topography was created by combining RTK GPS surveys conducted by Del Terra, Inc. on October 12, 2005 at a 1-foot contour accuracy with Light Detection and Ranging (LIDAR) survey conducted by Sanborn Map Company, Inc. on September 21, 2005 at a 2-foot contour accuracy (Table 2). All survey data coordinates are oriented to the NAD 83, California State Plane, Zone III, ft coordinate system and NGVD 29, ft vertical datum. All topographic survey data were combined in AutoCAD Land Development Desktop 2005, where final editing was accomplished by building a DTM, creating contours, and inspecting for horizontal and vertical errors. Contours and longitudinal profiles were generated from the pre- and post-construction DTMs.

3.3 Bed Texture (Pebble Counts and Bulk Samples)

Pebble counts (Leopold 1970) were used to document pre-project bed surface texture at riffles in the project reach and as-built surface texture at the augmentation patches. Pre-project pebble counts were conducted at Riffle 20 and Riffle 22 on May 22, 2003. As-built pebble counts were conducted at each augmentation patch in October 2005. As-built pebble count locations are shown in Figure 11.

To further document the texture of coarse sediment placed into the channel, one composite bulk sample was collected at each of the six augmentation patches. Because the coarse sediment placed at all patches was free of fines and well mixed, bulk samples were collected by shovel on dry bar surfaces or shallow riffles (rather than using a McNeil sampler). Each composite sample weighed approximately 300 lbs and consisted of four sub-samples collected across an augmentation patch (Figure 11). Subsample locations were selected to represent texture variability at each patch. Bulk samples were analyzed by Kleinfelder, Inc. using standard American Standards for Testing & Materials (ASTM) procedures. Sieve sizes used in the analysis are shown in Table 4.

3.4 Bed Mobility Thresholds (Marked Rocks, Paint Patches)

Bed mobility experiments were established between October 10 – 14, 2005 at cross sections 2413+20, 2412+90, 2412+10, 2408+10, 2403+95, 2395+90, and 2394+00 (Figure 11, Table 5). Experiments consisted of painted rock sets placed along monitoring cross sections in the wetted channel (during flows of ranging from 360 – 610 cfs) and painted *in-situ* patches on dry bar surfaces. Painted rock sets placed in the wetted channel represented the D_{84}, D_{50}, and D_{31} particle sizes for each patch (Table 5, Figure 11). Painted rocks were placed onto the bed surface to simulate the surrounding particle packing and protrusion (Figure 12). On dry portions of each cross section, 2-foot by 2-foot square "boxes" were painted onto the bar surface at four-foot spacing (spacing between the center of each box) to document mobility of *in-situ* particles (Figures 13 and 14). Tracer rocks will be revisited in summer 2006 to document whether and how far marked rocks were transported.

3.5 River Stage and Groundwater Elevation

Pre-project water surfaces were surveyed during cross section surveys during flows of 560 cfs. Ground water was also monitored prior to construction by placing staff plates in a series of dredger ponds surrounding the project area (Figure 10). Staff plates were monitored by FOT and McBain and Trush, Inc. between October 21, 2005 and April 25, 2004 (Table 6).

As-built water surface elevations were surveyed along with cross sections during flows ranging from 360 cfs to 610 cfs in October 2005 (see Section 3.1). To document water surface profiles during higher flows, FOT set water surface markers at the upstream and downstream ends of the floodplain and at Patch 5 during flows ranging from 1,700 cfs to 7,600 cfs in January and February 2006. These water surface markers will be surveyed in summer 2006.

3.6 Salmonid Habitat Mapping

Pre- and post-project Chinook salmon spawning habitat was mapped using habitat criteria shown in Table 7. Pre-project habitat area was mapped on May 22, 2003 during flows of 560 cfs. During pre-project surveys, suitable habitat area was visually estimated and drawn onto orthorectified aerial photographs (scale 1" = 50'). Mapped habitat polygons were digitized using AutoCAD Land Development Desktop software, which was also used to compute mapped habitat area.

As-built Chinook salmon spawning habitat was mapped on October 10 and 11, 2005 during flows of 360 cfs using the same habitat suitability criteria used for pre-project mapping (Table 7). Two methods were used for post-project spawning habitat mapping. The first method repeated the pre-project surveys, visually estimating spawning habitat and mapping polygons onto 1" = 50'-scale orthorectified aerial photographs. At the time of the post-project monitoring, as-built aerial photographs were not available, and spawning habitat was mapped onto pre-project photographs. This method posed two problems. First, with the changes in channel features resulting from project construction, accurately locating spawning habitat polygons onto the pre-project aerial photographs was difficult. Second, pre-project and post-project spawning habitat was mapped by different field crews, and although applying the habitat suitability criteria should reduce inconsistencies between mappers, there is the possibility of introducing this type of error between surveys. To provide a more precise and repeatable method for future monitoring, as-built spawning habitat was also mapped by spot measuring depth and velocity, and surveying spawning habitat polygon boundaries based on these measurements and the habitat suitability criteria. Depth and velocity were measured using a wading rod and Price AA velocity meter. Habitat polygon boundaries were mapped using a total station.

During post-project surveys, Chinook salmon fry and juvenile habitat was also mapped using habitat criteria shown in Table 7. Fry and juvenile habitat polygons were visually estimated and drawn onto pre-project aerial photographs. Polygon boundaries were digitized and area was quantified using AutoCAD Land Development Desktop software. The total station mapping approach (based on comparing measured depth and velocity with habitat suitability criteria) is a more accurate and repeatable method than air photo mapping, but more time consuming and expensive. The total station mapping approach was used for spawning habitat due to the importance of this project objective (increase spawning habitat). Because fry and juvenile rearing habitat was a less important project objective, as well as time and budget constraints, the air photo mapping approach was used for as-built fry and juvenile rearing habitat estimates.

3.7 Chinook Salmon Redd Counts

Pre-project and as-built Chinook salmon redds were counted in the project reach and at upstream and downstream control riffles. Riffles potentially used for spawning in the reach include Riffle 20 (Patches 1 and 2), Riffle 21 (no construction), and three new riffles created by the project at Patches 3, 4, and 6. Redd mapping also included Riffle 18, located approximately 900 ft upstream of the project reach, and Riffle 22, located approximately 300 ft downstream of the project reach, to provide reference sites for effectiveness monitoring.

Pre-project redd mapping was conducted by S.P Cramer and Associates from November 16, 2004 through January 3, 2005 (Appendix C). Post-construction (2005) redd mapping was conducted by FOT with the assistance of McBain & Trush, Inc. from October 29 through December 17, 2005 (Appendix D). Redd mapping was ended early for the 2005/06 season due to high flows in December and January.

Redd mapping was performed in the following manner:

(1) Crews walked or boated the entire reach of the main channel from Riffle 18 to 22, looking for Chinook salmon redds. As redds were identified in the field, their location was drawn on the laminated aerial photographs provided by McBain & Trush, Inc.
(2) Each new redd was assigned a number (from 1 to n). For each redd, the following data were recorded on a data sheet: (1) river station, (2) location of redd (left bank, right bank, or center of channel), (3) habitat code (pool tail, riffle, or lateral bar), (4) water depth at redd pit, (5) approximate distance to cover and description of type of cover (e.g., instream cover from turbulence, LWD, overhanging bank vegetation, etc.), (6) date and time redd is recorded, (7) observations describing if fish are still constructing the redd or depositing eggs, etc., and (8) estimates of the length of fish constructing the redd.
(3) Field crews also recorded anecdotal observations such as weather conditions, water temperature at start and end of field day, names of crew, estimates of number of adult salmonids observed within each riffle or within the reach, observations of unusual activities on redds, etc.
(4) After each field day, the data sheets and laminated photographs were photocopied and sent to McBain and Trush, Inc. for digitizing.

3.8 Photopoints

Pre-construction photos were taken of Patches 1, 2, 3, and 4 between May 22, and 23 2003 during flows of 560 cfs and Patches 5 and 6 just prior to construction in August 2005 during flows of 330 cfs.

As-built photopoints were established at each of the six augmentation patches in October 2005 (Figure 11). Photopoint locations were mapped using a total station to provide recoverable long term photopoint locations. As-built photographs were taken at each of the five photopoints during a flow of 360 cfs. Since no pre-project photopoints were established, direct photo pre-project and as-built comparisons are not available. Photopoints, however, will provide basis for future post project comparisons.

3.9 Aerial Photography

Pre-project aerial photographs were taken on November 17, 2000 during a flow of 360 cfs and scanned at a ½-foot pixel resolution. The November 2000 black and white photographs were rubbersheeted using aerial targets established prior to the flight. Post-project digital color aerial photographs were taken at a ½-foot pixel resolution on September 21, 2005 during a flow of 330 cfs. Digital photographs were orthorectified using LIDAR data collected at the time the aerial photographs were taken. These orthorectified photographs provide comparison to aerial photographs taken on November 17, 2000 (prior to construction) and document baseline conditions for future project monitoring.

4 AS-BUILT MONITORING RESULTS

4.1 Constructed Floodplain Topography

As-built and design contours for the floodplain are compared in Figure 15. The as-built floodplain surface, excluding the high flow scour channel, was constructed within 0.25 vertical feet of the floodplain design surface (Figures 15 and 16).

Several alterations to the project design were made based on field conditions at the site. These alterations are as follows:

- A 20-foot-wide access road was added along the northern portion of the floodplain starting at floodplain station 7+00 to allow access to the eastern portion of the property when the floodplain is inundated.
- The floodplain excavation area was widened by 40 feet along the southern edge of the design terrace between floodplain Station 10+15 and 12+15. This was done to compensate for the volume lost by the addition of the 20-foot wide access road described above, with the objective of maintaining access to an estimated 39,500 yd^3 of dredger tailings (Table 8, Figure 15).
- Floodplain excavation was narrowed by an average of 75 feet between floodplain station 2+00 and 10+00, and the high flow scour channel was reduced by one foot in depth and 10 feet in width to reduce excavation volume to amounts consistent with the project bid and contract. Though the high flow scour channel construction deviates from the design, the purpose and function of the channel, (i.e. to reduce fish stranding), is achieved because the floodplain drains as designed (Figures 17 and 18).

4.2 Excavation and Fill Volumes

The volume of excavation required to achieve design grade was estimated to be 39,500 yd^3 from the pre-project and design DTMs. The project contract and budget specified excavation of 49,500 yd^3 of material (39,500 yd^3 plus a contingency of 10,000 yd^3) rather than excavation to design grade. Due to the fixed excavation volume specified in the construction contract, excavation volume was tracked during construction by counting scraper loads. A total of 2,100 scraper loads were counted, yielding an estimated of excavation volume of 46,200 yd^3.

Following construction, excavation volume was recomputed by comparing the pre-construction and as-built DTMs using AutoCAD's standard grid method. The volume computed from comparison of the DTMs was 21,570 yd^3, or 53% less than the scraper count estimate. As an additional check, excavation volume was computed from the volume of material placed in the channel (see Section 4.3.1) combined with the volume of material stockpiled at the site (i.e., all excavated material not placed in the channel) (Figure 15). The volume of material placed in the channel was computed from pre-project and as-built channel morphology surveys (see Section 4.3.1). Stockpile volumes were computed using a DTM generated from the September 21, 2005 LIDAR survey and a DTM generated by building a surface around the toe of each of the stockpiles. Using this method, the total volume of material placed in the channel (10,820 yd^3) plus the material remaining in stockpiles (11,880 yd^3) was estimated to be 22,700 yd^3, or 5% more than the floodplain cut volumes calculated from pre- and post-construction surveys (Table 8). The consistency between the volume estimates using the pre- and post-construction DTMs (21,570 yd^3) and fill patch/stockpile (22,700 yd^3) volumes suggests that the truck counts overestimated excavation volumes. This is largely attributed to truck counts that measure excavated expanded material rather than the compacted material *in-situ*.

4.3 In-Channel Coarse Sediment Augmentation

4.3.1 Coarse Sediment Augmentation Volume

Estimated design and as-built fill volumes at each augmentation patch are shown in Table 4. Total design volume for coarse sediment augmentation was 12,000 yd^3. As-built fill volume was computed using two methods: (1) comparing augmentation patch topography and bathymetry to the pre-project total station survey conducted in 2003, and (2) comparing augmentation patch topography and bathymetry to the acoustic bathymetry survey conducted in 2005. Volumes for Patches 2, 3, and 4 were computed by comparing pre- and post-project total stations surveys at each patch. Patches 1, 5 and 6 were not included in the pre-project total station surveys. Volumes for these patches were computed by comparing the post-project total station survey to the pre-project 2005 bathymetry survey, which was accurate only to a 2-foot contour interval.

Total estimated fill volume for all augmentation patches was 10,820 yd^3, or 1,180 yd^3 (10%) less than design fill volume (Table 8). Fill volume for each augmentation patch ranged from 10 yd^3 to 720 yd^3 (1% to 43%) less than the anticipated design volume. Except for Patches 1 and 2, estimated fill volume was within 10% of design volume (Table 8). At Patch 1, fill volume was 170 yd^3 (43%) less than design volume. At Patch 2, fill volume was 230 yd^3 (29%) less than design volume. Design modifications that resulted in reduced fill volume are discussed Section 4.3.2.

Patch volumes calculated comparing the pre-project topography to the 2003 total station topography are assumed to be more accurate than the patch volumes calculated using topography generated from the July 2005 bathymetry surveys and differences can be attributed to the contour accuracy of each survey method. The 2003 total station survey was conducted to a 1-foot contour accuracy while the July 2005 bathymetry survey was to a 2-foot contour accuracy. Cross sections showing the differences between pre-project total station surveys and pre-project echo sounding surveys are shown in Appendix F. The less accurate pre-project survey conducted in 2005 using echo sounding can also be attributed to the following:

- difficulty of the boat and echo sounder get close enough to the bank to capture the toe of the channel due to overhanging trees and swift currents;
- vegetation along the bottom of the channel resulting in false bottom readings; and
- high velocities through riffles making it difficult to maneuver the boat.

Due to the less accurate topography generated using the pre-project 2005 bathymetry survey, volumes calculated comparing the as-built topography to the pre-project 2005 bathymetry survey are considered approximate.

4.3.2 Channel Morphology

Channel Cross Section

The channel designs were intended to provide estimated volumes (Table 8) and riffle control elevations at each of the patches. Once the bulk of the material was placed into a patch and roughly graded, micro-habitat consisting of dune sequences (e.g. pool tails, riffles and runs), was created under the supervision of the implementation team to improve the constructed salmonid habitat complexity.

Design cross sections 2400+50, 2403+40, 2408+75, and 2412+90 show pre-construction ground, design surface, and post-construction surfaces (Figure 16). Monitoring cross section surveys are illustrated in Appendix E and provide pre-construction, design, and as-built surfaces. Augmentation patches showing existing ground and as-built contours are shown in Figures 19-22. Deviations between design surfaces and as-built surveys are described below:

- Cross Section 2414+00 material was added along the left bank of Patch 1 forming a submerged point bar and modified placement of material along the right bank to maintain adult holding habitat;
- Cross Section 2412+90 a low flow channel along the backside of Patch 2 was left open and connected to the upstream pool providing additional juvenile rearing habitat;
- Cross Section 2412+10 the height of the point bar at Patch 2 is lower than designed, but additional material was extended into Riffle 20 reducing overall riffle slope;
- Cross Section 2408+75 the submerged right bank was extended further upstream than designed to maintain adult holding habitat downstream;
- Cross Section 2408+10 a dune was constructed as part of the final grading overseen by the implementation team;
- Cross Section 2403+95 right- and left-bank point bars were added to provide additional material for recruitment during high flows;
- Cross Section 2403+40 Patch 4 was extended to build a left bank point bar and preserve a deep pool along the right bank; and
- Cross Sections 2395+90 and 2394+00 since pre-project topography at Patches 5 and 6 was based upon a few depth soundings, design contours and volumes estimates were approximate. Variations to the design at Patches 5 and 6 were expected and overseen by the implementation team.

Channel Profile

The design reach average channel slope for the project design was 0.0013 (Figure 23). As-built reach-average slope was 0.002, or 35% steeper than the design slope. Individual patch slopes and riffle crests are provided in Table 9.

Variation between design slopes and riffle crest elevations and as-built riffle slopes and riffle crests elevations resulted from:

- refinement of riffle morphology in the field intended to provide morphology diversity between riffles and test Chinook salmon spawning use at different riffle designs;
- difficulty in reworking material once it was placed into the channel, which resulted in a riffle crest at Patch 1 being approximately 0.6 feet higher than the design elevation; and
- the riffle crest elevation was adapted and lowered at Patch 6 resulting in a riffle crest 0.9 feet lower than design elevation. The field adjustment to the riffle crest elevation was made to reduce the riffle slope at Patch 6 and increase Chinook spawning habitat.

4.3.3 Bed Texture (Pebble Counts and Bulk Samples)

As-built pebble count and bulk sample results are provided in Appendix F and Appendix G, respectively. The Coarse Sediment Management Plan for the Lower Tuolumne River (McBain and Trush 2004c) recommends two gradations for course sediment augmentation (Figure 24). While the D_{84} of the fill material placed at augmentation sites was consistent with the recommended texture, overall the fill volume was coarser than recommended (Figures 25 and 26).

Pre-project pebble counts were conducted at Riffle 20 and 21 and are shown in Figure 26. Comparing the D_{84} and D_{50} for pre- and post-project pebble counts at Riffle 20 resulted in an exact match for the D_{84} of 91 mm and a post-project D_{50}, of 56 mm, that is 5 mm larger than the pre-project D_{50} of 51 mm.

Post-project D_{84} and D_{50} at Riffle 20 are an average of pebble counts conducted at Patches 1 and 2. Riffle 21 pre-project pebble count resulted in a D_{84} of 111 mm and a D_{50} of 71 mm. Therefore, material placed at all six augmentation patches is finer than that of pre-project Riffle 21 (Appendix F and G).

4.3.4 Bed Mobility Thresholds (Marked Rocks, Paint Patches)

Results from marked rock experiments are not yet available. Marked rocks placed at the project site will be recovered in summer 2006 to document bed mobility for a dam release of at least 7,600 cfs.

4.3.5 Habitat Mapping

Pre-project and as-built Chinook salmon spawning habitat area is shown in Table 10 and Figure 10 (pre-project) and Figure 27 (post-project). Pre-project Chinook salmon spawning habitat area mapped during flows of 560 cfs totaled 6,240 ft^2. As-built habitat mapped during flows of 360 cfs using visual estimates plotted onto pre-project aerial photographs totaled 35,600 ft^2, an increase of 29,360 ft^2 (571%) compared to pre-project mapping. As-built habitat mapped using measured depth and velocity and total station mapping totaled 29,960 ft^2, an increase of 23,720 ft^2 (480%) compared to pre-project conditions. Assuming a defended redd area of 200 ft^2 (TID/MID 1992), this increase in spawning habitat area could potentially support an additional 119 Chinook salmon spawning pairs (using the total station estimate) or 147 pairs using (the air photo estimate).

Comparing the two methods, the survey using measured depth and velocity and total station mapping identified 5,640 ft^2 (16%) less habitat area than the survey using visual estimates. This difference is an order of magnitude less than estimated increase in habitat area between pre-project and as-built conditions. Because the total station method provides more repeatable identification of suitable habitat and more accurate placement of polygon boundaries (and thus more accurate quantification of polygon area), this method is preferred for future monitoring.

As-built Chinook salmon fry and rearing and adult holding are shown in Figure 27. Fry and rearing habitat was not mapped for pre-project conditions. Change in fry and juvenile rearing habitat area from pre-project to as-built conditions, therefore, cannot be quantified. Future mapping will allow comparison of as-built to future post-project rearing habitat area.

4.3.6 Chinook Salmon Redd Counts

Pre-project and as-built Chinook salmon redd counts are provided in Appendix C and Appendix D, respectively. No redds were observed during fall 2004 (pre-construction) surveys. Three redds, located at Riffle 18, Patch 3, and Patch 6 were observed during fall 2005 (post-construction) surveys (Figure 28). Additional analysis of Chinook salmon spawning use at the site will be conducted as additional years of data are gathered. Analyses will consider change in spawning use at the site relative to pre-project conditions, reference riffles, annual escapement, and river-wide spawning distribution.

4.3.7 Photopoints

Post-project photopoint photographs and the best available pre-project photographs for comparison are provided in Appendix H.

4.3.8 Aerial Photographs

Pre- and post-project aerial photographs are shown in Figure 29.

4.4 Conclusions and Recommendations

Excavation Volume

The bid and contract for project construction specified the volume of excavated material to be based on scraper counts rather than excavating to design grade and calculating the difference between pre- and post-project DTMs. Given the contract structure, FOT chose the method of counting scraper loads of excavated material from the floodplain for monitoring excavation volumes and ensuring consistency with the project contract and budget. This method, however, measured excavated material rather than the compacted material *in-situ*. In order to keep within the budget, the area excavated was reduced to accommodate the volume discrepancy generated by counting scrapers, thus reducing the *in-situ* volume of excavation completed under the contract. For future projects, we recommend specifying that the contractors bid and payment schedule is based on excavating to design grade.

Coarse Sediment Augmentation

Construction of Patches 1 through 6 resulted in 10,820 yd^3 (based on pre- and post-project surveys) of coarse sediment being placed into the river. The augmentation patches, as constructed, provide an additional 23,720 ft^2 of Chinook salmon spawning habitat in the project reach, an increase of 480% compared to pre-project conditions. Future monitoring will test whether and how Chinook salmon utilize these constructed habitat features.

Riffle construction, as overseen by FOT, provided for a diversity of riffle designs and preserved existing habitat features (such as pools and overhanging vegetation). The diversity of designs within the site and compared to projects recently constructed by CDFG near La Grange provides a valuable opportunity to compare habitat quality and spawning use for different riffle configurations.

Sediment Sieving

The as-built pebble counts and bulk samples show that the smaller size fractions of gravels were insufficient to satisfy the targeted particle size distribution of the recommended mix, Ongoing work by Mesick (2006, pers comm.) and Vyverberg (2006, pers comm.) is evaluating the biological impacts of insufficient fine gravels in the ¼-inch to ¾-inch range. If this ongoing research confirms the importance of this finer gravel mix, then additional refinement to the screening process may be necessary to meet the recommended mix. This could be achieved on future projects by:

- Reducing the upper screen size to 4 inches while maintaining lower screen size at 1/4-inches. A 4-inch square screen would still allow a 5.6 inch diameter rock to pass, which is suitable for Chinook salmon spawning, and will improve the suitability for O. mykiss spawning. Despite the low percentage of fines in remnant dredger tailings, the lower screen is necessary to reduce mercury contamination risk, primarily contained within the fines. Based on the materials available at Bobcat Flat, this approach would potentially reduce the "deficiency" in fine gravels, but not eliminate it, such that supplementation of fine gravels would still likely be necessary.
- Further processing materials on site and mixing together to meet the desired mix.
- Pre-sorting and stockpiling a greater percentage of ¾ to ¼-inch material to be mixed in to the spawning gravel prior to placement.
- Assessing pre-project materials testing to identify areas that have a greater proportion of ¼ to ¾-inch material for spawning gravel use, and using other source areas deficient in these fine gravels as underlying base material (place in deep areas). Then the spawning gravel mix would be placed on top of these base materials.

Further evaluation of these possible processing methods would be required for each site to find the most cost-effective means of achieving the desired mix for the smaller size classes of gravel.

5 REFERENCES

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TID/MID (Turlock and Modesto Irrigation Districts). 1992. Lower Tuolumne River spawning gravel availability and superimposition. Appendix 6 to Don Pedro Project Fisheries Studies Report (FERC Article 39, Project No. 2299). *In* Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. Vol. IV. Prepared for TID/MID by EA Engineering, Science, and Technology, Lafayette, California.

USFWS (U.S. Fish and Wildlife Service). 1995. The relationship between instream flow and physical habitat availability for chinook salmon in the lower Tuolumne River, California. Prepared by US Fish and Wildlife Service Ecological Services Sacramento Field Office for Turlock Irrigation District and Modesto Irrigation District.

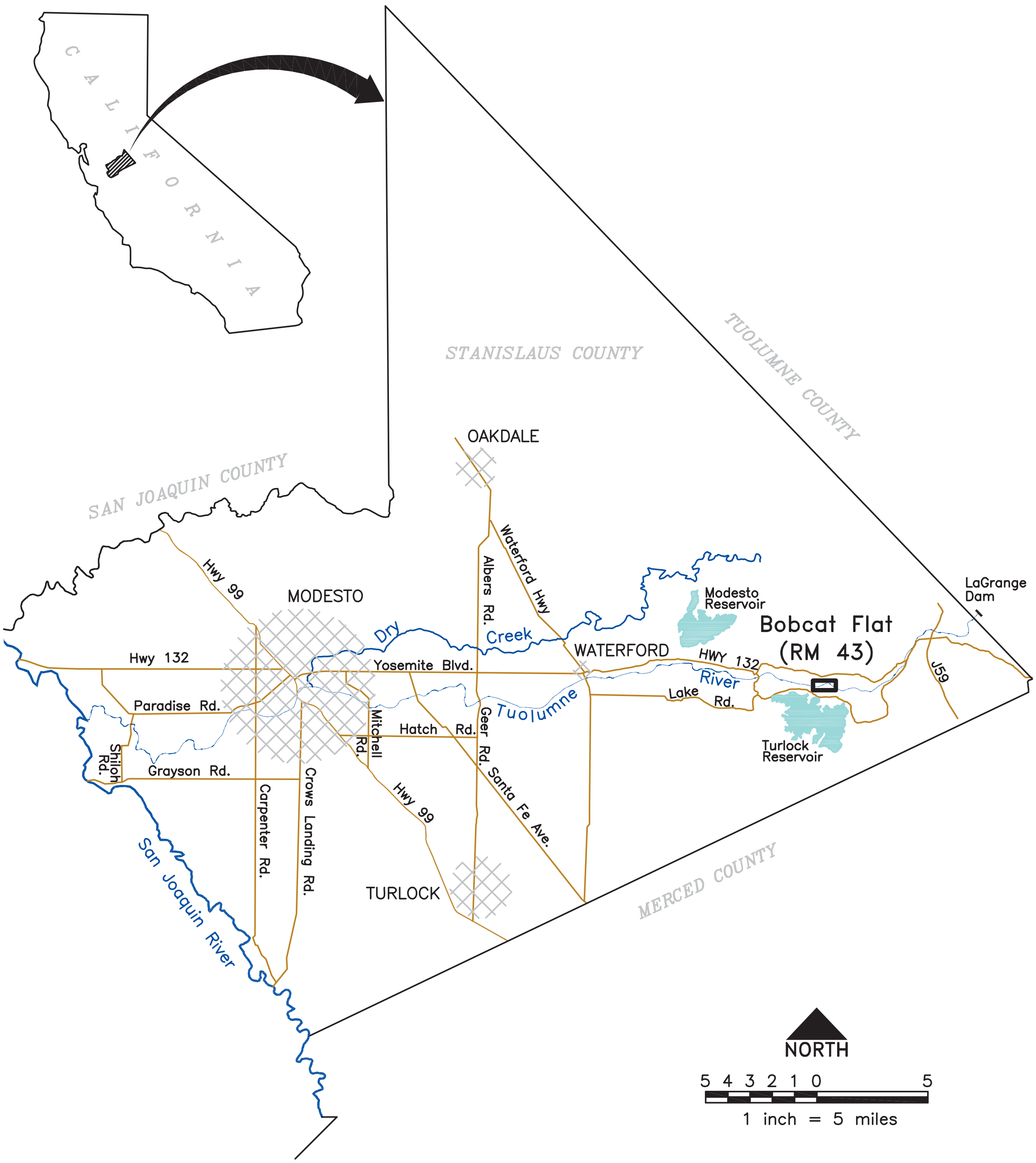

Figure 1. Bobcat Flat (RM 43) location map.

Figure 2. Two Caterpillar 627G scrapers working in tandem while excavating material from floodway (Photograph courtesy of Friends of the Tuolumne).

Figure 3. Caterpillar 14H grader providing final grading elevations (Photograph courtesy of Friends of the Tuolumne).

Figure 4. Caterpillar 980G front end loader placing raw material from stockpile into hopper for sieving and washing (Photograph courtesy of Friends of the Tuolumne).

Figure 5. Sieving and washing plant consisting of Construction Equipment Co. (CEC) Screen-It, diesel powered screener, retrofitted with an additional washing system that sprayed water through three fire nozzles aimed at the screen (Photograph courtesy of Friends of the Tuolumne).

Figure 6. Resulting ¼ to 5 inch sieved washed coarse sediment ready for placement in channel (Photograph courtesy of Friends of the Tuolumne).

Figure 7. Caterpillar D350E (21 yd^3) articulated truck dumping coarse sediment at Patch 2 (Photograph courtesy of Friends of the Tuolumne).

Figure 8. Hyundai 770-7 front end loader placing and grading coarse sediment at Patch 3 (Photograph courtesy of Friends of the Tuolumne).

Figure 9. Checking riffle crest elevations at Patch 1 prior to completing in-channel construction (Photograph courtesy of Friends of the Tuolumne).

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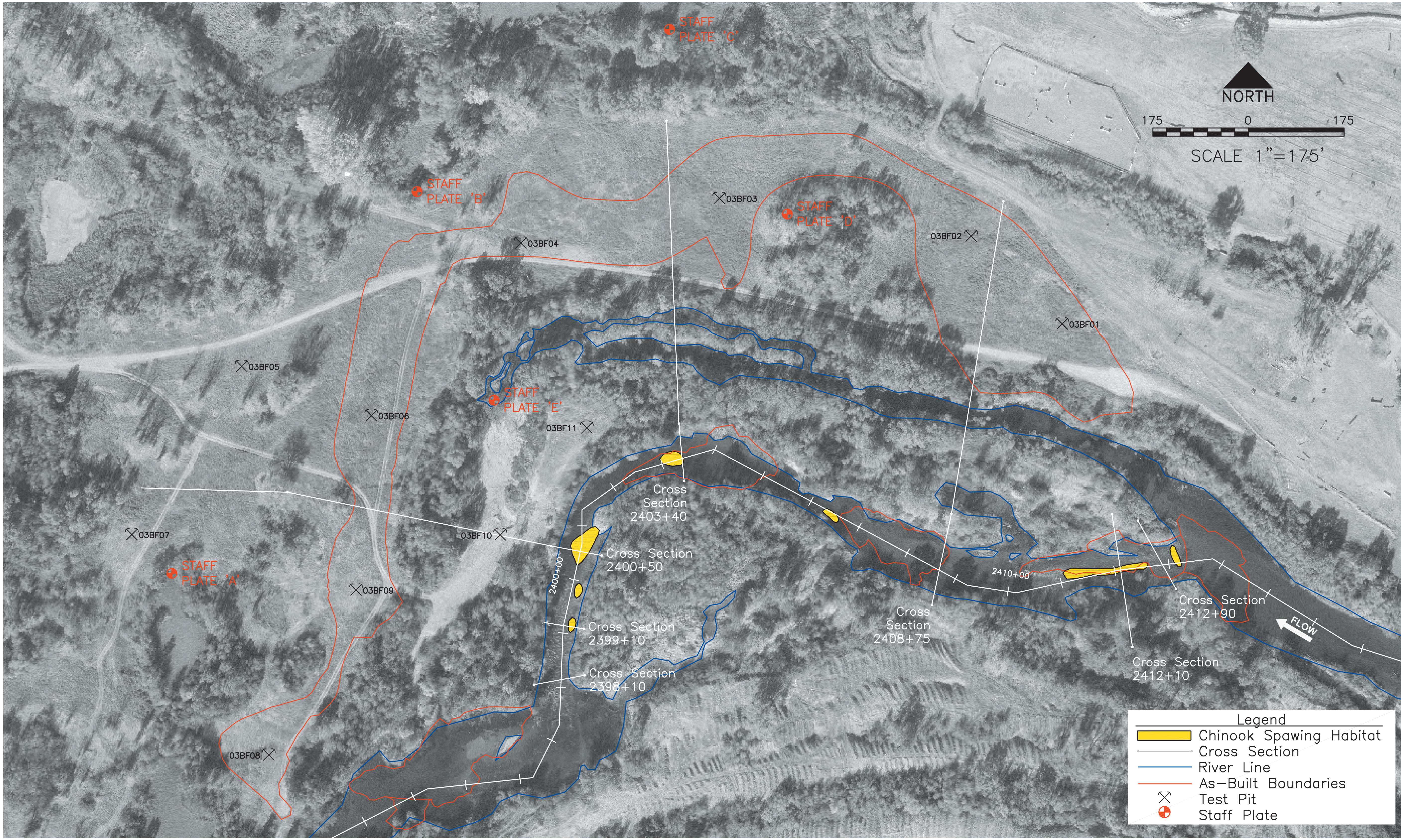

Figure 10. Pre-construction cross sections, ground water monitoring sites, material test pit locations, and Chinook spawning habitat areas.

Figure 11. Post-construction cross sections, photo points, bulk sample, pebble count, and marked rock deployment locations.

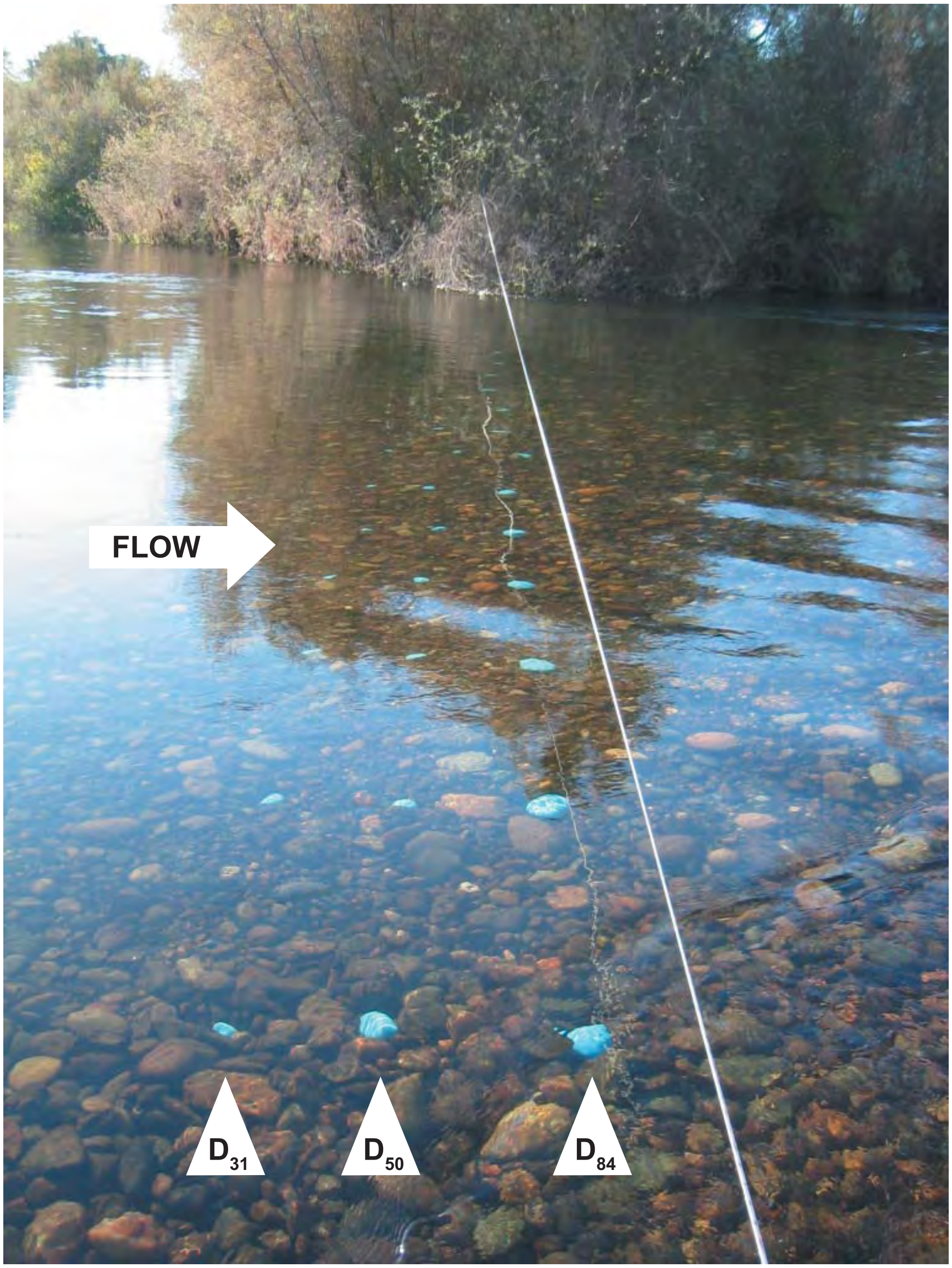

Figure 12. Example of marked rock placement at riffle crest Patch 1.

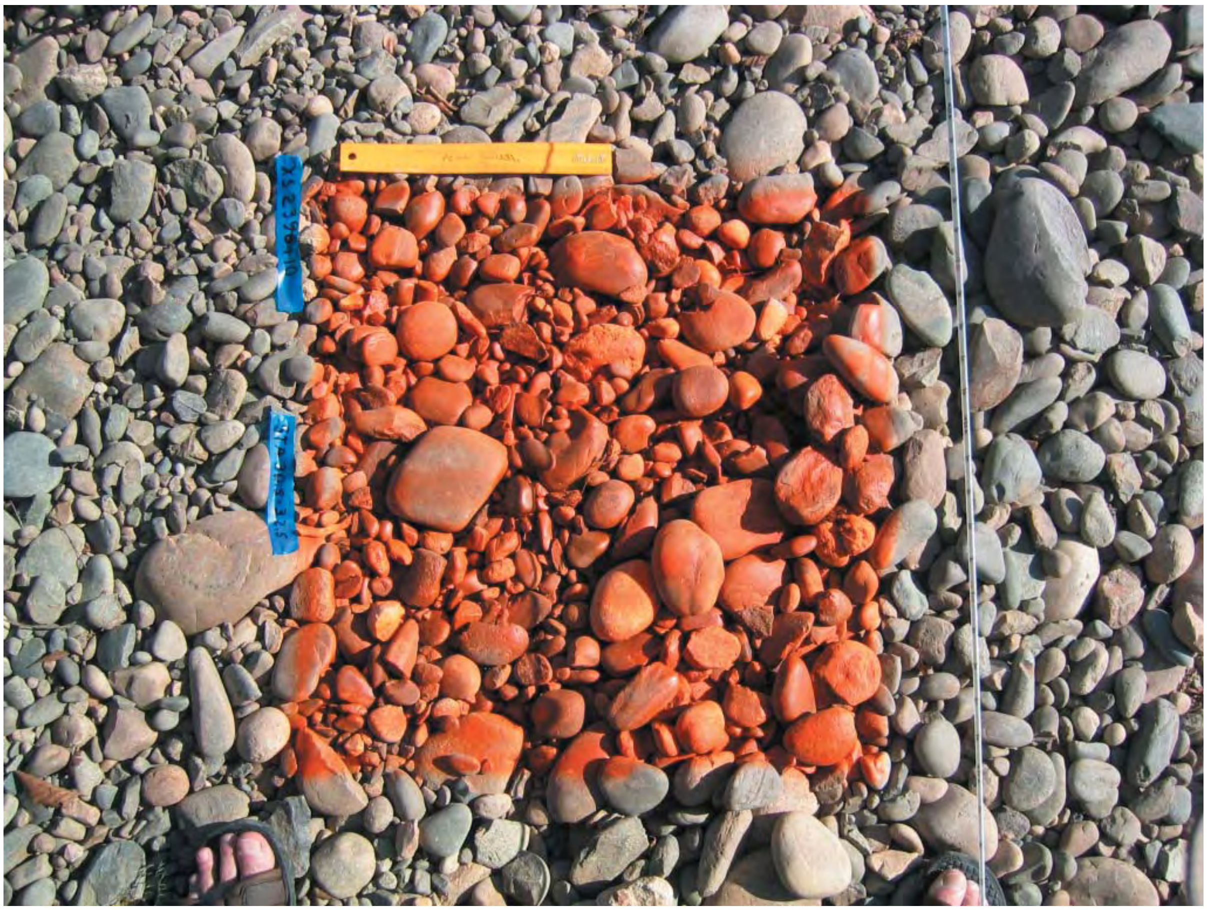

Figure 13. Example of a single 2 ft x 2 ft foot paint patch monitoring photograph.

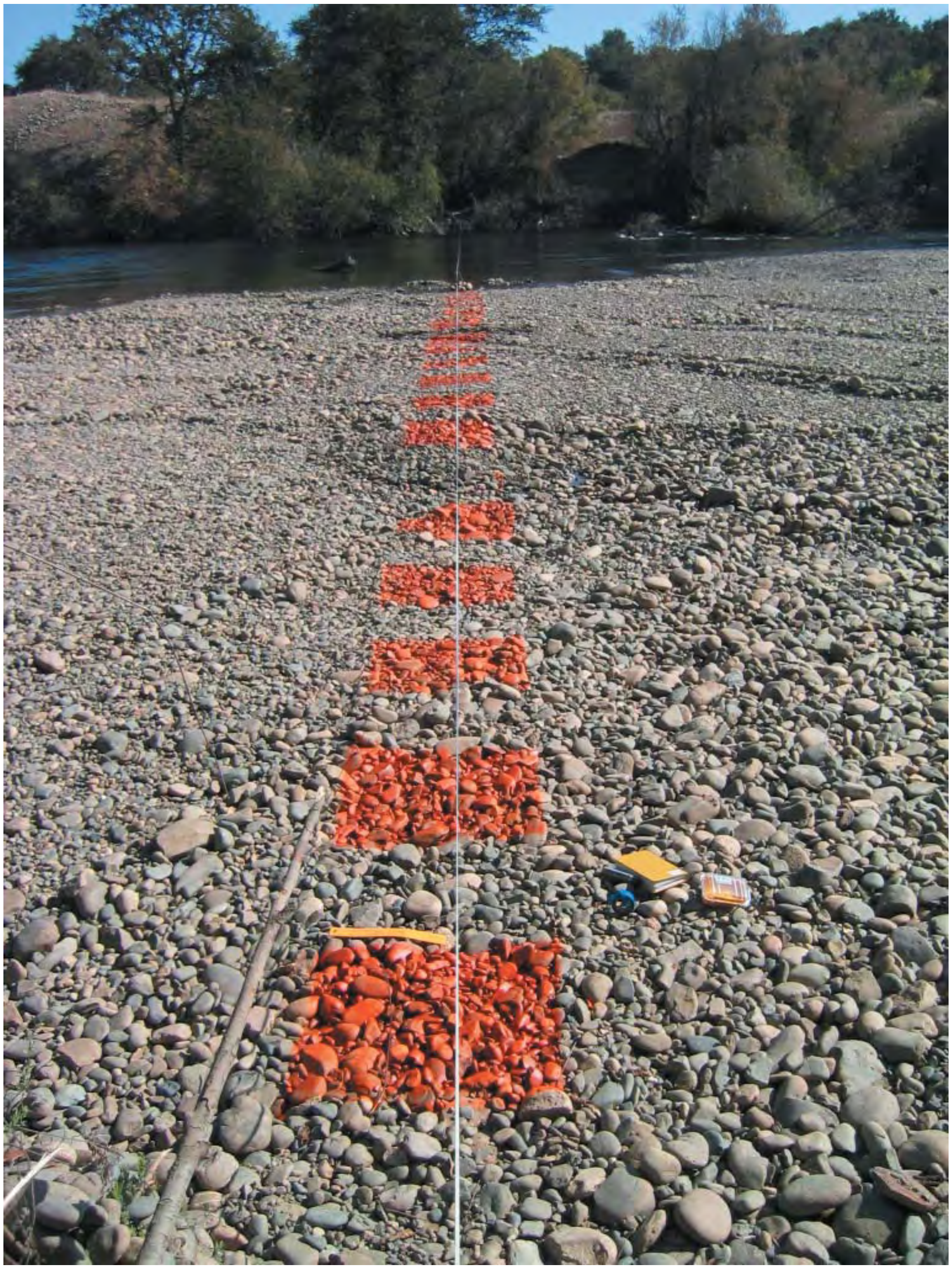

Figure 14. Example of 2 ft x 2 ft paint patches set at Patch 6.

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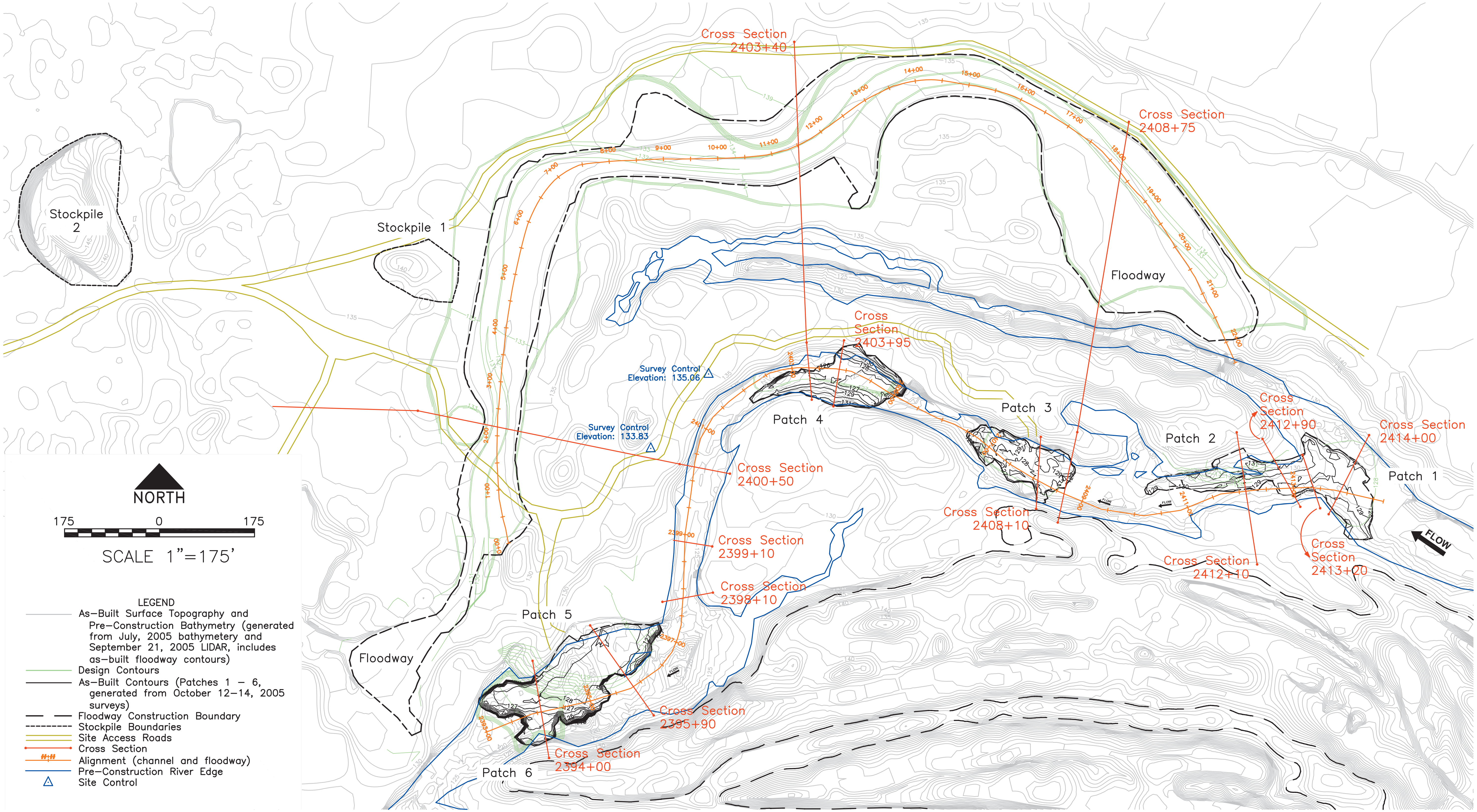

Figure 15. Bobcat Flat planform map of existing, design, and as-built contours.

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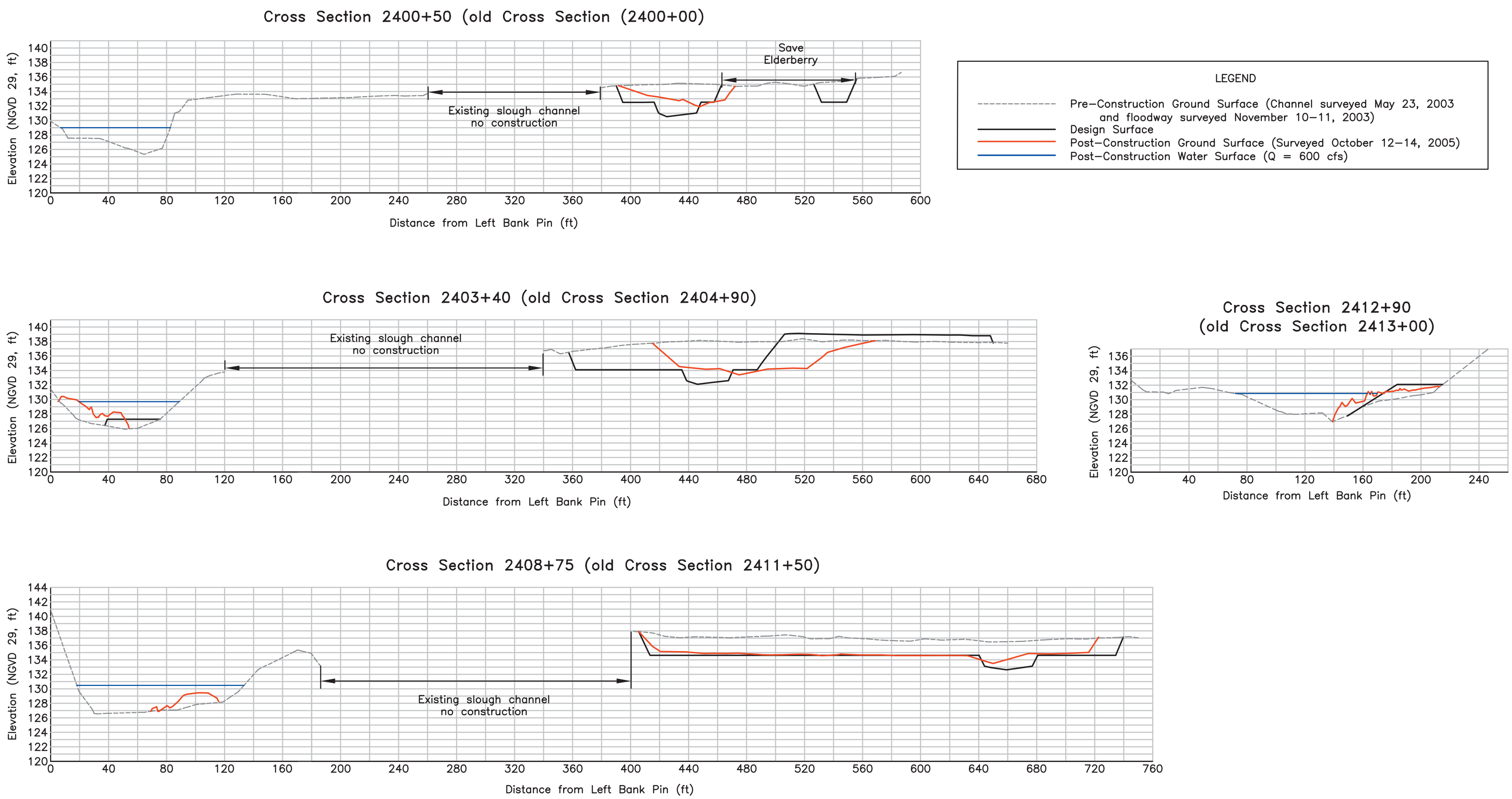

Figure 16. Bobcat Flat existing, design, and as-built cross sections. Cross section locations are shown on Figure 15.

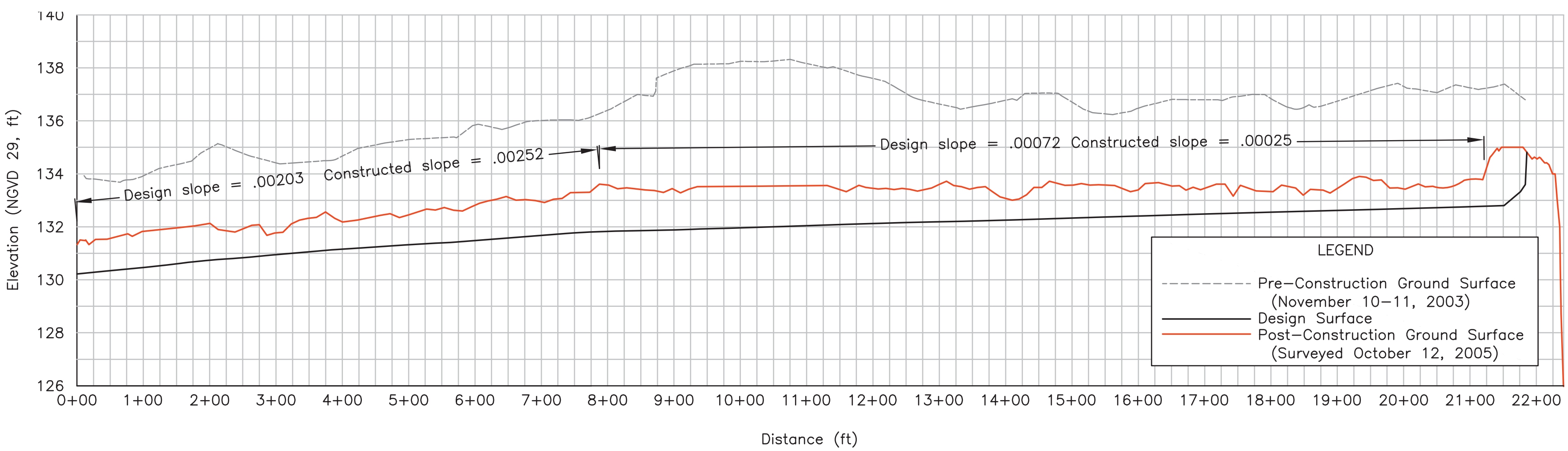

Figure 17. High flow scour channel existing, design, and as-built longitudinal profile. Longitudinal stationing for high flow scour channel is shown on Figure 15.

Figure 18. As-built high flow scour channel showing conveyance of flows from groundwater seepage during a dam release of 3,150 cfs. Photograph A) taken along the right side of the as-built floodplain at Station 16+00 looking downstream. Photograph B) Taken along the right side of the as-built floodplain at Station 16+50 looking back towards the main channel (Photograph courtesy of Friends of the Tuolumne).

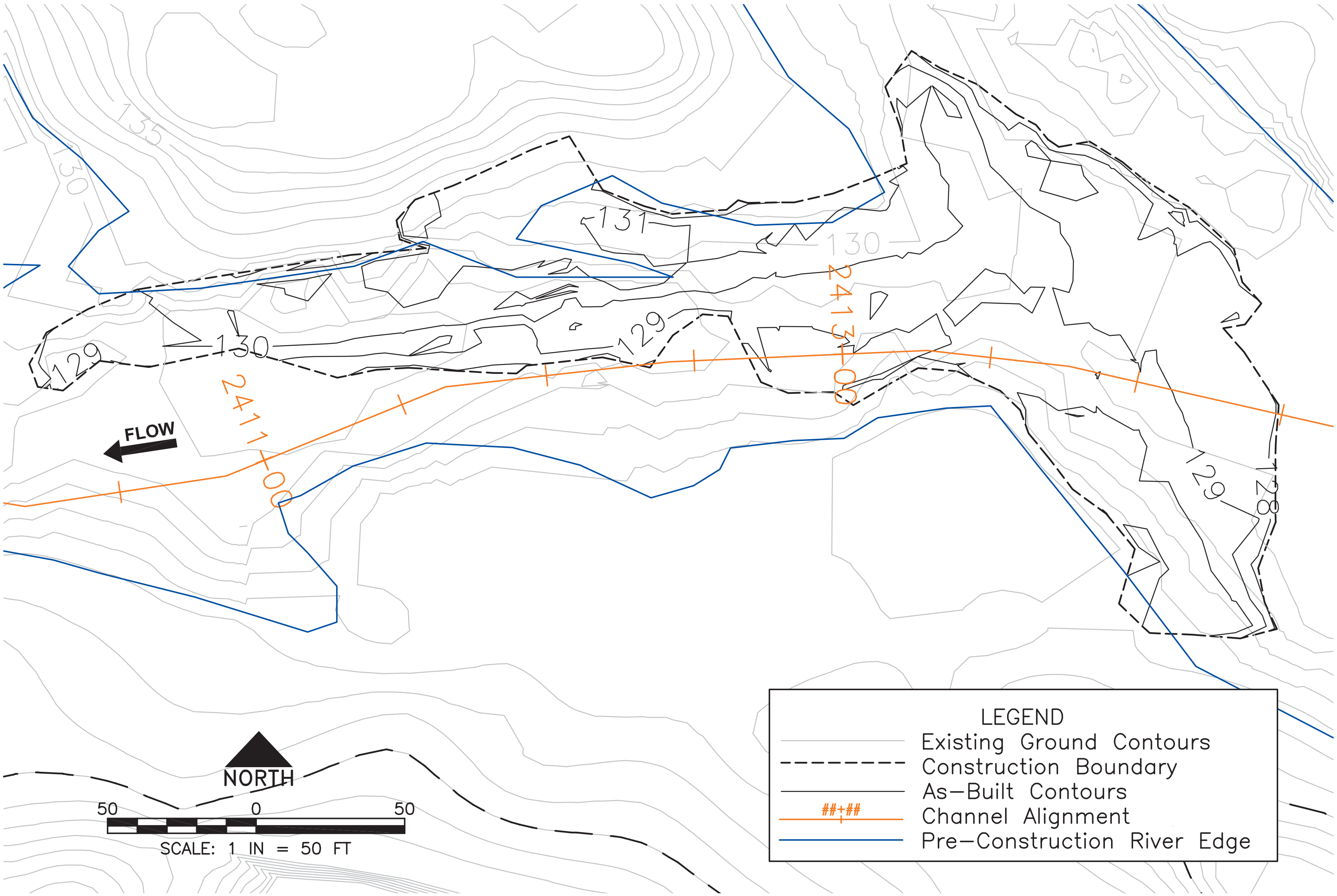

Figure 19. Existing and as-built contours at Patches 1 and 2.

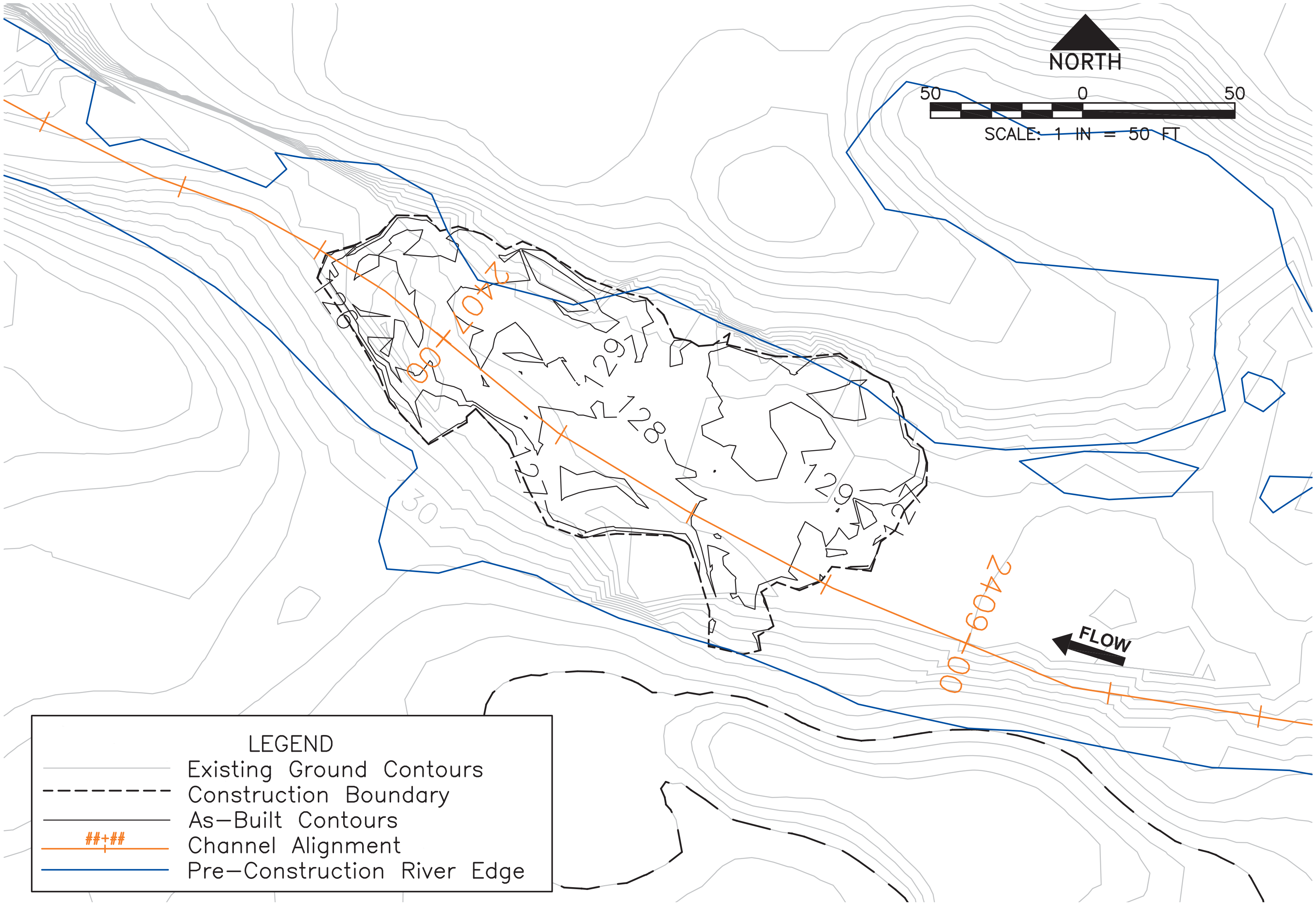

Figure 20. Existing and as-built contours at Patch 3.

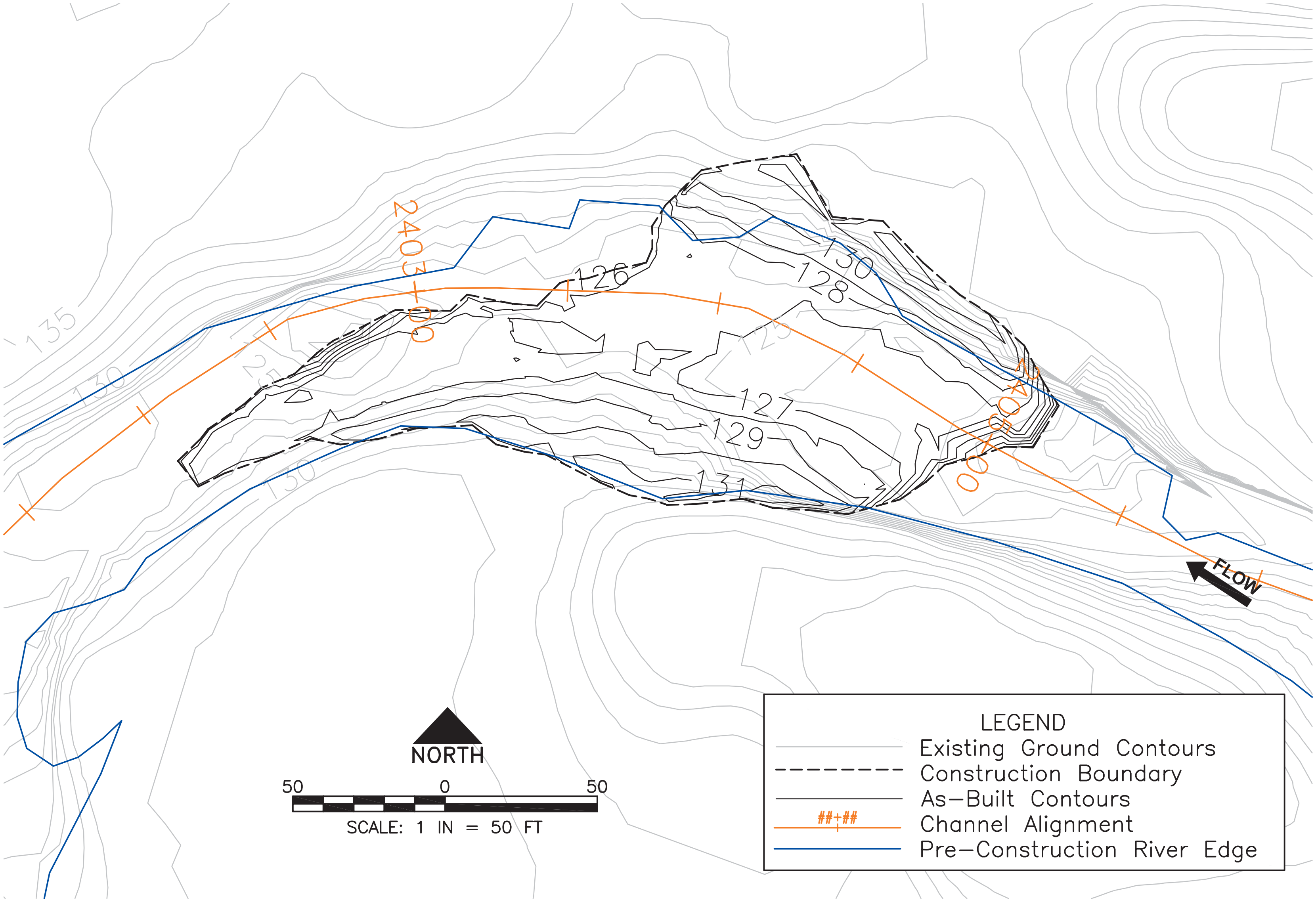

Figure 21. Existing and as-built contours at Patch 4.

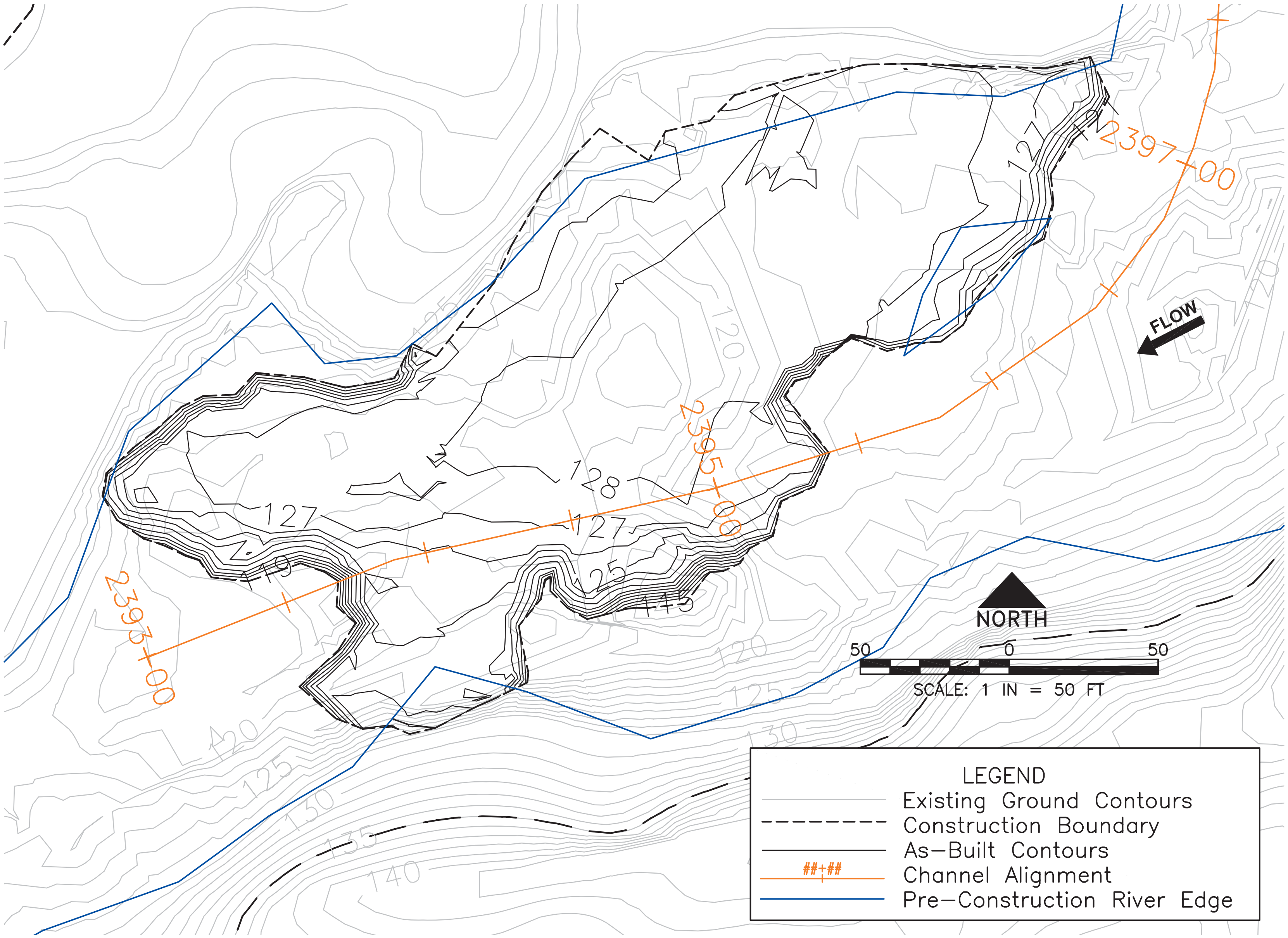

Figure 22. Existing and as-built contours at Patches 5 and 6.

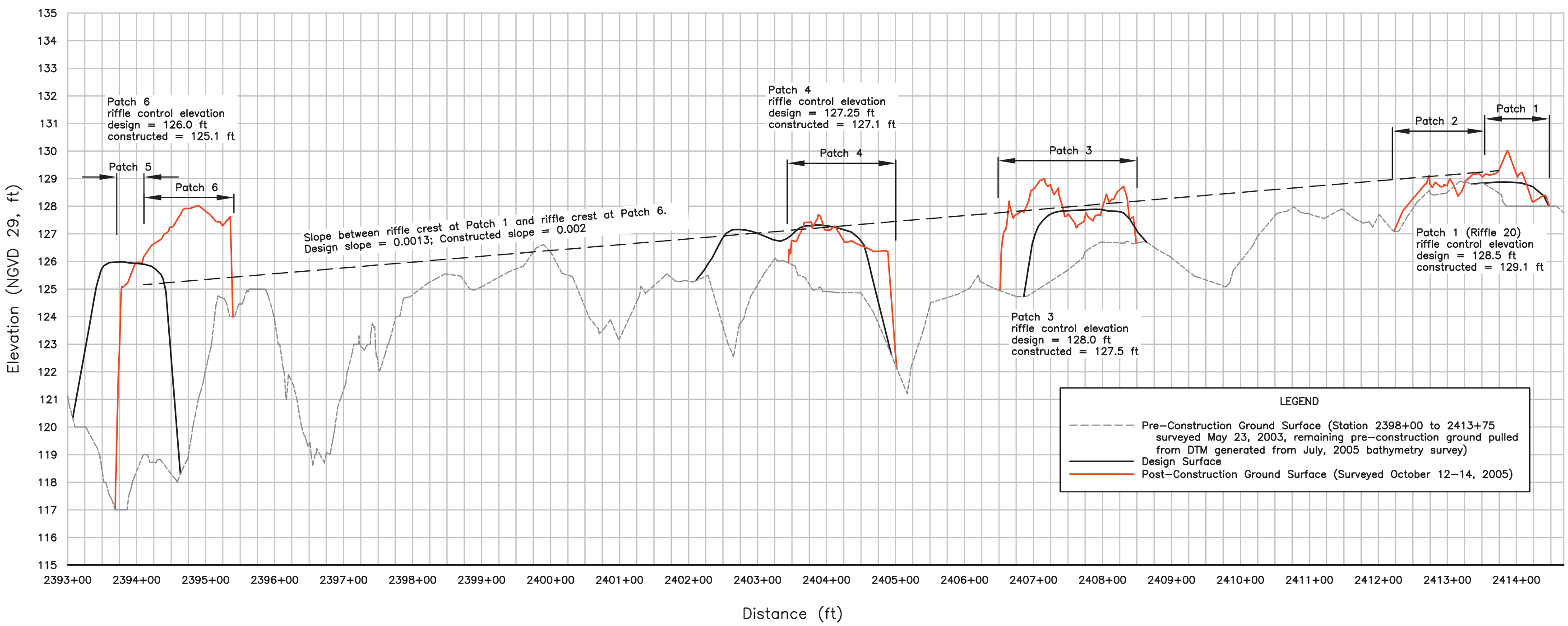

Figure 23. Longitudinal profile of existing, design, and as-built ground surfaces using pre-construction alignment. Longitudinal stationing and channel alignment location is shown on Figure 15.

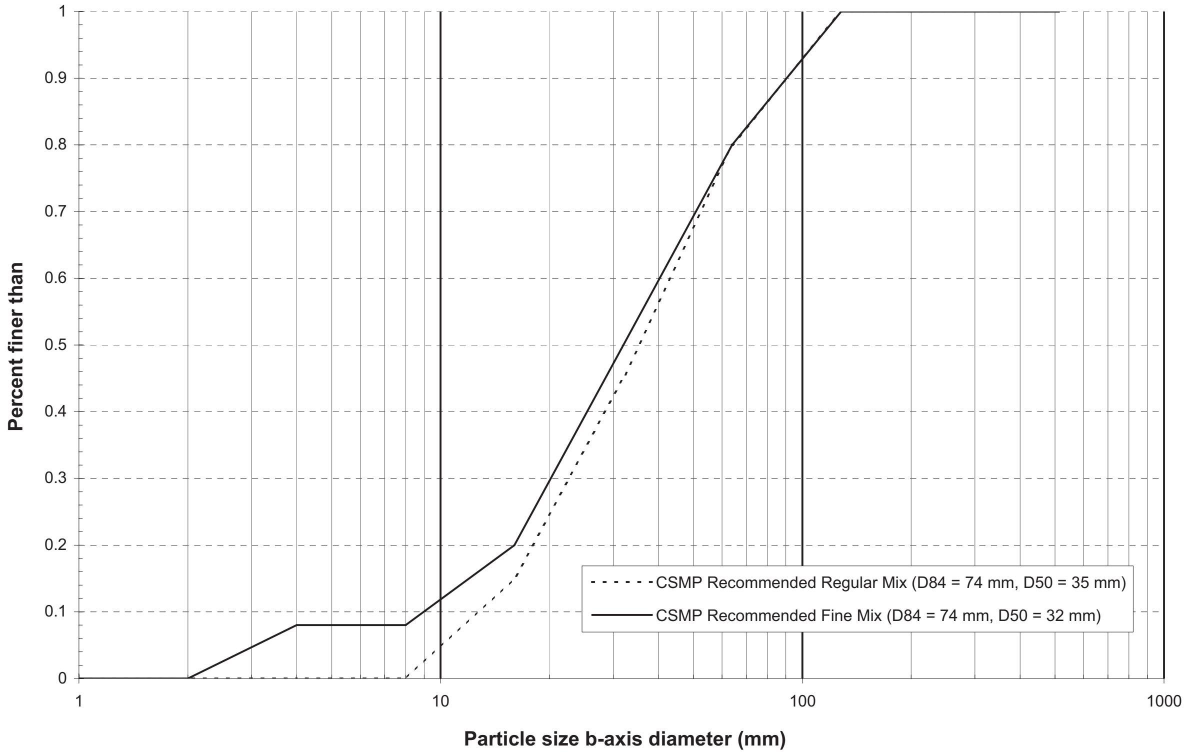

Figure 24. Recommended mixes for instream gravel augmentation projects (from McBain & Trush, Inc., 2004.

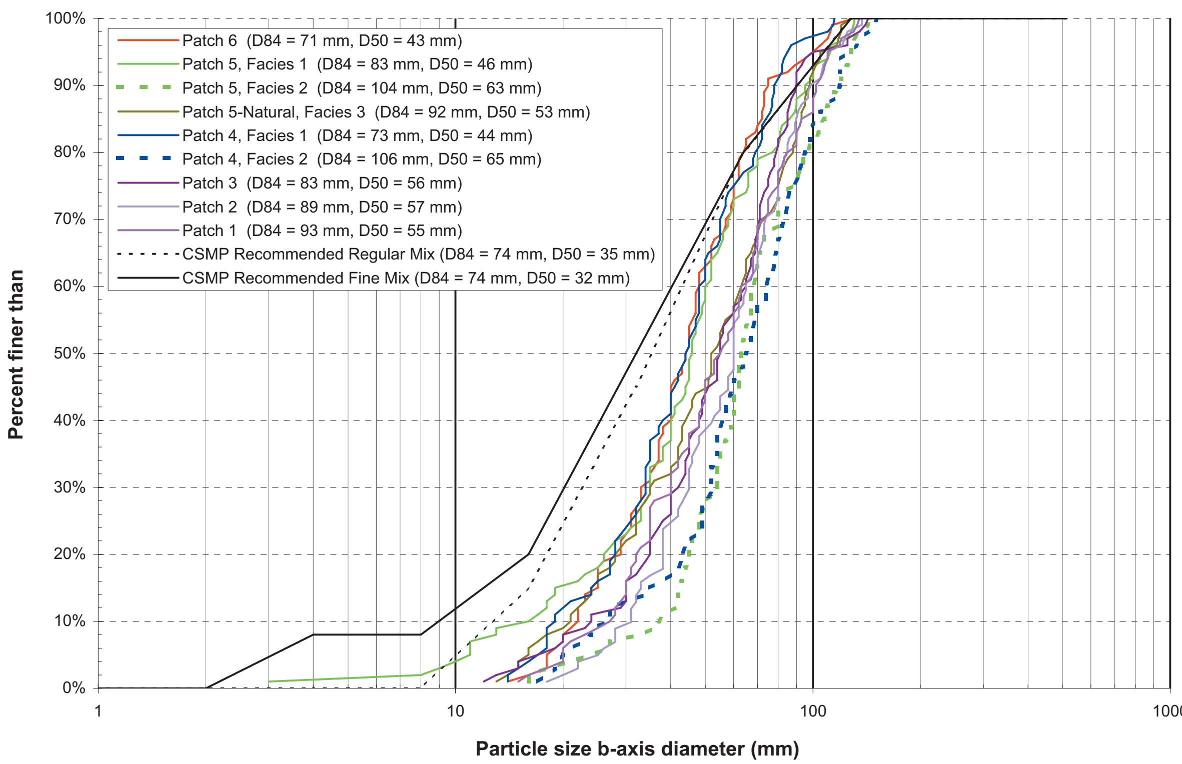

Figure 25. Summary of plotted results for each pebble count conducted at the constructed patches. Pebble count locations are shown on Figure 11.

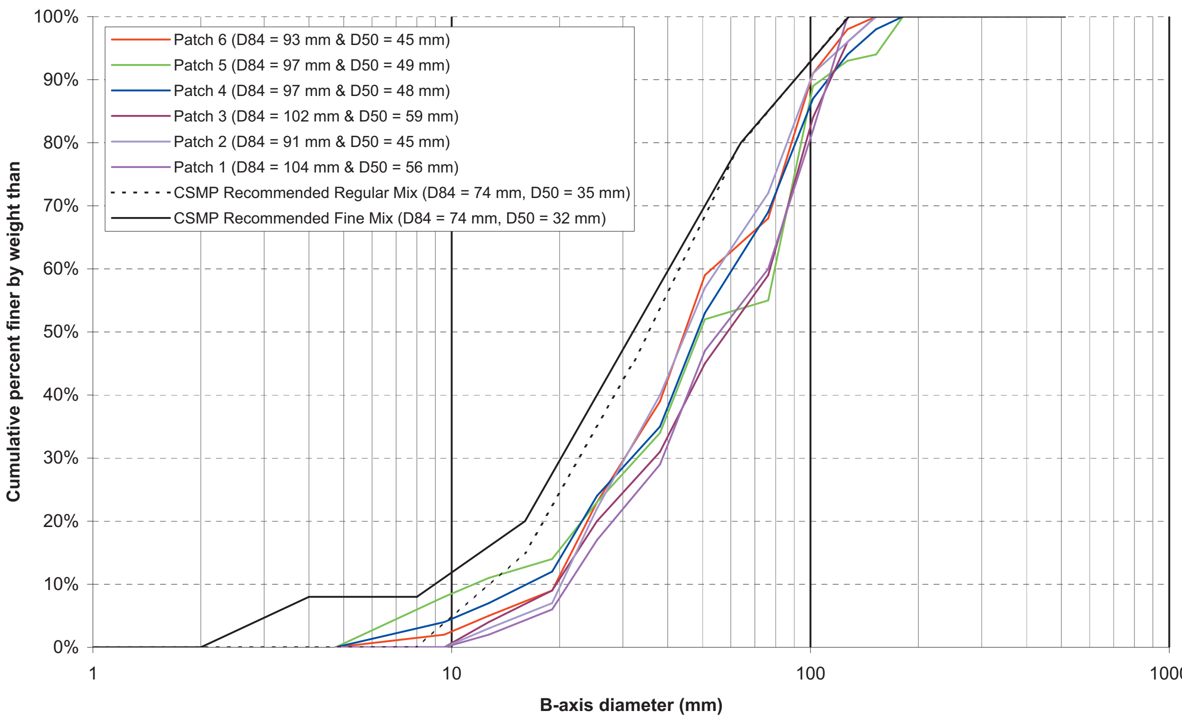

Figure 26. Plotted summary of results for bulk samples taken at each of the constructed patches. Bulk sample locations are shown on Figure 11.

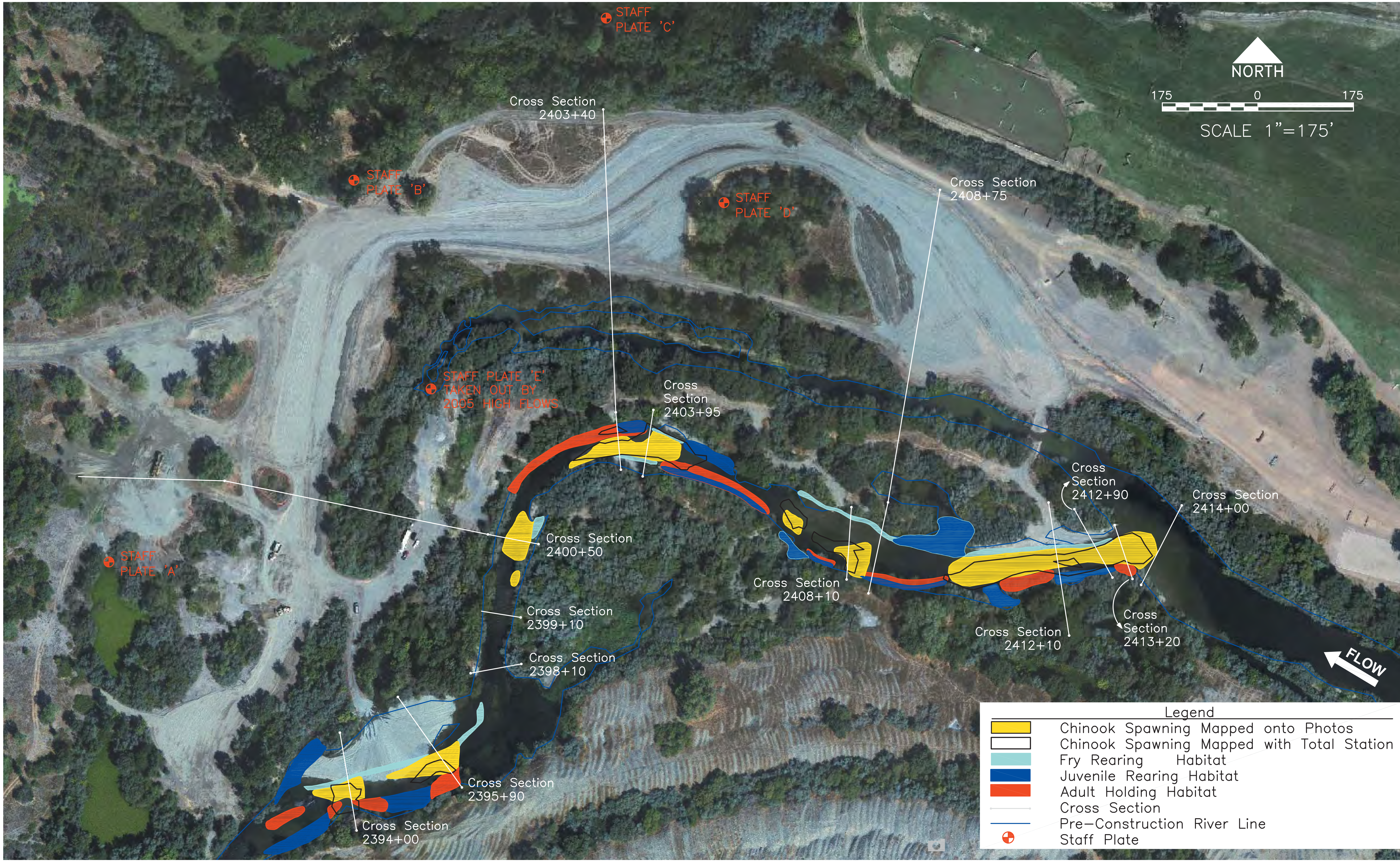

Figure 27. Post-construction aerial photograph showing cross sections locations, habitat areas for Chinook spawning, fry rearing, and juvenile rearing, and adult salmonid holding.

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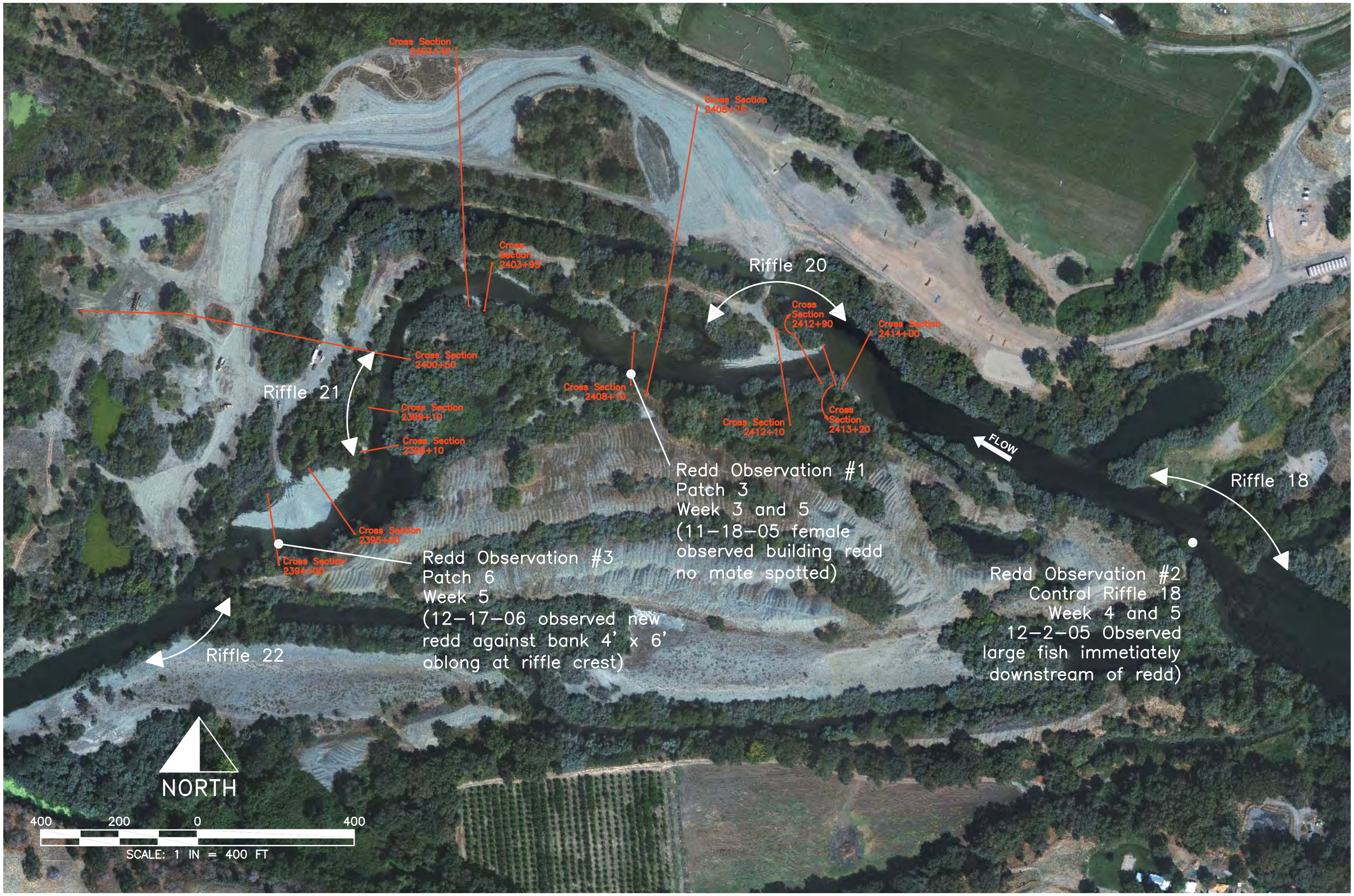

Figure 28. Location, data, and observations made for redds mapped at Bobcat Flat post-construction. No redds were observed during 2004 pre-construction spawning surveys.

Figure 29. Pre- and post-construction aerial photographs for Bobcat Flat RM43 Phase I project area.

Table 1. Summary of monitoring parameters and methods.

Monitoring Parameter	Method	Pre-project			As-built
		2003	2004	2005	2005
Channel cross section	Level and total station surveys	●			●
Channel profile	Level and total station surveys	●			●
	Acoustic bathymetry survey			●	
Augmentation patch volume and area	Total station survey (1-ft contour DTM)				●
Bed texture	Pebble counts	●			●
	Bulk samples				●
Bed mobility thresholds	Marked rock experiments				●
Floodplain Topography	Total station survey (1-ft contour DTM)	●			
	Kinematic GPS survey (1-ft contour DTM)				●
	LIDAR survey (2-ft contour DTM)				●
River Stage and Shallow Groundwater Table Fluctuations	2 staff plates installed along river channel				●
	5 staff plates installed in dredger ponds	●	●		
Chinook salmon spawning	Spawning habitat mapping	●			●
	redd counts		●		●

Table 2. Summary of topographic and bathymetry surveys at Bobcat Flat RM 43.

Survey Date	Discharge (cfs) at La Grange, Calif (USGS gage number 11289650)	Purpose of Survey	Horizontal and Vertical Datum (ft)	Survey Method	Surveyed / Mapped by
November 23, 2003	N/A	Establish horizontal and vertical control at the project site (previous surveys were adjusted to the survey control and all subsiquent surveys use the survey control)	California State Plane, Zone 3, NAD 83 & NGVD 29	Real-Time Kinematic (RTK) Global Positioning System (GPS)	Del Terra, Inc.
May 22, 2003	375	Establish monitoring cross sections	California State Plane, Zone 3, NAD 83 & NGVD 29	Total Station	McBain & Trush, Inc
May 23, 2003	375	Survey topography to generate a contour map with 1 ft accuracy and corrisponding digital terrain model (DTM) within the channel (from Station 2398+00 to 2413+75)	California State Plane, Zone 3, NAD 83 & NGVD 29	Total Station	McBain & Trush, Inc
November 10-11, 2003	230	Survey topography to generate a contour map with 1 ft accuracy and corrisponding DTM of the existing right bank floodway	California State Plane, Zone 3, NAD 83 & NGVD 29	Total Station	McBain & Trush, Inc
November 10, 2003	230	Extend monitoring cross sections 2408+75, 2403+40, and 2400+50 to include floodway	California State Plane, Zone 3, NAD 83 & NGVD 29	Total Station	McBain & Trush, Inc
November 23, 2003	N/A	Establish vertical control for 5 staff plates monitoring water elevation elevations	NGVD 29	Auto Level	McBain & Trush, Inc
November 23, 2003	N/A	Survey course sediment test pit locations	California State Plane, Zone 3, NAD 83 & NGVD 29	RTK GPS	Del Terra, Inc.
July, 2005	Variable (2,500 - 3,600 cfs)	Survey bathymetry to generate a contour map with 2 ft accuracy and corrisponding DTM of the channel between River Mile 37 (7/11 Materials haul road bridge) and RM 52 (2 miles below Old La Grange dam)	California State Plane, Zone 3, NAD 83 & NGVD 29	Using combination of Real-Time Kinematic GPS and echosounder	Graham Mathews and Associates
September 21, 2005	330	Survey topogrphy to generate a contour map with 2 ft accuracy and corrisponding DTM of groud surface between River Mile 0 (Tuolumne River confluence with the San Jaquin River) and RM 54 (Old La Grange dam)	California State Plane, Zone 3, NAD 83 & NAVD 88 (In order to adjust the vertical datum to NGVD 29, 2.34 ft was subtracted from all elevation nodes)	Light Detection and Ranging (LIDAR)	Sanborn Map Company, Inc.
October 10-11, 2005	361 & 383	Map Chinook spawing boundarys and survey monitoring cross sections post-construction	California State Plane, Zone 3, NAD 83 & NGVD 29	Total Station	McBain & Trush, Inc
October 10-11, 2005	361 & 383	Survey monitoring cross section post-construction	NGVD 29	Auto Level	McBain & Trush, Inc
October 12-14, 2005	589, 611, 613	As-built surveys of Patches 1 - 6. Generate an as-built contour map with 1 ft accuracy and corrisponding digital terrain model (DTM)	California State Plane, Zone 3, NAD 83 & NGVD 29	Total Station	McBain & Trush, Inc
Octboer 12, 2005	589	As-built surveys of Patch 5 and floodway to generate an as-built contour map with 1 ft accuracy and corrisponding digital terrain model (DTM)	California State Plane, Zone 3, NAD 83 & NGVD 29	RTK GPS	Del Terra, Inc.
October 14, 2005	613	Survey monitoring cross section post-construction	NGVD 29	Auto Level	McBain & Trush, Inc

Table 3. Summary of Bobcat Flat cross sections and year of survey.

Cross Section	Year Surveyed 2003	Year Surveyed 2005
2394+00		●
2395+90		●
2398+10	●	
2399+10	●	
2400+50	●	●
2403+40	●	●
2403+95		●
2408+10		●
2408+75	●	●
2412+10	●	●
2412+90	●	●
2413+20		●
2414+00		●

Table 4. Sieve sizes used by Kleinfelder in bulk sample analysis.

Gradation	Sieve (in)	Sieve (mm)	Particle size
6"	6.00	165.00	COBBLE
5"	5.00	127.00	
4"	4.00	101.60	
3"	3.00	76.20	
2"	2.00	50.80	GRAVEL
1"	1.00	25.40	
3/4"	0.75	19.05	
1/2"	0.50	12.70	
3/8"	0.38	9.53	
#4	0.19	4.75	
#8	0.09	2.36	
#16	0.05	1.18	SAND
#30	0.02	0.60	
#50	0.01	0.30	
#100	0.01	0.15	
#200	0.00	0.07	
Pan	SAND / SILT CUTOFF = 0.063mm		

Table 5. Bobcat Flat Marked rock and paint patch post-construction deployment.

Cross Section	Method	Paint Color	Stationing Established from Left Bank Pin Set at 0.0 ft.	Number Deployed	D_{84} (mm)	D_{50} (mm)	D_{31} (mm)	Comments
2413+20	Individual painted rocks representing D_{84}, D_{50}, D_{31} placed on cross section at 3 ft intervals (Figure #)	Blue	46, 49, 52, 55, 58, 61, 64, 67, 70, 73, 76, 79, 82, 85, 88, 91, 94, 97, 100, 103	20	93	55	40	D_{84}, D_{50}, D_{31} from Patch 1 pebble count
2412+90	2 x 2 ft paint patches with 2 ft intervals	Fluorescent Green	83-85, 87-89, 91-93	3				
2412+90	Individual painted rocks representing D_{84}, D_{50}, D_{31} placed on cross section at 2 ft intervals	Fluorescent Green	67, 69, 71, 73, 77, 79, 81	7	93	55	40	D_{84}, D_{50}, D_{31} from Patch 2 pebble count
2412+10	2 x 2 ft paint patches with 2 ft intervals	Fluorescent Pink	171.6-173.6, 175.6-177.6, 179.6-181.6, 183.6-185.6, 187.6-189.6, 191.6-193.6, 195.6-197.6, 199.6-201.6	7				
2412+10	Individual painted rocks representing D_{84}, D_{50}, D_{31} placed on cross section at 2 ft intervals	Fluorescent Pink	157.6, 159.6, 161.6, 163.6, 165.6, 167.6, 169.6	7	89	57	44	D_{84}, D_{50}, D_{31} from Patch 2 pebble count
2408+10	Individual painted rocks representing D_{84}, D_{50}, D_{31} placed on cross section at 2.5 ft intervals	Red	29.1, 31.6, 34.1, 36.6, 39.1, 41.6, 44.1, 46.6, 49.1, 51.6, 54.1, 56.6, 59.1, 61.6, 64.1, 66.6, 69.1, 71.6, 74.1, 76.6, 79.1, 81.6, 64.1, 86.6, 89.1	25	83	56	41	D_{84}, D_{50}, D_{31} established from Patch 3
2403+95	Individual painted rocks representing D_{84}, D_{50}, D_{31} placed on cross section at 4 ft intervals	Yellow	0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 68, 72	19	106	65	51	D_{84}, D_{50}, D_{31} established from Patch 4, Facies 1 pebble count
2403+95	Individual painted rocks representing D_{84}, D_{50}, D_{31} placed on cross section at 2.5 ft intervals	Fluorescent Yellow	74, 76.5, 79, 81.5, 84, 86.5, 89, 91.5, 94, 96.5, 99, 101.5, 104, 106.5, 109	15	73	44	34	D_{84}, D_{50}, D_{31} established from Patch 4, Facies 2 pebble count
2395+90	2 x 2 ft paint patches with 2 ft intervals	Orange	110.5-112.5, 114.5-116.5, 118.5-120.5, 122.5-124.5, 126.5-128.5, 130.5-132.5, 134.5-136.5, 138.5-140.5, 142.5-144.5, 146.5-148.5, 150.5-152.5, 154.5-156.5, 162.5-164.5, 166.5-168.5	14				No paint patch between Station 158.5 and 160.5. Ground surface below water surface elevation.
2395+90	Individual painted rocks representing D_{84}, D_{50}, D_{31} placed on cross section at 2 ft intervals	Green	33, 35, 37, 39, 41, 43, 45 & 103, 105, 107	10	83	46	35	D_{84}, D_{50}, D_{31} established from Patch 5, Facies 2 pebble count
2394+00	2 x 2 ft paint patches with 2 ft intervals	Blue	101.7-103.7, 105.7-107.7, 109.7-111.7, 113.7-115.7, 117.7-119.7, 121.7-123.7, 125.7-127.7, 129.7-131.7, 135.7-137.7	9				
2394+00	Individual painted rocks representing D_{84}, D_{50}, D_{31} placed on cross section at 2 ft intervals	Pink	71.7, 73.7, 75.7, 77.7, 79.7, 81.7, 83.7, 85.7, 87.7, 89.7, 91.7, 93.7, 95.7, 97.7, 99.7, 101.7, 103.7 105.7	18	71	43	34	D_{84}, D_{50}, D_{31} established from Patch 5, Facies 2 pebble count

Table 6. Summary of staff plate readings to monitor ground water elevations prior to construction.

Staff Plate	Elevation of the Staff Plate at 0.00 ft reading
A	125.18
B	128.86
C	130.88
D	129.19
E	127.41

Staff Plate	Date of Observation	Time	Staff Plate Reading (ft)	Water Surface Elevation (ft)	Discharge at La Grange Dam (cfs)	Monitoring Personnel
	10/21/2003	4:15 PM	3.65	128.83	376	McBain and Trush
	11/10/2003	8:30 AM	3.96	129.14	229	McBain and Trush
	2/16/2004	N/A	3.44	128.62	218	Friends of the Tuolumne
	2/28/2004	N/A	5.00	130.18	215	Friends of the Tuolumne
	3/4/2004	2:00 PM	4.84	130.02	550	McBain and Trush
A	3/14/2004	N/A	4.80	129.98	1100	Friends of the Tuolumne
	3/18/2004	N/A	5.96	131.14	2,810	Friends of the Tuolumne
	3/27/2004	N/A	4.78	129.96	570	Friends of the Tuolumne
	4/10/2004	N/A	4.60	129.78	820	Friends of the Tuolumne
	4/25/2004	N/A	4.52	129.70	629	Friends of the Tuolumne
	10/21/2003	4:30 PM	3.42	132.28	376	McBain and Trush
	11/10/2003	8:45 AM	3.47	132.33	229	McBain and Trush
	2/16/2004	N/A	3.56	132.42	218	Friends of the Tuolumne
	2/28/2004	N/A	NA	NA	215	Friends of the Tuolumne
	3/4/2004	2:00 PM	3.84	132.70	550	McBain and Trush
B	3/14/2004	N/A	4.16	133.02	1100	Friends of the Tuolumne
	3/18/2004	N/A	5.48	134.34	2,810	Friends of the Tuolumne
	3/27/2004	N/A	3.92	132.78	570	Friends of the Tuolumne
	4/10/2004	N/A	4.14	133.00	820	Friends of the Tuolumne
	4/25/2004	N/A	3.90	132.76	629	Friends of the Tuolumne
	10/21/2003	4:45 PM	3.61	134.49	376	McBain and Trush
	11/10/2003	9:30 AM	3.70	134.58	229	McBain and Trush
	2/16/2004	N/A	3.82	134.70	218	Friends of the Tuolumne
	2/28/2004	N/A	3.98	134.86	215	Friends of the Tuolumne
	3/4/2004	2:00 PM	3.94	134.82	550	McBain and Trush
C	3/14/2004	N/A	4.86	135.74	1100	Friends of the Tuolumne
	3/18/2004	N/A	3.88	134.76	2,810	Friends of the Tuolumne
	3/27/2004	N/A	3.85	134.73	570	Friends of the Tuolumne
	4/10/2004	N/A	4.00	134.88	820	Friends of the Tuolumne
	4/25/2004	N/A	3.80	134.68	629	Friends of the Tuolumne
	10/21/2003	5:00 PM	3.77	132.96	376	McBain and Trush
	11/10/2003	9:00 AM	3.81	133.00	229	McBain and Trush
	2/16/2004	N/A	3.9	133.09	218	Friends of the Tuolumne
	2/28/2004	N/A	4.1	133.29	215	Friends of the Tuolumne
	3/4/2004	2:00 PM	4.01	133.20	550	McBain and Trush
D	3/14/2004	N/A	4.08	133.27	1100	Friends of the Tuolumne
	3/18/2004	N/A	5.22	134.41	2,810	Friends of the Tuolumne
	3/27/2004	N/A	3.98	133.17	570	Friends of the Tuolumne
	4/10/2004	N/A	4.26	133.45	820	Friends of the Tuolumne
	4/25/2004	N/A	3.98	133.17	629	Friends of the Tuolumne
	10/21/2003	5:30 PM	3.98	131.39	376	McBain and Trush
	11/10/2003	7:30 AM	3.85	131.26	229	McBain and Trush
	2/16/2004	N/A	3.70	131.11	218	Friends of the Tuolumne
	2/28/2004	N/A	3.72	131.13	215	Friends of the Tuolumne
	3/4/2004	2:00 PM	4.38	131.79	550	McBain and Trush
E	3/14/2004	N/A	5.30	132.71	1100	Friends of the Tuolumne
	3/18/2004	N/A	6.30	133.71	2,810	Friends of the Tuolumne
	3/27/2004	N/A	4.48	131.89	570	Friends of the Tuolumne
	4/10/2004	N/A	4.78	132.19	820	Friends of the Tuolumne
	4/25/2004	N/A	4.50	131.91	629	Friends of the Tuolumne

Table 7. Suitability criteria used for Chinook salmon spawning habitat mapped with a total station (USFWS, 1995).

Habitat Requirement	Fry Rearing	Juvenile Rearing	Adult Spawning
Depth	0.2 – 2.0 ft	0.5 – 6.5 ft	0.6 - 2.8 ft
Velocity	0.0 – 0.6 ft/sec	0.0 – 1.0 ft/sec	0.9 - 3.2 ft/sec
Substrate	Not used	Not used	13 - 102 mm
Cover	vegetation and woody debris	vegetation and woody debris	Not used

Table 8. Comparison of as-built and design volumes.

Site Description	Channel Station / Location	Surfaces Compared: Existing Ground	Surfaces Compared: As-Built	As-Built Surveys: Fill Volume (yds^3)	As-Built Surveys: Cut Volume (yds^3)	Design Estimates (Attachment A): Fill Volume (yds^3)	Design Estimates (Attachment A): Cut Volume (yds^3)	Percent Difference Between As-Built
Patch 1	2413+00 to 2415+00	July, 2005 bathymetry survey	October 12-14, 2005 total station survey	230		[1] 400		43%
Patch 2	2410+00 to 2413+00	May 23, 2003 total station survey	October 12-14, 2005 total station survey	570		[2] 800		29%
Patch 3	2406+50 to 2408+75	May 23, 2003 total station survey	October 12-14, 2005 total station survey	990		[2] 1,000		1%
Patch 4	2402+00 to 2405+25	May 23, 2003 total station survey	October 12-14, 2005 total station survey	1,450		[2] 1,500		3%
Patch 5 & 6	2393+00 to 2397+50	July, 2005 bathymetry survey	October 12-14, 2005 total station survey	7,580		[1] 8,300		9%
Floodway	N/A	November 10-11, 2003 total station survey	October 12, 2005 GPS survey		21,570		39,500	45%
[3]Stockpile 1	N/A	September 21, 2005 LIDAR survey	September 21, 2005 LIDAR survey	580				
[3]Stockpile 2	N/A	September 21, 2005 LIDAR survey	September 21, 2005 LIDAR survey	11,300				
			Sub Total (Patches and Floodway)	**10,820**	**21,570**	**12,000**	**39,500**	
			Sub Total (Stockpiles)	**11,880**				
			Total	**22,700**	**21,570**	**12,000**	**39,500**	

[1] No topographic surveys done prior to design. Volumes calculated using 2 to 4 depth readings at site.

[2] Volumes calculated using May 23, 2003 total station survey and design surface

[3] Stockpile volumes calculated by generating a new September 21, 2005 LIDAR surface without stockpile (surface generated by cutting stockpile off at the toe [intersection between pre-stockpile ground and stockpile]) and compareing that to September 21, 2005 LIDAR surface with stockpile.

Table 9. Comparisons of as-built and design patch slopes and riffle control elevations.

Patch Number	Slope		Riffle Control Elevation (ft)	
	Design	Constructed	Design	Constructed
1	N/A	N/A	128.5	129.1
2	0.0013	0.0014	N/A	N/A
3	0.0013	0.0011	128.0	127.5
4	0.0013	0.00015	127.3	127.1
5	N/A	N/A	N/A	N/A
6	0.0013	0.0097	126.0	125.1

Notes:

Patch 1 was designed and constructed as a pool tail / riffle crest. The riffle and corrisponding riffle slope was constructed as part of Patch 2.

Patch 2 was designed and constructed as a point bar and riffle. The riffle control was constructed as a portion of Patch 1.

Patch 5 was designed and constructed as a point bar.

Table 10. Bobcat Flat Pre-construction habitat areas for Chinook salmon spawning, and post-construction habitat areas for Chinook salmon spawning, Chinook salmon fry and juvenile rearing, and adult slamonid holding.

Habitat Mapped	Pre-Construction (ft^2)	Post-Construction (ft^2)	Mapping Method
Chinook Spawning	6,240	35,600	Field mapped onto 1"=50' laminated November 17, 2000 aerial photos using Chinook salmon spawning criteria (Table 3)
Chinook Spawning	Not Mapped	29,960	Surveyed with total station using Chinook salmon spawning criteria (Table 3)
Chinook Fry Rearing	Not Mapped	16,730	Field mapped onto 1"=50' laminated November 17, 2000 aerial photos using Chinook salmon fry rearing criteria (Table 3)
Chinook Juvenile Rearing	Not Mapped	24,530	Field mapped onto 1"=50' laminated November 17, 2000 aerial photos using Chinook salmon juvenile rearing criteria (Table 3)
Adult Holding	Not Mapped	19,900	Field mapped onto 1"=50' laminated November 17, 2000 aerial photos