DRAFT BOBCAT FLAT PHASE III IMPLEMENTATION PHASING STRATEGY

Technical Memorandum: Bobcat Flat Phase III, Supplemental Deliverable for the Fisheries Restoration Grants Program Agreement Number – Q1940403

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1 INTRODUCTION AND BACKGROUND

This draft memorandum is intended to provide an implementation phasing strategy for restoring the 190-acre Bobcat Flat Phase III project site. As a draft memorandum, comments received from the California Department of Fish and Wildlife (CDFW) and other partners will be addressed prior to construction.

Bobcat Flat is located within the Dredger Tailing Reach of the lower Tuolumne River, approximately 44 river miles (RM) upstream of the confluence of the Tuolumne River with the San Joaquin River, approximately 5 RM west of the community of La Grange and 27 miles east of Modesto. Restoration of Bobcat Flat was initiated in 2003 as a multi-phase project to restore geomorphic function and habitat for target species within the Dredger Tailing Reach. The Bobcat Flat project is currently in Phase III, which began in October 2017. To date, products and analyses from collected data include conceptual designs; digital terrain models (DTM) of existing conditions; revised 30% design alternatives and options analysis; 65%, 90%, and 100% designs; 2-dimentional (2-D) hydraulic modeling of existing conditions, 30%, 65%, 90%, and 100% designs; and geomorphic, biologic, and riparian analyses.

The Tuolumne River is one of three major tributaries to the San Joaquin River that drain the west slopes of the Sierra Nevada. Beginning with the Gold Rush in 1848, the Tuolumne River has been extensively modified by land use practices (agriculture, ranching, and urbanization) and resource extraction (water for irrigation and municipal use, gold mining, and aggregate mining). Streamflow regulation began with construction of Wheaton Dam (1871) and La Grange Dam (1893) and culminated in 1971 with construction of the New Don Pedro Project (NDPP). During the first half of the 1900s, gold dredging of the channel and floodplain around RM 43 resulted in large, cobble-armored tailings piles separated by dredger sloughs that replaced the natural alluvial deposits and floodplain soils. In the 1960s, many of the tailings were excavated to provide construction material for NDP Dam. These areas, including the project site, remain largely barren, unproductive surfaces with exposed coarse sediment/cobble and little or no soil layer.

The current condition contributes little salmonid habitat for the lower Tuolumne River relative to the historic condition due to dredge mining converting the channel morphology from a natural pool–riffle sequence to a "lake–cascade" morphology, which is characterized by a series of deeper/longer pools and steep riffles (Figure 1). This conversion removed numerous low-gradient riffles highly conducive to salmonid spawning and rearing habitat for Chinook Salmon

(*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) to a smaller number of high-gradient riffles separated by long backwater pools. This conversion to steep riffles and long pools resulted in a dramatic decrease in Chinook Salmon and steelhead (*Oncorhynchus mykiss*) spawning and rearing habitat due to adverse hydraulic conditions (higher gradient, higher velocities) and reduced number of riffles. Additionally, the lack of coarse sediment supply below the dam, combined with regulated flows from NDP Dam, has contributed to the loss of salmonid habitat.

2 PROJECT OBJECTIVES

Project objectives for Bobcat Flat Phase III are focused on creating a dynamic system where ecological and geomorphic aspects evolve together. The restoration objectives have an ecological and geomorphic perspective that is focused on readjusting the river's scale to function naturally under contemporary flow and sediment regimes.

There are four primary objectives:

1. Scale surfaces adjacent to the mainstem channel and reconnect the river to its floodplains so adjacent surfaces can function under the contemporary regulated flow regime;
2. Create low-gradient riffles with a slope of less than 0.2% by redistributing the elevation drop in the short, steep riffles to restructure the lake–cascade channel morphology (Figure 1) to be a more natural pool–riffle morphology (Figure 2);
3. Reduce predator habitat; and
4. Increase off-channel and river edge rearing habitat for fry and juvenile salmonids via construction of low-flow side channels and annually inundated floodplain benches.

If achieved, these four objectives should create a lasting impact on aquatic, terrestrial, and riparian species by improving existing degraded habitat and providing additional new habitat.

3 PROJECT DESCRIPTION

The Bobcat Flat Phase III (Phase III) project encompasses approximately 190 acres and 0.9 miles of the Tuolumne River. The downstream 0.6 miles of mainstem channel begins at what remains of Riffle 18, consisting of a straight 4–8 ft deep section of channel with little topographic complexity (Figure 3). High flows have begun to rework the upstream 0.3 miles of channel, creating complex alluvial features such as, pools, eroding banks, and adjacent surfaces that inundate frequently under contemporary flows. The channel bottom is clay hardpan overlayed with pockets of coarse sediment (i.e., cobble and gravel). The limited coarse sediment within the project reach provides some macroinvertebrate production, while the remaining two riffles at the upstream and downstream ends of the project include areas of suitable salmonid spawning. The limited spawning areas are near the upstream end of the riffles, after that the riffles become steep with slopes exceeding 0.2%, consistent with the conceptual model shown in Figure 1.

A majority of the surfaces (unconnected floodplains) adjacent to the mainstem channel consist of an armored layer of coarse sediment (gravels and cobbles) one to several feet thick that is devoid of woody riparian vegetation and isolated from contemporary surface flows and groundwater. What vegetation exists on these surfaces consists of non-native grasses and yellow star-thistle. Interspersed throughout the Phase III project area large dredger ponds, swales, and sloughs which support warm water non-native predatory fish and aquatic vegetation.

The dredger ponds and sloughs vary in their connectivity to the mainstem channel. Some have flow year-round while others are isolated except during annual high flow events. Dredger ponds and sloughs have near vertical banks and bottoms that are comprised of silt and organic matter up to several feet thick. These ponds and sloughs provide little to no salmonid habitat but do provide habitat for a variety of native species, such as wood ducks and Western Pond turtles. However, these areas that are connected to the river also provide refugia for predatory species, such as Largemouth and Smallmouth Bass and bullfrogs.

The Phase III design includes recovery of coarse sediment resources throughout the site by lowering adjacent surfaces to interact with contemporary flows, and through the construction of side channels (Figure 4 and McBain Associates, 2021). Recovered coarse sediment would then be used to construct in-channel bars and riffles, as well as to modify the geometry of existing sloughs and ponds to reduce non-native predator habitat while improving native species habitat (Figure 4 and McBain Associates, 2021). Test pit investigations conducted during the initial site investigation in October 2017 were used to estimate the recoverable volume of coarse sediment (i.e., gravel) available for recovery within the Phase III project boundary (Section 4). The Phase III 100% design, supporting analyses, and report were finalized in 2021 (McBain Associates, 2021). Implementation of the Phase III project is expected to be performed over multiple years along with annual monitoring (as funding allows) to assess effectiveness of the design. Coarse sediment excavated from adjacent surfaces will be sorted to include 1/4 to 5 inch material that will be placed in the channel.

Bobcat Flat downstream projects (Phases I and II) that included coarse sediment recovery, sorting and restoration of in-channel bars and riffles were monitored by U.S. Fish and Wildlife Service (USFWS). Monitoring of these features following construction showed immediate increases in channel complexity, invertebrate habitat, and salmonid habitat within the project site (Benn and Gard, 2019). However, over time, large flows are expected to mobilize (as intended) coarse sediment to downstream reaches. Monitoring by USFWS within the Bobcat Flat Phase I and II project areas, as well as reaches directly downstream, concluded that constructed reaches lost coarse sediment resulting in diminished channel complexity and salmonid habitat while in downstream reaches the channel became more complex and salmonid habitat increased (Benn and Gard, 2019). The USFWS monitoring of Bobcat Flat Phase I and II projects provides support for an implementation strategy that maximizes coarse sediment placement within the Phase III mainstem channel as well as periodic replenishment to maintain designed complexity.

4 AVAILABLE COARSE SEDIMENT RESOURCES

Coarse sediment resources are prevalent throughout the Phase III site as a result of historic dredger mining and subsequent excavation of dredger tailings for the construction of New Don Pedro Dam. These materials will be recovered via excavation, sorting, and cleaning for use in the construction of Phase III bars and riffles. Based on initial test pit investigations (Figure 5) the estimated volume of recoverable coarse sediment resources associated with the Phase III 100% design is approximately 218,800 cubic yards (Table 1). The Tuolumne River Conservancy is dedicated to recovering and placing the entire 218,800 cubic yards into the Tuolumne River mainstem channel.

5 DETERMINING RATE AND FREQUENCY NEEDED TO REPLENISH PHASE III IN-CHANNEL DESIGN FEATURES

The estimated initial coarse sediment volume (1/4 to 5 inch) required to build the Phase III 100% designs includes 4,700 cubic yards within floodplain areas, 4,000 cubic yards within side channels, and 65,300 cubic yards associated with in-channel features, totaling 74,000 cubic yards. In addition, a 20% contingency (15,000 cubic yards) is added to the initial 74,000 cubic yards making the anticipated volume of coarse sediment needed to construct the Phase III 100% designs 89,000 cubic yards (Table 1, McBain Associates, 2021). Existing mobility monitoring and associated analyses in the Lower Tuolumne River Coarse Sediment Management Plan (McBain & Trush 2004) and TID/MID Spawning Gravel Report (Stillwater 2013), as well as an updated flood frequency and flow duration analysis, were used to estimate the rate and frequency that coarse sediment would be needed to replenish Phase III in-channel design features. Additionally, large pools upstream of the Phase III project at RM 48 (Basso) and RM 46 (Zanker) function as sediment sinks capturing what little coarse sediment is transported from upstream reaches. Therefore, the analysis below assumes that no coarse sediment is routing into the Phase III project site from upstream reaches (transport out of the Phase III reach only, no upstream supply).

The following bed mobility thresholds were selected from existing documents and provide a range of flows to evaluate:

- 5,400 cfs (low estimate; Stillwater, 2013)
- 6,880 cfs (high estimate; Stillwater, 2013))
- 8,000 cfs (McBain and Trush, 2004)

Using the period of record from 1971 to 2021 (50-years), daily average flow at La Grange (USGS Gage#: 11-289500) exceeded the mobility thresholds as follows:

- 5,400 cfs: 16 years (32%)
- 6,880 cfs: 13 years (26%)
- 8,000 cfs: 9 years (18%)

The volume of coarse sediment transported to downstream reaches was estimated using the bedload rating curve generated from 2005 measured bedload data at Tuolumne River Riffle 4b (Figure 7). The Riffle 4b bedload rating curve was applied to each year having a daily average flow exceeding the mobility threshold. Based on the Riffle 4b bedload rating curve, 107,581 tons of coarse sediment would be mobilized at a flow of 5,400 cfs over the 50 year period analyzed (Table 2 and Figure 8). Years where flows did not exceed mobility thresholds transport were assumed to be zero. Taking the total volume transported 107,581 tons and dividing the total by the 50 year period analyzed, the estimated annual volume of coarse sediment transported would be 2,152 tons (1,655 cubic yards) per year (Table 2).

The Phase III 100% design estimates that 74,000 cubic yards of coarse sediment is needed to build the entire project with 65,300 cubic yards associated with in-channel features (Table 1). The total including the 20% contingency for these in-channel features is 78,400 cubic yards. The number of years estimated to mobilize the in-channel features downstream was determined by dividing 78,400 cubic yards by 1,655 cubic yards/year (Table 2). The total number of years to transport 78,400 cubic yards is estimated to be 47 (Table 2). The remaining coarse sediment available after the initial placement is 129,800 cubic yards. Assuming another 39 years to transport 64,900 cubic yards of the second coarse sediment placement (half of the remaining 129,800 cubic yards), the total number of years to place all 218, 800 cubic yards of coarse sediment is estimated to be 86 years (Table 2).

However, the estimate does not account for extreme events such as the January 1997 flood that exceeded 40,000 cfs and provides conservative estimates for years where flows exceed mobility thresholds for long periods of time, such as 2017 when flows exceeded 5,400 cfs for 153 days. These types of extreme events could occur at any time. For example, should a 2017 event occur directly following implementation, an estimated 31,273 tons (24,000 cubic yards) of the coarse sediment placed into the channel could be mobilized and transported to downstream reaches (Table 2). High flow events like these would expedite the time period necessary to restore adjacent surface and subsequently the coarse sediment needed to restore the in-channel design features to the 100% design grade.

Ultimately, monitoring of the Phase III in-channel features after flows that exceed 5,400 cfs is the most effective and accurate way to determine volume of coarse sediment transported to downstream reaches and subsequently the volume needed to rebuild those features. Project monitoring would consist of bathymetric surveys using a combination of RTK and sonar. A digital terrain model (DTM) would then be prepared from the data collected. The monitoring DTM would then be differenced from the as-built DTM to determine the total volume of coarse sediment mobilized downstream (and thus the volume needed to rebuild in-channel features scoured by high flows).

6 GROUPING ACTIVITY AREAS FOR IMPLEMENTATION PHASING

Bobcat Flat Phase III design activity areas are grouped based on proximity and hydraulic connectivity between features, construction logistics, and quantities of recoverable coarse sediment. Implementation of activity area groupings will occur within a single work period or multiple periods if necessary. The colored polygons in Figure 6 designate how design activity areas have been grouped. The following sections provide more detail on implementation phasing groups. The naming convention of these groups is arbitrary, however there are logistical and practical considerations that will dictate the order in which implementation phasing should occur.

6.1 Group A

Group A is colored red in Figure 6 and consists of upland areas U-2 through U-6. Coarse sediment will be recovered from upland areas in Group A (except for area U-5), cleaned and washed, then used to construct in-channel bars and riffles (orange colored Group B activity areas). All fine sediment resulting from coarse sediment recovery within areas U-2, U-3, U-4, and U-6 will be incorporated back into these borrow areas to provide a suitable substrate for native oak woodland establishment. Upland area U-5 will not be used as borrow area. Instead, the armored surface of the remnant dredger swale within area U-5 will be broken up and amended with fines to facilitate the establishment of oak woodland cover, connecting the adjacent vegetated areas immediately north and south. Excess fine sediment resulting from implementation of Groups C through E may also be incorporated into Group A upland areas as those activity areas are constructed. Fine material placed in these upland areas will be contoured to meld with the natural shape and undulations of adjacent existing ground.

Since Group A activity areas serve as the initial coarse sediment borrow area, as well as a place to distribute fines from other activity areas, implementation of this group should be performed prior to other groups so that coarse sediment resources can be recovered from existing ground before fines are incorporated and the activity areas are brought to finished grade. Upland area U-1 will serve as a contractor use area for Group A as well as all other implementation groups. U-1 will also be a temporary staging area for coarse material during construction work periods and a spoils site for fines at the end of Phase III implementation, at which point it will be contoured to meld with the natural shape and undulations of adjacent existing ground.

6.2 Group B

Group B is colored orange in Figure 6 and includes all in-channel bars, riffles, and gravel patches from IC-2 through IC-9. These areas represent sites for gravel augmentation where coarse sediment recovered from uplands, floodplain lowering, and side channel excavation will be introduced to the river. Some or part of the coarse sediment will be routed downstream by flow events. Initially, these features will be constructed with recovered coarse sediment from Group A activity areas (initial borrow areas). As flow events transport coarse sediment in these features downstream in the years following implementation, the features will be replenished with coarse sediment recovered from other implementation groups. This strategy of lowering adjacent surfaces to recover coarse sediment, sort, wash, and place into the mainstem channel fulfills objectives of the Phase III project (Section 2) as well as the responsibility to utilize recoverable coarse sediment resources within the site for gravel augmentation within the river.

6.3 Group C

Group C is colored blue in Figure 6 and includes: the upper half of side channel SC-1; side channels SC-2 and SC-3; wetlands W-1 to W-3; IC-1; and floodplains FP-1 and FP-2. Areas C-1 and C-2 will be the primary contractor use and staging area for the implementation of Group C. The inclusion of SC-2 and SC-3 allow the upstream portion of area SC-1 to function as a side channel independent of the construction of the downstream portion. Floodplains FP-1 and FP-2 are hydraulically connected to SC-1, allowing flow to interact with these areas when inundation thresholds are met. Material excavated from the side channels and floodplains in Group C will be used to construct IC-1 (using recovered coarse sediment) and wetlands W-1 to W-3 (using unsorted fill or fines). Excavated material will also be sorted to recover coarse sediment for use in replenishing Group B coarse sediment augmentation patches as they are depleted by natural recruitment into the river. Floodplain areas will be planted with grass seed for erosion control and meadow enhancement. No planting will be done within the side channel or any existing scour channel or on its slopes in order to maintain or improve flood conveyance.

All design features included in Group C will function independent of the construction of other implementation groups. In terms of logistics, the construction of side channel SC-1 will disrupt the path required for heavy equipment to reach activity areas in the river as well as floodplain FP-4 from upland area U-1/contractor use area C-1. A wet ford will be constructed to allow heavy equipment access between these areas during the implementation of Group D (see Section 6.4) and when replenishing gravel to IC-2 and decommissioned when construction activities are complete. The function of the lower portion of SC-1 will be dependent on whether or not the upper half is constructed first: SC-1 as a whole will function as designed when the full length of the side channel is constructed; the lower half of SC-1 alone will lower the floodplain and inundate during flood flows and will not function as a flow-through side channel unless the inlet and upper half of the channel are constructed. This consideration will affect the sequencing of implementation for Group C and Group E (see Section 6.5).

6.4 Group D

Group D is colored green in Figure 6 and consists of the floodplain areas FP-3, FP-4, and FP-5. Areas C-1 and C-3 will be the contractor use and staging areas for implementation of Group D. Implementation of this group will create high and low flow floodplains that are hydraulically connected to side channel SC-1 and the mainstem channel. Excavation will yield recoverable coarse sediment for use in replenishing Group B gravel augmentation bars and riffles as they are depleted by natural recruitment by the river. Floodplain areas will be planted with grass seed for erosion control and meadow enhancement. No planting will be done within the side channel or any existing scour channel or on its slopes in order to maintain or improve flood conveyance.

While FP-4 will still function as a floodplain for the Tuolumne River, floodplains FP-3 and FP-5 are hydraulically connected to SC-1 and not the mainstem channel. These floodplains will not provide the benefits of off-channel rearing habitat for salmonids in the absence of SC-1. Additionally, the increase in groundwater table elevation expected to accompany the construction of SC-1 would greatly benefit the natural recruitment or establishment of riparian plantings within floodplains FP-3 and FP-5. Considering construction logistics of other groups, implementation of Group C activity areas would require access routes through floodplain FP-3 and FP-4. If Group D is implemented before Group C, heavy equipment access routes would most likely damage riparian vegetation in FP-3 and FP-4. These considerations will affect the sequencing of implementation for Group D with respect to Group C.

6.5 Group E

Group E is colored yellow in Figure 6 and includes the downstream half of side channel SC-1, side channel SC-4, and floodplain areas FP-6 and FP-7. Excavation will yield recoverable coarse sediment for use in replenishing Group B gravel augmentation patches as they are depleted by recruitment into the river. Floodplain areas will be planted with grass seed for erosion control and meadow enhancement. No planting will be done within the side channel or any existing scour channel or on its slopes in order to maintain or improve flood conveyance.

The hydraulic performance and habitat function of the design features in Group E are dependent on the construction of other design features. The inlet to SC-1 is not included in Group E, and flow through SC-4 is dependent on flow through SC-1. Without the existence of the upstream end of SC-1, both Group E side channels will function as backwater alcoves rather than flowing side channels. This would reduce the amount of year-round off-channel rearing habitat created by the side channels compared to the results if the full length of SC-1 had been constructed. Additionally, the majority of FP-6 and FP-7 is hydraulically connected to the SC-1 and SC-4, while only a portion is adjacent to the mainstem channel. The increase in groundwater table elevation expected to accompany the construction of the entirety of SC-1 would greatly benefit the natural recruitment or establishment of riparian plantings within these floodplains. Overall flood conveyance for the site will be higher if the entirety of SC-1 is constructed compared to Group E features alone. These considerations will affect the sequencing of implementation for Group E with respect to other groups.

7 SUMMARY

The Phase III design activity areas (floodplain areas, side channels, and in-channel features) were grouped based on proximity, construction logistics, and quantities of recoverable coarse sediment (Section 5). Depending on funding, annual peak flows, and monitoring results, the Phase III project is expected be constructed over multiple years. Assuming a 50 year average annual transport rate of 1,655 cubic yards, Section 5 estimates it will take 86-years to place all 218,800 cubic yards of coarse sediment into the mainstem channel. In order to maximize sediment transport potential, the in-channel features will be constructed as part of the first phase. Surfaces directly adjacent to in-channel features IC-2 through IC-9 (Figure 4) would be the last areas excavated to maintain access for future coarse sediment additions as well as to provide confinement that will help mainstem velocities and subsequently transport sediments downstream. In this way, coarse sediment will be introduced to the river gradually, allowing for geomorphic processes to reach a dynamic equilibrium before additional surfaces are excavated and coarse sediment added to in-channel features. In-channel work is limited to July to October as described in the Streambed Alteration Application (SBAA) submitted to California Department of Fish and Wildlife (CDFW) for the project. It is anticipated that the first project would require 2-years to place the estimated 78,400 cubic yards (includes 20% contingency) of coarse sediment into the mainstem channel. Monitoring of the Phase III project is recommended to better determine coarse sediment quantities needed to maintain constructed in-channel features.

The second project recommended for implementation is Group C which may be constructed without jeopardizing project access to Group D areas (Figure 6). The remaining Groups (D and E) would be phased in this manner to allow time for peak flow events to mobilize the coarse sediment that comprises riffles and bars (IC-2 through IC-9, Figure 4), transporting it downstream. As surfaces associated with groups D and E are lowered, coarse sediment sorted and washed from these areas would be used to re-build in-channel features.

Over time, it is expected that ongoing coarse sediment additions upstream, near the La Grange dam, would restore coarse sediment balance to the Lower Tuolumne River providing a continuous supply to Bobcat Flat that would maintain channel complexity and associated habitats. It is estimated that prior to the downstream transport and distribution of the upstream gravel augmentations by TID, all 218,800 cubic yards of available coarse sediment at Bobcat Flat Phase III would need to be placed into the Bobcat Flat Phase III in-channel areas.

8 REFERENCES

Benn, E.K. and M. Gard. 2019. Bobcat Flat Rehabilitation Project, Post-Project Effectiveness Monitoring of Juvenile Salmonid Rearing, Years 2013, 2014, and 2018, Tuolumne River, CA. Stockton Fish and Wildlife Office, Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service, Lodi, California.

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McBain & Trush, 2004. Coarse Sediment Plan for the Lower Tuolumne River. Revised Final Report, Prepared for the Tuolumne River Technical Advisory Committee, Turlock California Bay-Delta Authority, Arcata, CA.

Stillwater Sciences, 2013. Spawning Grave in the Lower Tuolumne River. Study Report Don Pedro Project FERC No. 2299. Prepared for Turlock Irrigation District and Modesto Irrigation District.

9 FIGURES AND TABLES

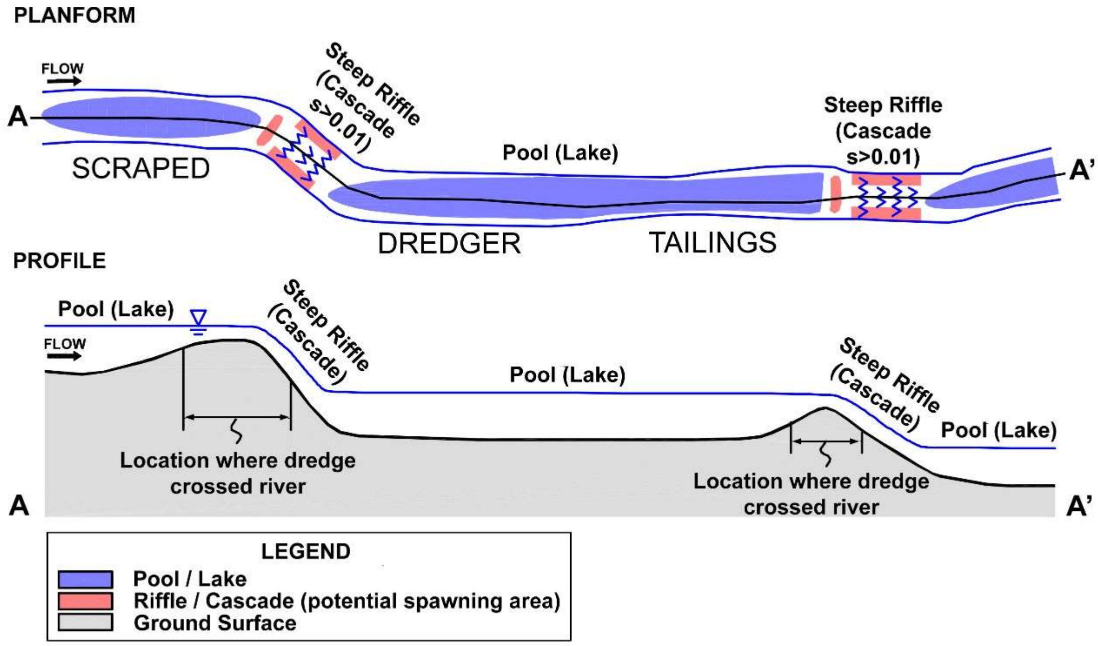

Figure 1. Post-gold dredge mining planform and longitudinal profile conceptual model showing the impacts of mining on the channel through the disruption of natural pool–riffle segments and creation of long stagnant pools separated by over-steepened riffles.

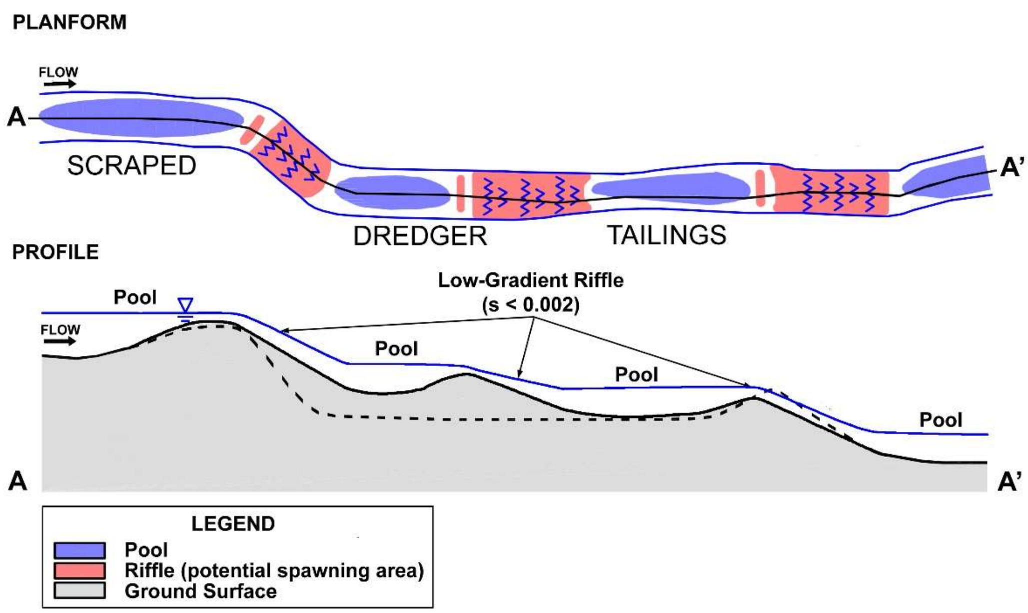

Figure 2. Example of riffle slope redistribution from steep riffles associated with existing lake–cascade channel morphology by constructing intermediate riffles and bars that backwater into the steep upstream riffle.

Figure 3. Bobcat Flat Phase III existing project site map describing major area of focus for rehabilitation. Image date: October 27, 2017, from DJI Phantom 4 drone, when flows were 440 cfs.

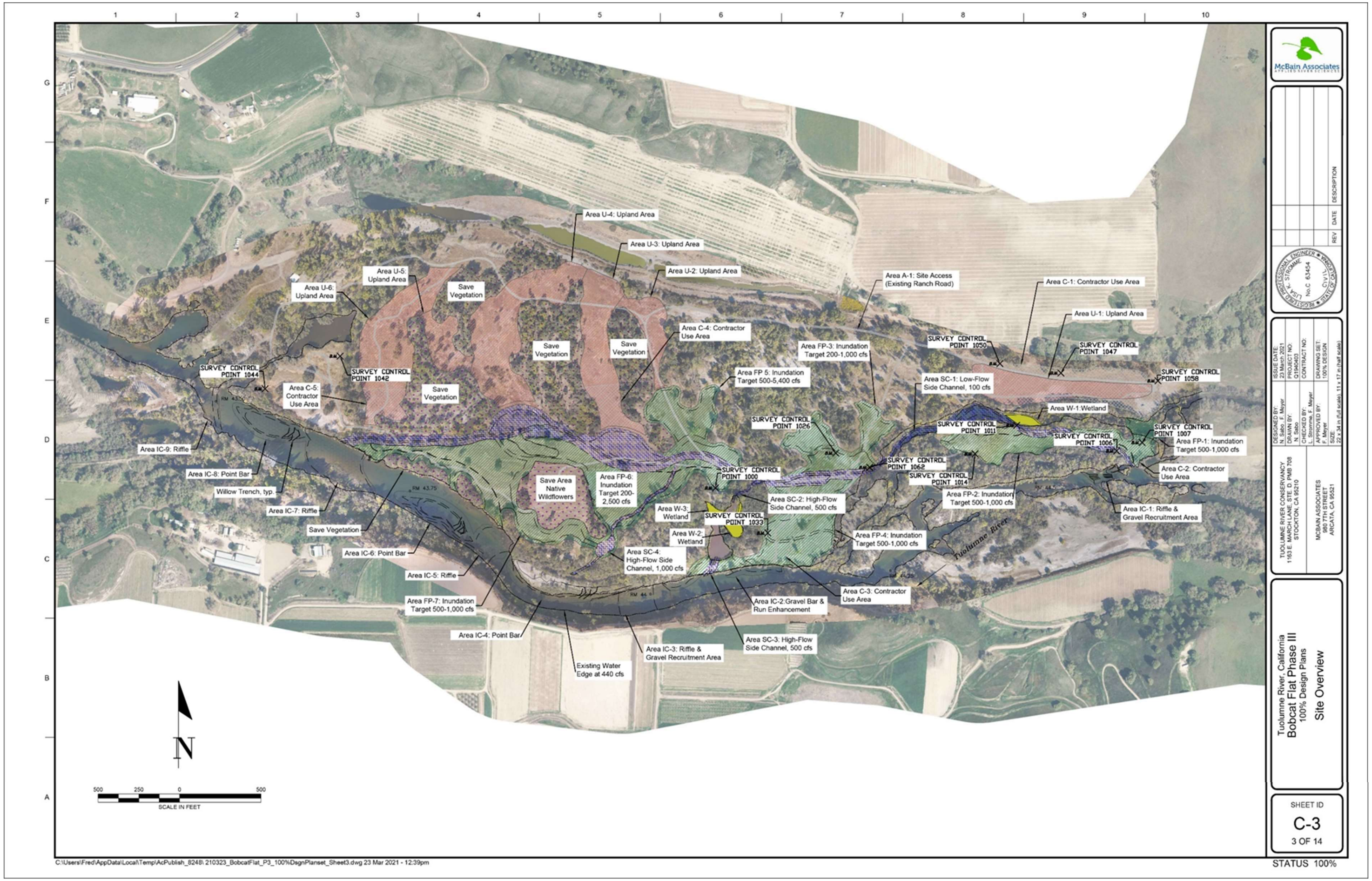

Figure 4. Planform overview sheet for Bobcat Flat Phase III 100% Design.

100%	Average volume in map area (yd^3)		
Map area	Less than 2 mm (0.08 in)	2 mm to 64 mm (0.08 in - 2.5 in)	64 mm to 128 mm (2.5 in - 5 in)
1	2,200	16,900	3,700
2	2,200	7,100	1,500
3	20,600	46,700	13,200
4	1,700	15,500	6,300
5	5,000	27,900	10,700
6	9,700	59,000	6,100
7	14,800	20,100	8,500
8	1,400	15,800	4,400

75%	Average volume in map area (yd^3)		
Map area	Less than 2 mm (0.08 in)	2 mm to 64 mm (0.08 in - 2.5 in)	64 mm to 128 mm (2.5 in - 5 in)
1	1,650	12,675	2,775
2	1,650	5,325	1,125
3	15,450	35,025	9,900
4	1,275	11,625	4,725
5	3,750	20,925	8,025
6	7,275	44,250	4,575
7	11,100	15,075	6,375
8	1,050	11,850	3,300

50%	Average volume in map area (yd^3)		
Map area	Less than 2 mm (0.08 in)	2 mm to 64 mm (0.08 in - 2.5 in)	64 mm to 128 mm (2.5 in - 5 in)
1	1,100	8,450	1,850
2	1,100	3,550	750
3	10,300	23,350	6,600
4	850	7,750	3,150
5	2,500	13,950	5,350
6	4,850	29,500	3,050
7	7,400	10,050	4,250
8	700	7,900	2,200

25%	Average volume in map area (yd^3)		
Map area	Less than 2 mm (0.08 in)	2 mm to 64 mm (0.08 in - 2.5 in)	64 mm to 128 mm (2.5 in - 5 in)
1	550	4,225	925
2	550	1,775	375
3	5,150	11,675	3,300
4	425	3,875	1,575
5	1,250	6,975	2,675
6	2,425	14,750	1,525
7	3,700	5,025	2,125
8	350	3,950	1,100

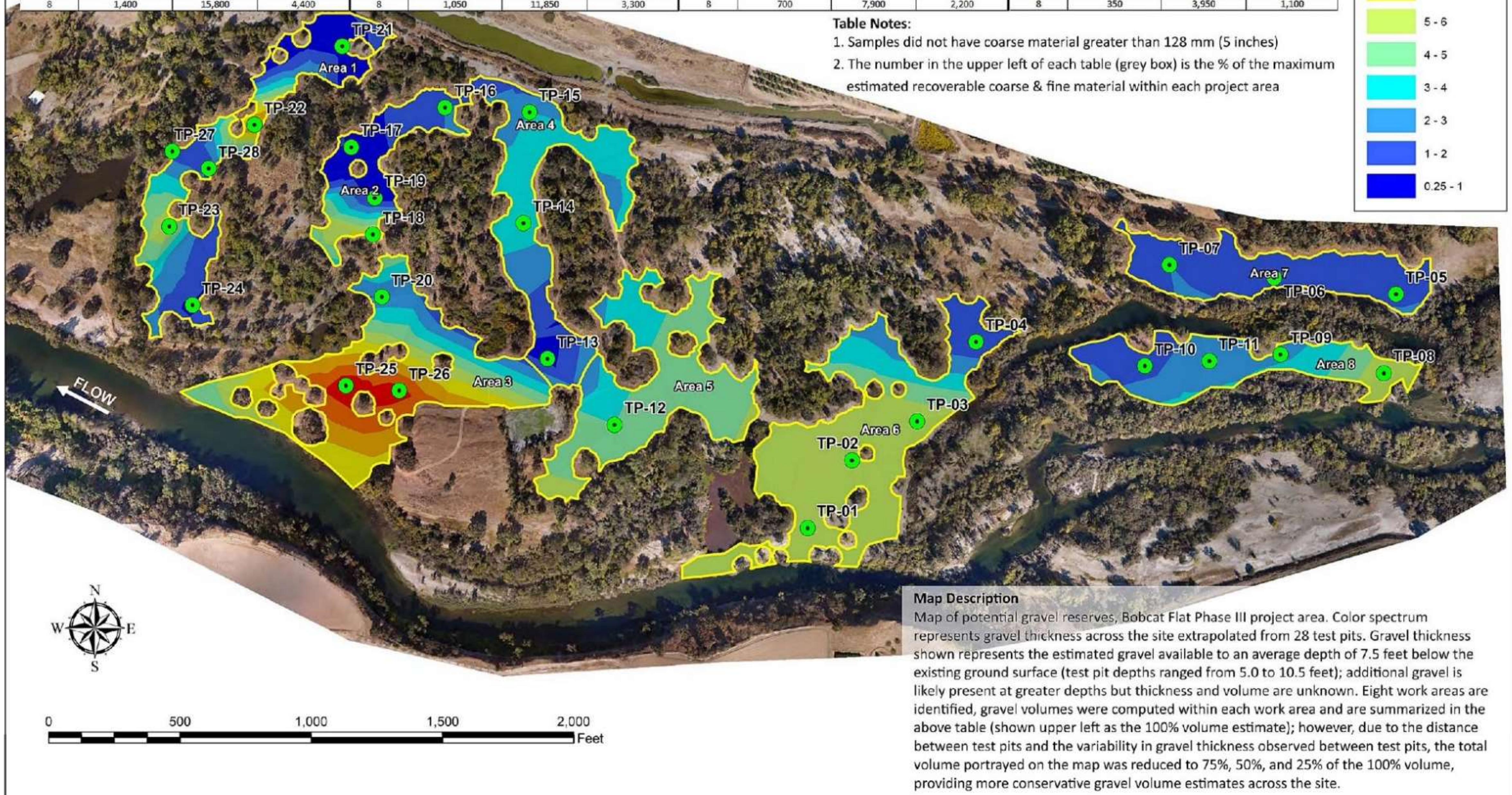

Figure 5. Map of the coarse sediment volume estimates of the maximum (100%) amount and fractions of the maximum amount of predicted coarse sediment available for harvesting. Note that Area 3 is predicted to contain the highest volume of coarse sediment.

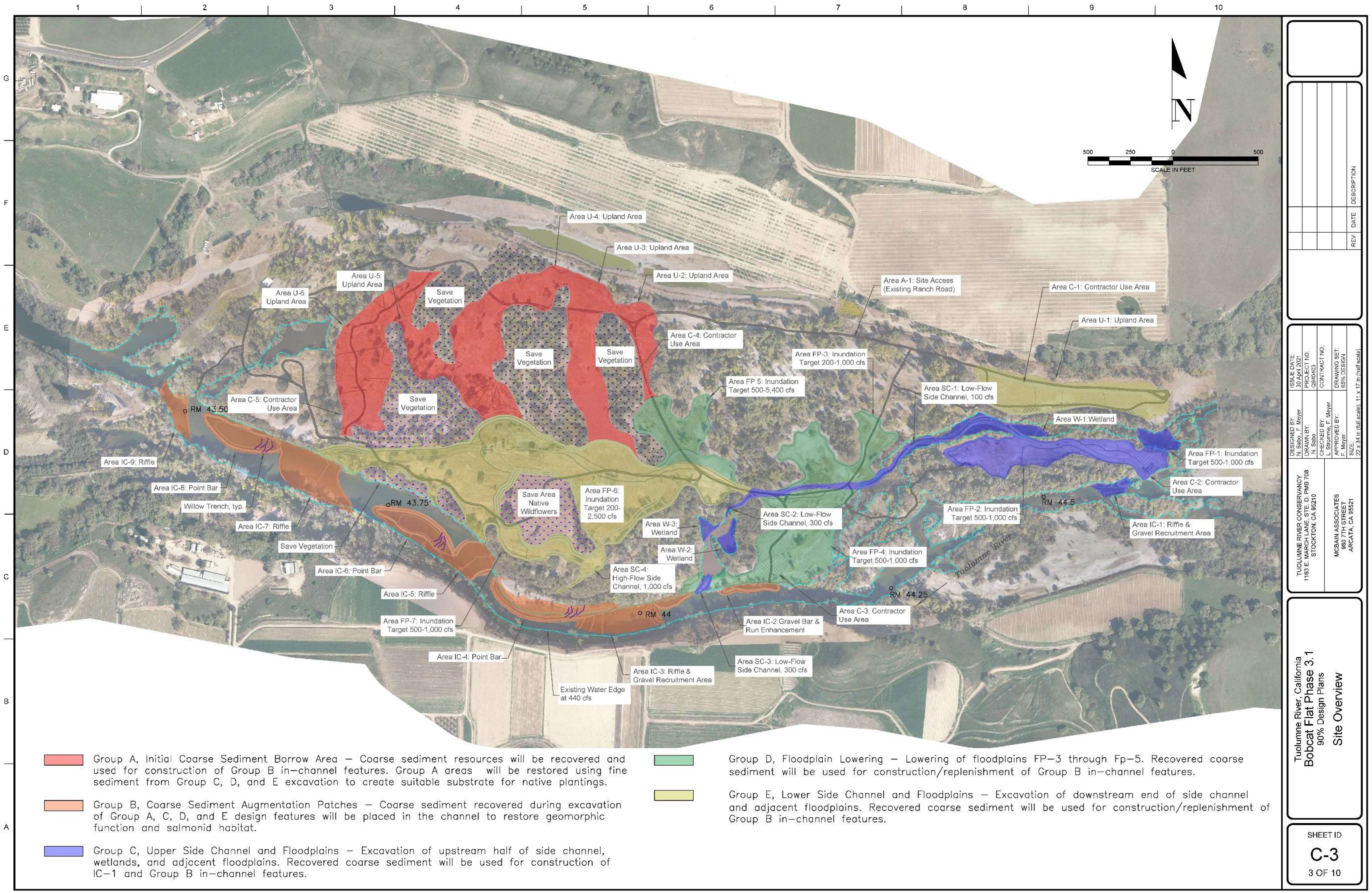

Figure 6. Bobcat Flat Phase III design activity areas grouped for implementation phasing. Colored polygons designate the activity areas within each group. One-foot contour lines displayed for design features.

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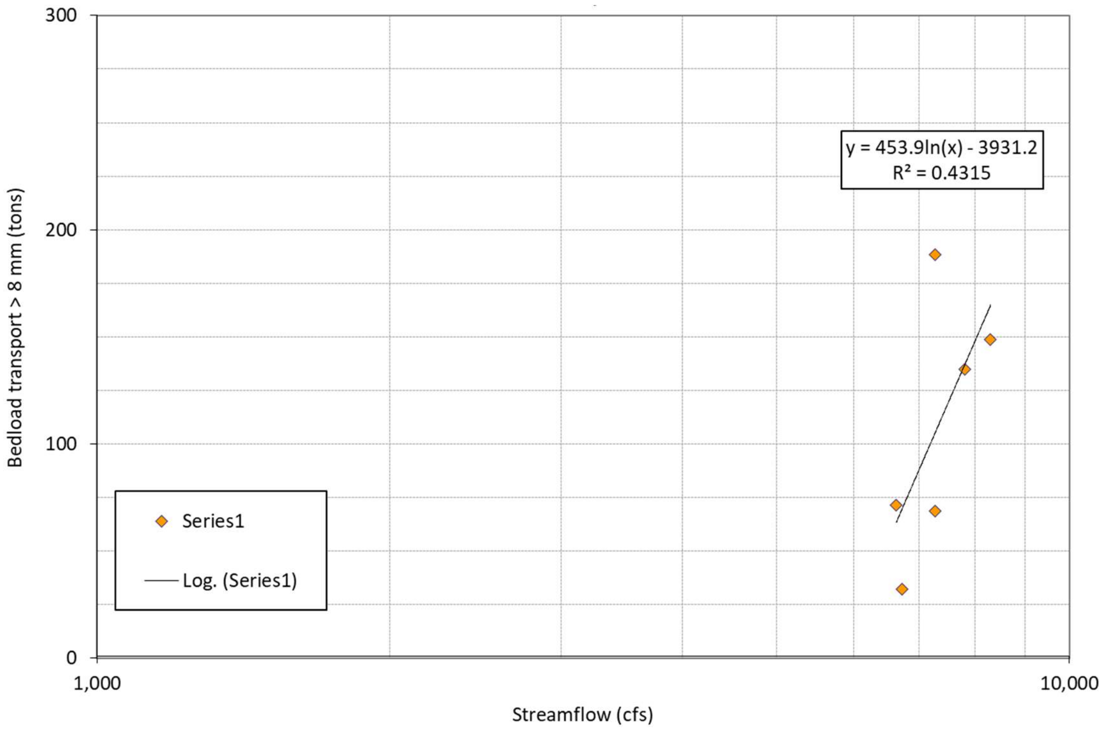

Figure 7. Sediment transport rating curve for material greater than 8 mm, generated from bedload monitoring of Lower Tuolumne River Riffle 4b between June 21-22, 2005.

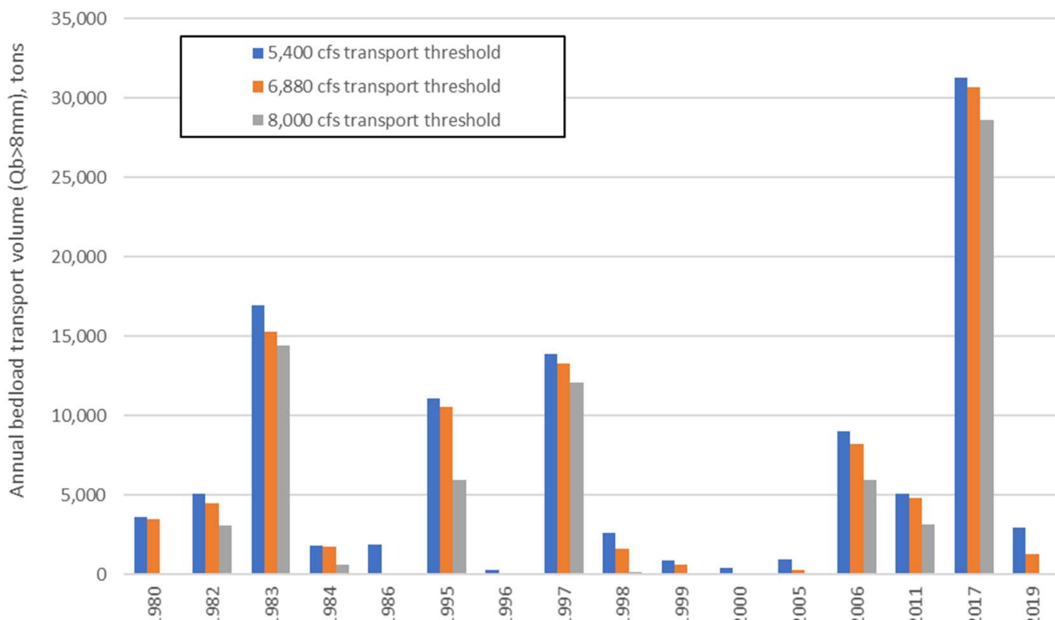

Figure 8. Lower Tuolumne River Riffle 4b predicted greater than 8 mm annual bedload transport volume plotted from Table 2.

Table 1. Bobcat Flat Phase III 100% design cut and fill volumes, area, estimated usable coarse sediment, and remaining sand based on the 100% design surface by work area. Note that fill quantities for upland areas represent fine sediment cut from other activity areas used to provide suitable substrate for oak woodland establishment.

Bobcat Flat Phase III 100% Design					
Feature Type	**100% Design Volumes by Area**		**Sorted 100% Design Cut by Volume**		**Total Feature Area (Acres)**
	Cut (yd^3)	**Fill (yd^3)**	**Coarse Sediment (yd^3)**	**Sand (yd^3)**	
Area FP-1	4,200	2,500	3,800	400	1.7
Area FP-2	10,100	0	9,100	1,000	2.5
Area FP-3	30,500	0	26,000	4,500	3.5
Area FP-4	29,400	0	24,900	4,500	5.1
Area FP-5	26,500	0	14,800	11,700	3.3
Area FP-6	52,000	200	27,100	24,900	4.4
Area FP-7	90,400	0	58,100	32,300	6.3
Area IC-1	0	1,600	0	0	0.3
Area IC-2	0	2,500	0	0	0.5
Area IC-3	0	5,700	0	0	1.7
Area IC-4	0	5,900	0	0	1.7
Area IC-5	0	5,900	0	0	0.9
Area IC-6	0	23,900	0	0	1.8
Area IC-7	0	4,900	0	0	2.1
Area IC-8	0	13,800	0	0	1.5
Area IC-9	0	1,100	0	0	0.7
Area SC-1	101,000	4,000	41,400	59,600	9.1
Area SC-2	700	0	500	200	0.1
Area SC-3	1,300	0	1,000	300	0.4
Area SC-4	23,300	0	12,100	11,200	2.4
Area U-1	0	92,700	0	0	4.9
Area U-2	0	14,000	0	0	1.6
Area U-3	0	39,000	0	0	4.3
Area U-4	0	59,000	0	0	6.1
Area U-5	0	0	0	0	1.5
Area U-6	0	53,400	0	0	5.8
Area W-1	0	1,300	0	0	0.2
Area W-2	0	800	0	0	0.2
Area W-3	0	700	0	0	0.3
Fines for Soil Augmentation*		36,500			
Totals	**369,400**	**369,400**	**218,800**	**150,600**	**74.8**

Table 2. Summarized Qb>8mm calculations using Riffle 4b rating curve using all data for each of the bedload transport flow options. Years where flows did not exceed 5,400 cfs are not shown.

All data rating, Qb>8mm (tons)					
			5,400 cfs transport threshold	**6,880 cfs transport threshold**	**8,000 cfs transport threshold**
Ex Wet	WY1980	1980	3,602	3,481	0
Ex Wet	WY1982	1982	5,075	4,470	3,093
Ex Wet	WY1983	1983	16,967	15,289	14,385
Wet	WY1984	1984	1,790	1,712	593
Wet	WY1986	1986	1,879	0	0
Ex Wet	WY1995	1995	11,043	10,553	5,915
Wet	WY1996	1996	250	0	0
Ex Wet	WY1997	1997	13,860	13,266	12,054
Ex Wet	WY1998	1998	2,590	1,574	149
Wet	WY1999	1999	897	571	0
Wet	WY2000	2000	411	0	0
Wet	WY2005	2005	963	271	0
Ex Wet	WY2006	2006	8,974	8,193	5,939
Ex Wet	WY2011	2011	5,057	4,777	3,151
Ex Wet	WY2017	2017	31,273	30,700	28,586
Ex Wet	WY2019	2019	2,949	1,292	0
		TOTAL volume transported (tons):	107,581	96,151	73,864
		Total no years of record (1971-2021):	50	50	50
		Average volume transported for all years of record (n=50), tons:	2,152	1,923	1,477
		Average volume transported for all years of record (n=50); Tons divided by 1.3 tons/cy (cu. yd.):	1,655	1,479	1,136
		Qb Max (tons/yr):	31,273	30,700	28,586
		Qb Min (tons/yr):	0	0	0
		Initial Phase III 100% design in-channel coarse sediment placement with 20% contingency (cu. yds.):	78,400	78,400	78,400
		Number of years to transport initial coarse sediment in-channel placement downstream (years):	47	53	69
		Remaining coarse sediment after all Phase III 100% design coarse sediment features constructed with 20% contingency; 218,800 less 89,000 (cu. yds.):	129,800	129,800	129,800
Assuming another 39 years to transport 64,900 cubic yards of the second coarse sediment placement (half of the remaining 129,800 cubic yards), the total number of years to place all 218, 800 cubic yards of coarse sediment is estimated to be 86 years.					