American River Gravel Studies 2004

Phase 3 Gravel Assessment

on the Lower American River

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I) INTRODUCTION AND OBJECTIVES

The 23 miles of unobstructed channel that lie below Nimbus Dam form the Lower American River. This portion of the river produces approximately one third of the salmon in northern California, but dams, urbanization, artificial levees, channel modification and input from the Nimbus Fish Hatchery have altered the natural balance of the system. The lower American River is the site of significant natural spawning activity for Fall run Chinook salmon, with lesser Winter and Spring runs. Salmonid populations on the Lower American River have declined dramatically from historical levels, and evidence suggests that the quantity and quality of spawning gravel is a limiting factor. For this reason, significant effort has been made to evaluate and restore habitat quality on the lower American River (Snider and Vyverberg, 1995; Vyverberg et al., 1997; DFG Technical Report no. 01-2). Activities described in this report build on existing work by examining spawning gravel quality in and near several recent gravel manipulation experiments.

Work centered around three gravel bars and adjacent areas that were the site of gravel manipulation experiments in 1999. These areas are known locally as Sailor Bar, Lower Sunrise Bar and Sacramento Bar (Fig. 1). The main emphasis of the project was to compare present-day gravel conditions in the restored areas to *pre*-restoration conditions that were documented in the California Department of Fish and Game (DFG) reports listed above. Control sites were also selected from nearby non-restored areas to describe differences between manipulated and non-manipulated areas. Measurements focused on physical conditions described in earlier reports. These included stream flow, water depth, grain size, gravel permeability, dissolved oxygen content and temperature. Previous work has identified these parameters as controlling variables for redd site selection and spawning success.

II) PROJECT OVERVIEW, SUMMARY OF PREVIOUS WORK

Work described in this report is the third phase of a concentrated effort to study salmon spawning habitat on the Lower American River. Phases 1 and 2 were partially funded by the U.S. Bureau of Reclamation (BOR) as part of the requirements of the Central Valley Project Improvement Act (CVPIA). This Act requires on-going study of the need and type of physical habitat restoration that would benefit anadromous fish within stream reaches influenced by Central Valley Project facilities. Project facilities on the American River include Folsom Dam and Nimbus Dam, which act as barriers to upstream migration of anadromous fish. Preliminary investigations of salmon spawning habitat conditions, and implementation of an experimental restoration project constructed during Fall 1999, have been primarily supported by funds provided to DFG by the BOR as outlined by the CVPIA.

<u>A) Phase 1- Spawning Use and Gravel Analysis</u>

Phase 1 of this project started in 1994, when DFG began a quantitative evaluation of of spawning gravel on the Lower American River. In this initial phase, 18 study sites were chosen to represent a variety of spawning use and geomorphic conditions. Selection was based on previous work by Snider et al. (1992), who divided the 18 river miles directly below Nimbus Dam into four river reaches based on gradient, bed material and tidal influence. Redd surveys indicated that approximately 90% of the natural spawning occurred in reach three and reach four, so these upper reaches became the focus of more intensive study. Reaches three and four are the six miles of river directly below Nimbus Dam, and contain coarse gravel bed material, with gradient ranging from 0.06 to 0.8. This stretch of river was further subdivided into 75 habitat units based on the morphology of in-stream channel features (bar forms) and channel flow characteristics. 18 of these habitat units were randomly chosen as study sites for the Phase 1 analysis, with distribution representing 6 riffles, 6 runs and 6 glides.

Within each set of riffles, runs and glides, three of the selected sites were characterized as having high spawning use, and three sites were described has having low or no spawning use. This distinction was based on aerial photograph sets taken between 1996 and 1998. In these photographs, Fall-run Chinook salmon spawning activity and distribution was monitored at different intervals during the typical salmon spawning period (November–December). Ground surveys were conducted concurrent with the aerial surveys to verify distribution and abundance of salmon redds recorded by aerial photography.

Phase 1 also included assessment of juvenile salmonid rearing (distribution and abundance) and Chinook salmon emigration (index of production). These data were developed to evaluate the response of juvenile salmon and steelhead to restoration-associated channel modifications (project level) and to identify relative changes in salmon spawning success (production index at the system scale).

Intensive physical investigations were carried out at each of the 18 habitat areas. Physical measurements focused on parameters that other studies have identified as factors for spawning site selection, including substrate composition, permeability, and intragravel conditions (e.g., dissolved oxygen, compaction). Measured physical attributes included gravel size distribution, water depth, water velocity, and substrate permeability. Physical conditions were then compared to spawning activity to identify those parameters that may be influencing spawning use (Vyverberg et al., 1997).

Results of physical and habitat use studies suggested that areas of low or no spawning use consistently contained poor intragravel conditions, primarily associated with 1) low permeability, 2) cemented or interlocking substrate materials, and 3) inappropriate gravel composition. The Phase 1 project served as the groundwork for later gravel manipulation experiments, and allowed direct comparison of spawning use, river morphology, and physical characteristics of the river system.

B) Phase 2- Gravel Manipulation Experiments

In Phase 2 of this project, three impacted sites were selected from among the 18 intensively studied habitat areas described in Phase 1. All impacted sites are located in reach 4 of the Lower American River to minimize differences in substrate and gradient.

Impacted areas all had low permeability and marginal quality spawning gravel, but the physical conditions responsible for poor quality gravel were different at each site. Low permeability and low suitability for spawning were due to combinations of excess fine sediment, excess coarse sediment, surficial armoring, clay layers, or the presence of coarse lag deposits. Treatments were designed to address the specific problems at each site, with the ultimate goal of improving spawning use. Construction was completed during low flow conditions in September 1999 at a cost of approximately $250,000.

At Sailor Bar, habitat sites 2, 3 and 7 were selected for gravel enhancement. Phase 1 analysis showed low spawning use, low permeability, gravel armoring, coarse lag deposits, and variable grain size distribution that ranged from excess fine material to excess coarse material. Gravel at this site was generally coarser than the optimal spawning grain size. Treatment at this location (habitat sites two, three and seven) included addition of finer gravel to a depth of two feet and redistribution of coarse surface gravel layers using a heavy ripping blade.

At Lower Sunrise Access habitat sites 37 and 39 were selected for gravel enhancement. Phase 1 analysis showed spawning use ranging from low to high, with consistently low permeability, some coarse lag deposits, some armoring, and subsurface clay layers. This site (habitat sites 37 and 39) was treated by loosening the substrate to a depth of 60 cm (2 ft) using a ripping blade and adding gravel of intermediate size to a depth of one foot.

At Sacramento Bar, habitat site 42 was chosen as part of the gravel manipulation experiment. Phase 1 analysis showed high spawning use, but low permeability and some presence of excess fine material. Gravel at habitat site 42 was treated by loosening the substrate to a depth of 60 cm (2 ft) with a ripping blade, and lowering the gradient of the point bar to allow spawning fish more access to shallow, near-shore habitat. Appropriate sized gravel was added to a depth of two feet.

A summary of gravel added is given below (Kris Vyverberg, personal communication):

Habitat Site	Project area dimensions	Amount of Gravel to be Added to the River at Each Project Site
2	200' x 50' = 10,000 ft^2	gravel to a depth of 2' [200'x50'x2' of gravel = 20,000 ft^3 = 1,000 tons of gravel]
3	200' x 50' = 10,000 ft^2	gravel to a depth of 2' [200'x50'x2' of gravel = 20,000 ft^3 = 1,000 tons of gravel]
7	200' x 50' = 10,000 ft^2	gravel to a depth of 1' [200'x50'x1' of gravel = 10,000 ft^3 = 500 tons of gravel]
37/39	450' x 50' = 22,500 ft^2	gravel to a depth of 1' [450'x50'x1' of gravel = 22,500 ft^3 = 1,125 tons of gravel]
42	450' x 50 = 22,500 ft^2	gravel to a depth of 2' [450'x50'x2' of gravel = 45,000 ft^3 = 2,250 tons of gravel]

Table 1: Habitat sites, project dimensions and volume of gravel added to each site during Phase 2 gravel manipulation experiment.

Gravel size distribution for new gravel was specified to the contractor who performed the restoration work, and used the following guidelines:

100 percent finer than 5-inch
85-90 percent finer than the 4-inch sieve
75-85 percent finer than the 3-inch sieve
30-35 percent finer than the 2-inch sieve
0-5 percent finer than ½ inch sieve

The intended result from these Phase 2 actions was to improve spawning habitat, and to allow later comparison of the effectiveness of different treatment methods on spawning gravels that had a range of pre-project physical limitations.

C) Phase 3- Post-treatment Monitoring and Evaluation

Beginning in Fall 1999, post-treatment spawning use, spawning densities and redd distribution were monitored using the aerial photograph survey approach applied to pre-project conditions. Similarly, juvenile salmonid rearing distribution and emigration has continued through the present. These monitoring efforts are combined with re-evaluation of the physical conditions in each gravel bar, conducted from September 2002 to August 2003. The goal of Phase 3 is to assess the effectiveness of each gravel treatment, with respect to spawning use and current substrate conditions. The remainder of this report summarizes results from post-treatment monitoring and evaluation.

III) PHYSICAL ATTRIBUTES OF MANIPULATED AND UNMANIPULATED SPAWNING GRAVEL

Physical and hydrologic characteristics of the three experimental gravel manipulation sites were examined in detail. Measurements and site locations for the 2002/2003 analysis (this project) are similar to methods and locations used by Vyverberg et al. (1997) for the pre-project study. This allows comparison of physical attributes of spawning gravels before and after the gravel manipulation experiments. Nearby un-manipulated gravel sites were also examined to provide a comparison or background level for each experimental gravel restoration project. Methods and results for the physical and hydrologic analyses are given in this section.

A) Site location and macroscopic changes over a three year period

Three years after the initial gravel enhancement experiment, several factors have blurred the boundaries between gravel manipulation sites and nearby unrestored areas. Examples of post-project changes are shown on sets of photographs for the three study sites (Fig. 2, 3, 4). Each set has a photo of a gravel manipulation site in November 1999 (just after completion of the gravel enhancement), and a photo of the same site in November 2002. Flows are slightly lower in the more recent photographs, and are partially responsible for differences in gravel submergence. The more recent series of photos will be used as base maps for the remainder of this project.

Several changes are evident when viewed at this macroscopic scale. Edges of the project areas are no longer distinct, and blade or tread marks from the heavy equipment have faded. These changes are partially due to human influence (hikers, dog walkers and fishers), but river processes have also modified the sites. Small changes in shoreline configuration are seen in the more recent photos. There is a slight tail of material on the downstream (left) side of each study site, and this is probably caused by coarse sediment mobility during high flow events. Colonization by pioneer species and soil development are significant processes at some sites, and fine sediment has infiltrated a quiet, backwater area at Lower Sunrise Access. The result is a “seasoning” of the newly added gravel that alters the original appearance. Macroscopic changes at each site are summarized below:

Gravel manipulation site	Downstream coarse sediment tail	New vegetation	Soil development	Accumulation of fine sediment
Sacramento Bar	X	minor	minor	
Lower Sunrise Access	X	X	X	X
Sailor Bar	X	minor		

Table 2: Macroscopic changes at study sites.

Lower Sunrise Access has experienced the most changes, with accumulation of fine sediment, colonization by willows and grasses, and soil development on the surface of new gravel. This gravel bar has the lowest gradient and lowest associated flow velocities of the three study areas, and under some flow conditions is serving as a site for accumulation for fine sediment.

Many of these changes can be attributed to river morphology and flow conditions. A hydrograph of the Lower American River from August 1999 to present (Fig. 5) shows that a large flow event occurred in February 2000, approximately six months after gravel emplacement. Peak flow during this event exceeded 25,000 cfs, and affected the new gravel at a time when armoring, fine sediment accumulation and organic buildup were minimal. Estimates by Ayers and Associates (ref.) place the threshold velocity for gravel bed movement at about 35,000, but it is conceivable that flows of 25,000 cfs could produce sliding, rolling or tumbling movement on uniform, unstable material. This may explain the tail of coarse gravel that is visible on the downstream side of each gravel enhancement area.

Fine sediment tends to accumulate during summer months and in low gradient areas. This has been the dominant influence since February 2000, with dam-controlled releases that remain well below the threshold velocity for gravel mobility. Algal blooms contribute significant amounts of fine organic debris during warm summer months, and this material infiltrates into the pore spaces of coarser gravel deposits.

Silt and clay accumulate as a thin veneer of sediment on the bar surface, deposited during waning flow events. Flows of 4,000– 5,000 cfs raise river stage enough to submerge a major portion of the manipulated gravel bars, although fine sediment is kept in suspension at these higher flows. As the flow receeds, some sites have grasses, willows and rough bed material that baffle the current. Sediment begins to drop from suspension, and the gravel surface becomes the site of low velocity, backwater deposition. Lower Sunrise Access is especially susceptible to this type of fine sediment influx, because the gravel bar has very low gradient. Periodic flooding and fine sediment deposition have enhanced soil development and plant growth, which in turn tends to stabilize the gravel even more. Continued pulses of 3,000 to 5,000 cfs (without larger flushing flows) will result in continued stabilization of channel-margin gravel at Lower Sunrise Access, and will increase the threshold velocity necessary for gravel movement. This effect is less pronounced along the steeper edges of gravel enhancement sites at Sacramento Bar and Sailor Bar. Steeper gravel surfaces have a narrower zone of low flow velocity, and do not appear to accumulate as much fine sediment.

B) Grain size analysis

Gravel size is often a limiting factor for salmon spawning habitat (Pollard 1955). Grains that have a median size greater than 10% of the female spawner's length are usually too large to be moved during redd construction, and therefore limit habitat suitability. Excess coarse material may be a problem on the Lower American River, where upstream gravel recruitment has been cut off by Nimbus Dam. There is a tendency for each flushing flow or flood event to remove finer, more mobile material, leaving behind gravel that is too coarse for redd construction. Limited new gravel recruitment occurs from stream-side exposures of the Mehrten and Fair Oaks Formations, but these units probably do not contribute the volume of sediment that was transported through the system prior to construction of Folsom and Nimbus dams.

Gravel armoring is a related problem. Lag deposits form when high flow events remove finer material, and the remaining coarse bed load develops an interlocking texture. This armored surface layer may be further strengthened by infiltration of fine material during lower flow periods. The result is an interlocking, coarse lag deposit, that sometimes contains more cohesive intergravel fines. Armoring is identified by taking separate surface and subsurface samples, and comparing the grain size distribution in each. Determination of the depth of sampling for “surface” vs. “subsurface” layers is somewhat arbitrary, since the thickness of armored layers tends to increase with increasing grain size. We used the general guidelines of Bunte and Abt (2001) to differentiate between surface and subsurface samples. In this method, the largest surface grain is identified, and the diameter of that grain is used as a boundary between surface and subsurface samples.

Fine-grained sediment also limits habitat suitability. This becomes important during egg development and fry escapement. Fine-grained sediment is defined by fisheries workers as material < 8 mm, and the presence of excess fine material limits permeability. Lower permeability means that less water flows through the gravels, and slower-moving pore waters have reduced dissolved oxygen content. Escaping fry are sometimes trapped in the gravel when pore spaces are blocked by later infiltration of fine-grained sediment. Fine-grained material can be added to a redd during winter storm events, or when later spawners clean nearby gravel and mobilize existing fine sediment. Low gradient streams or streams with limited gravel supply may also contain excess fine material. In all cases the presence of fine sediment is detrimental, and greater than 20% fine sediment is thought to be limiting for successful egg development (Soulsby, 2001; Milan et al., 2000).

1) Gravel sampling sites Three gravel samples were collected from each of the manipulated areas (Fig. 6, 7), and grain size distribution was determined using sieves and hand templates. This quantitative approach allows comparison or pre- and post-project conditions, with the current sampling event representative of conditions three years after the initial gravel emplacement. A fourth (background) sample was collected just outside of each gravel manipulation area to compare grain size distribution in undisturbed areas.

2) Pebble counts Standard pebble counts (Wolman, 1954) were used to examine sediment size distribution at the surface of the stream bed. These results were compared to sieve analyses to determine the effectiveness of pebble counts (see below). Pebble counts were conducted by walking a series of short transects across a representative area of the stream channel. Each time the observer’s foot landed, the grain diameter at the observer’s toe was measured and recorded. Grain diameter was measured with a hand template, and results were converted to percent size distribution. 100 or 200 grains were counted at each study area to ensure statistical accuracy.

3) Sieve analysis Bulk grain size analysis was performed on-site for coarse fractions, and fine fractions were split and returned to the lab for later sieve analysis. Representative sites were selected in the field, and a hammer was tossed into the representative area to randomly choose a smaller 1 meter grid for bulk sampling. Fishers and parkway users often construct piles of coarse gravel at the river’s edge, so this visual survey and representative site selection are important first steps.

Sample size was determined by weighing the largest surface grain within 1 meter of the hammer. This weight was taken as 1% of the total sample weight necessary for a statistically representative sample (Church et al., 1987; Bunte and Abt, 2001). Samples were collected with shovels, and the total sample weight was recorded using an on-site digital balance and weighing buckets (Fig. 8). Samples were collected during low flow conditions whenever possible, so that most samples were collected at or above the waterline. This minimized loss of fine material. In-stream samples were collected at two localities, and at these sites a baffle was constructed from plywood and rebar to minimize flow past the sampling site. Loss of fine sediment was assumed to be negligible at all sample sites.

Surface and subsurface samples were collected and analyzed separately so that an armoring index could be determined. A few of the early gravel sampling events did not include separate surface samples, and in these cases a armoring index was calculated by comparing the surface sample to the bulk sample (surface and surface combined). Error introduced by The armoring index is defined as:

$$\frac{d_{50}\ \text{surface}}{d_{50}\ \text{subsurface}}$$

As the bulk sample was collected, it was spread onto a tarp to dry. Samples with low abundance of fine material dried quickly, and did not require additional treatment before passing through a series of rocker sieves to determine particle size distribution (Fig. 8). Samples with higher proportions of fine material did not dry as quickly, and were washed through the rocker sieves to separate fine from coarse material. Fine sediment (<8 mm) was collected from all samples. If the volume of fine sediment was less than 8 liters, the entire fine sample was transported to the lab, split, and run through a rotap to determine particle size distribution of the <8 mm fraction. Larger volumes of fine sediment were weighed and split in the field, and a representative sample was transported to the lab for later rotap sieving.

4) Results of grain size analysis Grain size distribution curves were constructed for each of the gravel sampling sites. A representative example from site 3003 is shown in this section, and complete grain size results from all sites are available in Appendix A. Bulk grain size data from field and lab sieving were converted to a percentage basis (Table 3), and cumulative frequency curves were plotted for each locality (Fig. 9). Surface and subsurface samples are plotted on the same chart to allow visual identification of armoring.

SITE 3003						
SIEVE ANALYSIS (SURFACE SAMPLE)						
	Sieve Opening (mm)	**Mass of Sediment Retained**	**Percent**	**Cumulative Mass of Sediment Retained**	**Mass of Sediment Passing**	**Percent Finer**
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*286.46*	*100.0%*
↓	180.0000	*0.00*	*0.0%*	*0.00*	*286.46*	*100.0%*
	128.0000	*0.00*	*0.0%*	*0.00*	*286.46*	*100.0%*
	90.0000	*50.78*	*17.7%*	*50.78*	*235.68*	*82.3%*
	64.0000	*60.73*	*21.2%*	*111.51*	*174.95*	*61.1%*
	45.0000	*72.98*	*25.5%*	*184.49*	*101.97*	*35.6%*

	32.0000	*97.02*	*33.9%*	*281.51*	*4.95*	*1.7%*
	22.0000	*3.62*	*1.3%*	*285.12*	*1.34*	*0.5%*
	16.0000	*0.21*	*0.1%*	*285.34*	*1.12*	*0.4%*
	8.0000	*0.00*	*0.0%*	*285.34*	*1.12*	*0.4%*
FINES	7.0000	*0.06*	*0.0%*	*0.06*	*1.06*	*0.4%*
	4.0000	*0.10*	*0.0%*	*0.16*	*0.96*	*0.3%*
	2.8300	*0.03*	*0.0%*	*0.19*	*0.93*	*0.3%*
	2.0000	*0.06*	*0.0%*	*0.25*	*0.87*	*0.3%*
	1.4100	*0.06*	*0.0%*	*0.31*	*0.81*	*0.3%*
	1.0000	*0.06*	*0.0%*	*0.36*	*0.76*	*0.3%*
	0.7100	*0.08*	*0.0%*	*0.44*	*0.68*	*0.2%*
	0.5000	*0.14*	*0.0%*	*0.58*	*0.54*	*0.2%*
	0.3500	*0.19*	*0.1%*	*0.77*	*0.36*	*0.1%*
	0.2500	*0.15*	*0.1%*	*0.92*	*0.21*	*0.1%*
	0.1770	*0.07*	*0.0%*	*0.99*	*0.13*	*0.0%*
	0.1250	*0.05*	*0.0%*	*1.04*	*0.08*	*0.0%*
	0.0880	*0.04*	*0.0%*	*1.08*	*0.04*	*0.0%*
	0.0625	*0.01*	*0.0%*	*1.09*	*0.03*	*0.0%*
	0.0100	*0.03*	*0.0%*	*1.12*	*0.00*	*0.0%*
	Total=	286.46	kilograms			

Table 3: Typical sieve analysis from a surface sample includes field data and fines that were analyzed in the lab. The “percent finer” is plotted on a cumulative frequency curve to show habitat suitability (see Fig. 9). Subsurface and bulk samples were also plotted to identify armoring.

C) Mini-piezometer installation- gravel manipulation and spawning areas

Clusters of stainless steel mini piezometer tips were installed so that pore water samples could be collected from discrete intervals in the stream gravel. This is important because salmonids cover their eggs with 20-40 cm of gravel, and geochemical conditions in the pore water affect egg development. Sampling tips span the critical depths where eggs are emplaced, and allow small volumes of pore water to be collected from known depths in the sediment. Each sampling tip is connected to the surface by a 6 mm diameter plastic tube, and each site has a cluster of tips located at depths of 30, 60, and 90 cm below the gravel surface (Fig. 10). Golf tees are used to plug the tubes and prevent communication with river water.

Mini-piezometer clusters are located at the edge of gravel manipulation sites to show geochemical conditions in the newly emplaced gravel. Mini-piezometer clusters were also installed in nearby heavily used spawning areas (riffles and glides) to allow comparison of physical and geochemical conditions between gravel enhancement sites and nearby spawning areas (Fig. 11, 12, 13).

D) Field Parameters

Field parameters are used to make basic interpretations about the source or history of water. Field sampling was initially designed to be completed in three events (Fig. 14), with December sampling to document spawning conditions, March/April sampling representative of high Spring flows, and August sampling for low-flow summer conditions. Flows in the American River did not follow this idealized plan, and there were three additional releases of water during the project year. All of these releases were designed to improve Delta water standards, and were not related to hydrologic conditions within the American River Basin. Higher flows tend to flush more water through the stream gravel, so August sampling may not be typical of the low flow and baseflow conditions that would have been present on the American River before human intervention.

Samples were collected by withdrawing a small volume of water from mini-piezometer tips installed in the stream gravel. A car battery powered a portable peristaltic pump, and equipment was transported from site to site in a small raft (Fig. 15). Field parameters were measured by pumping water through a flow-through cell, so that water samples did not contact the atmosphere prior to measurements.

During sampling, tubes were purged of three times their internal volume, or purged until readings stabilize within 10% of the previous readings. Readings were taken at two-minute intervals. 125 ml samples were filtered through a 0.45 micron filter, acidified to pH<2, and stored on ice for transport to the lab. Quality assurance/quality control procedures followed Koterba et al. (1995), and included trip blanks, equipment blanks and replicate samples.

1) Dissolved oxygen Dissolved oxygen (DO) is one of the trickiest measurements to make in the field. Water samples with low DO equilibrate rapidly when exposed to ambient conditions or oxygenated water, so sample handling and measurement techniques are critical for good results. Samples should be isolated from the atmosphere and other water samples during measurement, and most meters require a specified minimum flow past the probe tip for good results. This means that the average DO meter cannot be used in a standpipe or well, because stagnant water in the borehole is not moving fast enough past the probe tip. Meter technology is evolving, and the new Model 95 meter from YSI may address problems associated with low rates of flow past the DO probe tip YSI model 52 or model 50 meters were used in conjunction with a flow-through cell and pump for this study, and probe membranes were checked or serviced daily.

Typical results from dissolved oxygen analysis are shown in Figure 16. Additional analyses from earlier sampling runs and other localities are shown in Appendix C. Most sites show depletion in dissolved oxygen with depth, although riffles have higher dissolved oxygen contents at depth than nearby glides. Surface water is assumed to be nearly saturated with dissolved oxygen, although this varies slightly depending on water releases from the base of Folsom Dam. Low velocity areas near the bank have the lowest dissolved oxygen content. These areas also have a silty, organic-rich, impermeable, surface layer. Low permeability and low flow velocity equate to longer residence time for pore water, and dissolved oxygen is consumed. Higher velocity riffle sequences (far downstream sites) have the highest dissolved oxygen content, and less oxygen depletion at depth. Oxygenated surface water is flushed rapidly through these sites, and pore water residence time is shorter. Dissolved oxygen values below 3-4 mg/l are limiting for egg development, so nearshore sites with low D.O. values may not be appropriate spawning habitat. This would apply to the area along the edge of the recent gravel manipulation experiment.

Dissolved oxygen levels at the farthest upstream site (far right) at Lower Sunrise Access are problematic. This is an area with heavy spawning use, yet dissolved oxygen levels in the gravel are consistently low (see results from other sampling runs, Appendix B). Spawning salmonids seem to be keying in on some other feature here, and don't sense the limitations imposed by low dissolved oxygen content in pore waters. It is likely that redd construction improves sediment permeability and flow through the gravel, as females manipulate the gravel when they clean the sediment and bury their eggs. Values measured in undisturbed gravel (from mini piezometer tips) are likely to be minimum values, and spawning may improve sediment permeability and dissolved oxygen content.

2) pH pH was measured with an Orion field meter, gel-filled electrode, and separate temperature compensation probe. Two-point calibration was carried out daily or twice daily, and calibration fluids were selected to bracket the pH of pore water samples (often acidic). Temperature-compensated pH measurements were taken inside the flow-through cell, although this measurement is fairly stable under a variety of atmospheric and surface water conditions.

Typical pH patterns are shown in Figure 17. pH tends to decrease (become more acidic) with increasing depth in the gravel, and surface water generally slightly basic. Decreases in pH with depth are probably caused by organic acids that form during decomposition of organic matter (algal debris). Complete results from pH analysis are shown in Appendix B. pH in surface or shallow samples was usually at or near neutral, and is probably not a factor in spawning site selection or habitat suitability.

3) Temperature Temperature was measured by three different field meters (dissolved oxygen, pH and conductivity meters), since all are temperature compensated. Our field methods make accurate measurements for pH, dissolved oxygen, electrical conductivity and turbidity, but temperature is a problem. All of our meters make their measurements inside a flow-through cell, and sample water may have undergone a significant temperature change as it traveled to the cell. On warm sunny days the tubing and flow-through cell heat up in the sun, and temperature readings are too high. In cold, winter months the sample cell may be significantly colder than river water, giving a value that is too low. The solution to these problems is a different type of temperature measurement- either in-situ measurements with thermocouples, or a data logging resistive thermal device (RTD). Different temperature devices will be deployed in next year's gravel study.

Temperature was recorded during field sampling runs, but because of the problems stated above, values reported in this summary may not be representative of gravel temperatures. Temperature values from river water and shallow gravel samples at Sacramento Bar are shown in Fig. 18, and additional results are reported in Appendix B.

4) Electrical conductivity Electrical conductivity was measured using an Orion model 128 field meter and probe through a dedicated sampling port in the flow-through cell. The meter was calibrated daily using a one-point check (standard solution = 84 μS/cm). Electrical conductivity (EC) ranged from 48 μS/cm to 71.9 48 μS/cm, with a mean of 54.5 μS/cm. This included river water samples and unfiltered pore water samples collected from depths in the gravel. American River water has very low dissolved ion content, and is valued as a drinking water source or high quality water supply. Low dissolved ion content means low ability to conduct electricity, so uniformly low electrical conductivity values are an indicator of the high water quality of American River water. Complete results from electrical conductivity analysis are contained in Appendix B (Field parameter measurements). Results are not plotted on maps because there were no apparent trends

E) Surface Water Velocity

Stream depth and velocity are important factors for redd site selection by spawning salmonids. Estimates of acceptable stream parameters vary, but most workers agree that optimal spawning velocities are in the range of 0.5 to 2.0 m/s (Chapman et al., 1986). Stream velocities that fall in this range cause significant amounts of oxygenated water to flush through the gravel, and the survivability of eggs increases. When stream velocity decreases the volume of water flowing though stream bed gravel also decreases, so lower flow velocities are not desirable. Optimal stream depths range from the fin height of the spawning salmon (lower limit) to one or two meters of water depth (upper limit). Spawning has been reported from depths of seven or more meters, but is not well documented.

Stream velocities that exceed the optimal range present a different set of problems. Higher stream velocity causes the female to work harder to stay on the redd after spawning, and adds stress at a critical part of the life cycle. Salmonids will protect the redd for 10-14 days after spawning, during which they weaken and die. Higher stream velocity increases the energy output and decreases total time on the redd for salmonids, and is not desirable. These factors combine to produce an optimal range for stream velocity.

1) Velocity measurements Techniques used to measure stream velocity followed USGS guidelines (USGS, 1980). Surface water depth and velocity were measured with a Price AA or Pygmy current meter mounted on a topset wading rod. The Price AA meter was used when water depth was greater than 69 cm (1.5 ft), and the Pygmy current meter was used when water depths ranged from 10 cm (0.3 ft) to 69 cm (1.5 ft).

Water depth also affects the position of the measurement in the water column. At water depths less than 76 cm (2.5 ft), a single reading from 0.6 times the water depth was used to estimate stream velocity. At water depths greater than 76 cm (2.5 ft), velocity measurements were taken at 0.2 and 0.8 times the water depth, and averaged. During field measurements, cup revolutions from the current meter were timed with a stopwatch, then converted to stream velocity using the following formulas:

Price AA meter: $V = 2.2048 (R) + 0.0178$

Pygmy meter: $V = 0.9604 (R) + 0.0312$

Where R = Revolutions per second

2) Results Stream velocity was measured at established monitoring points in the river, and results are reported from an August sampling run that included Lower Sunrise Access and Sacramento Bar (Fig. 19). Delta water quality demands resulted in large flow increases during August 2003, so measurements are not comparable between the two gravel bars. In general, the higher current velocities are associated with shallow riffles. High velocity areas are also the site of heavy spawning use. Lower current velocity is associated with very shallow water at the river's edge, and intermediate velocity is found in deeper runs, pools or glides.

F) Upwelling and Downwelling Conditions

Upwelling and downwelling conditions were identified based on measurements of vertical hydraulic head. A bubble manometer board was used to compare pressure differences between the river and mini-piezometer tips embedded in the gravel bar. Higher total hydraulic head (pressure) in the river vs. depth in the gravel indicates downward flow or losing conditions. Higher pressure at depth vs. the river indicates upward flow or gaining conditions. Differences in hydraulic head control the direction of inter-gravel flow, and may be one of the factors that spawning salmonids use to locate potentially good spawning sites.

Hydraulic head differences were measured at each mini-piezometer site (Fig. 20), and vertical head gradients were calculated based on the offset of the bubble (dH) and depth of the mini-piezometer tip (dL). See Appendix B for complete results of vertical head gradient measurements.

Upwelling zones were identified in the bottom half of several riffle sequences, and were the site of intense spawning activity (Fig. 21). Spawning was also common in pool tailouts and the upper half of the same riffle sequences, so spawning on the Lower American River does not appear to be related exclusively to upwelling or downwelling conditions. This conceptual model for hyporheic flow compares favorably to a model from Jones and Mulholland (2000) (see Fig. 22).

G) Substrate Permeability

Substrate permeability was measured at 0.3 and 0.6 m depths in the gravel by performing the constant drawdown tests of Terhune (1958), as modified by Bernard and

McBain (1994, 1998). The modified technique uses an adjustable pump to maintain a fixed water level depression in the standpipe, and the rate that the aquifer can deliver water to the standpipe is used to calculate sediment permeability.

Results from permeability tests are shown in Table XXXXXX, Appendix C. Values range from 1 cm/sec to 30 cm/sec, and seem anomalously high. Additional work during the next project year will compare these permeability results to other standard methods.

IV) SYNTHESIS OF 2002/2003 RESULTS

Grain size analysis shows that sediments in the experimental gravel manipulation sites are slightly courser than published optimal grain size, but are generally within a suitable range for spawning.

The largest factors that affect spawning habitat in gravel manipulation areas are:

- Excess fine sediment input on the low-gradient bar at Lower Sunrise Access
- Presence of ash-rich intervals from the Mehrten Formation that reduce permeability at Sailor Bar.
- Lack of fine sediment at Sailor Bar
- Lack of submergence at Sailor Bar and Sacramento Bar

Several generalizations can be made about the physical and (field) geochemical conditions encountered during this study:

- Grain size distribution is generally within the accepted range for successful salmonid spawning, and does not appear to be a limiting factor.
- Dissolved oxygen content decreases with depth in gravel pore water, and may be a limiting factor in areas with excess fine sediment.
- pH has a slight trend toward decrease at depth, probably as a result of decomposition of organic matter.
- Gravel permeability varies over several orders of magnitude, and meter-scale variability often exceeds variability between sites.

These results point to the close relationship between stream configuration (fluvial geomorphology) and the physical state of the stream bed. Permeability, grain size distribution, field geochemistry and flow characteristics are produced by the interplay between river characteristics and the underlying gravel. A more detailed comparison of pre- and post- manipulation conditions will be completed in the next report.

REFERENCES

Bunte, K., and Abt., S.R., 2001, Sampling surface and subsurface particle-size distributions in wadable gravel- and cobble-bed streams for analyses in sediment transport, hydraulics, and streambed monitoring: Fort Collins, Colorado, USDA- Forest Service Rocky Mountain Research Station general technical report RMRS-GTR-74, 428 p.

Chapman, D.W., Weitkamp, D.E., Welsh, T.L., Dell, M.B., and Schadt, T.H., 1986, Effects of river flow on the distribution of Chinook salmon redds: Transactions of the American Fisheries Society, v. 115, p. 537-547.

Church, M., McLean, D.G., and Walcott, J.F., 1987, River bed gravels: sampling and analysis. *in* Thorne, C.R., Bathhurst, J.C., and Hey, R.D., eds., Sediment transport in gravel-bed rivers: Chister, John Wiley and Sons, pp. 43-88.

DFG Technical Report 01-2, 2001, Evaluation of effects of flow fluctuations on the anadromous fish populations in the lower American River: CA Dept. of Fish and Game, Stream Evaluation Program, 93 p.

Horner, T.C., and Bush, N.J., 2000, abs., Small scale gain and loss and geochemical variability of pore water in the hyporheic zone of a gravel bar used for salmon spawning in the American River, California: Geological Society of American Abstracts with Programs, v. 32, no. 7., p. 141.

Jones, J.B., and Mulholland, P.J., 2000, Streams and ground waters: San Diego, Academic Press.

Koterba, M.T., Wilde, F.D., and Lapham, W.W., 1995, Ground-water data-collection protocols and procedures for the national water-quality assessment program: Collection and documentation of water-quality samples and related data: Reston VA, U.S. Geological Survey open file report 95-399, 113 p.

Milan, D.J., Petts, G.E., and Sambrook, H., 2000, Regional variations in the sediment structure of trout streams in southern England: benchmark data for siltation assessment and restoration: Aquatic Conservation: Marine and Freshwater ecosystems, v. 10, p. 407-420.

Pollard, R.A., 1955, Measuring seepage through salmon spawning gravel: Journal Fisheries Research Board of Canada, v. 12, p. 706-741.

Soulsby, C., Youngson, A.F., Moir, H.J., and Malcolm, I.A., 2001, Fine sediment influence on salmonid spawning habitat in a lowland stream: a preliminary assessment: The Science of the Total Environment, v. 265, p. 295-307.

Snider, B., Christophel, B.L., Jackson, L., and Bratovitch, P., 1992, Habitat characgterization of the lower American River. California Department of Fish and Game, Environmental Services Division in cooperation with Beak Consultants and the County of Sacramento, California. Unpublished report, 20 p.

Snider, B., and Vyverberg, K., 1996, Chinook Salmon Redd Survey lower American River: California Department of Fish and Game Environmental Services Division. Technical Report No. 97-2, 60 p.

Terhune, L.D.B., 1958, The Mark VI groundwater standpipe for measuring seepage through salmon spawning gravel: Journal Fisheries Resource Board of Canada, v. 15, pp. 1027-1063.

USGS, 1980, National handbook of recommended methods for water-data acquisition (updates): Reston, VA, U.S. Department of Interior, Office of Water Data Coordination, U.S. Geological Survey.

Vyverberg , K., Snider, B., and Titus, R.G., 1997, Lower American River Chinook Salmon Spawning Habitat Evaluation October 1994: California Department of Fish and Game Environmental Services Division. Technical Report No. 97-2, 112 p.

Wilde, F.D., and Radtke, D.B., 1999, Chapter A6. Field Measurements, in Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., eds., Techniques of Water Resources Investigations Handbook for Water Resources Investigations Book 9, National Field Manual for the Collection of Water Quality Data: Washington, U.S. Geological Survey, p. T1-T15.

Weight, W.D., and Sonderegger, J.L., 2001, Manual of applied field hydrogeology: NY, McGraw-Hill, 608 p.

Figures

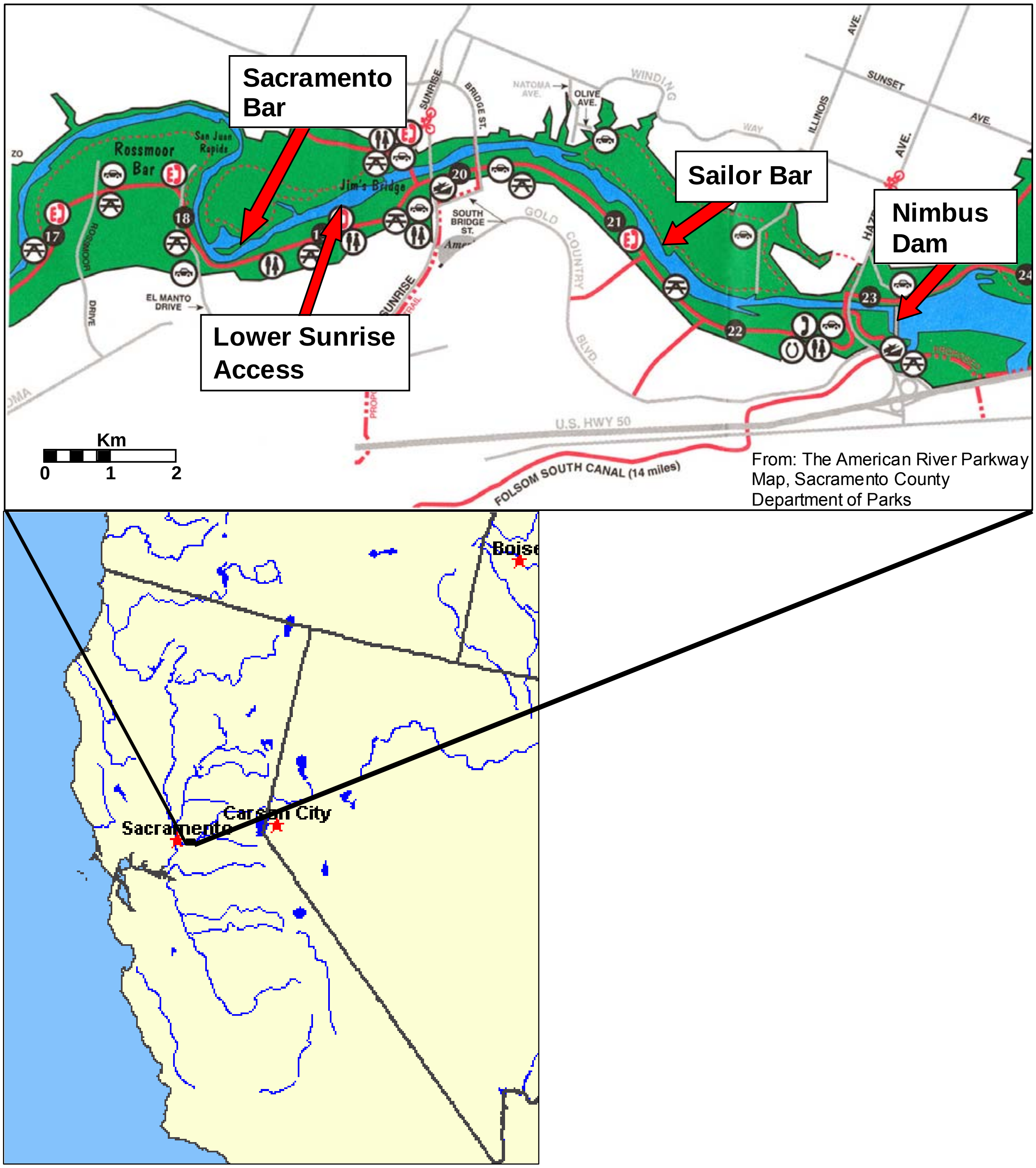


Figure 1: Location of experimental gravel manipulation sites. The 13 km (six miles) of river channel that lie below Nimbus Dam account for approximately 90% of the natural salmon spawning that occurs in the American River. Gravel enhancement projects were conducted at three sites 1999, and were re-examined in this study to determine the post-project effects of gravel manipulation.

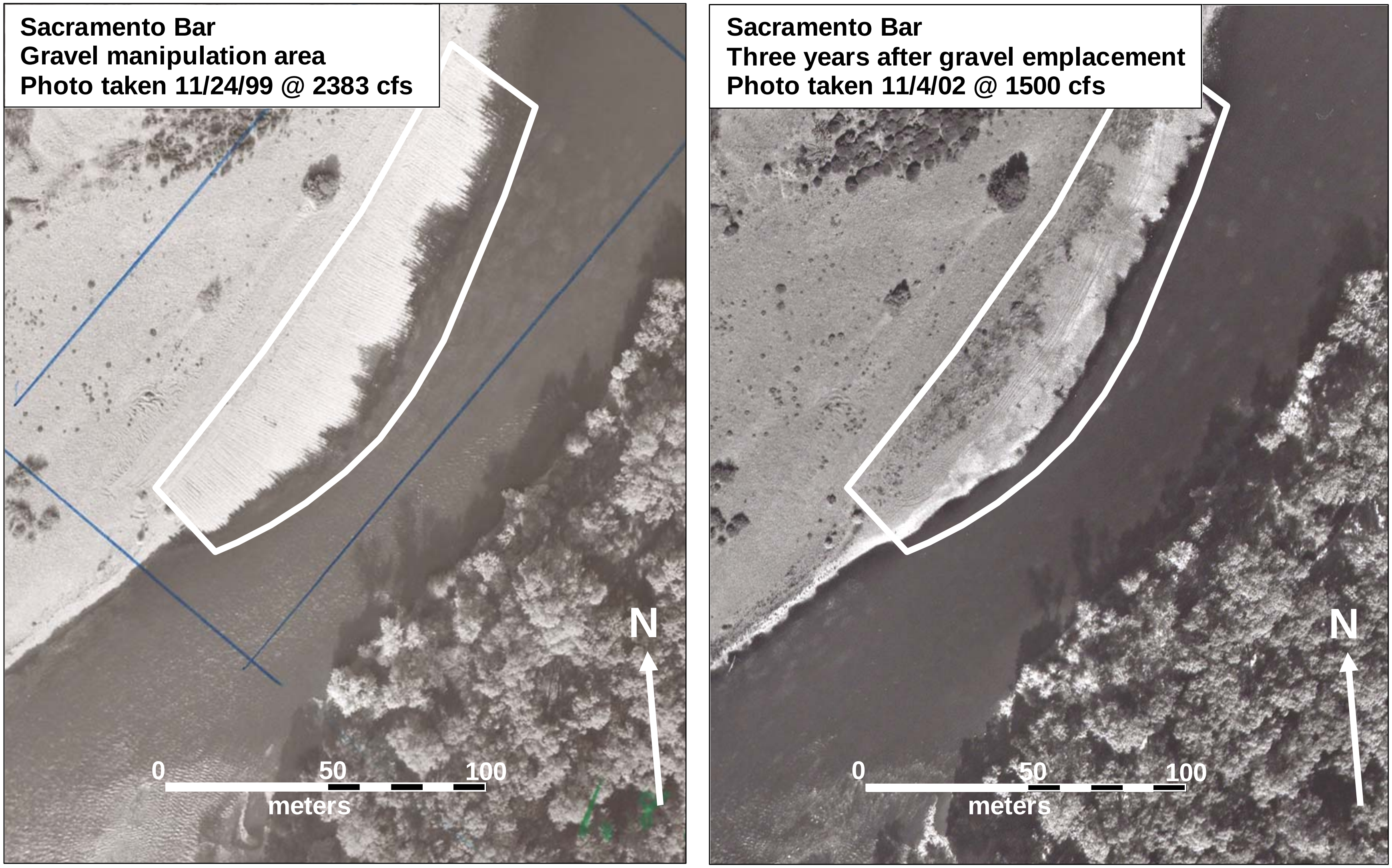


Figure 2: Sacramento Bar immediately after gravel emplacement (left photo) and three years later (right photo).

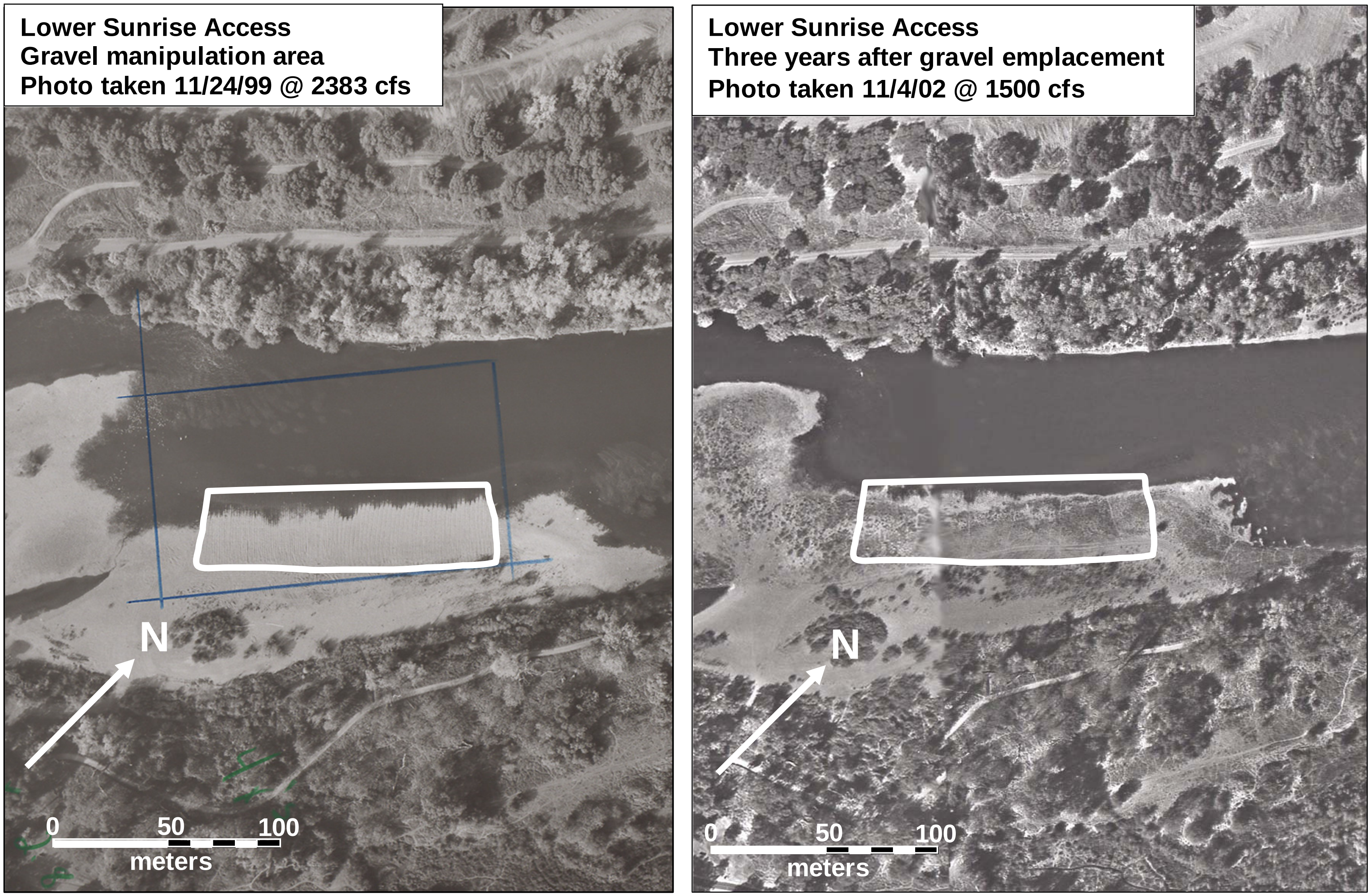
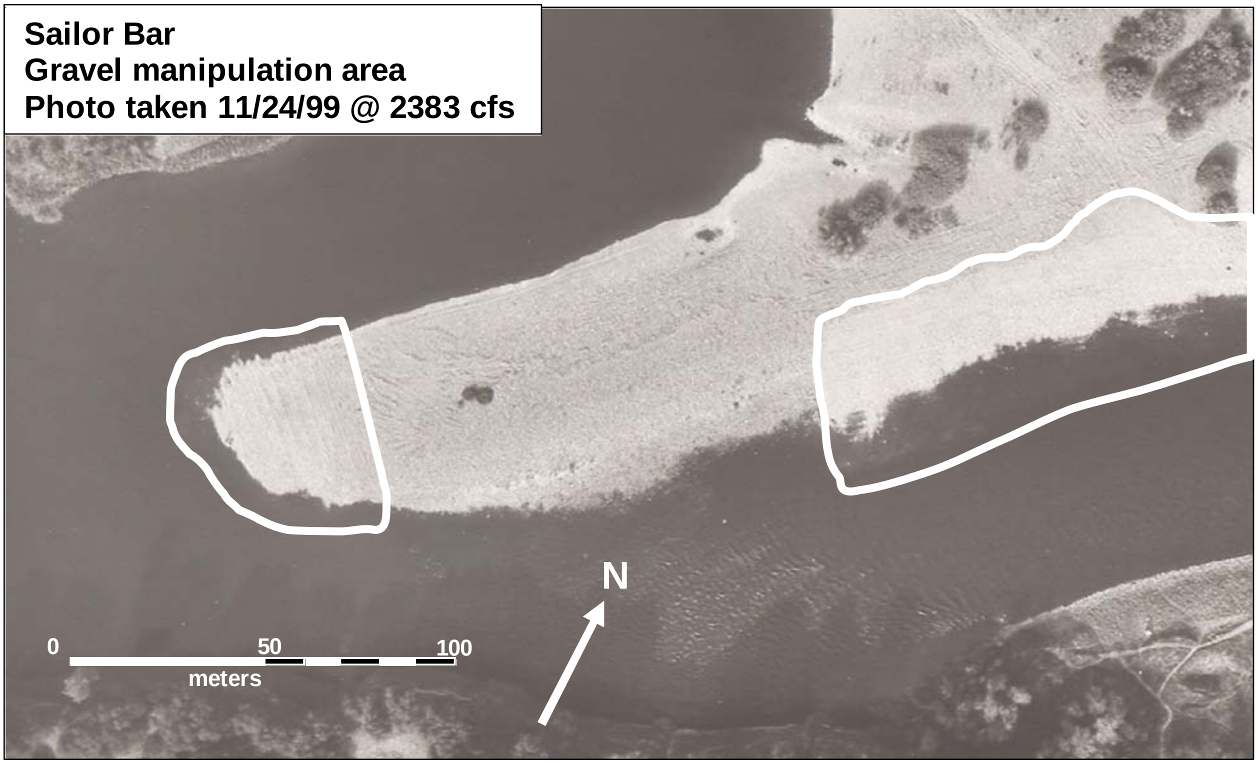


Figure 3: Lower Sunrise Access immediately after gravel emplacement (left photo) and three years later (right photo).



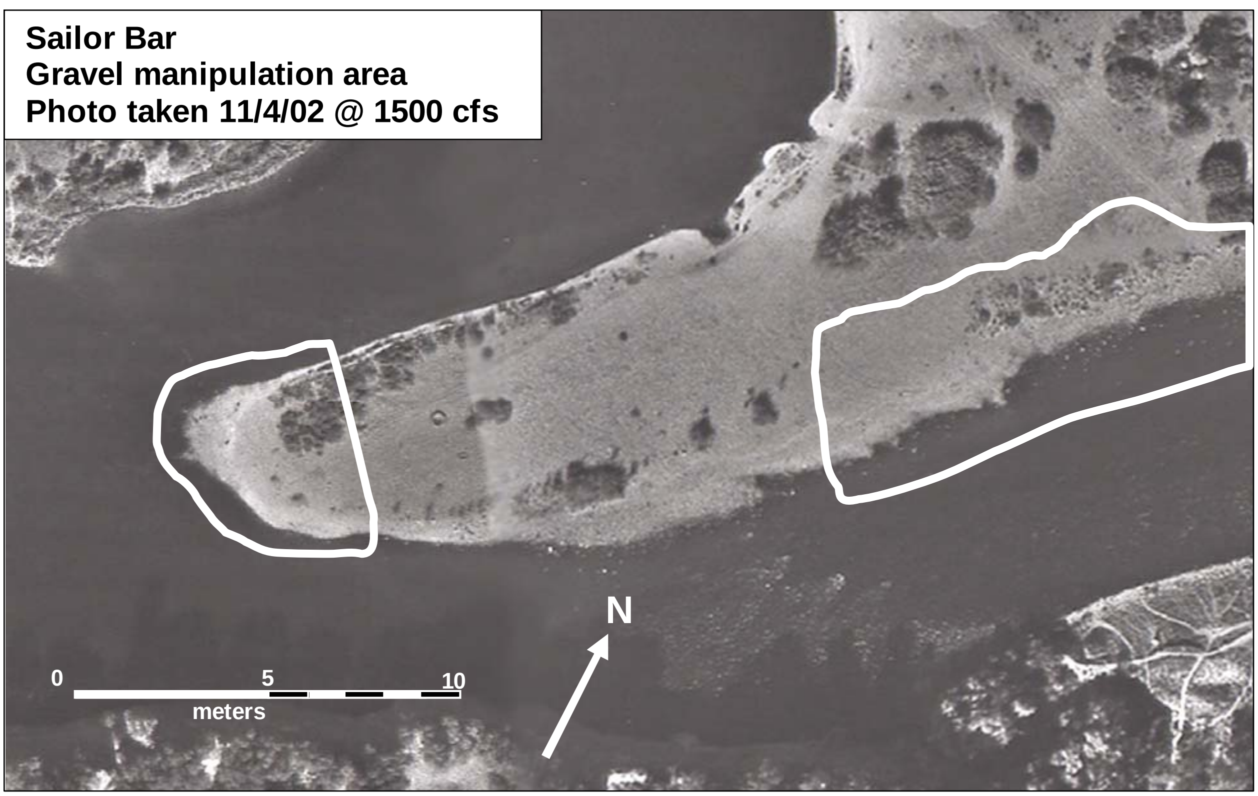


Figure 4: Sailor Bar immediately after gravel emplacement (top picture) and three years later (bottom picture)

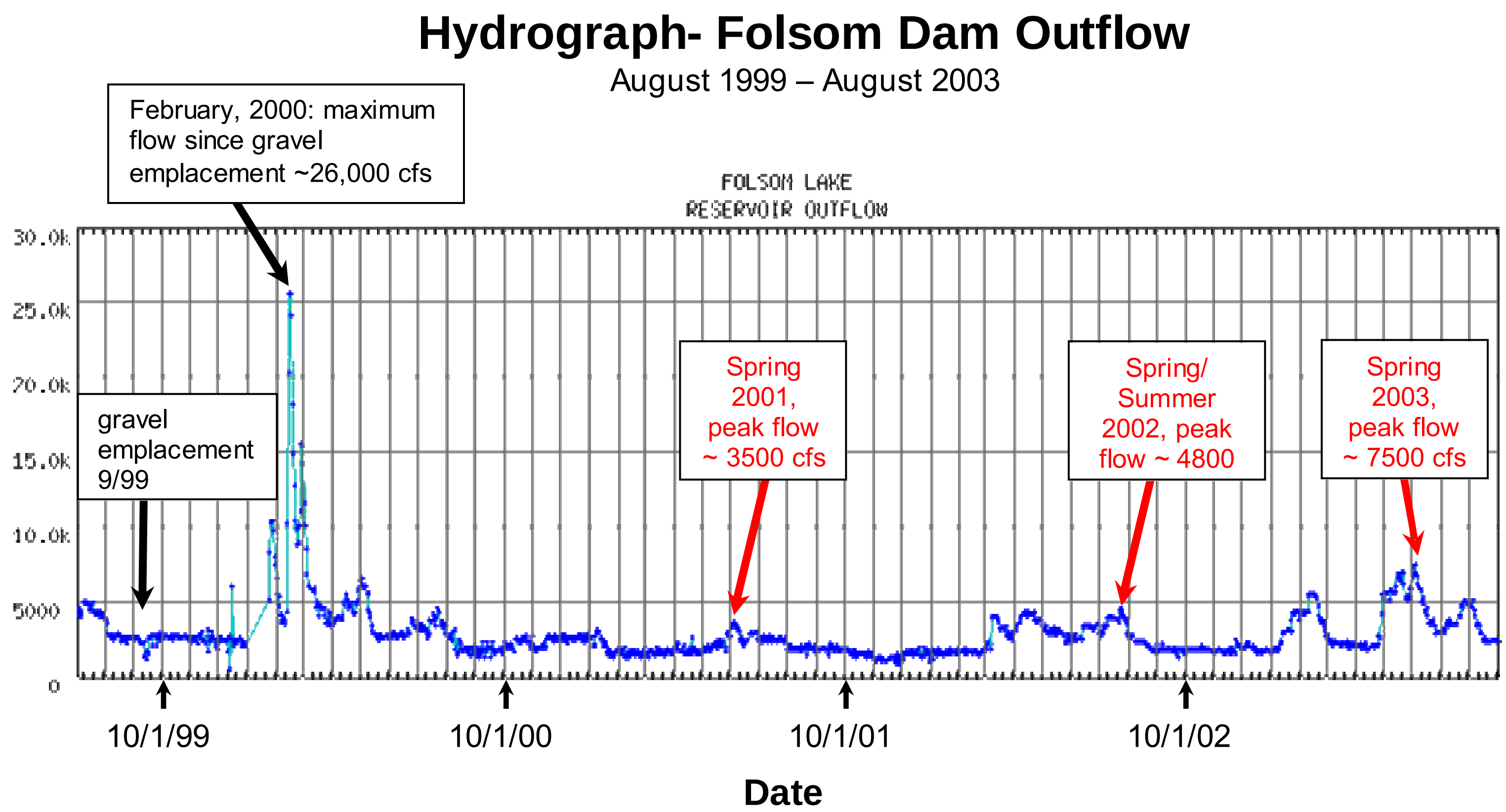


Figure 5: Hydrograph of the Lower American River since gravel emplacement. Peak flows are most likely to mobilize coarse sediment, and quiescent periods favor accumulation of organic matter and fine sediment. Highest flows occurred in February 2000 (six months after gravel emplacement) with a maximum of about 26,000 cfs. Since that time yearly peak flows have occurred in the Spring, with maxima ranging from 3500 cfs to 7500 cfs. In general, fine sediment has accumulated and bank material has stabilized over the past three years. High summer flows are not part of the natural hydrologic cycle, and are a result of controlled dam releases to meet Delta water standards.

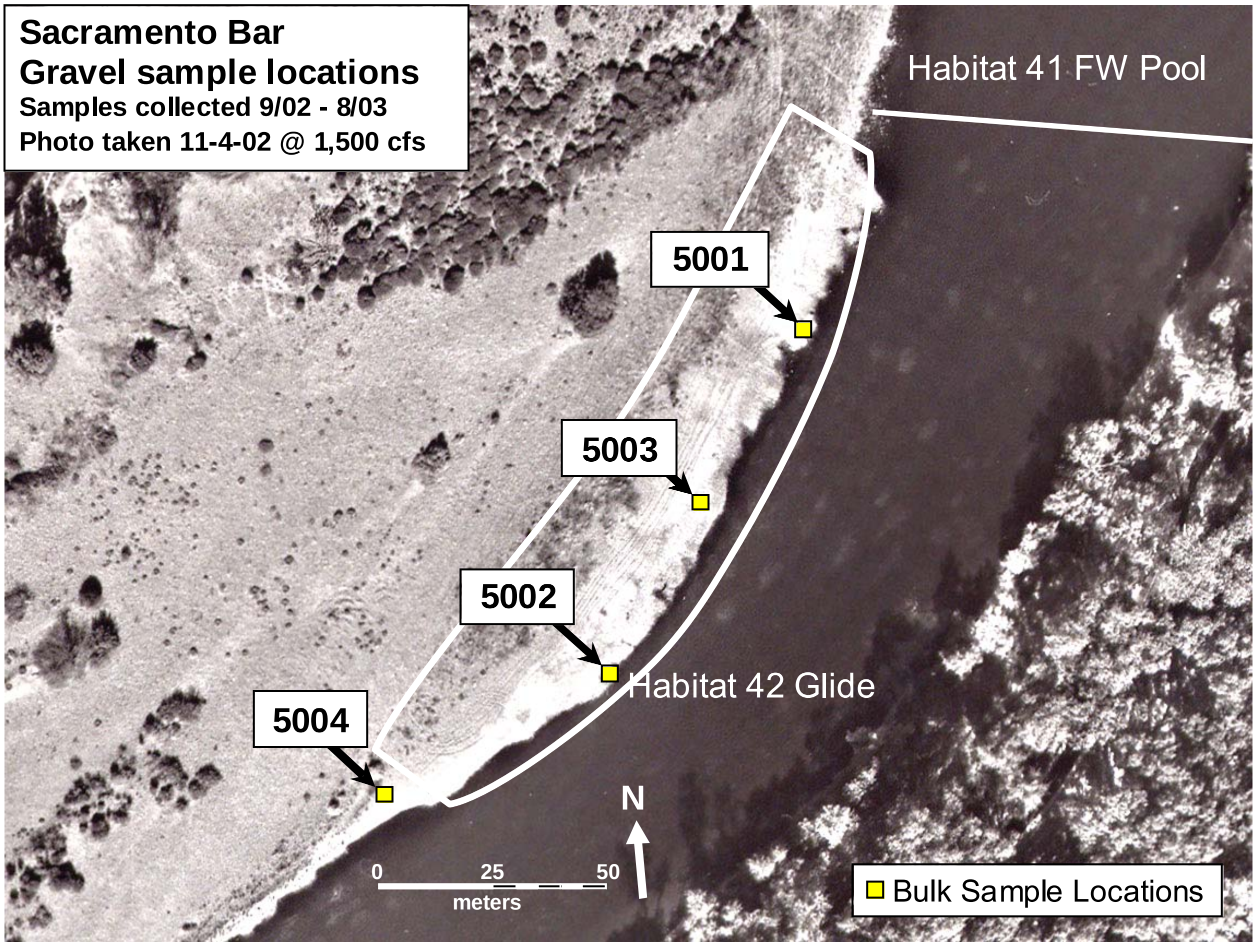
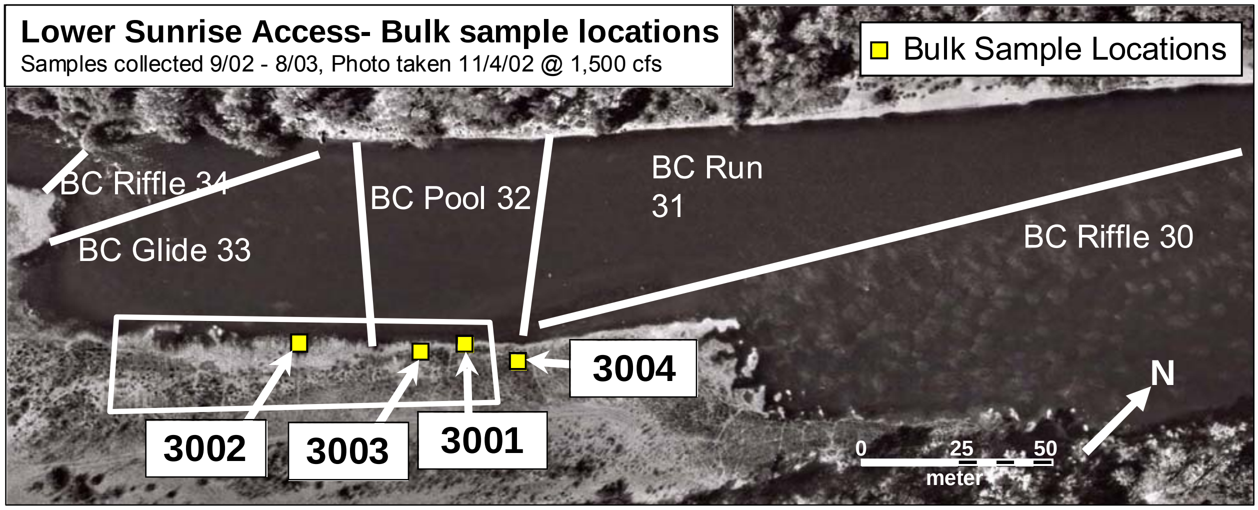
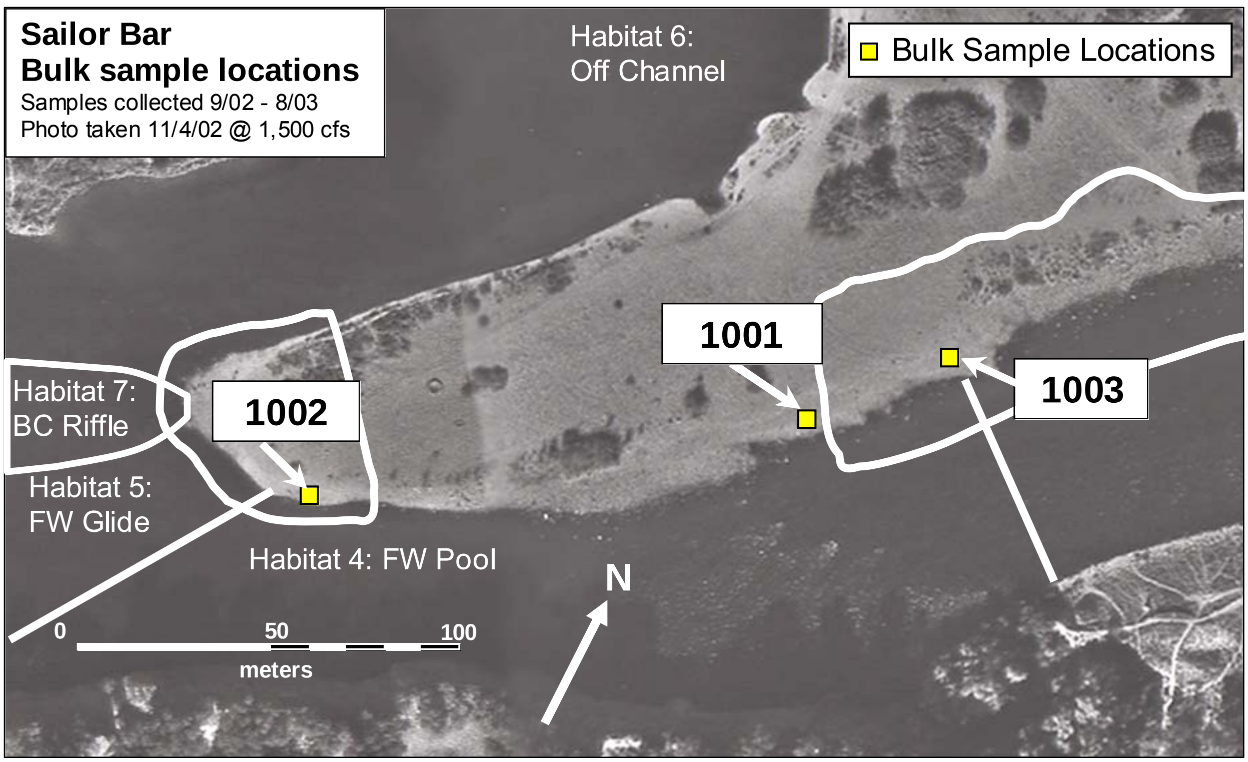


Figure 6: Gravel sampling sites at Sacramento Bar. The experimental gravel manipulation area is outlined with a white line. Sites 5001, 5002 and 5003 are inside the gravel enhancement area, and provide information about gravel size distribution three years after the manipulation experiment. Site 5004 was intended to be a background (undisturbed) sample, and is located approximately 10 m downstream from the site of gravel addition. Site 5004 may have received some of the new gravel as it washed downstream during high flow events, and in this case is not a representative background sample.



A.



B.

Figure 7: Gravel sampling sites from Lower Sunrise Access and Sailor Bar. Manipulated sites are outlined with white lines to show the extent of gravel ripping and new gravel emplacement during the 1999 construction event. A.) Gravel sampling sites from Lower Sunrise Access. B.) Gravel sampling sites from Sailor Bar. Site 1001 is downstream from the new gravel, and may not be an appropriate background site if gravel has mobilized after emplacement.

A.

B.

Figure 8: A.) Portable rocker sieves were used in the field to determine particle size distribution of spawning gravels. B.) Samples were weighed using a tripod and digital balance.

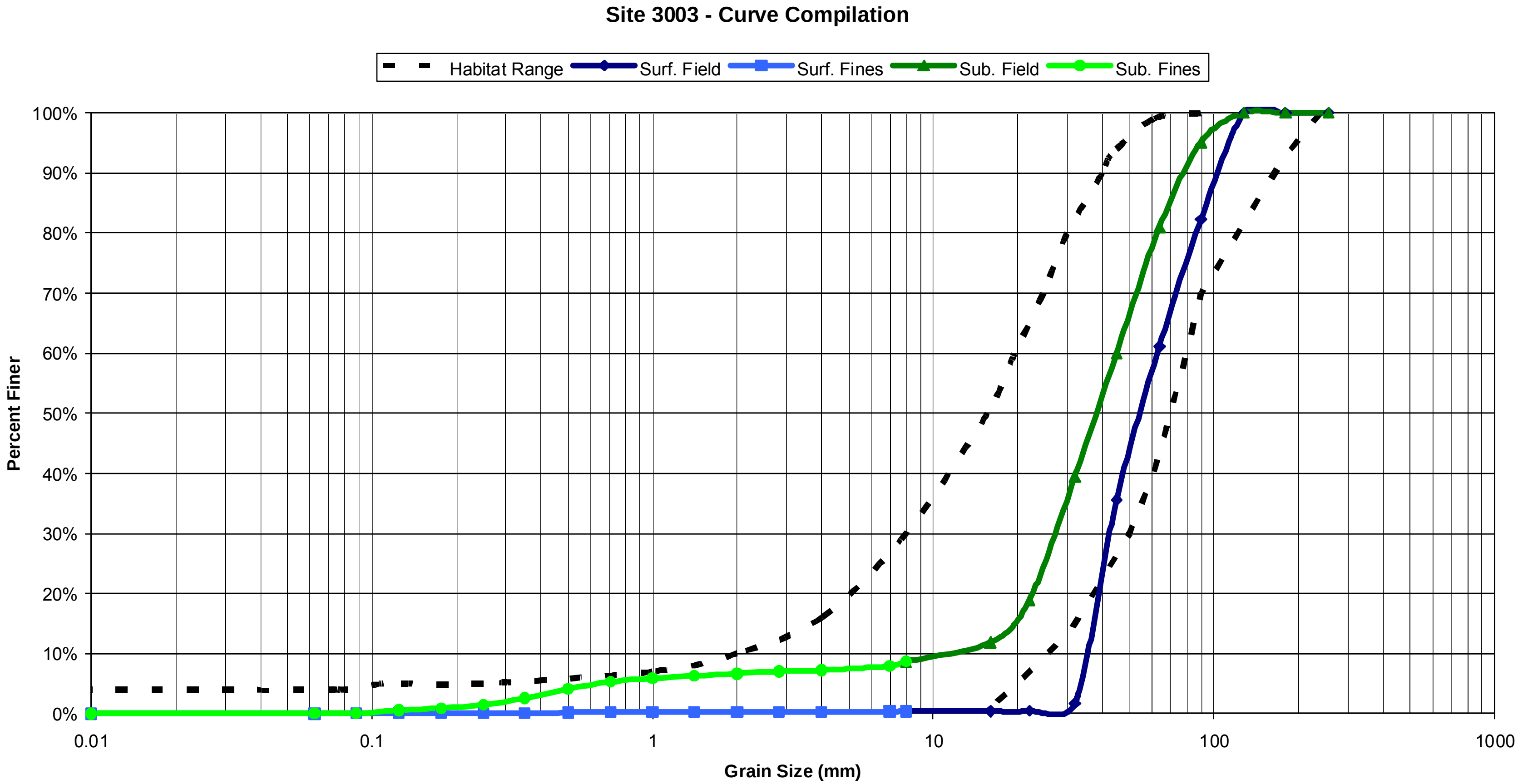
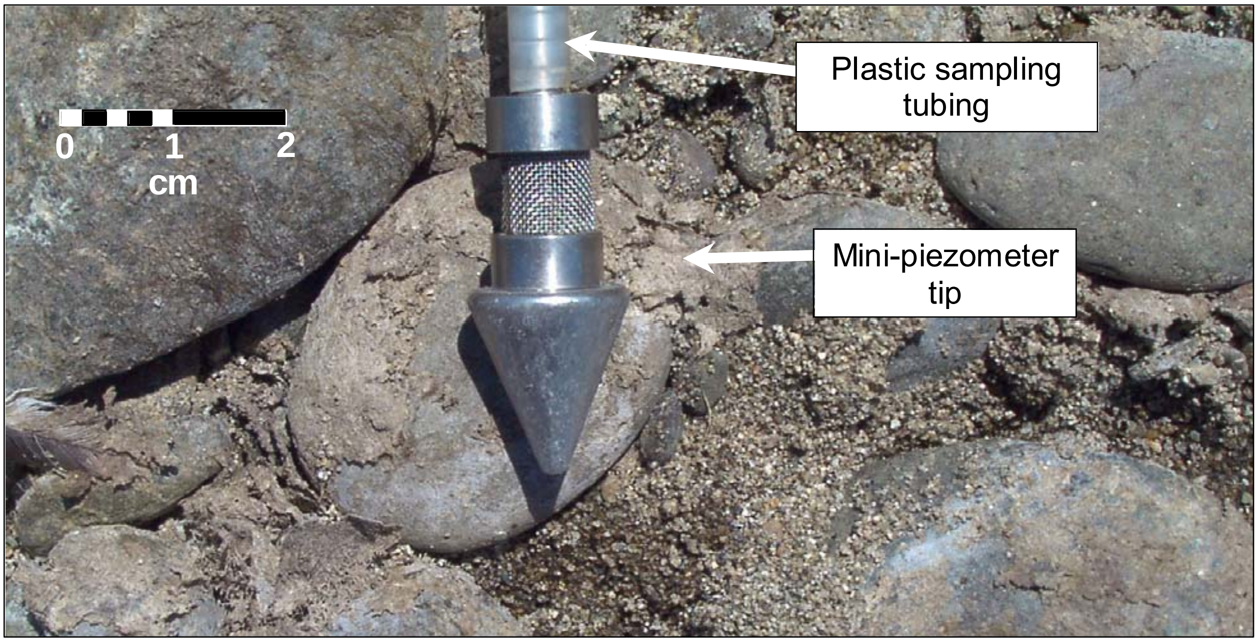
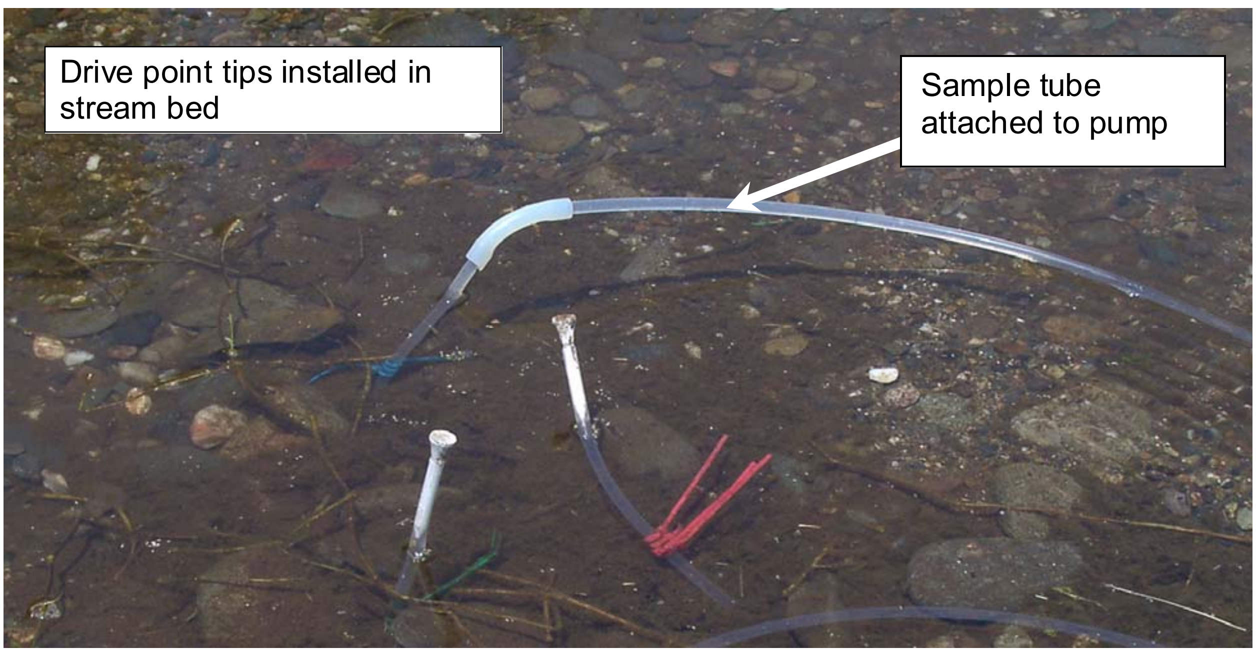


Figure 9: Grain size analysis compilation curve- surface and subsurface samples.

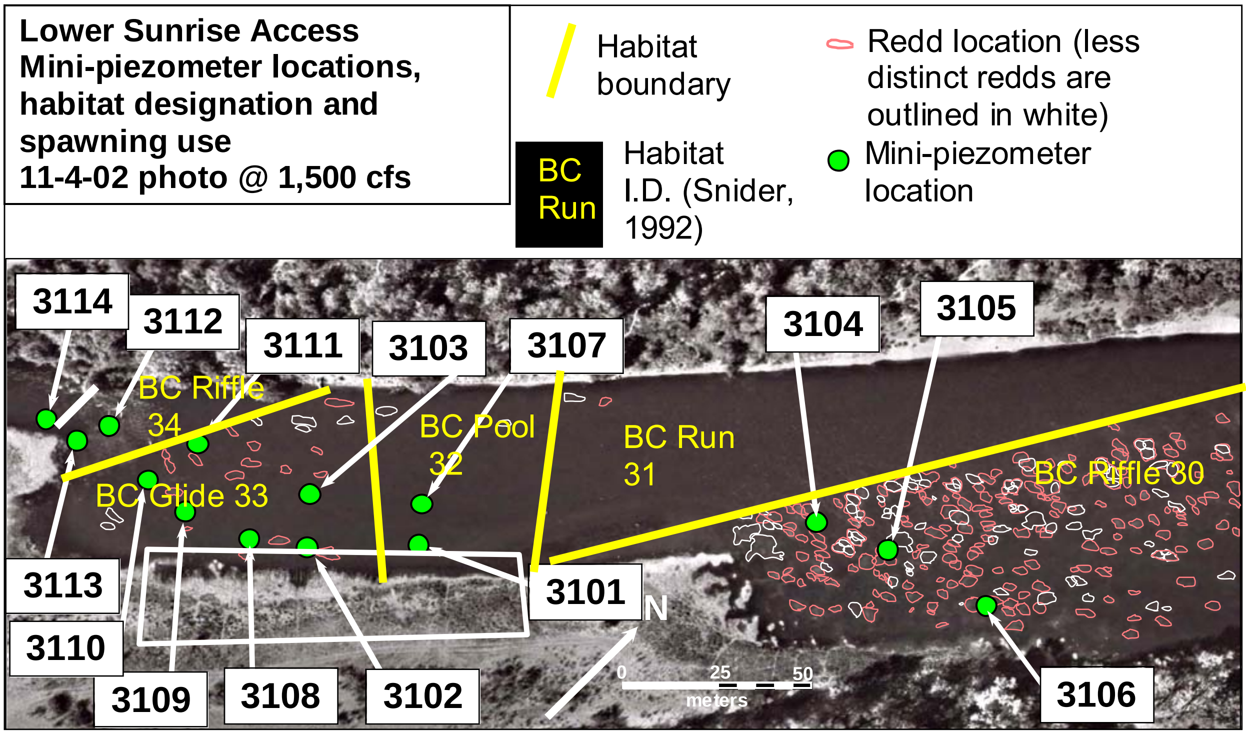


A.



B.

Figure 10: Plastic tubes with stainless steel tips are used to collect water samples from measured depths in the gravel bar. A.) Stainless steel mini-piezometer tip has screened interval less than 1 cm long. B.) Nests or clusters of sample tips are installed at each site, with tips driven to depths of 30, 60 and 90 cm in the gravel. Sample tubes are color coded by depth, and blocked with golf tees to prevent flow or cross-contamination between surface water and the sample interval.



A.

Figure 11: Mini-piezometer locations, habitat units and spawning use at Lower Sunrise Access. Highest spawning density is in riffles and glide/riffle transition. Gravel manipulation area is outlined by a white polygon on the south bank. Minor spawning occurs at the edge of the gravel enhancement project, although most of the new gravel is above the waterline at 1,500 cfs. Habitat identification and number are from Snider, 1992.

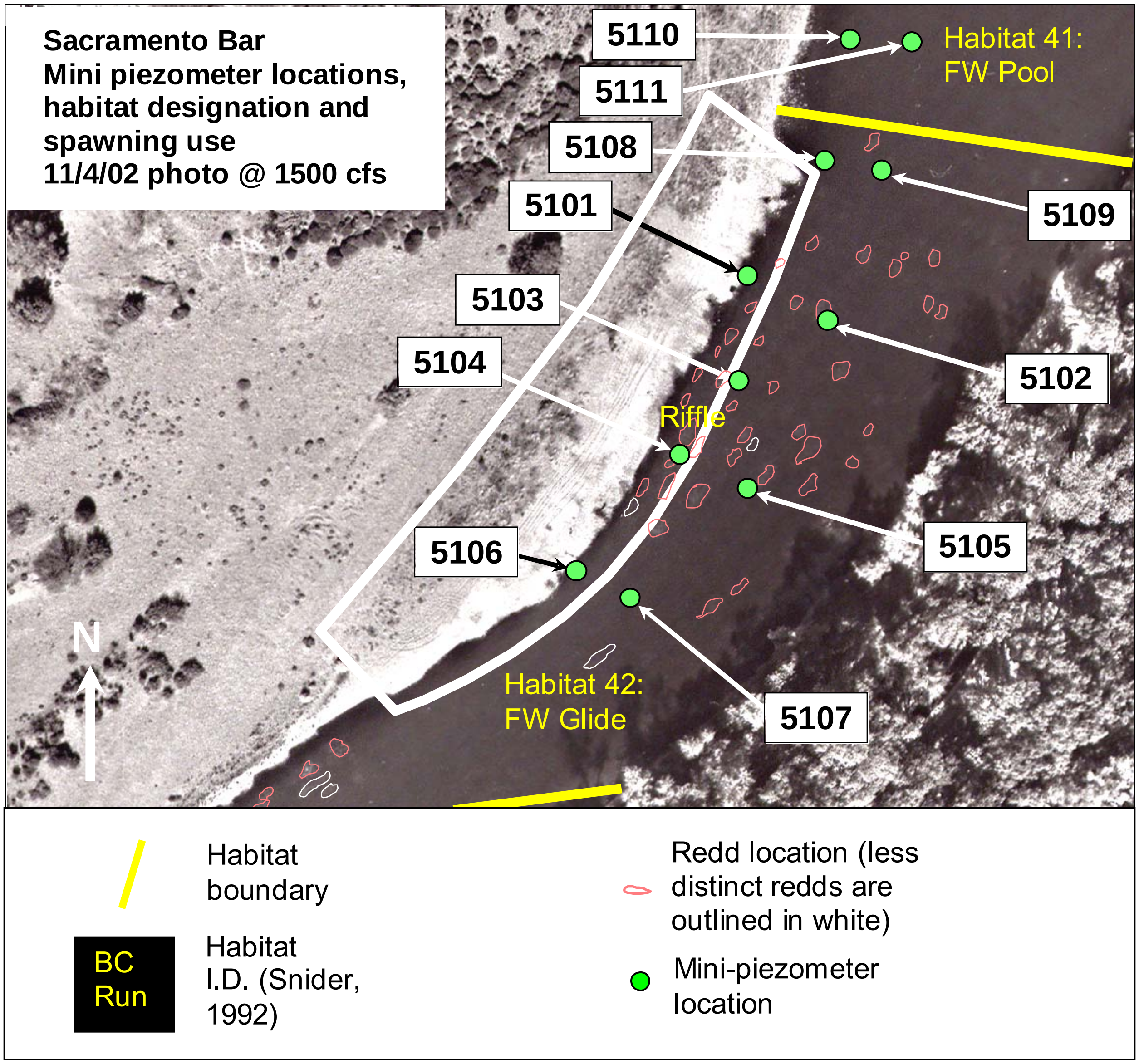


Figure 12: Mini-piezometer locations, habitat units and spawning use at Sacramento Bar. Significant spawning occurs in shallow, high velocity water at the edge of the gravel enhancement project. Gravel manipulation area is outlined by a white polygon on the north bank, showing that much of the new gravel is above the waterline at 1,500 cfs. Habitat identification and numbers are from Snider, 1992, with an additional (un-numbered) riffle designation added for this project.

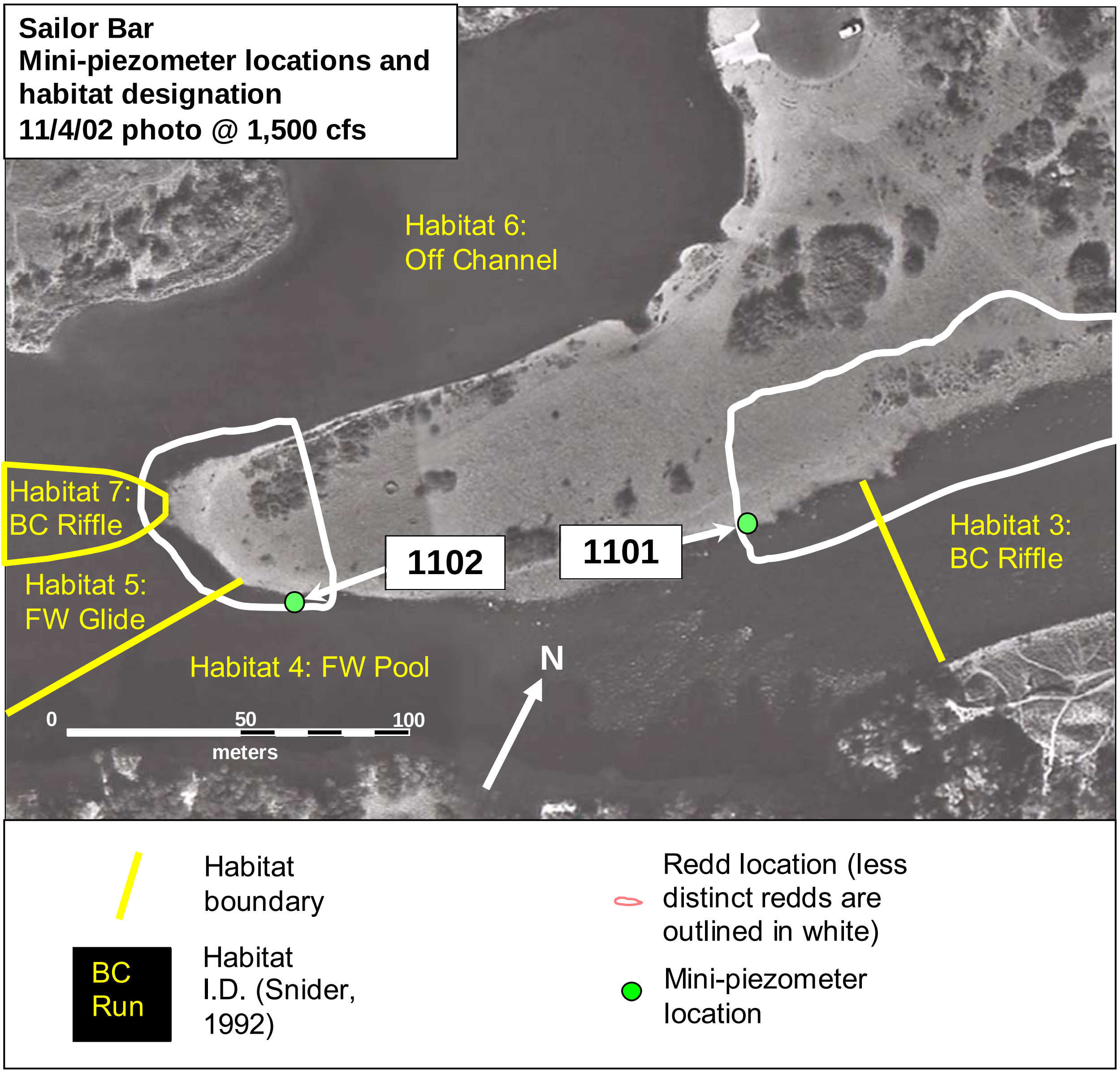


Figure 13: Mini-piezometer locations and habitat units at Sailor Bar. Gravel enhancement areas are outlined by white lines. Additional piezometers will be installed as part of the 2003/2004 gravel assessment project.

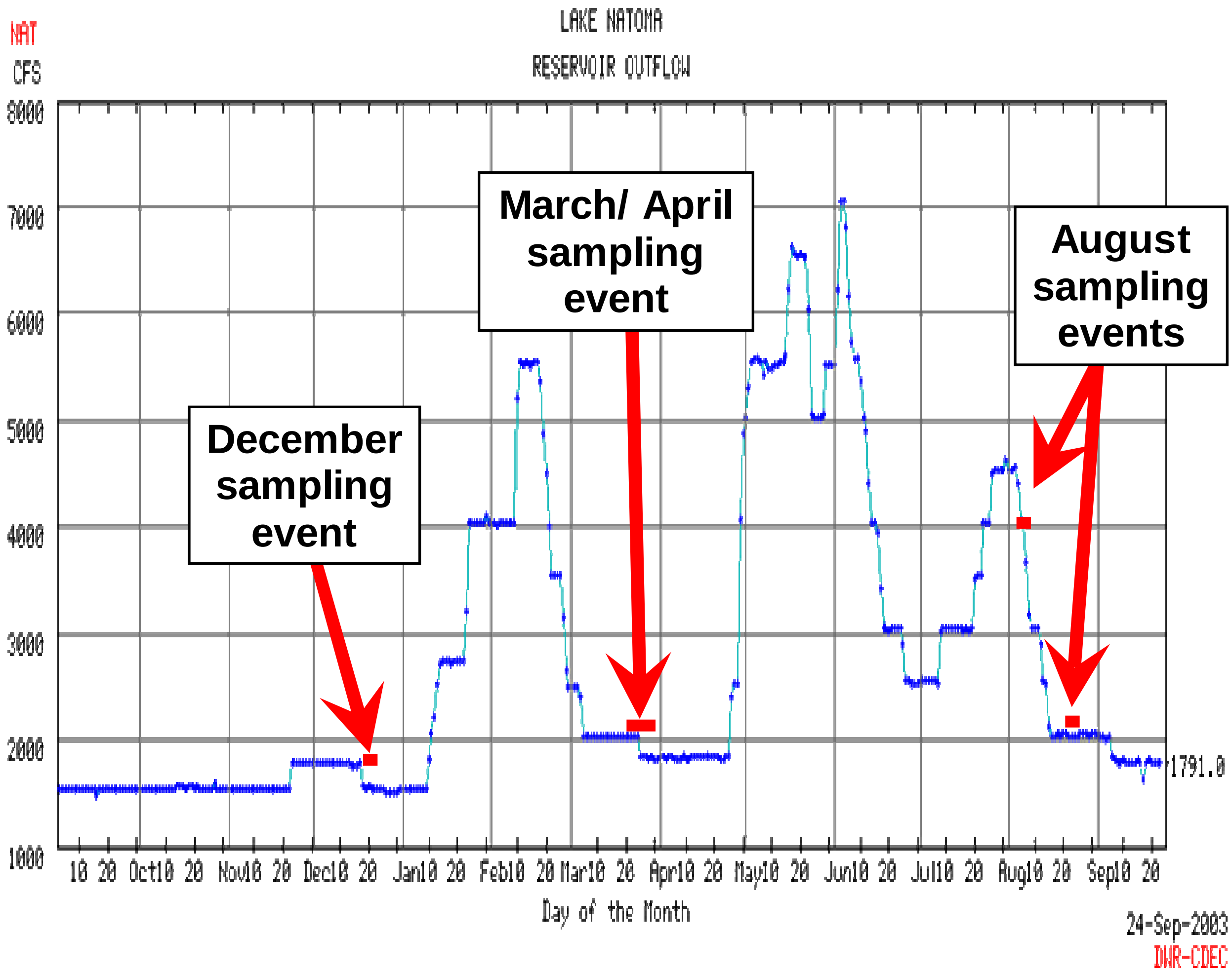


Figure 14: Dates for field sampling events and year-long hydrograph of American River flows. Field parameters were measured and water samples were collected three times during the project year. More sampling points were added as the project progressed, so the August sampling event is most comprehensive. Peak flows in February, June and August are in response to Delta water quality demands, and are not related to weather or hydrologic conditions in the American River basin.

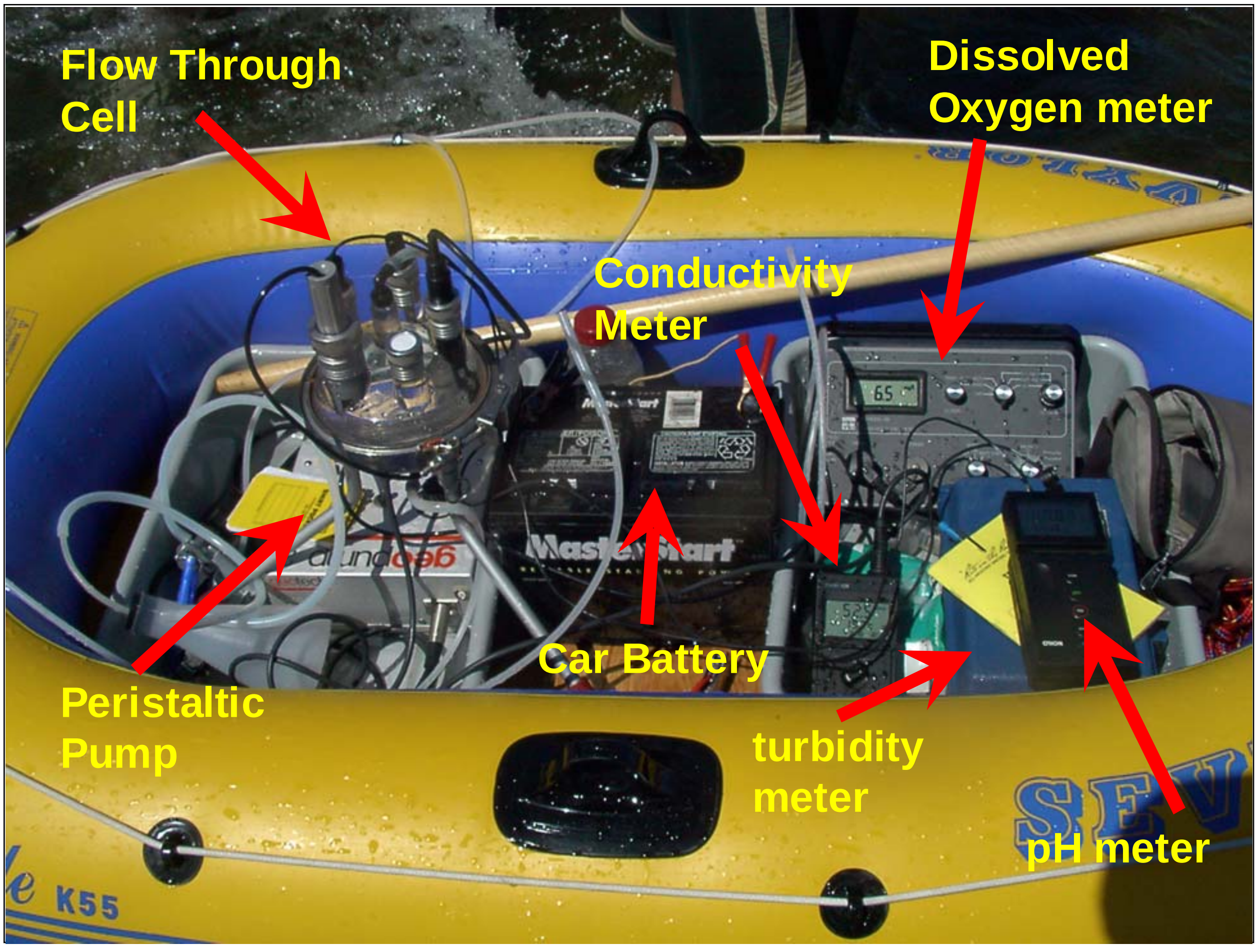


Figure 15: Raft and field sampling equipment. Plastic tubing connects a peristaltic pump to mini-piezometer tips installed in the gravel. Water is pumped from the gravel, through the flow-through cell. Probe tips for dissolved oxygen, conductivity, pH, and temperature read directly from the flow-through cell, so water samples are not exposed to atmospheric conditions. Samples are filtered through a 0.45 μm filter, acidified, and transported to the lab for major and trace element analysis.

Lower Sunrise Access
Dissolved oxygen in river water and stream gravel
August 2003 @ 4000 cfs

D.O. at 30 cm depth (mg/L)
D.O. at 60 cm depth (mg/L)
D.O. at 90 cm depth (mg/L)
Stream D.O. = 8.5 mg/L

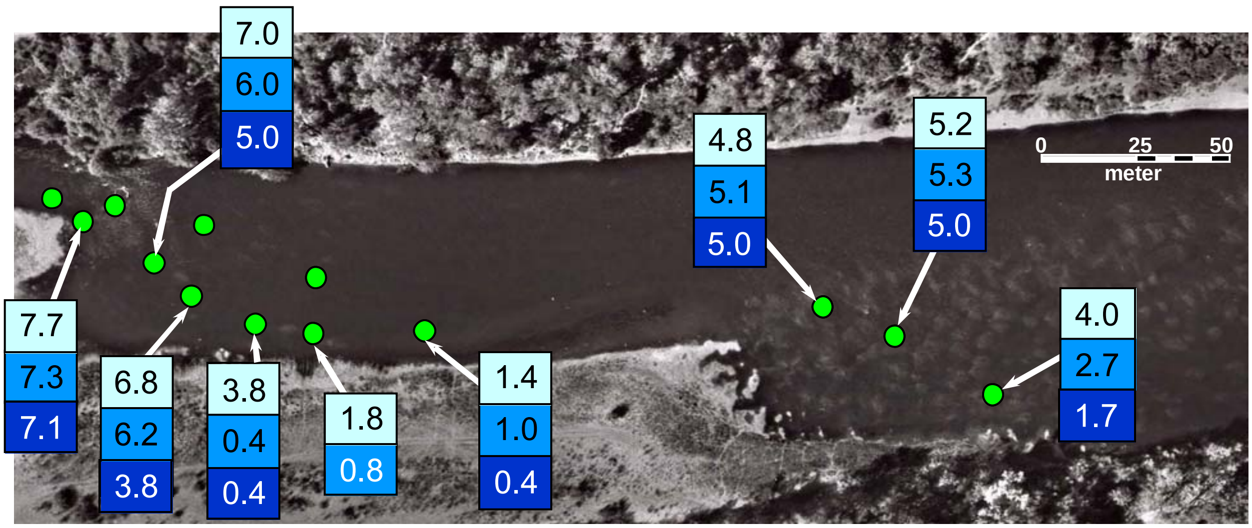


Figure 16: Dissolved oxygen in river water and stream gravel pore water. River water is assumed to be relatively saturated with dissolved oxygen, and pore waters have reduced D.O. content. D.O. content generally decreases with increasing depth in the gravel, and is influenced by decomposition of organic matter and oxidation of mineral species. Highest D.O. values are in the downstream riffle, where pore waters have short flow paths and rapid exchange with surface water.

Sacramento Bar
pH Levels
August, 2003

pH at 30 cm bgs (mg/L)
pH at 60 cm bgs (mg/L)
pH at 90 cm bgs (mg/L)
Stream pH = 7.64mg/L

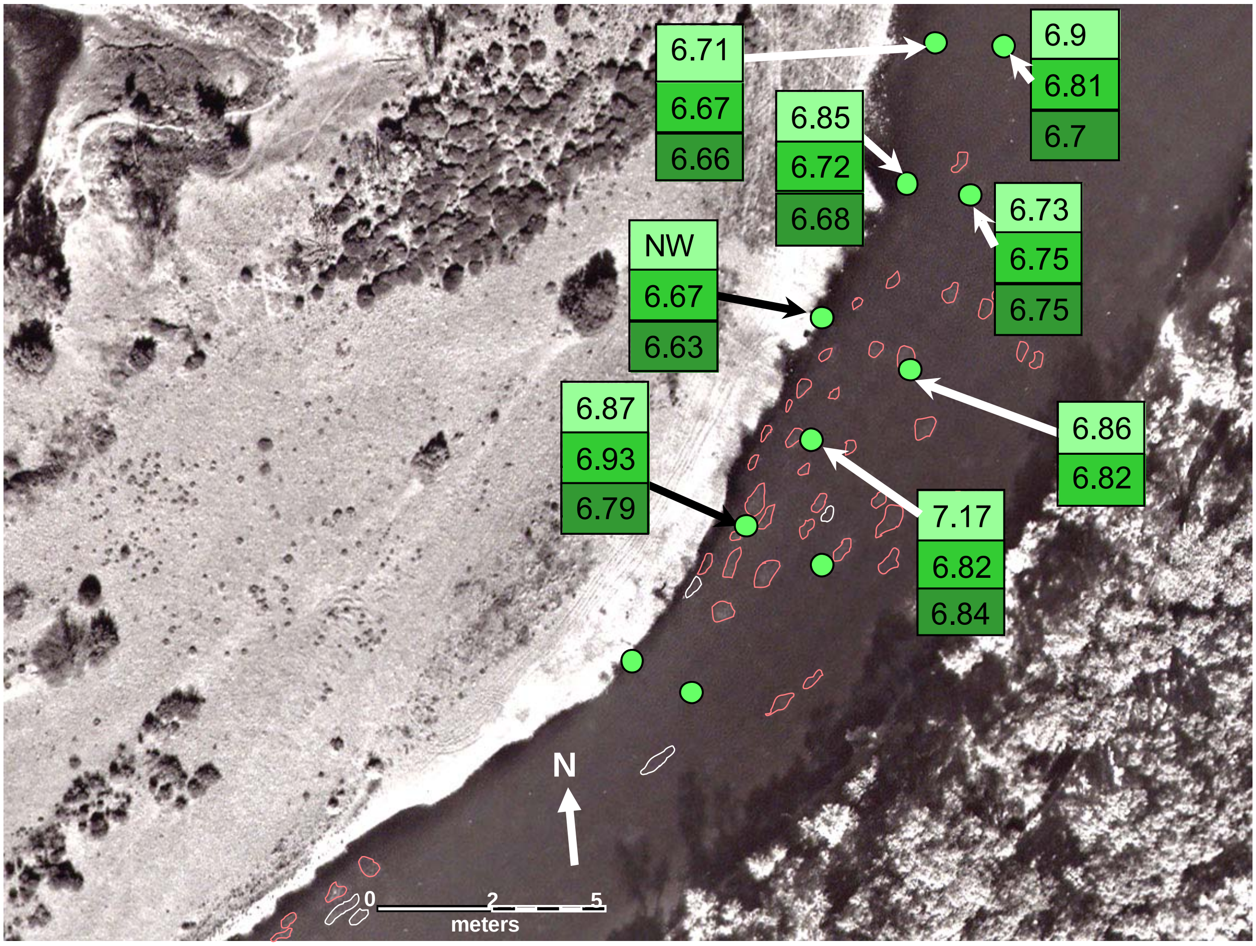


Figure 17: pH measurements from Sacramento Bar, August 2003. pH generally decreases (becomes more acidic) with increasing depth in the gravel.

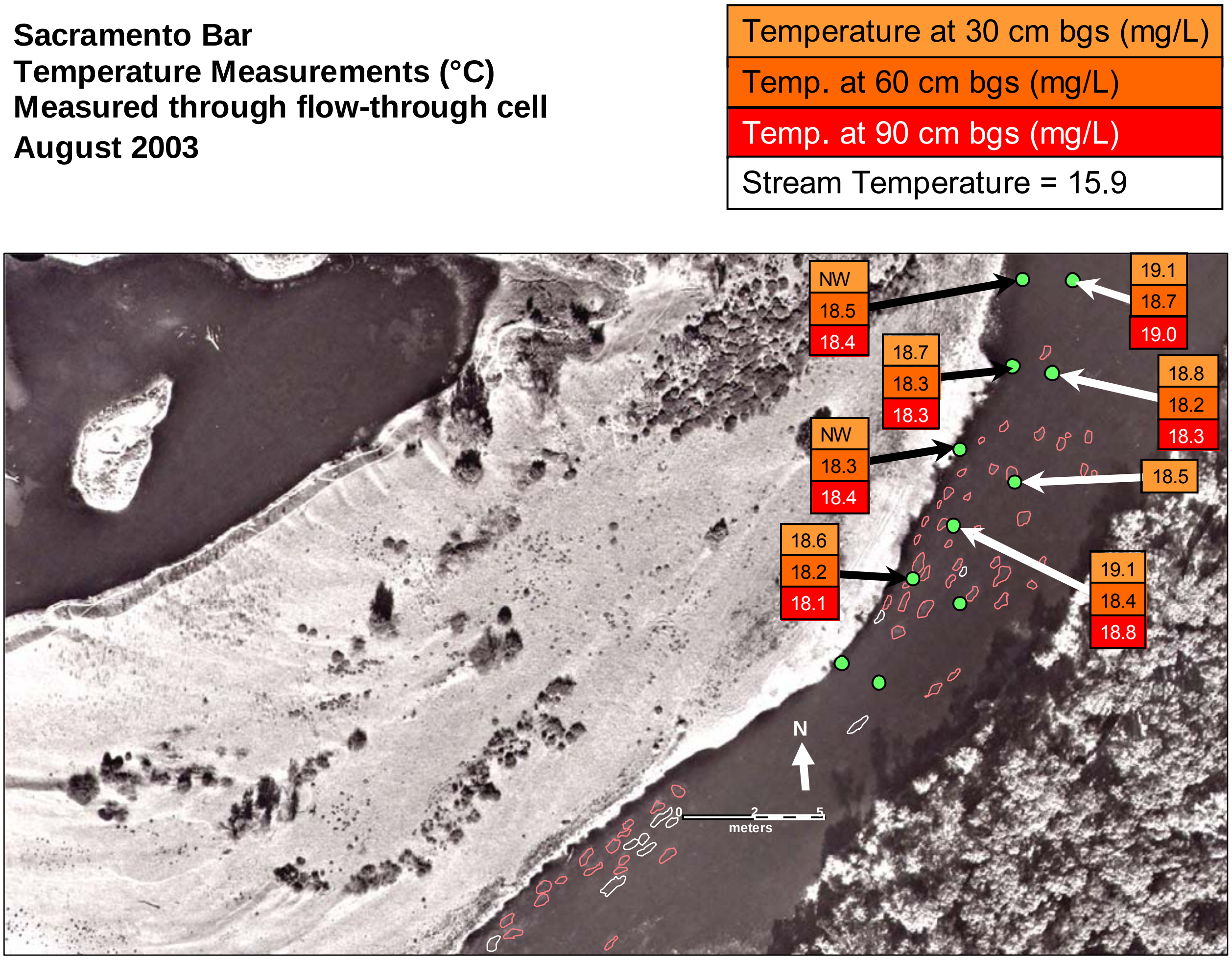
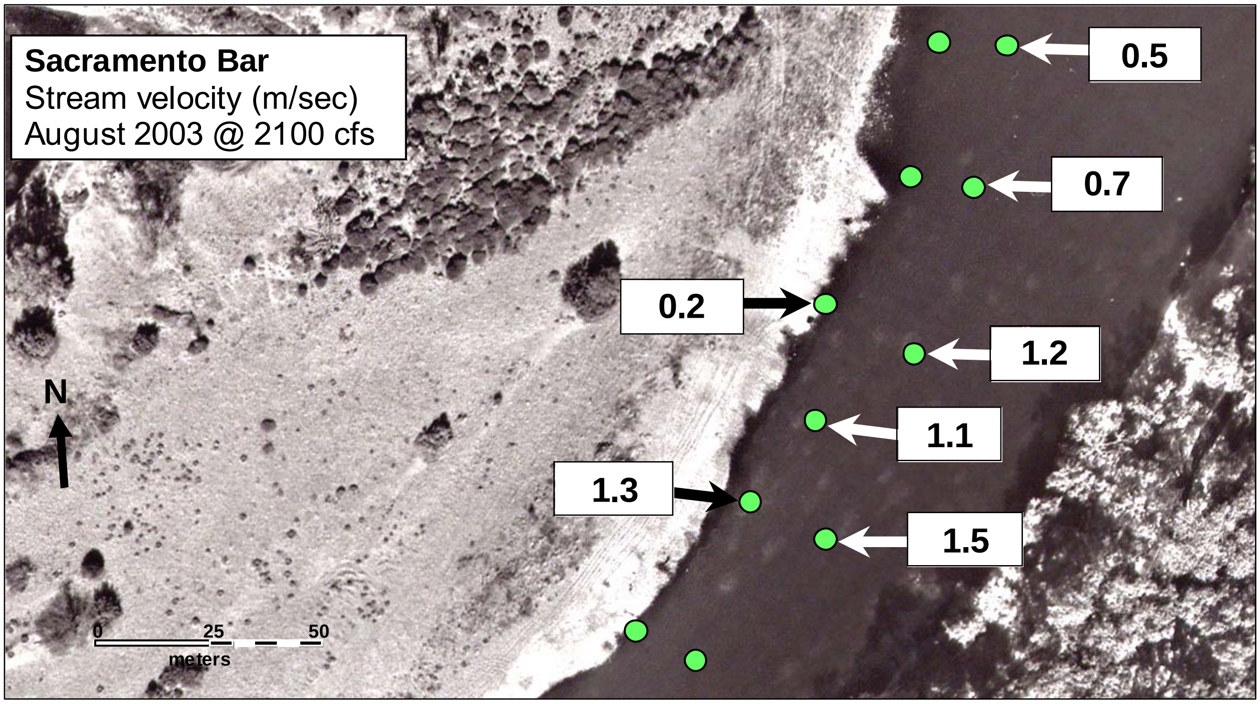
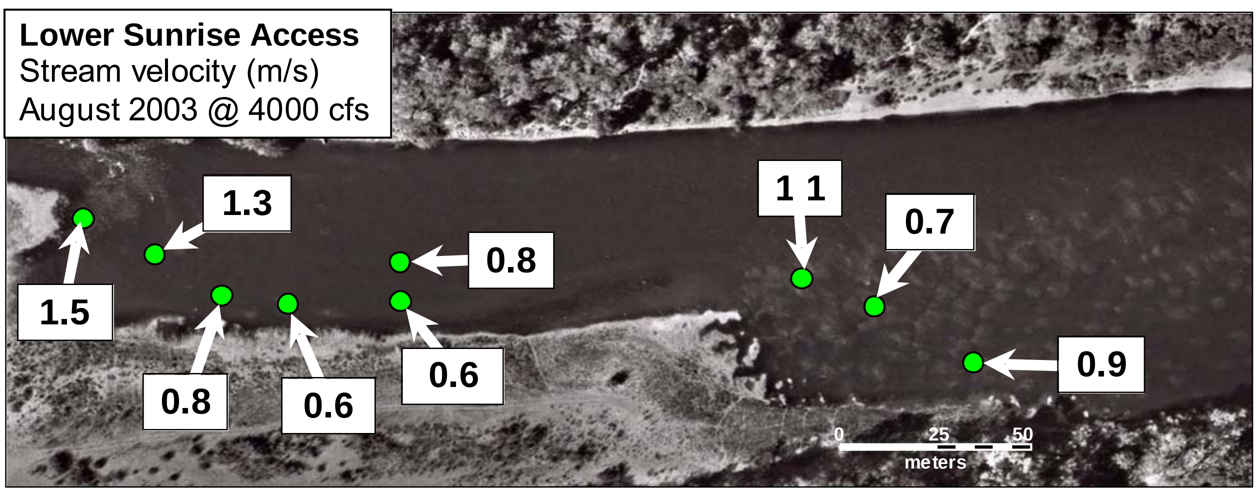


Figure 18: Temperature measurements from Sacramento Bar, when river temperature = 15.9°C. Temperature is measured in a flow-through cell, and may not be representative of conditions in the gravel.



A.



B.

Figure 19: Stream velocity measurements for Sacramento Bar and Lower Sunrise Access. Measurements were all made during August 2003, although flows were different by a factor of two due to Delta water quality demands. A.) At Sacramento Bar, stream velocity is highest in a mid-channel riffle. This is also the site of heaviest spawning use. B.) At Lower Sunrise Access, stream velocity is lowest in shallow areas that border gravel manipulation sites, and highest in mid-channel riffles. Low velocity regions are sites of sediment accumulation. High velocity areas are heavily used for spawning.

Higher head in stream than at depth indicates losing conditions.

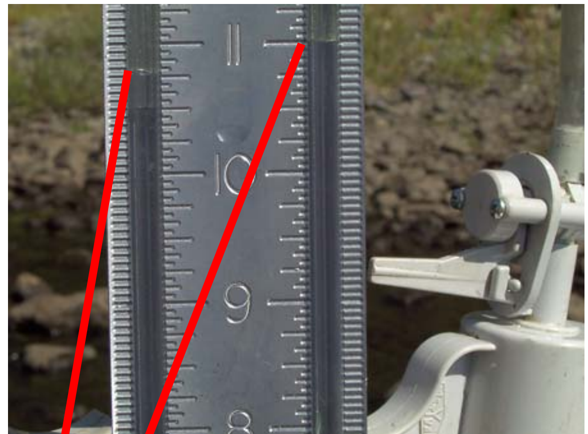


Figure 20: A manometer board is attached to subsurface sampling tubes to measure differences in hydraulic head. Higher head in the stream indicates losing conditions, although gaining conditions (upwelling) are common at the downstream ends of riffles and gravel bars. A baffle box is used to restrict current flow and minimize pressure differences past the open end of the tube.

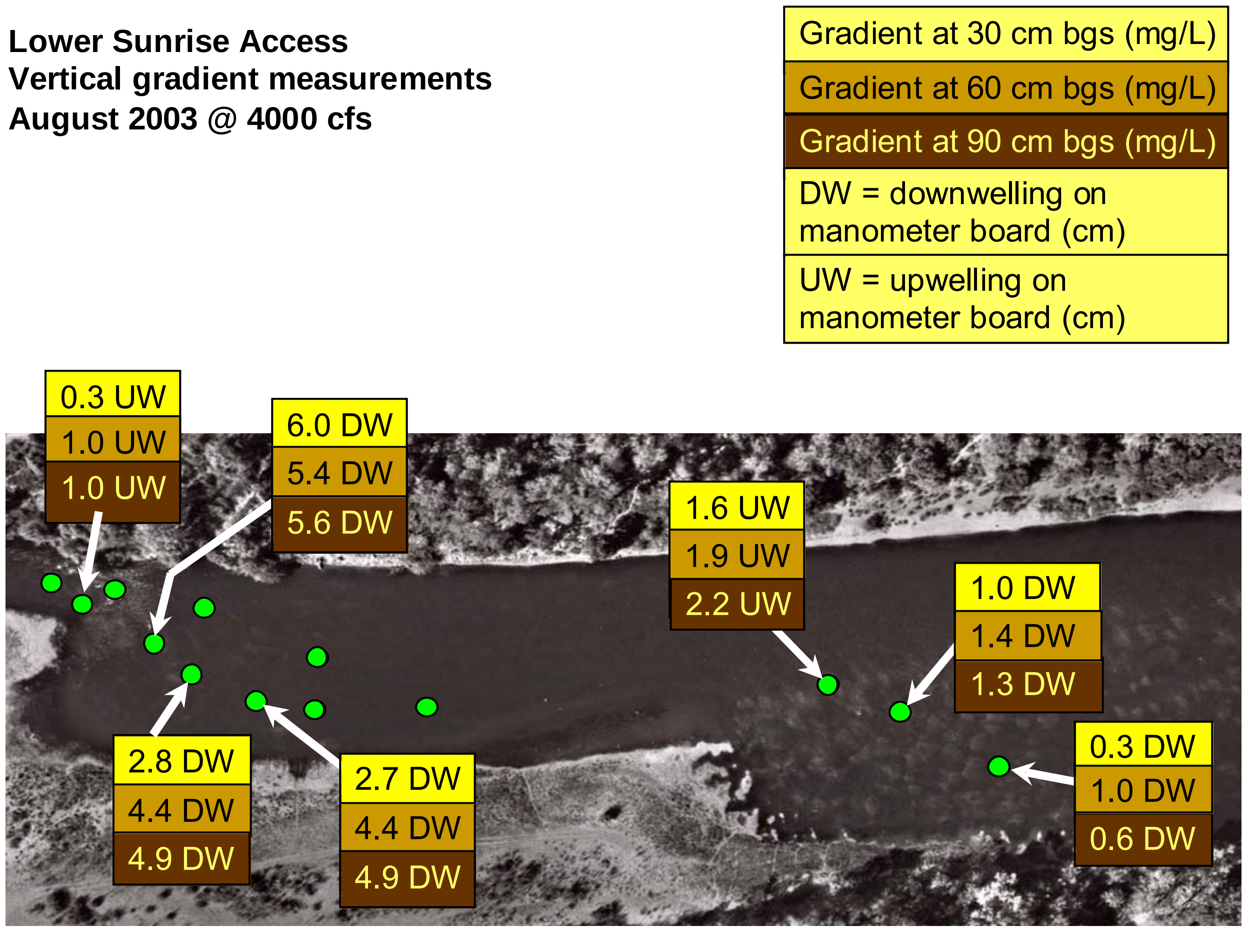


Figure 21: Gaining and losing conditions at Lower Sunrise Access. Shallow flow cells form in the hyporheic zone, and pore water moves because of changes in the pressure gradient. Downwelling is common at pool tailouts and the middle to upper portion of riffles. Upwelling conditions are found on the downstream half of riffles.

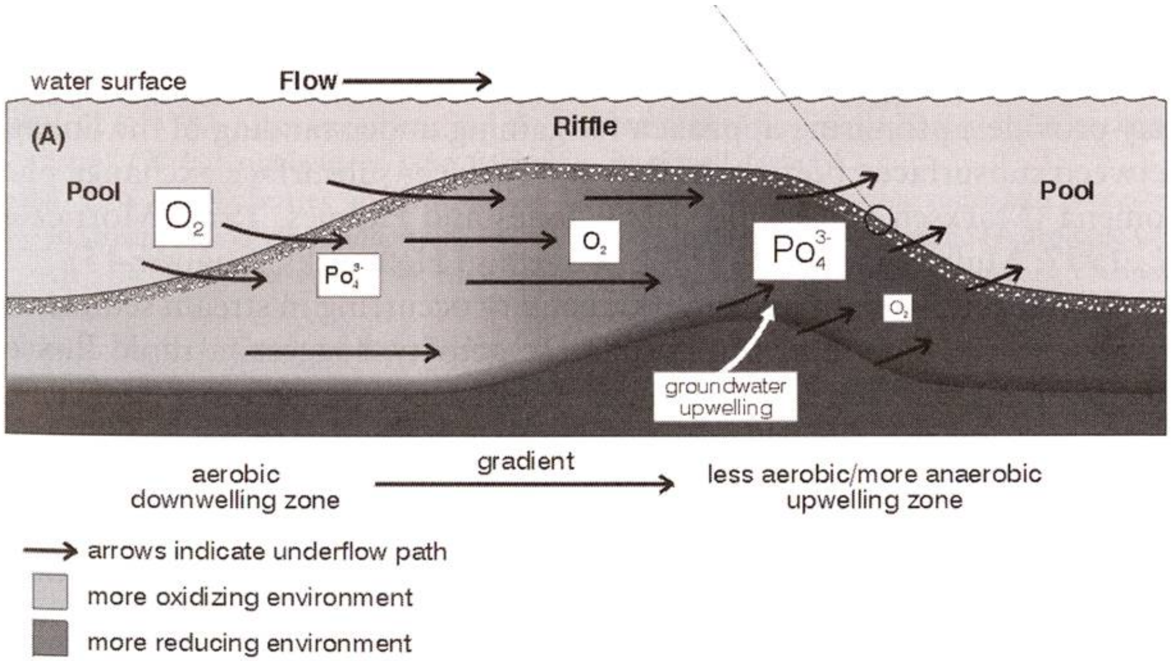


Figure 22: Conceptual model for flow through a pool tailout/riffle sequence. This flow pattern appears to be present in several riffle sequences on the American River. From Jones and Mulholland (2000).

Appendix A: Grain size analysis

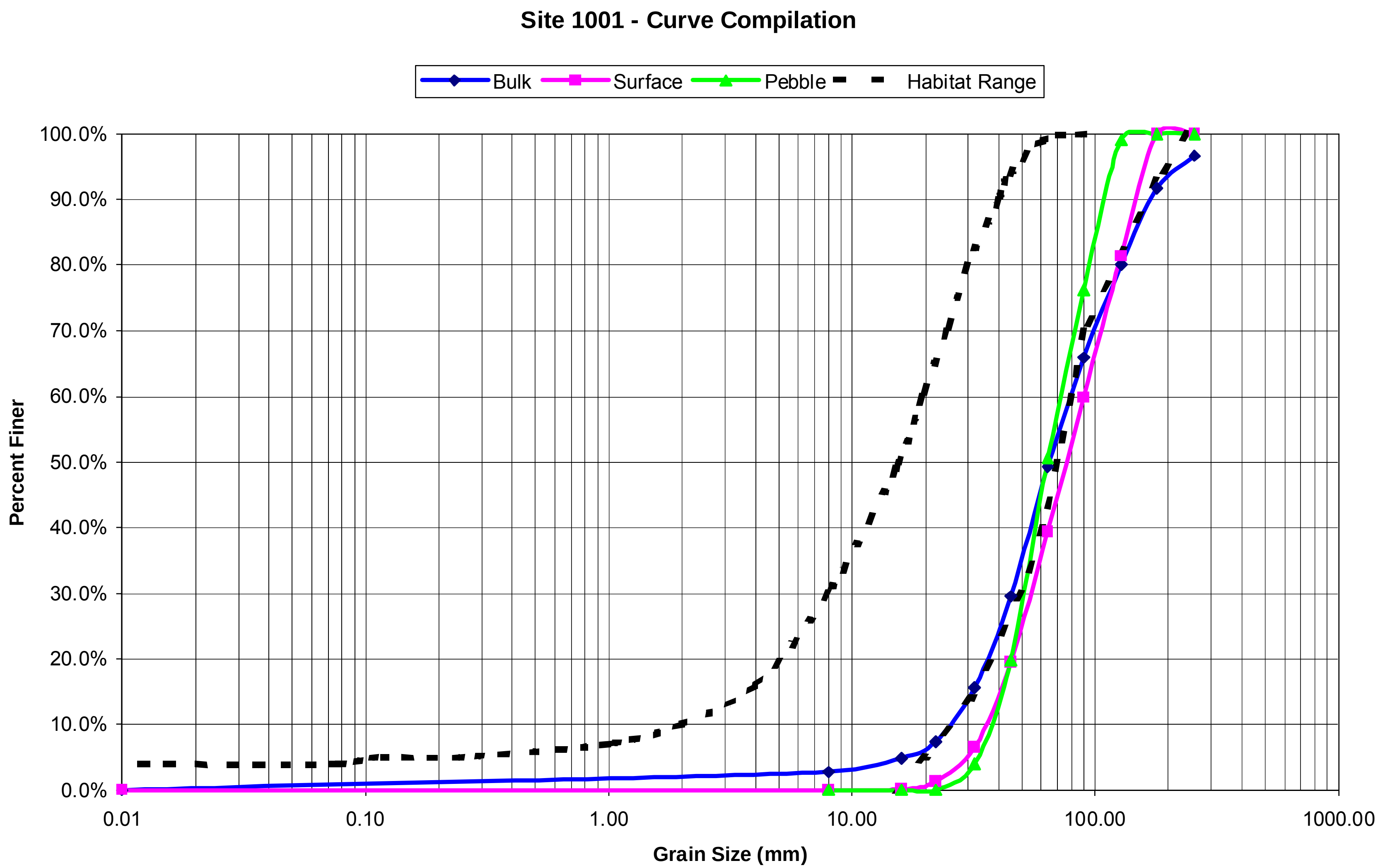


Figure 23: Sieve analysis for Sailor Bar site 1001. Sample is slightly course, but does not have significant armoring. This is an improvement over pre-project conditions.

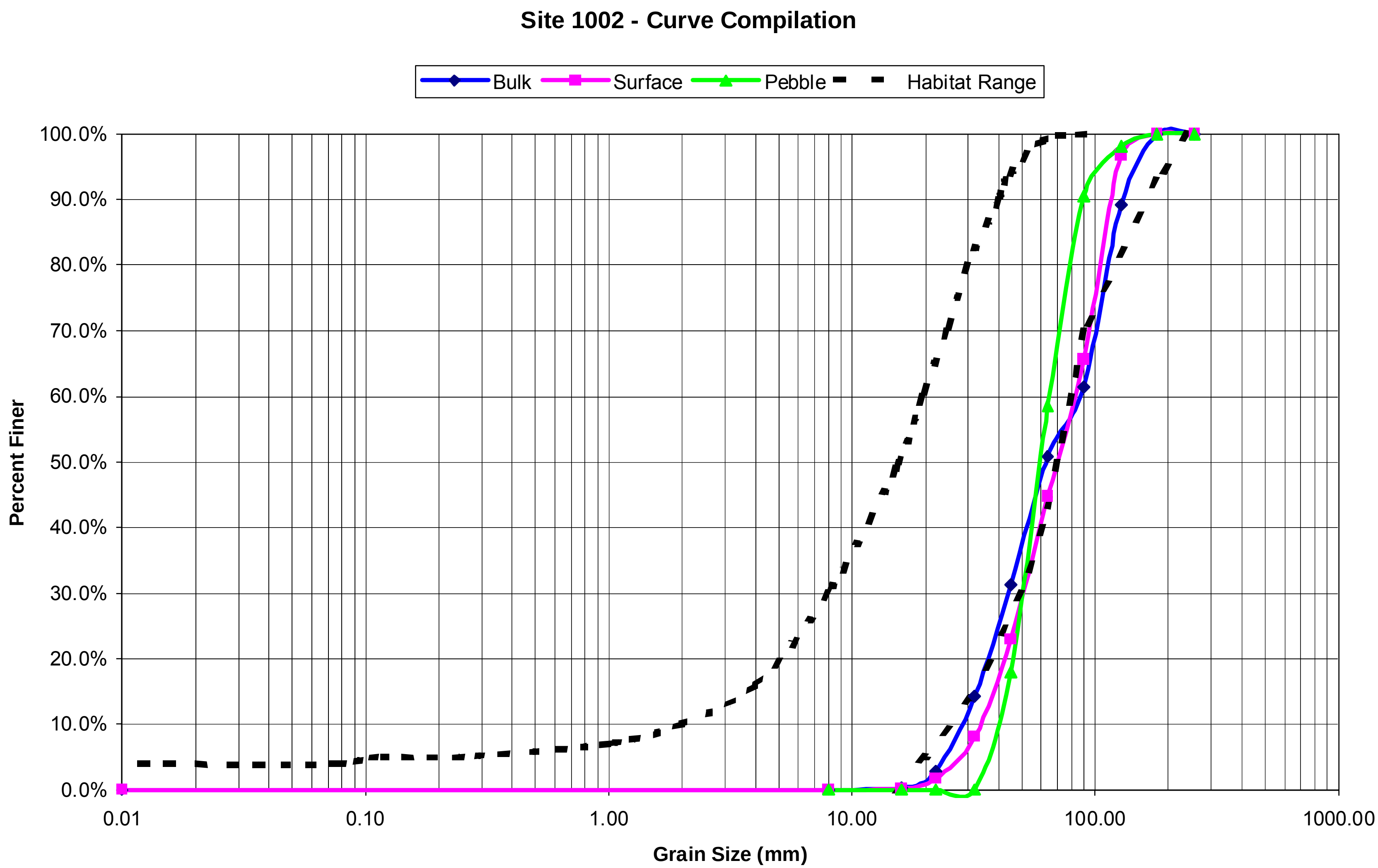


Figure 24: Sieve analysis for Sailor Bar site 1002. Sample is slightly course, but does not have significant armoring. This is an improvement over pre-project conditions.

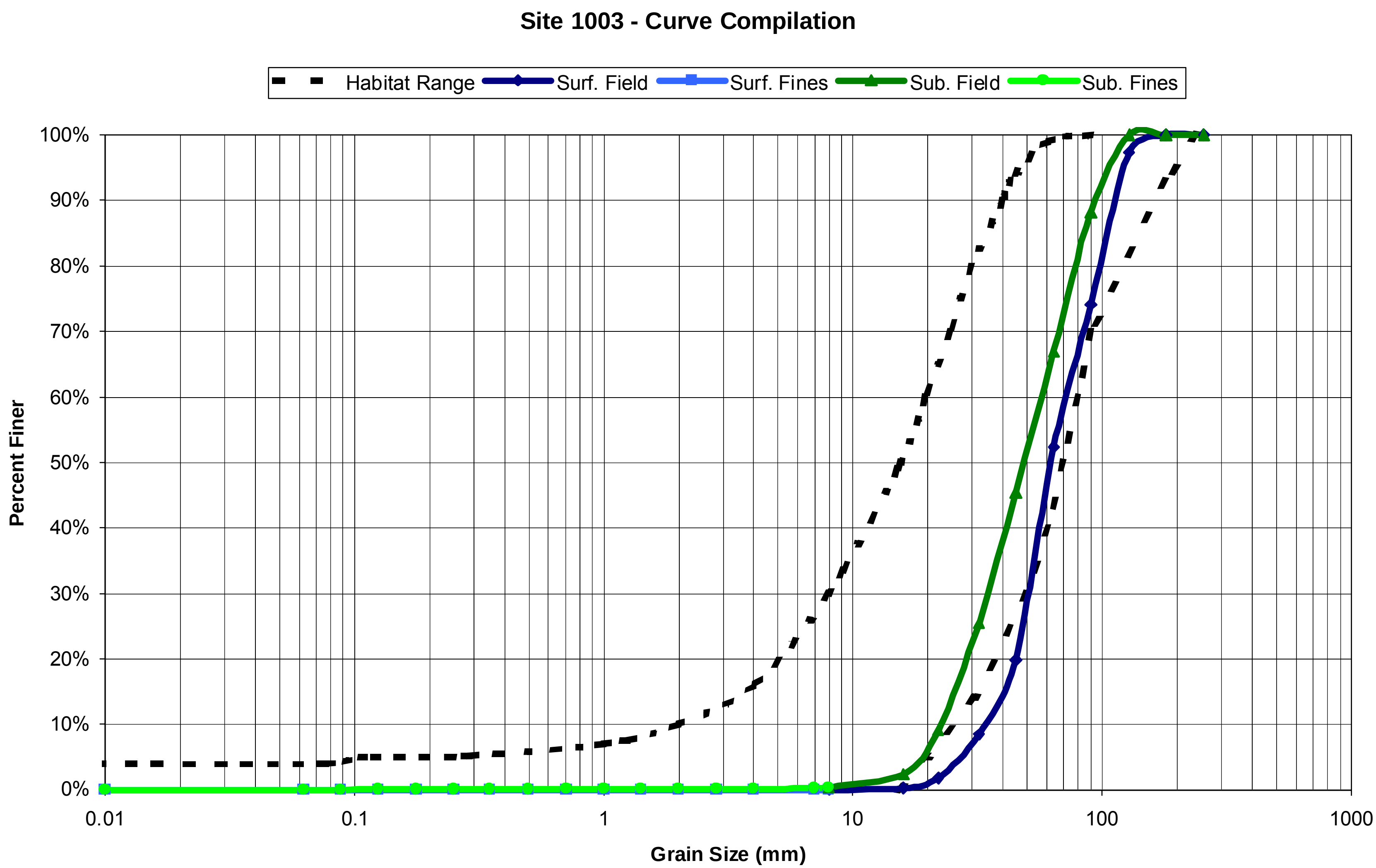


Figure 25: Sieve analysis for Sailor Bar site 1003. Sample is slightly course, but does not have significant armoring. This is an improvement over pre-project conditions.

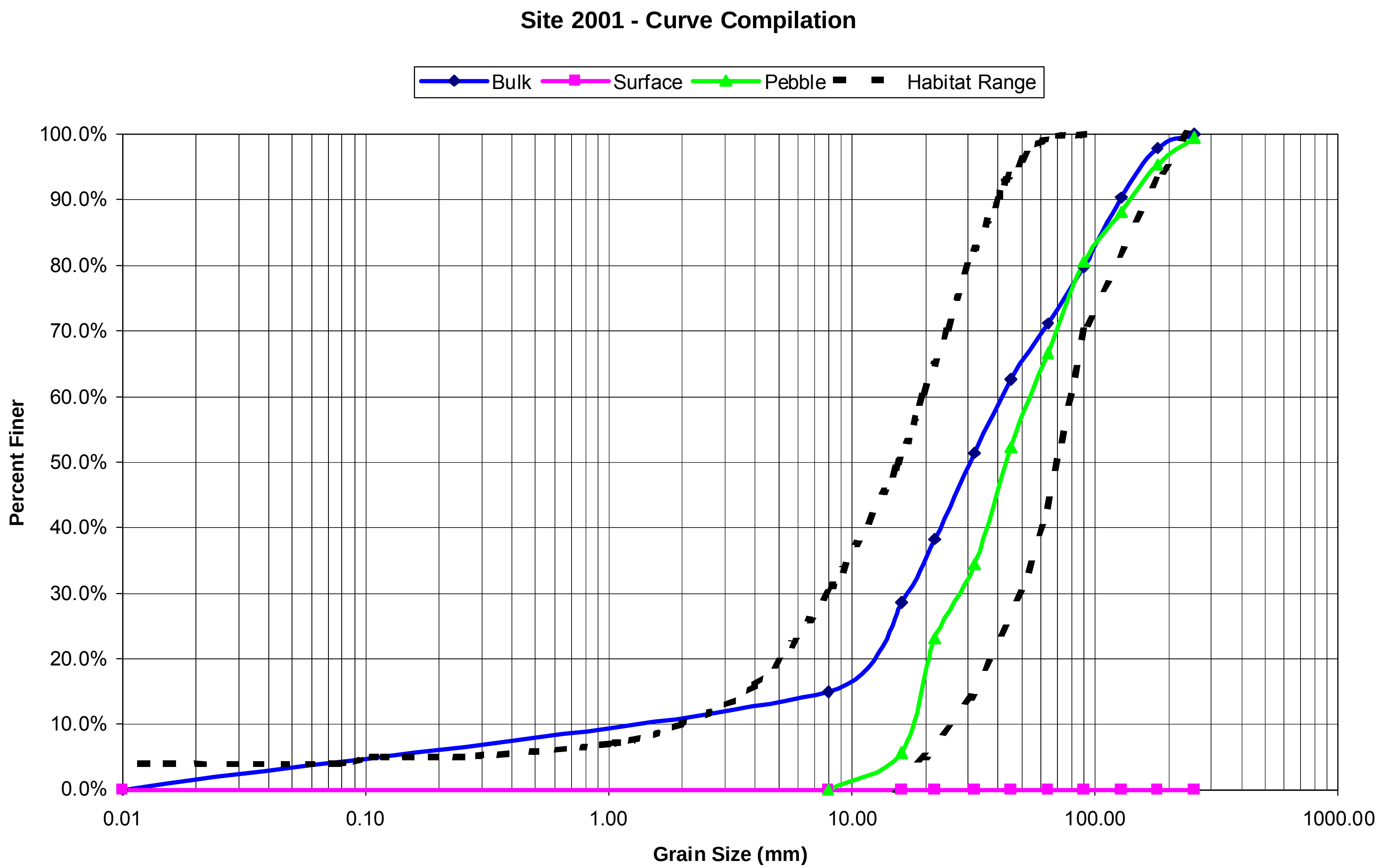


Figure 26: Sieve analysis for lower Sailor Bar site 2001. Sample has more fine and medium-sized gravel than previous samples, but lies within acceptable habitat range.

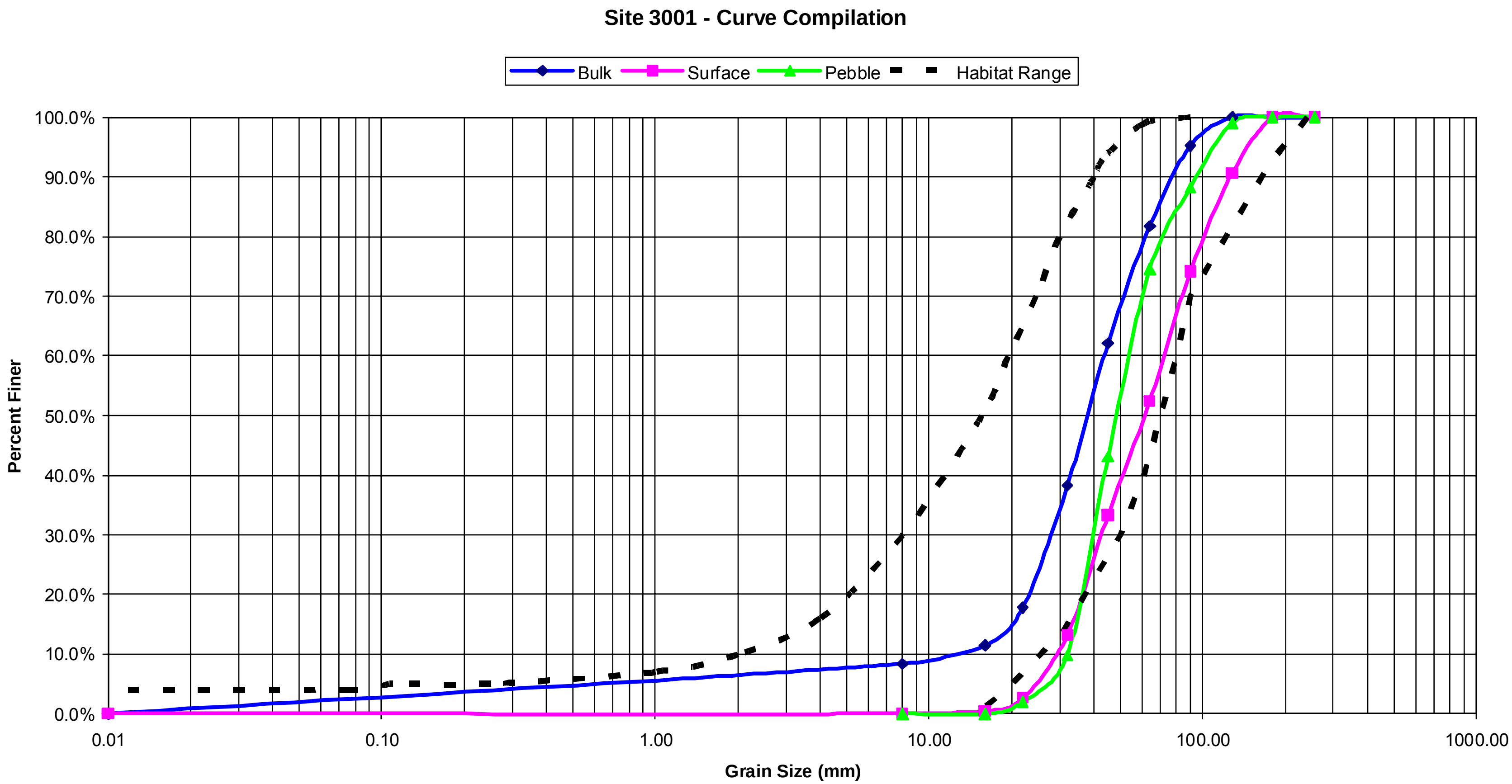


Figure 27: Sieve analysis for Lower Sunrise Access site 3001. Comparison of surface and subsurface grain size distribution shows coarser surface layer (armoring).

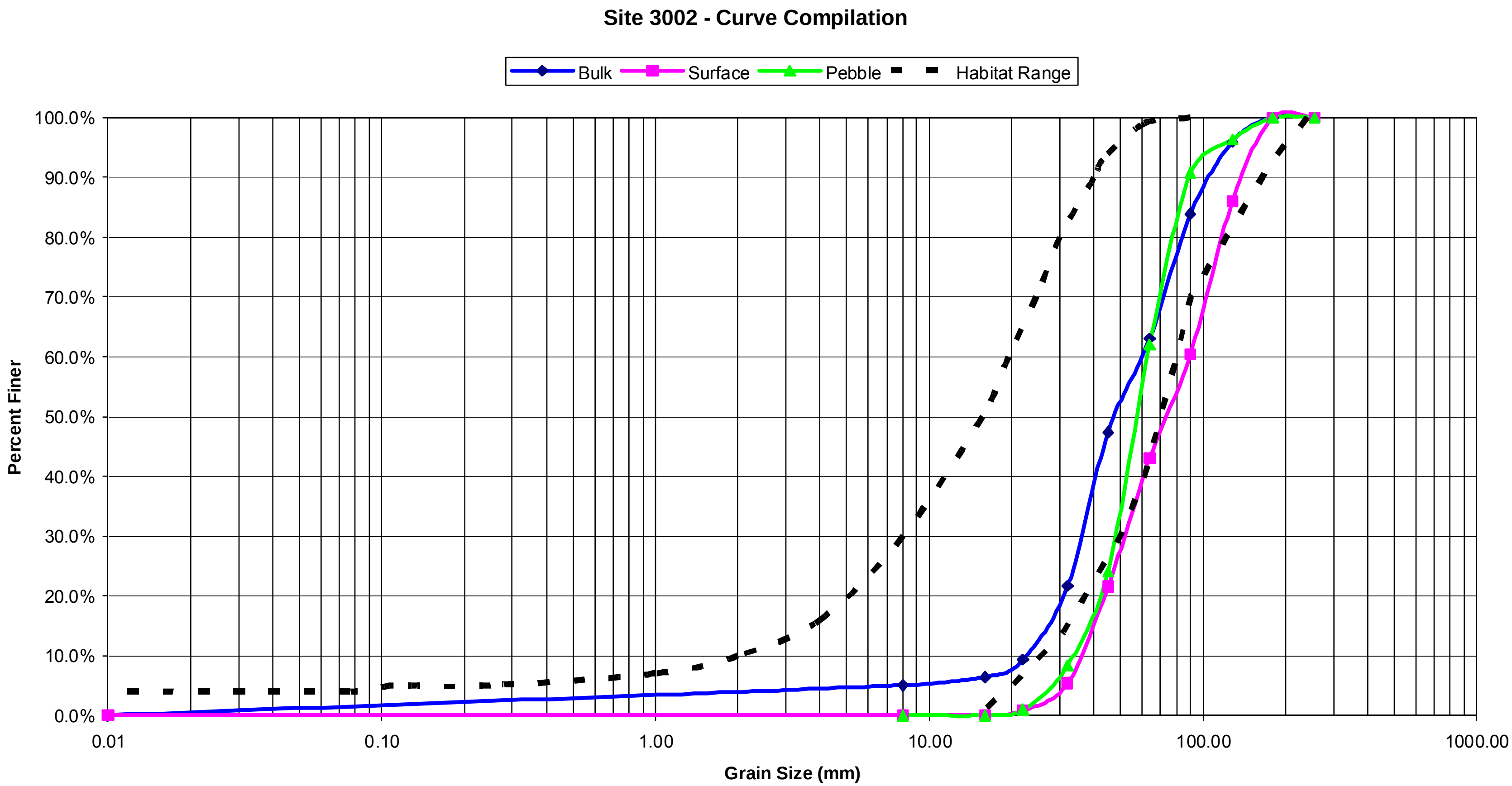


Figure 28: Sieve analysis for Lower Sunrise Access site 3002. Comparison of surface and subsurface grain size distribution shows coarser surface layer (armoring).

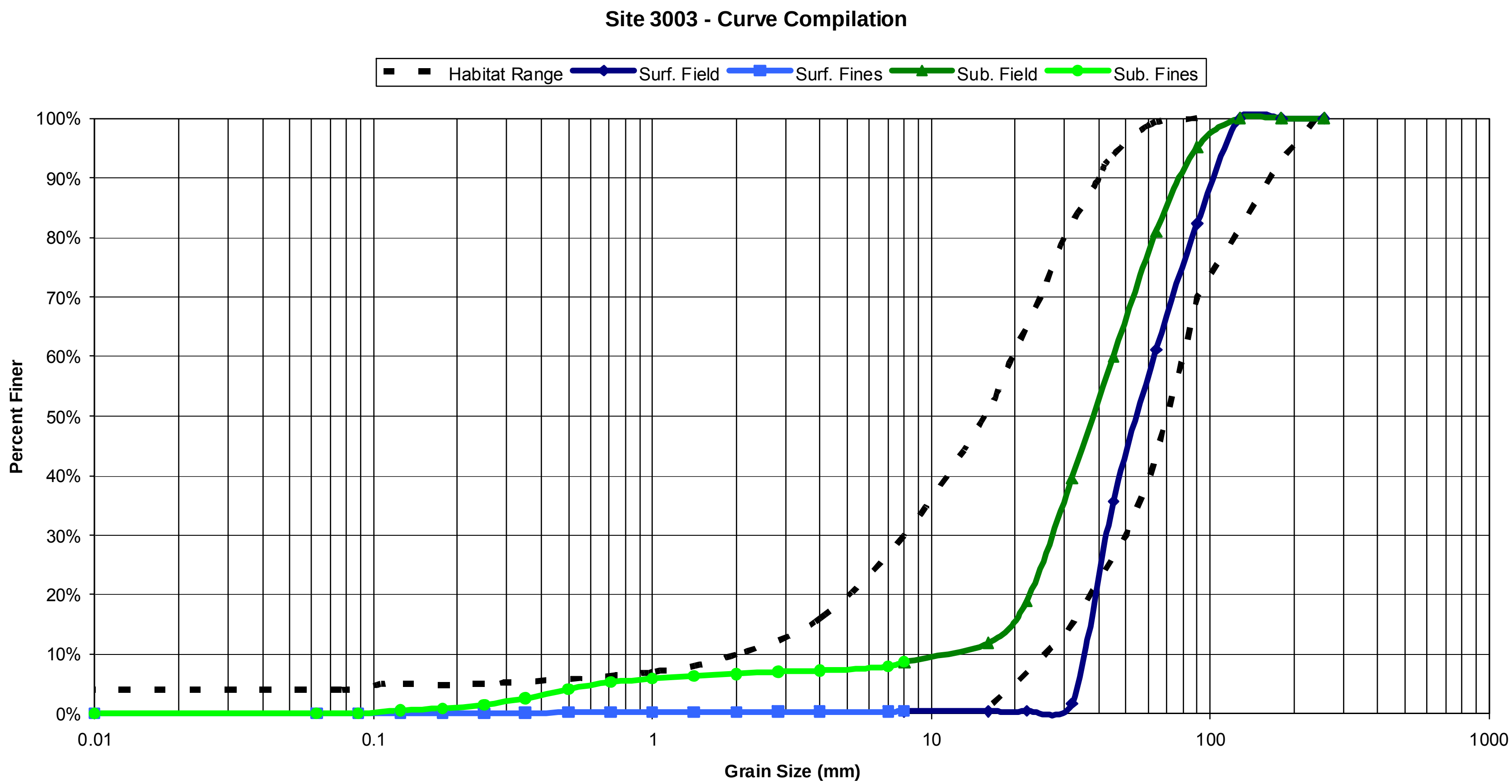


Figure 29: Sieve analysis for Lower Sunrise Access site 3003. Comparison of surface and subsurface grain size distribution shows coarser surface layer (armoring), although grain size distribution is generally within the acceptable range.

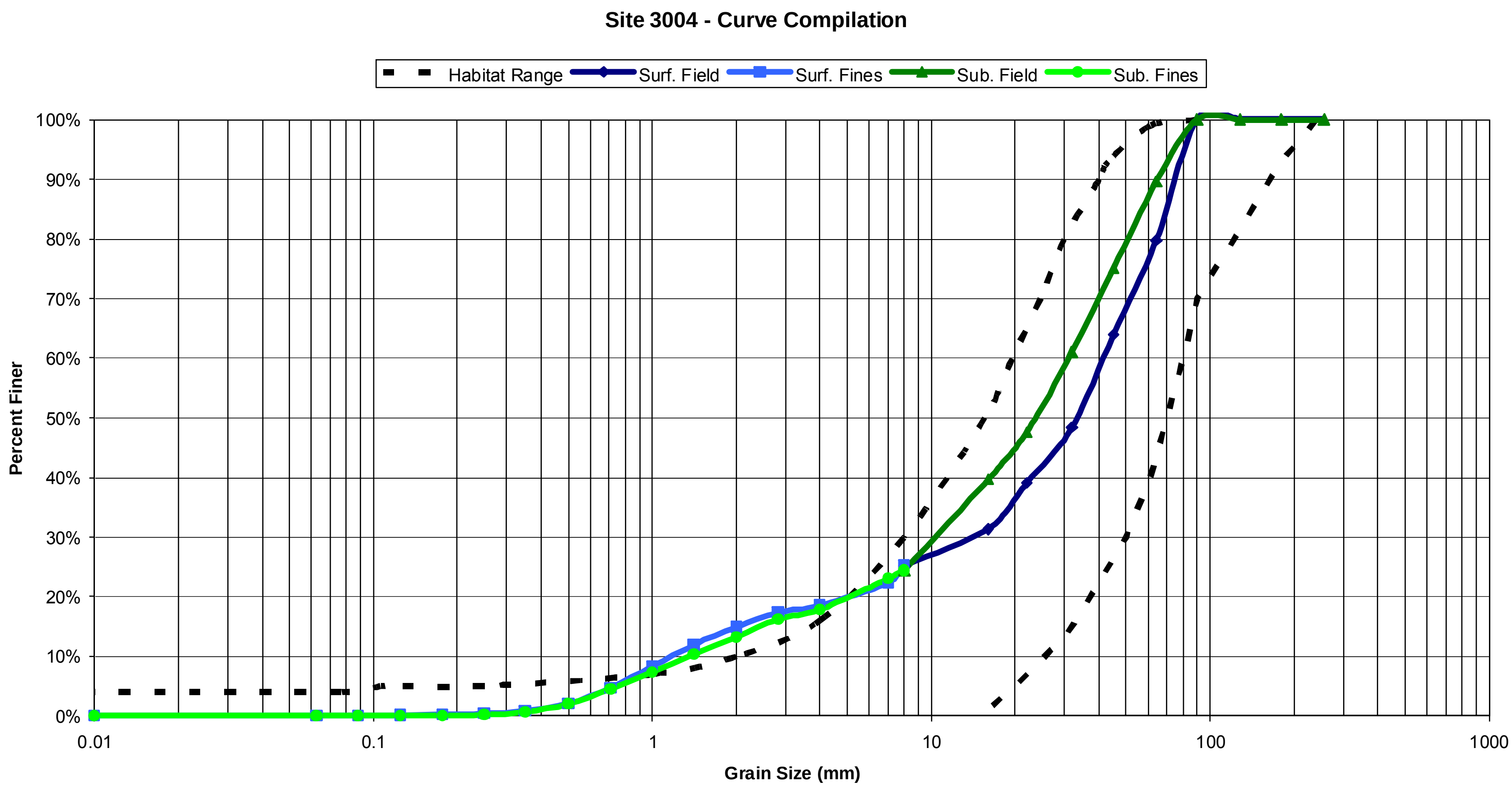


Figure 30: Sieve analysis for Lower Sunrise Access site 3004. Comparison of surface and subsurface grain size distribution shows little or no armoring, but there is an excess of fine sediment at this site that might limit spawning habitat.

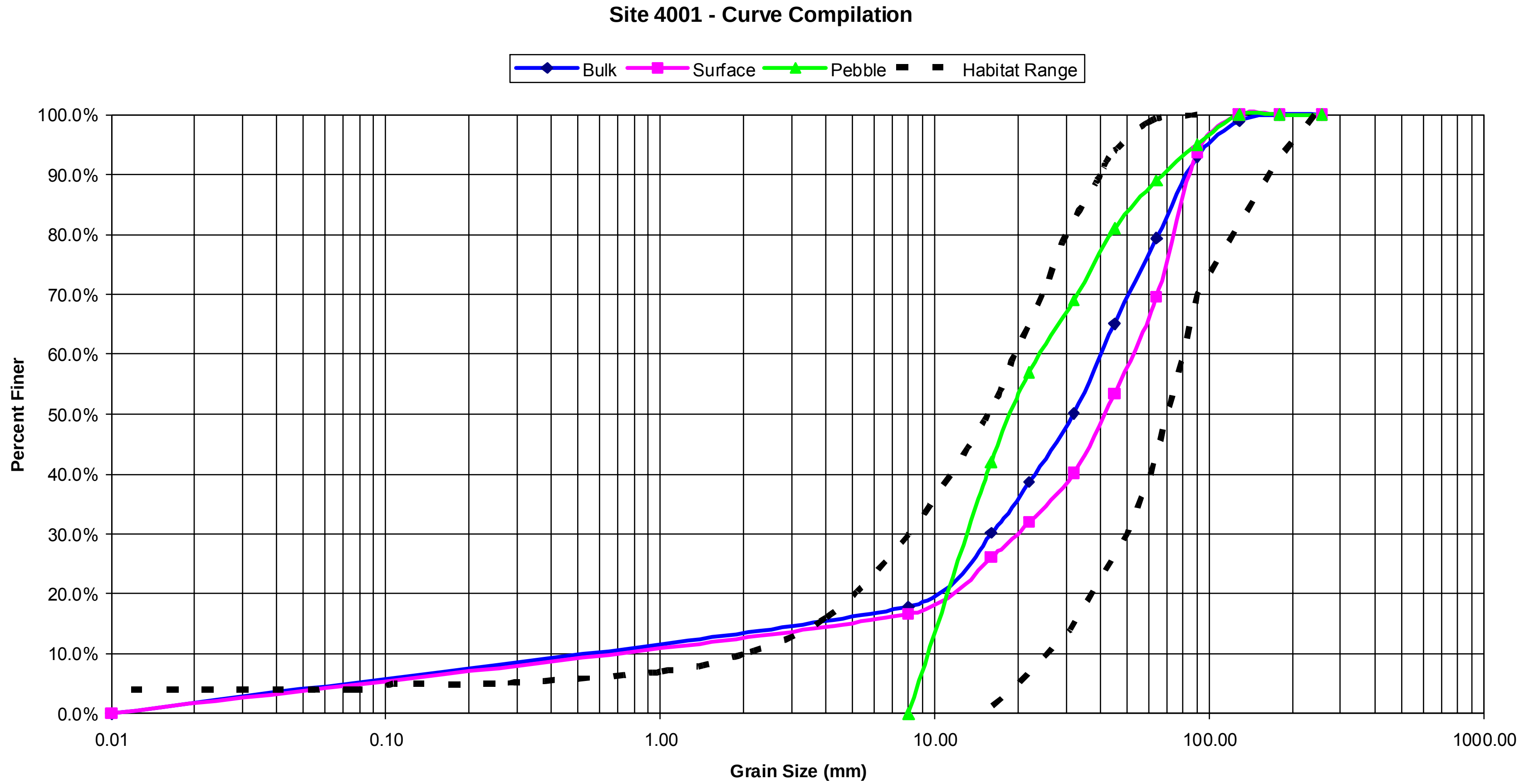


Figure 31: Sieve analysis for Lower Sunrise Access site 4001. Comparison of surface and subsurface grain size distribution shows slight armoring (coarsening) of the surface layer

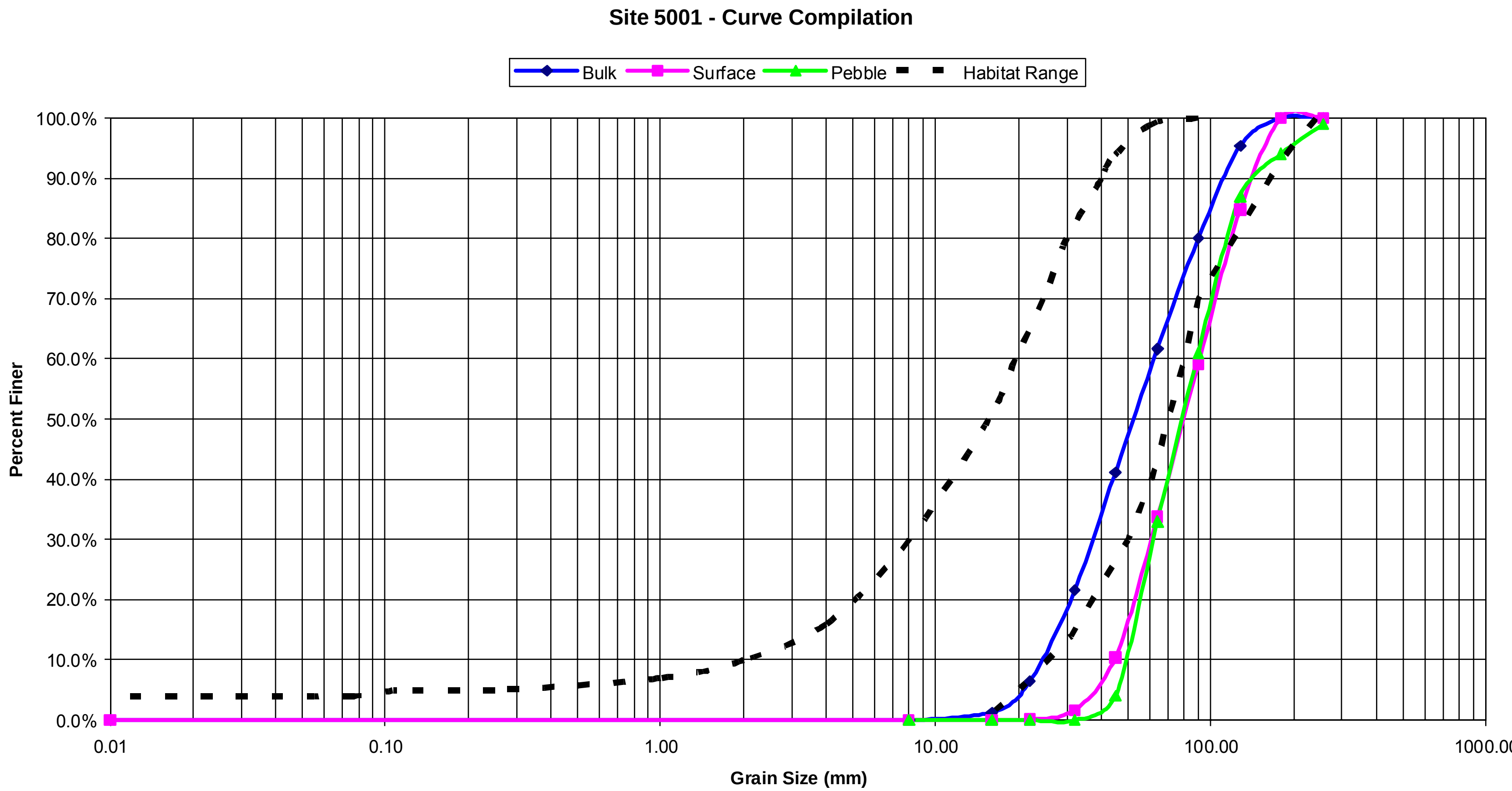


Figure 32: Sieve analysis Sacramento Bar site 5001. Comparison of surface and subsurface grain size distribution shows slight armoring and generally coarse grain size distribution.

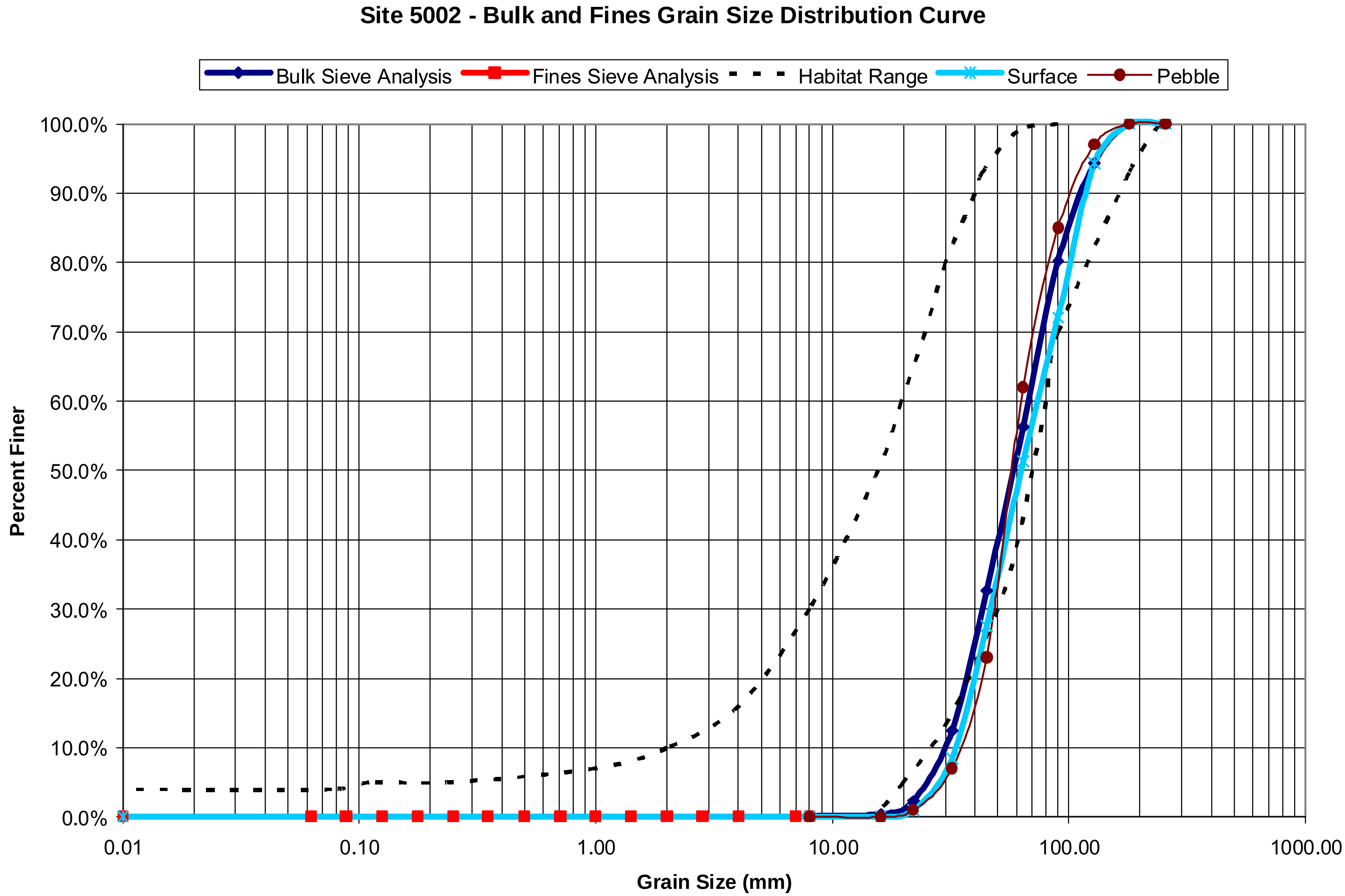


Figure 33: Sieve analysis Sacramento Bar site 5002. Comparison of surface and subsurface grain size distribution shows coarse grain size distribution, but no appreciable armoring.

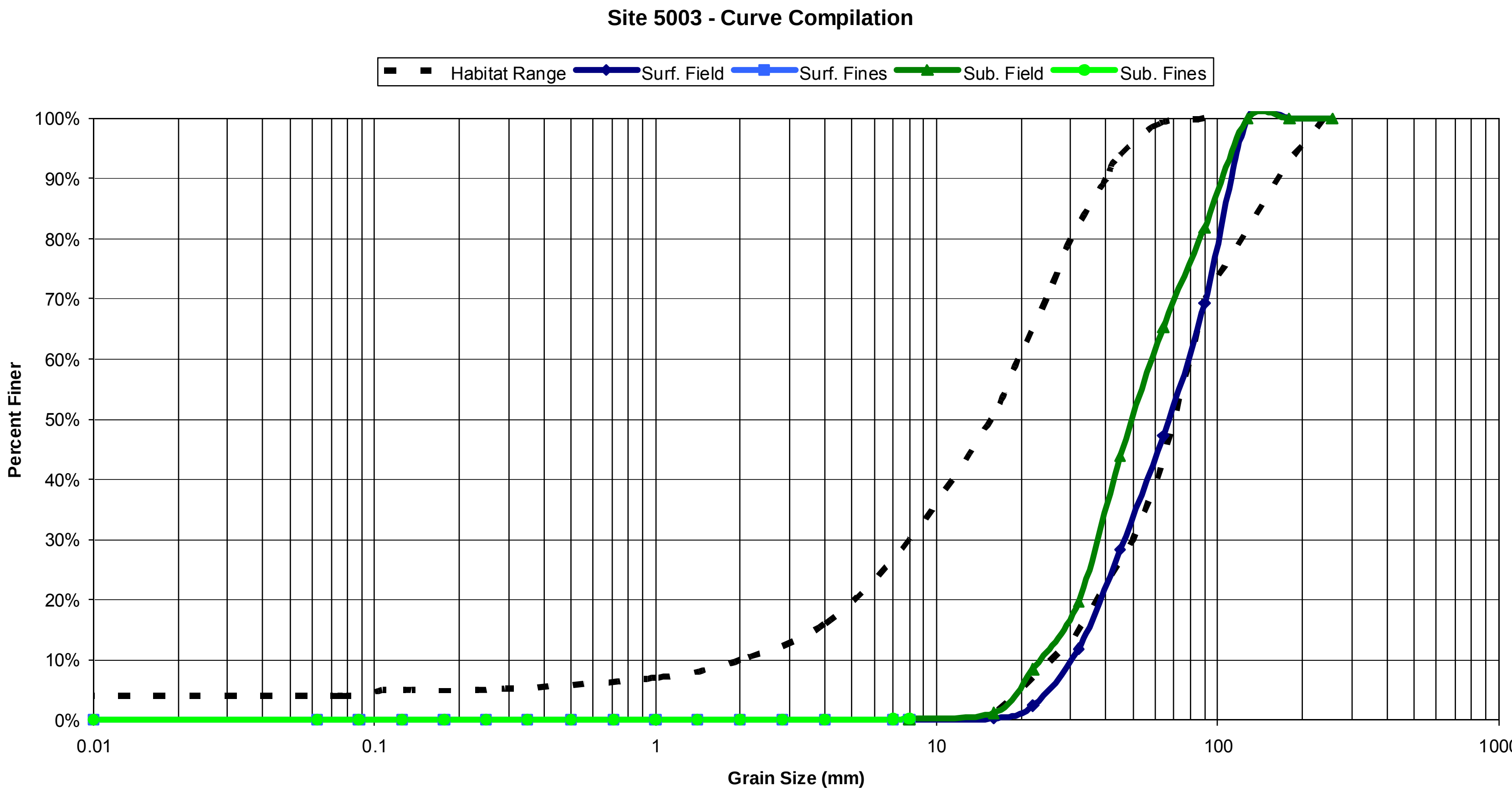


Figure 34: Sieve analysis Sacramento Bar site 5003. Comparison of surface and subsurface grain size distribution shows coarse grain size distribution, and very slight armoring.

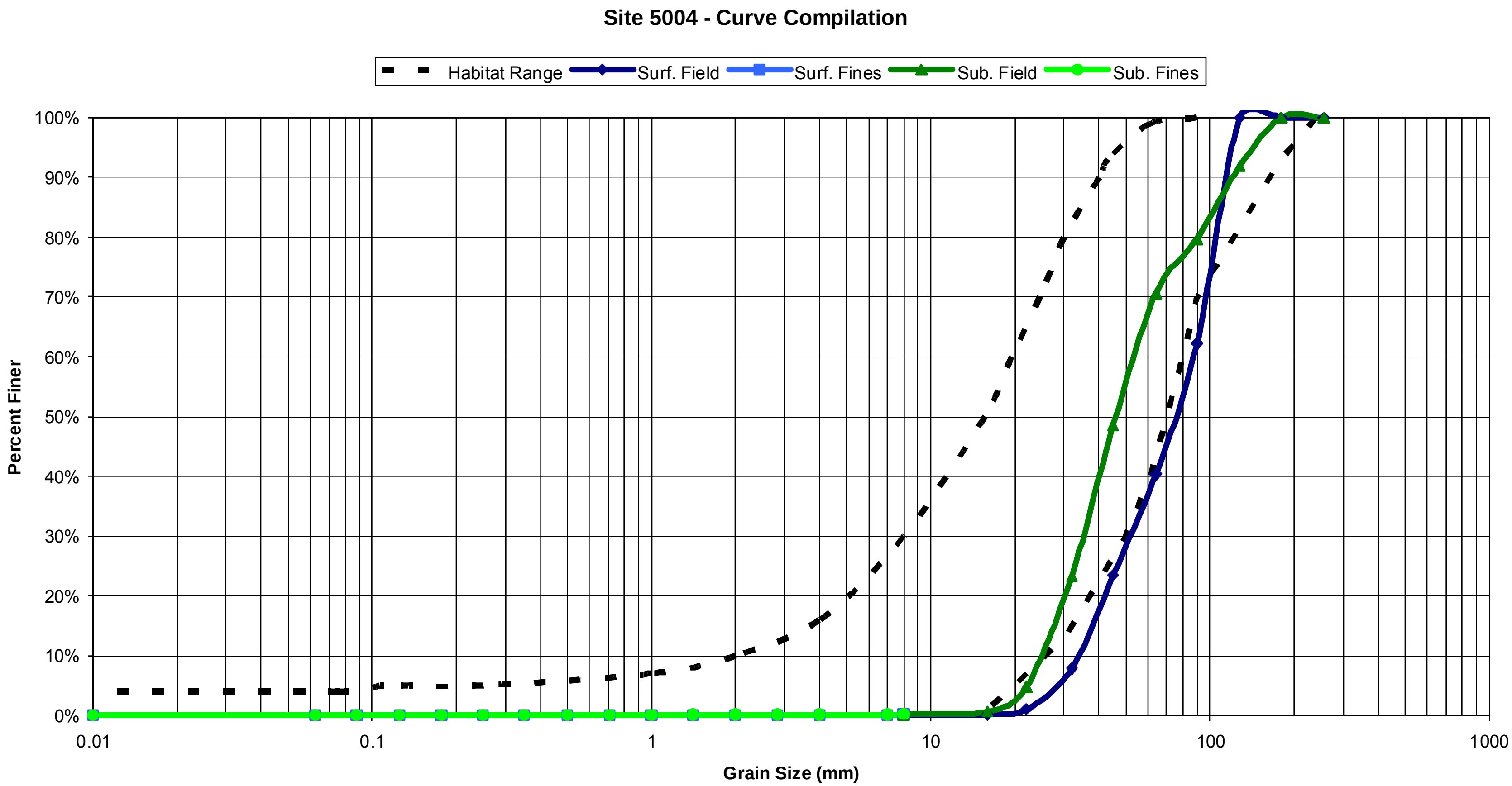


Figure 35: Sieve analysis Sacramento Bar site 5004. Comparison of surface and subsurface grain size distribution shows coarse grain size distribution with some surface armoring.

SITE 1001						
SIEVE ANALYSIS (BULK AND FINES)						
	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
BULK	256.0000	110.62	3.3%	110.62	3214.13	96.7%
	180.0000	164.80	5.0%	275.42	3049.33	91.7%
	128.0000	385.08	11.6%	660.50	2664.25	80.1%
	90.0000	473.32	14.2%	1133.82	2190.93	65.9%
	64.0000	550.84	16.6%	1684.66	1640.09	49.3%
	45.0000	659.98	19.9%	2344.64	980.11	29.5%
	32.0000	461.70	13.9%	2806.34	518.41	15.6%
	22.0000	274.56	8.3%	3080.90	243.85	7.3%
	16.0000	82.24	2.5%	3163.14	161.61	4.9%
	8.0000	71.12	2.1%	3234.26	90.49	2.7%
FINES	7.0000	14.96	0.4%	14.96	75.53	2.3%
	4.0000	23.90	0.7%	38.86	51.63	1.6%
	2.8300	7.14	0.2%	46.00	44.49	1.3%
	2.0000	12.77	0.4%	58.77	31.72	1.0%
	1.4100	11.48	0.3%	70.26	20.23	0.6%
	1.0000	7.95	0.2%	78.21	12.28	0.4%
	0.7100	4.61	0.1%	82.82	7.67	0.2%
	0.5000	2.49	0.1%	85.31	5.18	0.2%
	0.3500	1.49	0.0%	86.79	3.70	0.1%
	0.2500	1.20	0.0%	87.99	2.50	0.1%
	0.1770	0.69	0.0%	88.68	1.81	0.1%
	0.1250	1.12	0.0%	89.80	0.69	0.0%
	0.0880	0.02	0.0%	89.83	0.66	0.0%
	0.0625	0.35	0.0%	90.17	0.32	0.0%
	0.0100	0.32	0.0%	90.49	0.00	0.0%
	Total=	3324.75	kilograms			

Table 4: Bulk sample analysis from Sailor Bar site 1001.

SITE 1002						
SIEVE ANALYSIS (BULK AND FINES)						
	Sieve Opening (mm)	**Mass of Soil Retained**	**Percent**	**Cumulative Mass of Soil Retained**	**Mass of Soil Passing**	**Percent Finer**
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*139.64*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*139.64*	*100.0%*
	128.0000	*4.48*	*3.2%*	*4.48*	*135.16*	*96.8%*
	90.0000	*43.46*	*31.1%*	*47.94*	*91.70*	*65.7%*
	64.0000	*29.28*	*21.0%*	*77.22*	*62.42*	*44.7%*
	45.0000	*30.36*	*21.7%*	*107.58*	*32.06*	*23.0%*
	32.0000	*20.72*	*14.8%*	*128.30*	*11.34*	*8.1%*
	22.0000	*9.02*	*6.5%*	*137.32*	*2.32*	*1.7%*
	16.0000	*2.10*	*1.5%*	*139.42*	*0.22*	*0.2%*
	8.0000	*0.22*	*0.2%*	*139.64*	*0.00*	*0.0%*
FINES	7.0000	*0.00*	*0.0%*	*139.64*	*0.00*	*0.0%*
	4.0000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	2.8300	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	2.0000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	1.4100	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	1.0000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.7100	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.5000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.3500	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.2500	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.1770	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.1250	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.0880	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.0625	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.0100	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	Total=	139.64	kilograms			

Table 5: Bulk sample analysis from Sailor Bar, site 1002

SITE 2001							
SIEVE ANALYSIS (BULK AND FINES)							
	Sieve Opening (mm)	**Mass of Soil Retained**	**Percent**	**Cumulative Mass of Soil Retained**	**Mass of Soil Passing**	**Percent Finer**
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*973.50*	*100.0%*
	180.0000	*20.48*	*2.1%*	*20.48*	*953.02*	*97.9%*
	128.0000	*73.14*	*7.5%*	*93.62*	*879.88*	*90.4%*
	90.0000	*103.10*	*10.6%*	*196.72*	*776.78*	*79.8%*
	64.0000	*84.36*	*8.7%*	*281.08*	*692.42*	*71.1%*
	45.0000	*83.52*	*8.6%*	*364.60*	*608.90*	*62.5%*
	32.0000	*109.08*	*11.2%*	*473.68*	*499.82*	*51.3%*
	22.0000	*127.26*	*13.1%*	*600.94*	*372.56*	*38.3%*
	16.0000	*95.16*	*9.8%*	*696.10*	*277.40*	*28.5%*
	8.0000	*132.18*	*13.6%*	*828.28*	*145.22*	*14.9%*
FINES	7.0000	*26.96*	*2.8%*	*26.96*	*118.26*	*12.1%*
	4.0000	*33.11*	*3.4%*	*60.07*	*85.15*	*8.7%*
	2.8300	*10.31*	*1.1%*	*70.38*	*74.84*	*7.7%*
	2.0000	*17.62*	*1.8%*	*88.00*	*57.22*	*5.9%*
	1.4100	*14.28*	*1.5%*	*102.28*	*42.94*	*4.4%*
	1.0000	*12.55*	*1.3%*	*114.84*	*30.38*	*3.1%*
	0.7100	*11.53*	*1.2%*	*126.37*	*18.85*	*1.9%*
	0.5000	*9.50*	*1.0%*	*135.87*	*9.35*	*1.0%*
	0.3500	*5.04*	*0.5%*	*140.90*	*4.32*	*0.4%*
	0.2500	*2.69*	*0.3%*	*143.59*	*1.63*	*0.2%*
	0.1770	*0.74*	*0.1%*	*144.34*	*0.88*	*0.1%*
	0.1250	*0.51*	*0.1%*	*144.85*	*0.37*	*0.0%*
	0.0880	*0.02*	*0.0%*	*144.87*	*0.35*	*0.0%*
	0.0625	*0.10*	*0.0%*	*144.97*	*0.25*	*0.0%*
	0.0100	*0.25*	*0.0%*	*145.22*	*0.00*	*0.0%*
	Total=	973.50	kilograms			

Table 6: Bulk sample analysis from Sailor Bar, site 2001.

Site 3001						
SIEVE ANALYSIS (BULK AND FINES)						
	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*134.38*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*134.38*	*100.0%*
	128.0000	*12.68*	*9.4%*	*12.68*	*121.70*	*90.6%*
	90.0000	*22.08*	*16.4%*	*34.76*	*99.62*	*74.1%*
	64.0000	*29.24*	*21.8%*	*64.00*	*70.38*	*52.4%*
	45.0000	*25.62*	*19.1%*	*89.62*	*44.76*	*33.3%*
	32.0000	*27.04*	*20.1%*	*116.66*	*17.72*	*13.2%*
	22.0000	*14.14*	*10.5%*	*130.80*	*3.58*	*2.7%*
	16.0000	*2.98*	*2.2%*	*133.78*	*0.60*	*0.4%*
	8.0000	*0.60*	*0.4%*	*134.38*	*0.00*	*0.0%*
FINES	7.0000	*0.00*	*0.0%*	*134.38*	*0.00*	*0.0%*
	4.0000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	2.8300	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	2.0000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	1.4100	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	1.0000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.7100	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.5000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.3500	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.2500	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.1770	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.1250	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.0880	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.0625	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.0100	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	Total=	134.38	kilograms			

Table 7: Bulk sample analysis from Sailor Bar, site 3001.

SITE 3002							
SIEVE ANALYSIS (BULK AND FINES)							
	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*148.70*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*148.70*	*100.0%*
	128.0000	*20.82*	*14.0%*	*20.82*	*127.88*	*86.0%*
	90.0000	*38.08*	*25.6%*	*58.90*	*89.80*	*60.4%*
	64.0000	*25.78*	*17.3%*	*84.68*	*64.02*	*43.1%*
	45.0000	*32.04*	*21.5%*	*116.72*	*31.98*	*21.5%*
	32.0000	*23.96*	*16.1%*	*140.68*	*8.02*	*5.4%*
	22.0000	*6.80*	*4.6%*	*147.48*	*1.22*	*0.8%*
	16.0000	*1.22*	*0.8%*	*148.70*	*0.00*	*0.0%*
	8.0000	*0.00*	*0.0%*	*148.70*	*0.00*	*0.0%*
FINES	7.0000	*0.00*	*0.0%*	*148.70*	*0.00*	*0.0%*
	4.0000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	2.8300	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	2.0000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	1.4100	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	1.0000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.7100	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.5000	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.3500	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.2500	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.1770	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.1250	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.0880	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.0625	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	0.0100	*0.00*	*0.0%*	*0.00*	*0.00*	*0.0%*
	Total=	148.70	kilograms			

Table 8: Bulk sample analysis from Lower Sunrise Access, site 3002.

SITE 3003						
SIEVE ANALYSIS (SUBSURFACE)						
	Sieve Opening (mm)	**Mass of Soil Retained**	**Percent**	**Cumulative Mass of Soil Retained**	**Mass of Soil Passing**	**Percent Finer**
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*354.95*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*354.95*	*100.0%*
	128.0000	*0.00*	*0.0%*	*0.00*	*354.95*	*100.0%*
	90.0000	*17.22*	*4.9%*	*17.22*	*337.73*	*95.1%*
	64.0000	*50.32*	*14.2%*	*67.55*	*287.40*	*81.0%*
	45.0000	*74.34*	*20.9%*	*141.89*	*213.06*	*60.0%*
	32.0000	*72.99*	*20.6%*	*214.88*	*140.07*	*39.5%*
	22.0000	*72.99*	*20.6%*	*287.87*	*67.08*	*18.9%*
	16.0000	*24.94*	*7.0%*	*312.80*	*42.15*	*11.9%*
	8.0000	*11.33*	*3.2%*	*324.13*	*30.82*	*8.7%*
FINES	7.0000	*2.68*	*0.8%*	*2.68*	*28.14*	*7.9%*
	4.0000	*2.47*	*0.7%*	*5.15*	*25.67*	*7.2%*
	2.8300	*0.71*	*0.2%*	*5.86*	*24.96*	*7.0%*
	2.0000	*1.32*	*0.4%*	*7.18*	*23.64*	*6.7%*
	1.4100	*1.37*	*0.4%*	*8.55*	*22.27*	*6.3%*
	1.0000	*1.47*	*0.4%*	*10.02*	*20.80*	*5.9%*
	0.7100	*1.97*	*0.6%*	*11.98*	*18.84*	*5.3%*
	0.5000	*4.11*	*1.2%*	*16.09*	*14.73*	*4.1%*
	0.3500	*5.61*	*1.6%*	*21.70*	*9.11*	*2.6%*
	0.2500	*3.78*	*1.1%*	*25.49*	*5.33*	*1.5%*
	0.1770	*2.14*	*0.6%*	*27.63*	*3.19*	*0.9%*
	0.1250	*1.20*	*0.3%*	*28.83*	*1.99*	*0.6%*
	0.0880	*1.70*	*0.5%*	*30.53*	*0.29*	*0.1%*
	0.0625	*0.20*	*0.1%*	*30.73*	*0.09*	*0.0%*
	0.0100	*0.09*	*0.0%*	*30.82*	*0.00*	*0.0%*
	Total=	354.95	kilograms			

Table 9: Bulk sample analysis from Lower Sunrise Access, site 3003.

SITE 3004						
SIEVE ANALYSIS (SUBSURFACE)						
	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
BULK	256.0000	0.00	0.0%	0.00	74.30	100.0%
	180.0000	0.00	0.0%	0.00	74.30	100.0%
	128.0000	0.00	0.0%	0.00	74.30	100.0%
	90.0000	0.00	0.0%	0.00	74.30	100.0%
	64.0000	7.70	10.4%	7.70	66.60	89.6%
	45.0000	10.87	14.6%	18.57	55.73	75.0%
	32.0000	10.42	14.0%	28.99	45.31	61.0%
	22.0000	9.97	13.4%	38.96	35.34	47.6%
	16.0000	5.88	7.9%	44.84	29.46	39.6%
	8.0000	11.33	15.2%	56.17	18.13	24.4%
FINES	7.0000	1.00	1.3%	1.00	17.13	23.1%
	4.0000	3.87	5.2%	4.87	13.26	17.8%
	2.8300	1.23	1.7%	6.11	12.02	16.2%
	2.0000	2.17	2.9%	8.28	9.85	13.3%
	1.4100	2.19	2.9%	10.46	7.67	10.3%
	1.0000	2.22	3.0%	12.68	5.45	7.3%
	0.7100	2.05	2.8%	14.73	3.40	4.6%
	0.5000	1.90	2.6%	16.63	1.50	2.0%
	0.3500	1.00	1.3%	17.63	0.50	0.7%
	0.2500	0.35	0.5%	17.97	0.16	0.2%
	0.1770	0.09	0.1%	18.06	0.07	0.1%
	0.1250	0.03	0.0%	18.09	0.04	0.1%
	0.0880	0.03	0.0%	18.12	0.01	0.0%
	0.0625	0.00	0.0%	18.13	0.01	0.0%
	0.0100	0.01	0.0%	18.13	0.00	0.0%
	Total=	74.30	kilograms			

Table 10: Bulk sample analysis from Lower Sunrise Access, site 3004.

SITE 4001						
SIEVE ANALYSIS (BULK AND FINES)						
	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*507.48*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*507.48*	*100.0%*
	128.0000	*5.52*	*1.1%*	*5.52*	*501.96*	*98.9%*
	90.0000	*30.14*	*5.9%*	*35.66*	*471.82*	*93.0%*
	64.0000	*68.98*	*13.6%*	*104.64*	*402.84*	*79.4%*
	45.0000	*72.40*	*14.3%*	*177.04*	*330.44*	*65.1%*
	32.0000	*76.16*	*15.0%*	*253.20*	*254.28*	*50.1%*
	22.0000	*57.98*	*11.4%*	*311.18*	*196.30*	*38.7%*
	16.0000	*43.06*	*8.5%*	*354.24*	*153.24*	*30.2%*
	8.0000	*62.58*	*12.3%*	*416.82*	*90.66*	*17.9%*
FINES	7.0000	*15.10*	*3.0%*	*15.10*	*75.56*	*14.9%*
	4.0000	*18.45*	*3.6%*	*33.55*	*57.11*	*11.3%*
	2.8300	*5.65*	*1.1%*	*39.20*	*51.46*	*10.1%*
	2.0000	*10.00*	*2.0%*	*49.20*	*41.46*	*8.2%*
	1.4100	*9.46*	*1.9%*	*58.66*	*32.00*	*6.3%*
	1.0000	*9.18*	*1.8%*	*67.84*	*22.82*	*4.5%*
	0.7100	*7.93*	*1.6%*	*75.77*	*14.89*	*2.9%*
	0.5000	*6.61*	*1.3%*	*82.38*	*8.28*	*1.6%*
	0.3500	*3.94*	*0.8%*	*86.32*	*4.34*	*0.9%*
	0.2500	*2.10*	*0.4%*	*88.42*	*2.24*	*0.4%*
	0.1770	*0.84*	*0.2%*	*89.26*	*1.40*	*0.3%*
	0.1250	*0.49*	*0.1%*	*89.75*	*0.91*	*0.2%*
	0.0880	*0.49*	*0.1%*	*90.25*	*0.41*	*0.1%*
	0.0625	*0.15*	*0.0%*	*90.39*	*0.27*	*0.1%*
	0.0100	*0.27*	*0.1%*	*90.66*	*0.00*	*0.0%*
	Total=	507.48	kilograms			

Table 11: Bulk sample analysis from Lower Sunrise Access, site 4001.

Site 5001							
SIEVE ANALYSIS (BULK AND FINES)							
	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
BULK	256.0000	0.00	0.0%	0.00	212.18	100.0%
	180.0000	0.00	0.0%	0.00	212.18	100.0%
	128.0000	32.34	0.0%	32.34	179.84	84.8%
	90.0000	54.46	0.0%	86.80	125.38	59.1%
	64.0000	53.78	0.0%	140.58	71.60	33.7%
	45.0000	49.54	0.0%	190.12	22.06	10.4%
	32.0000	18.46	0.0%	208.58	3.60	1.7%
	22.0000	3.34	0.0%	211.92	0.26	0.1%
	16.0000	0.26	0.0%	212.18	0.00	0.0%
	8.0000	0.00	0.0%	212.18	0.00	0.0%
FINES	7.0000	0.00	0.0%	212.18	0.00	0.0%
	4.0000	0.00	0.0%	0.00	0.00	0.0%
	2.8300	0.00	0.0%	0.00	0.00	0.0%
	2.0000	0.00	0.0%	0.00	0.00	0.0%
	1.4100	0.00	0.0%	0.00	0.00	0.0%
	1.0000	0.00	0.0%	0.00	0.00	0.0%
	0.7100	0.00	0.0%	0.00	0.00	0.0%
	0.5000	0.00	0.0%	0.00	0.00	0.0%
	0.3500	0.00	0.0%	0.00	0.00	0.0%
	0.2500	0.00	0.0%	0.00	0.00	0.0%
	0.1770	0.00	0.0%	0.00	0.00	0.0%
	0.1250	0.00	0.0%	0.00	0.00	0.0%
	0.0880	0.00	0.0%	0.00	0.00	0.0%
	0.0625	0.00	0.0%	0.00	0.00	0.0%
	0.0100	0.00	0.0%	0.00	0.00	0.0%
	Total=	212.18	kilograms			

Table 12: Bulk sample analysis from Lower Sunrise Access, site 5001.

SITE 5002						
SIEVE ANALYSIS (BULK AND FINES)						
	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*686.66*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*686.66*	*100.0%*
	128.0000	*38.74*	*5.6%*	*38.74*	*647.92*	*94.4%*
	90.0000	*96.92*	*14.1%*	*135.66*	*551.00*	*80.2%*
	64.0000	*164.48*	*24.0%*	*300.14*	*386.52*	*56.3%*
	45.0000	*162.18*	*23.6%*	*462.32*	*224.34*	*32.7%*
	32.0000	*138.86*	*20.2%*	*601.18*	*85.48*	*12.4%*
	22.0000	*69.66*	*10.1%*	*670.84*	*15.82*	*2.3%*
	16.0000	*12.92*	*1.9%*	*683.76*	*2.90*	*0.4%*
	8.0000	*2.26*	*0.3%*	*686.02*	*0.64*	*0.1%*
FINES	7.0000	*0.10*	*0.0%*	*0.10*	*0.54*	*0.1%*
	4.0000	*0.08*	*0.0%*	*0.18*	*0.46*	*0.1%*
	2.8300	*0.02*	*0.0%*	*0.20*	*0.44*	*0.1%*
	2.0000	*0.05*	*0.0%*	*0.25*	*0.39*	*0.1%*
	1.4100	*0.04*	*0.0%*	*0.29*	*0.35*	*0.1%*
	1.0000	*0.03*	*0.0%*	*0.32*	*0.32*	*0.0%*
	0.7100	*0.03*	*0.0%*	*0.35*	*0.29*	*0.0%*
	0.5000	*0.03*	*0.0%*	*0.38*	*0.26*	*0.0%*
	0.3500	*0.03*	*0.0%*	*0.42*	*0.22*	*0.0%*
	0.2500	*0.04*	*0.0%*	*0.46*	*0.18*	*0.0%*
	0.1770	*0.04*	*0.0%*	*0.50*	*0.14*	*0.0%*
	0.1250	*0.04*	*0.0%*	*0.54*	*0.10*	*0.0%*
	0.0880	*0.05*	*0.0%*	*0.59*	*0.05*	*0.0%*
	0.0625	*0.02*	*0.0%*	*0.61*	*0.03*	*0.0%*
	0.0100	*0.03*	*0.0%*	*0.64*	*0.00*	*0.0%*
	Total=	686.66	kilograms			

Table 13: Bulk sample analysis from Sacramento Bar, site 5002.

	SITE 5003					
	SIEVE ANALYSIS (SUBSURFACE)					
	Sieve Opening (mm)	**Mass of Soil Retained**	**Percent**	**Cumulative Mass of Soil Retained**	**Mass of Soil Passing**	**Percent Finer**
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*430.87*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*430.87*	*100.0%*
	128.0000	*0.00*	*0.0%*	*0.00*	*430.87*	*100.0%*
	90.0000	*78.42*	*18.2%*	*78.42*	*352.44*	*81.8%*
	64.0000	*71.18*	*16.5%*	*149.60*	*281.27*	*65.3%*
	45.0000	*92.48*	*21.5%*	*242.08*	*188.78*	*43.8%*
	32.0000	*104.28*	*24.2%*	*346.36*	*84.51*	*19.6%*
	22.0000	*48.04*	*11.2%*	*394.40*	*36.46*	*8.5%*
	16.0000	*31.27*	*7.3%*	*425.67*	*5.19*	*1.2%*
	8.0000	*4.52*	*1.0%*	*430.20*	*0.67*	*0.2%*
FINES	7.0000	*0.19*	*0.0%*	*0.19*	*0.48*	*0.1%*
	4.0000	*0.14*	*0.0%*	*0.33*	*0.34*	*0.1%*
	2.8300	*0.03*	*0.0%*	*0.36*	*0.31*	*0.1%*
	2.0000	*0.04*	*0.0%*	*0.40*	*0.27*	*0.1%*
	1.4100	*0.03*	*0.0%*	*0.43*	*0.24*	*0.1%*
	1.0000	*0.03*	*0.0%*	*0.45*	*0.21*	*0.0%*
	0.7100	*0.02*	*0.0%*	*0.48*	*0.19*	*0.0%*
	0.5000	*0.02*	*0.0%*	*0.50*	*0.17*	*0.0%*
	0.3500	*0.03*	*0.0%*	*0.53*	*0.14*	*0.0%*
	0.2500	*0.03*	*0.0%*	*0.56*	*0.10*	*0.0%*
	0.1770	*0.03*	*0.0%*	*0.59*	*0.07*	*0.0%*
	0.1250	*0.02*	*0.0%*	*0.62*	*0.05*	*0.0%*
	0.0880	*0.03*	*0.0%*	*0.65*	*0.02*	*0.0%*
	0.0625	*0.01*	*0.0%*	*0.66*	*0.01*	*0.0%*
	0.0100	*0.01*	*0.0%*	*0.67*	*0.00*	*0.0%*
	Total=	430.87	kilograms			

Table14: Bulk sample analysis from Sacramento Bar, site 5003.

SITE 5004						
SIEVE ANALYSIS (SUBSURFACE)						
	Sieve Opening (mm)	**Mass of Soil Retained**	**Percent**	**Cumulative Mass of Soil Retained**	**Mass of Soil Passing**	**Percent Finer**
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*290.10*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*290.10*	*100.0%*
	128.0000	*23.57*	*8.1%*	*23.57*	*266.52*	*91.9%*
	90.0000	*35.36*	*12.2%*	*58.93*	*231.17*	*79.7%*
	64.0000	*26.30*	*9.1%*	*85.23*	*204.87*	*70.6%*
	45.0000	*63.92*	*22.0%*	*149.14*	*140.95*	*48.6%*
	32.0000	*73.43*	*25.3%*	*222.58*	*67.52*	*23.3%*
	22.0000	*53.50*	*18.4%*	*276.08*	*14.02*	*4.8%*
	16.0000	*12.23*	*4.2%*	*288.31*	*1.79*	*0.6%*
	8.0000	*1.35*	*0.5%*	*289.66*	*0.44*	*0.2%*
FINES	7.0000	*0.07*	*0.0%*	*0.07*	*0.37*	*0.1%*
	4.0000	*0.03*	*0.0%*	*0.10*	*0.34*	*0.1%*
	2.8300	*0.01*	*0.0%*	*0.11*	*0.33*	*0.1%*
	2.0000	*0.01*	*0.0%*	*0.12*	*0.32*	*0.1%*
	1.4100	*0.01*	*0.0%*	*0.14*	*0.30*	*0.1%*
	1.0000	*0.01*	*0.0%*	*0.15*	*0.29*	*0.1%*
	0.7100	*0.02*	*0.0%*	*0.17*	*0.27*	*0.1%*
	0.5000	*0.02*	*0.0%*	*0.19*	*0.25*	*0.1%*
	0.3500	*0.03*	*0.0%*	*0.22*	*0.22*	*0.1%*
	0.2500	*0.03*	*0.0%*	*0.25*	*0.19*	*0.1%*
	0.1770	*0.04*	*0.0%*	*0.29*	*0.16*	*0.1%*
	0.1250	*0.03*	*0.0%*	*0.32*	*0.12*	*0.0%*
	0.0880	*0.09*	*0.0%*	*0.40*	*0.04*	*0.0%*
	0.0625	*0.02*	*0.0%*	*0.43*	*0.02*	*0.0%*
	0.0100	*0.02*	*0.0%*	*0.44*	*0.00*	*0.0%*
	Total=	290.10	kilograms			

Table 15: Bulk sample analysis from Sacramento Bar, site 5004.

SITE 1001					
SURFACE PARTICLE SIZE ANALYSIS **Pebble Count**					
Stream:	*LAR*			**Date:**	*10/17/2002*
Data Recorder:	*Tim Bishop*			**Data Collector:**	*Tim Bishop*
SIZE (mm)	**SIZE CLASS**	**COUNT TOTAL**	**PERCENT**	**PASSING GRAINS**	**PERCENT FINER**
256.00	10" (≥256mm)		0.0%	101	100.0%
180.00	7" (≥180mm)		0.0%	101	100.0%
128.00	5" (≥128mm)	*1*	1.0%	100	99.0%
90.00	3½" (≥90mm)	*23*	22.8%	77	76.2%
64.00	2½" (≥64mm)	*26*	25.7%	51	50.5%
45.00	1¾" (≥45mm)	*31*	30.7%	20	19.8%
32.00	1¼" (≥32mm)	*16*	15.8%	4	4.0%
22.00	⅞" (≥22mm)	*4*	4.0%	0	0.0%
16.00	⅝" (≥16mm)		0.0%	0	0.0%
8.00	5/16" (≥8mm)		0.0%	0	0.0%
TOTAL		101	100.0%	454	449.5%
Comments:					

Table 16: Pebble count for site 1001.

SITE 1002					
SURFACE PARTICLE SIZE ANALYSIS Pebble Count					
Stream:	*LAR*			**Date:**	*10/17/2002*
Data Recorder:	*Tim Bishop*			**Data Collector:**	*Tim Bishop*
SIZE (mm)	**SIZE CLASS**	**COUNT TOTAL**	**PERCENT**	**PASSING GRAINS**	**PERCENT FINER**
256.00	10" (≥256mm)		0.0%	106	100.0%
180.00	7" (≥180mm)		0.0%	106	100.0%
128.00	5" (≥128mm)	*2*	1.9%	104	98.1%
90.00	3½" (≥90mm)	*8*	7.5%	96	90.6%
64.00	2½" (≥64mm)	*34*	32.1%	62	58.5%
45.00	1¾" (≥45mm)	*43*	40.6%	19	17.9%
32.00	1¼" (≥32mm)	*19*	17.9%	0	0.0%
22.00	⅞" (≥22mm)		0.0%	0	0.0%
16.00	⅝" (≥16mm)		0.0%	0	0.0%
8.00	5/16" (≥8mm)		0.0%	0	0.0%
TOTAL		106	100.0%	493	465.1%
Comments:					

Table 17: Pebble count for site 1002.

	SITE 1003					
	SIEVE ANALYSIS (SURFACE)					
	Sieve Opening (mm)	**Mass of Soil Retained**	**Percent**	**Cumulative Mass of Soil Retained**	**Mass of Soil Passing**	**Percent Finer**
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*587.19*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*587.19*	*100.0%*
	128.0000	*15.42*	*2.6%*	*15.42*	*571.76*	*97.4%*
	90.0000	*136.53*	*23.3%*	*151.96*	*435.23*	*74.1%*
	64.0000	*127.92*	*21.8%*	*279.87*	*307.31*	*52.3%*
	45.0000	*190.51*	*32.4%*	*470.38*	*116.80*	*19.9%*
	32.0000	*67.13*	*11.4%*	*537.52*	*49.67*	*8.5%*
	22.0000	*39.01*	*6.6%*	*576.53*	*10.66*	*1.8%*
	16.0000	*9.07*	*1.5%*	*585.60*	*1.59*	*0.3%*
	8.0000	*1.36*	*0.2%*	*586.96*	*0.23*	*0.0%*
FINES	7.0000	*0.04*	*0.0%*	*0.04*	*0.19*	*0.0%*
	4.0000	*0.03*	*0.0%*	*0.07*	*016*	*0.0%*
	2.8300	*0.01*	*0.0%*	*0.08*	*0.15*	*0.0%*
	2.0000	*0.01*	*0.0%*	*0.09*	*0.14*	*0.0%*
	1.4100	*0.01*	*0.0%*	*0.10*	*0.13*	*0.0%*
	1.0000	*0.01*	*0.0%*	*0.11*	*0.12*	*0.0%*
	0.7100	*0.01*	*0.0%*	*0.11*	*0.11*	*0.0%*
	0.5000	*0.01*	*0.0%*	*0.12*	*0.11*	*0.0%*
	0.3500	*0.01*	*0.0%*	*0.13*	*0.10*	*0.0%*
	0.2500	*0.01*	*0.0%*	*0.14*	*0.09*	*0.0%*
	0.1770	*0.01*	*0.0%*	*0.15*	*0.08*	*0.0%*
	0.1250	*0.01*	*0.0%*	*0.16*	*0.07*	*0.0%*
	0.0880	*0.06*	*0.0%*	*0.22*	*0.01*	*0.0%*
	0.0625	*0.00*	*0.0%*	*0.22*	*0.00*	*0.0%*
	0.0100	*0.00*	*0.0%*	*0.23*	*0.00*	*0.0%*
	Total=	587.19	kilograms			

Table 18: Surface fraction site 1003- grain size analysis.

SITE 2001					
SURFACE PARTICLE SIZE ANALYSIS **Pebble Count**					
Stream:	*LAR*			**Date:**	*10/17/2002*
Data Recorder:	*Tim Bishop*			**Data Collector:**	*Tim Bishop*
SIZE (mm)	**SIZE CLASS**	**COUNT TOTAL**	**PERCENT**	**PASSING GRAINS**	**PERCENT FINER**
256.00	10" (≥256mm)	*1*	0.5%	194	99.5%
180.00	7" (≥180mm)	*8*	4.1%	186	95.4%
128.00	5" (≥128mm)	*14*	7.2%	172	88.2%
90.00	3½" (≥90mm)	*15*	7.7%	157	80.5%
64.00	2½" (≥64mm)	*27*	13.8%	130	66.7%
45.00	1¾" (≥45mm)	*28*	14.4%	102	52.3%
32.00	1¼" (≥32mm)	*35*	17.9%	67	34.4%
22.00	⅞" (≥22mm)	*22*	11.3%	45	23.1%
16.00	⅝" (≥16mm)	*34*	17.4%	11	5.6%
8.00	5/16" (≥8mm)	*11*	5.6%	0	0.0%
TOTAL		195	100.0%	1064	545.6%
Comments:					

Table 19: Pebble count for site 2001.

Site 3001					
SURFACE PARTICLE SIZE ANALYSIS **Pebble Count**					
Stream:	*LAR*			**Date:**	*10/17/2002*
Data Recorder:	*Tim Bishop*			**Data Collector:**	*Tim Bishop*
SIZE (mm)	**SIZE CLASS**	**COUNT TOTAL**	**PERCENT**	**PASSING GRAINS**	**PERCENT FINER**
256.00	10" (≥256mm)		0.0%	102	100.0%
180.00	7" (≥180mm)		0.0%	102	100.0%
128.00	5" (≥128mm)	*1*	1.0%	101	99.0%
90.00	3½" (≥90mm)	*11*	10.8%	90	88.2%
64.00	2½" (≥64mm)	*14*	13.7%	76	74.5%
45.00	1¾" (≥45mm)	*32*	31.4%	44	43.1%
32.00	1¼" (≥32mm)	*34*	33.3%	10	9.8%
22.00	⅞" (≥22mm)	*8*	7.8%	2	2.0%
16.00	⅝" (≥16mm)	*2*	2.0%	0	0.0%
8.00	5/16" (≥8mm)		0.0%	0	0.0%
TOTAL		102	100.0%	527	516.7%
Comments:					

Table 20: Pebble count for site 3001.

SITE 3002					
SURFACE PARTICLE SIZE ANALYSIS **Pebble Count**					
Stream:	*LAR*			**Date:**	*10/17/2002*
Data Recorder:	*Tim Bishop*			**Data Collector:**	*Tim Bishop*
SIZE (mm)	**SIZE CLASS**	**COUNT TOTAL**	**PERCENT**	**PASSING GRAINS**	**PERCENT FINER**
256.00	10" (≥256mm)		0.0%	108	100.0%
180.00	7" (≥180mm)		0.0%	108	100.0%
128.00	5" (≥128mm)	*4*	3.7%	104	96.3%
90.00	3½" (≥90mm)	*6*	5.6%	98	90.7%
64.00	2½" (≥64mm)	*31*	28.7%	67	62.0%
45.00	1¾" (≥45mm)	*41*	38.0%	26	24.1%
32.00	1¼" (≥32mm)	*17*	15.7%	9	8.3%
22.00	⅞" (≥22mm)	*8*	7.4%	1	0.9%
16.00	⅝" (≥16mm)	*1*	0.9%	0	0.0%
8.00	5/16" (≥8mm)		0.0%	0	0.0%
TOTAL		108	100.0%	521	482.4%

Table 21: Pebble count for site 3002.

SITE 3003						
SIEVE ANALYSIS (SURFACE)						
	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*286.46*	*100.0%*
	180.0000	*0.00*	*0.0%*	*0.00*	*286.46*	*100.0%*
	128.0000	*0.00*	*0.0%*	*0.00*	*286.46*	*100.0%*
	90.0000	*50.78*	*17.7%*	*50.78*	*235.68*	*82.3%*
	64.0000	*60.73*	*21.2%*	*111.51*	*174.95*	*61.1%*
	45.0000	*72.98*	*25.5%*	*184.49*	*101.97*	*35.6%*
	32.0000	*97.02*	*33.9%*	*281.51*	*4.95*	*1.7%*
	22.0000	*3.62*	*1.3%*	*285.12*	*1.34*	*0.5%*
	16.0000	*0.21*	*0.1%*	*285.34*	*1.12*	*0.4%*
	8.0000	*0.00*	*0.0%*	*285.34*	*1.12*	*0.4%*
FINES	7.0000	*0.06*	*0.0%*	*0.06*	*1.06*	*0.4%*
	4.0000	*0.10*	*0.0%*	*0.16*	*0.96*	*0.3%*
	2.8300	*0.03*	*0.0%*	*0.19*	*0.93*	*0.3%*
	2.0000	*0.06*	*0.0%*	*0.25*	*0.87*	*0.3%*
	1.4100	*0.06*	*0.0%*	*0.31*	*0.81*	*0.3%*
	1.0000	*0.06*	*0.0%*	*0.36*	*0.76*	*0.3%*
	0.7100	*0.08*	*0.0%*	*0.44*	*0.68*	*0.2%*
	0.5000	*0.14*	*0.0%*	*0.58*	*0.54*	*0.2%*
	0.3500	*0.19*	*0.1%*	*0.77*	*0.36*	*0.1%*
	0.2500	*0.15*	*0.1%*	*0.92*	*0.21*	*0.1%*
	0.1770	*0.07*	*0.0%*	*0.99*	*0.13*	*0.0%*
	0.1250	*0.05*	*0.0%*	*1.04*	*0.08*	*0.0%*
	0.0880	*0.04*	*0.0%*	*1.08*	*0.04*	*0.0%*
	0.0625	*0.01*	*0.0%*	*1.09*	*0.03*	*0.0%*
	0.0100	*0.03*	*0.0%*	*1.12*	*0.00*	*0.0%*
	Total=	286.46	kilograms			

Table 22: Sieve data from surface sample.

SITE 3004						
SIEVE ANALYSIS (SURFACE)						
	Sieve Opening (mm)	**Mass of Soil Retained**	**Percent**	**Cumulative Mass of Soil Retained**	**Mass of Soil Passing**	**Percent Finer**
BULK	256.0000	*0.00*	*0.0%*	*0.00*	*111.50*	*100.1%*
	180.0000	*0.00*	*0.0%*	*0.00*	*111.50*	*100.1%*
	128.0000	*0.00*	*0.0%*	*0.00*	*111.50*	*100.1%*
	90.0000	*0.00*	*0.0%*	*0.00*	*111.50*	*100.1%*
	64.0000	*22.67*	*20.4%*	*22.67*	*88.83*	*79.8%*
	45.0000	*17.68*	*15.9%*	*40.34*	*71.15*	*63.9%*
	32.0000	*17.22*	*15.5%*	*57.57*	*53.93*	*48.4%*
	22.0000	*10.42*	*9.4%*	*67.99*	*43.51*	*39.1%*
	16.0000	*8.61*	*7.7%*	*76.59*	*34.90*	*31.3%*
	8.0000	*6.79*	*6.1%*	*83.39*	*28.11*	*25.2%*
FINES	7.0000	*3.14*	*2.8%*	*3.26*	*24.85*	*22.3%*
	4.0000	*4.20*	*3.8%*	*7.46*	*20.65*	*18.5%*
	2.8300	*1.37*	*1.2%*	*8.82*	*19.29*	*17.3%*
	2.0000	*2.70*	*2.4%*	*11.52*	*16.59*	*14.9%*
	1.4100	*3.37*	*3.0%*	*14.88*	*13.23*	*11.9%*
	1.0000	*3.96*	*3.6%*	*18.84*	*9.27*	*8.3%*
	0.7100	*3.96*	*3.6%*	*22.80*	*5.31*	*4.8%*
	0.5000	*3.09*	*2.8%*	*25.89*	*2.22*	*2.0%*
	0.3500	*1.28*	*1.1%*	*27.16*	*0.95*	*0.9%*
	0.2500	*0.51*	*0.5%*	*27.67*	*0.44*	*0.4%*
	0.1770	*0.18*	*0.2%*	*27.85*	*0.26*	*0.2%*
	0.1250	*0.11*	*0.1%*	*27.95*	*0.16*	*0.1%*
	0.0880	*0.11*	*0.1%*	*28.07*	*0.04*	*0.0%*
	0.0625	*0.01*	*0.0%*	*28.08*	*0.03*	*0.0%*
	0.0100	*0.03*	*0.0%*	*28.11*	*0.00*	*0.0%*
	Total=	111.37	kilograms			

Table 23: Sieve data from surface sample.

SITE 4001					
SURFACE PARTICLE SIZE ANALYSIS **Pebble Count**					
Stream:	*LAR*			**Date:**	*10/17/2002*
Data Recorder:	*Tim Bishop*			**Data Collector:**	*Tim Bishop*
SIZE (mm)	**SIZE CLASS**	**COUNT TOTAL**	**PERCENT**	**PASSING GRAINS**	**PERCENT FINER**
256.00	10" (≥256mm)		0.0%	100	100.0%
180.00	7" (≥180mm)		0.0%	100	100.0%
128.00	5" (≥128mm)		0.0%	100	100.0%
90.00	3½" (≥90mm)	*5*	5.0%	95	95.0%
64.00	2½" (≥64mm)	*6*	6.0%	89	89.0%
45.00	1¾" (≥45mm)	*8*	8.0%	81	81.0%
32.00	1¼" (≥32mm)	*12*	12.0%	69	69.0%
22.00	⅞" (≥22mm)	*12*	12.0%	57	57.0%
16.00	⅝" (≥16mm)	*15*	15.0%	42	42.0%
8.00	5/16" (≥8mm)	*42*	42.0%	0	0.0%
TOTAL		100	100.0%	733	733.0%
Comments:					

Table 24: Pebble count for site 4001.

Site 5001					
SURFACE PARTICLE SIZE ANALYSIS Pebble Count					
Stream:	*LAR*			**Date:**	*10/17/2002*
Data Recorder:	*Tim Bishop*			**Data Collector:**	*Tim Bishop*
SIZE (mm)	**SIZE CLASS**	**COUNT TOTAL**	**PERCENT**	**PASSING GRAINS**	**PERCENT FINER**
256.00	10" (≥256mm)	*1*	1.0%	99	99.0%
180.00	7" (≥180mm)	*5*	5.0%	94	94.0%
128.00	5" (≥128mm)	*7*	7.0%	87	87.0%
90.00	3½" (≥90mm)	*26*	26.0%	61	61.0%
64.00	2½" (≥64mm)	*28*	28.0%	33	33.0%
45.00	1¾" (≥45mm)	*29*	29.0%	4	4.0%
32.00	1¼" (≥32mm)	*4*	4.0%	0	0.0%
22.00	⅞" (≥22mm)		0.0%	0	0.0%
16.00	⅝" (≥16mm)		0.0%	0	0.0%
8.00	5/16" (≥8mm)		0.0%	0	0.0%
TOTAL		100	100.0%	378	378.0%

Table 25: Pebble count for site 5001.

SITE 5002					
SURFACE PARTICLE SIZE ANALYSIS **Pebble Count**					
Stream:	*LAR*			**Date:**	*10/17/2002*
Data Recorder:	*Tim Bishop*			**Data Collector:**	*Tim Bishop*
SIZE (mm)	**SIZE CLASS**	**COUNT TOTAL**	**PERCENT**	**PASSING GRAINS**	**PERCENT FINER**
256.00	10" (≥256mm)		0.0%	100	100.0%
180.00	7" (≥180mm)		0.0%	100	100.0%
128.00	5" (≥128mm)	*3*	3.0%	97	97.0%
90.00	3½" (≥90mm)	*12*	12.0%	85	85.0%
64.00	2½" (≥64mm)	*23*	23.0%	62	62.0%
45.00	1¾" (≥45mm)	*39*	39.0%	23	23.0%
32.00	1¼" (≥32mm)	*16*	16.0%	7	7.0%
22.00	⅞" (≥22mm)	*6*	6.0%	1	1.0%
16.00	⅝" (≥16mm)	*1*	1.0%	0	0.0%
8.00	5/16" (≥8mm)		0.0%	0	0.0%
TOTAL		100	100.0%	475	475.0%

Table 26: Pebble count for site 5002.

	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
SITE 5003						
SIEVE ANALYSIS (SURFACE)						
BULK	256.0000	0.00	0.0%	0.00	384.47	100.0%
	180.0000	0.00	0.0%	0.00	384.47	100.0%
	128.0000	0.00	0.0%	0.00	384.47	100.0%
	90.0000	118.30	30.8%	118.30	266.17	69.2%
	64.0000	84.77	22.1%	203.07	181.40	47.2%
	45.0000	72.52	18.9%	275.60	108.88	28.3%
	32.0000	63.47	16.5%	339.06	45.41	11.8%
	22.0000	36.26	9.4%	375.32	9.15	2.4%
	16.0000	8.15	2.1%	383.48	1.00	0.3%
	8.0000	0.89	0.2%	384.37	0.10	0.0%
FINES	7.0000	0.00	0.0%	0.00	0.00	0.0%
	4.0000	0.00	0.0%	0.00	0.00	0.0%
	2.8300	0.00	0.0%	0.00	0.00	0.0%
	2.0000	0.00	0.0%	0.00	0.00	0.0%
	1.4100	0.00	0.0%	0.00	0.00	0.0%
	1.0000	0.00	0.0%	0.00	0.00	0.0%
	0.7100	0.00	0.0%	0.00	0.00	0.0%
	0.5000	0.00	0.0%	0.00	0.00	0.0%
	0.3500	0.00	0.0%	0.00	0.00	0.0%
	0.2500	0.00	0.0%	0.00	0.00	0.0%
	0.1770	0.00	0.0%	0.00	0.00	0.0%
	0.1250	0.00	0.0%	0.00	0.00	0.0%
	0.0880	0.00	0.0%	0.00	0.00	0.0%
	0.0625	0.00	0.0%	0.00	0.00	0.0%
	0.0100	0.00	0.0%	0.00	0.00	0.0%
	Total=	384.37	kilograms			

Table 27: Surface analysis for site 5002.

SITE 5004						
SIEVE ANALYSIS (SURFACE)						
	Sieve Opening (mm)	Mass of Soil Retained	Percent	Cumulative Mass of Soil Retained	Mass of Soil Passing	Percent Finer
BULK	256.0000	0.00	0.0%	0.00	418.61	100.0%
	180.0000	0.00	0.0%	0.00	418.61	100.0%
	128.0000	0.00	0.0%	0.00	418.61	100.0%
	90.0000	157.76	37.7%	157.76	260.84	62.3%
	64.0000	92.02	22.0%	249.78	168.83	40.3%
	45.0000	70.72	16.9%	320.50	98.10	23.4%
	32.0000	65.28	15.6%	385.78	32.82	7.8%
	22.0000	28.55	6.8%	414.33	4.27	1.0%
	16.0000	3.62	0.9%	417.95	0.65	0.2%
	8.0000	0.21	0.1%	418.16	0.44	0.1%
FINES	7.0000	0.06	0.0%	0.06	0.38	0.1%
	4.0000	0.04	0.0%	0.10	0.34	0.1%
	2.8300	0.01	0.0%	0.11	0.33	0.1%
	2.0000	0.02	0.0%	0.13	0.31	0.1%
	1.4100	0.02	0.0%	0.15	0.29	0.1%
	1.0000	0.02	0.0%	0.18	0.26	0.1%
	0.7100	0.03	0.0%	0.21	0.23	0.1%
	0.5000	0.05	0.0%	0.25	0.19	0.0%
	0.3500	0.04	0.0%	0.29	0.15	0.0%
	0.2500	0.03	0.0%	0.32	0.12	0.0%
	0.1770	0.02	0.0%	0.35	0.09	0.0%
	0.1250	0.02	0.0%	0.36	0.08	0.0%
	0.0880	0.07	0.0%	0.43	0.01	0.0%
	0.0625	0.00	0.0%	0.43	0.01	0.0%
	0.0100	0.01	0.0%	0.44	0.00	0.0%
	Total=	418.61	kilograms			

Table 28: Surface analysis for site 5002.

Appendix B: Field Parameter Measurements

Site	Dissolved oxygen (mg/l)	pH	Temperature (°C)- in flow-through cell	Electrical Conductivity (uS/cm)	Turbidity (NTU)	Water depth (m)	Average Stream Velocity (m/s)	Gradient direction	Gradient (cm)
	August sampling event- field parameters								
Lower Sunrise Access:									
3101-1	1.4	6.79	19.3	63			0.6		
3101-2	1	6.12	19.3	60.5	10				
3101-3	0.4	6.62	20	65.4	8				
3102-1	1.8	6.8	20.1	56.8	5		0.61		
3102-2	0.8	6.75	20	60.5	2.8				
3102-3	0.6	6.71	20.1	62.8	1				
3103-1						0.85	0.97	down	0.95
3103-2								down	0.95
3104-1	4.8	6.83	19	53.2			1.1	up	1.6
3104-2	5.1	6.9	19	53.1	0.71			up	1.6
3104-3	5	6.91	19	53.2	0.83			up	2.2
3105-1	5.2	7.1		53.6			0.67	down	0.95
3105-2	5.3	6.65		53.3				down	1.4
3105-3	5	6.81		53.3				down	1.4
3106-1	4	6.58		56.1			0.85	down	0.32
3106-2	2.7	6.69		56.2				down	0.95
3106-3	1.7	6.65		58.8				down	0.63
3107-1	3	6.6		56.5			0.79	down	1.6
3107-2	1.3	6.57		59.1				down	1.9
3107-3	1.3	6.61		60.4				down	1.9
3108-1	3.8	6.75		57.7			0.76	down	0.95

3108-2	0.4	6.62		65.3				down	0.64
3108-3	0.4	6.73		71.9				down	0.79
3109-1	6.8	7.1		52.3			0.82	down	1.27
3109-2	6.2	6.81		51.6				down	5.4
3109-3	3.8	6.71		51.9				down	5.4
3110-1	7	6.32	20	51.9	1.9		1.3	down	6
3110-2	6	6.95	20.2	52.1	1.5			down	5.4
3110-3	5	6.86	19.5	52.4	0.8			down	5.6
3111-1						0.58	1.4	down	3.8
3111-2								down	3.7
3111-3								down	3.2
3113-1	7.7	7.09		52.2		0.1	1.5	up	3.2
3113-2	7.3	7.08		52.3				up	3.3
3113-3	7.1	7.07		52.3				up	2.5
3114-1						0.48	0.3		
3114-2								up	0.95
3114-3								up	1.1
River water	7.01	8.2	20	52.9	2				
Sacramento Bar:									
5101-1							0.2	up	0.32
5101-2	2.3	6.4		55				down	0.64
5101-3	2.5	6.45		54				down	0.64
5101-1 rep									
5101-2 rep	1.6	6.67	18.3	56				down	1.27
5101-3 rep	1.2	6.6	18.4	53					
5102-1	5.8	6.86	18.5	49		1.06	1		
5102-2	5.5	6.85	18.2	49					
5102-3	5.1	6.85	18.7	50					
5103-1	6.3	7.17	19.1	48		0.73	1.1	down	0.63
5103-2	4.6	6.82	18.4	50				down	0.47

5103-3	4.6	6.84	18.8	50				down	0.64
5104-1	5.2	6.87	18.6	50		0.58	1.3	down	0.32
5104-2	3.9	6.93	18.2	52				down	0.32
5104-3	3.9	6.79	18.1	52					
5105						0.91	1.4		
5108-1	4.8	6.83	19	54.2				down	2.22
5108-2	2.2	6.7	18.3	54				down	2.54
5108-3	1.9	6.68	18.3	55				down	2.22
5108-1 rep									
5108-2 rep	2.24	6.55	19.5	57.7					
5108-3 rep	2.39	6.08	19	58.4	6.76				
5109-1	3.1	6.73	18.8	52		0.8	0.7		
5109-2	3.3	6.75	18.2	52				down	1.27
5109-3	3.3	6.75	18.3	53				down	1.58
5110-1	3.1	6.71		54				down	1.27
5110-2	1.7	6.6		55				down	0.64
5110-3	1.2	6.08		56				down	0.79
5110-1 rep	3.7	6.71	18.5	51				down	1.1
5110-2 rep	2.4	6.67	18.4	52				down	0.95
5110-3 rep	1.9	6.66	19.1	54				down	1.11
5111-1	5.6	6.9	19.1	49		0.76	1.1	down	1.27
5111-2	3.7	6.81	18.7	52				down	0.95
5111-3	2.6	6.7	19	53				down	1.27
River water	6.58	6.98	20.3	53.2	2.7				
River water 2	7.9	7.62	19.8	48					

Table 29: Field parameters were measured in August to characterize summer conditions in stream gravel. Numbers after each sample number tell depth in gravel. Ex: 5111-1 is the 30 cm mini-piezometer tip, 5111-2 is the 60 cm sample tip, and 5111-3 is the 90 cm mini-piezometer tip. Flows during summer 2003 were unusually high due to Delta water quality demands. Temperature was measured in a flow-through cell, and may not be representative of inter-gravel temperature.

	April/May sampling event- field parameters								
Site	**Dissolved oxygen (mg/l)**	**pH**	**Temperature (°C)- in flow-through cell**	**Electrical Conductivity (uS/cm)**	**Turbidity (NTU)**	**Water depth (m)**	**Average Stream Velocity (m/s)**	**Gradient direction**	**Gradient magnitude (cm)**
Sailor Bar									
1101-1	8.8	7.64	14.2	66.2					
1101-2	1.4	7.03	13.5	74					
1102-1	1.8	7.22	15.1	71.5		0.85	0.59	up	1.1
1102-2	0.4	7.36	13.3	93.4					
Lower Sunrise Access									
3101-1	3.2	6.91	14.2	70					
3101-2	3.4	6.74	13.5	69.7					
3102-1	3.8	6.87	15.8	67.7					
3102-2	5.9	7.06	13.3	68.9					
3103-1	7	7.26	13.2	67.9					
3103-2	6.9	7.21	13.2	68.1					
3104-1	6.9	7.08	13.3	67.8					
3104-2	7.1	7.15	13.1	67.9					
3104-3	7.2	7.15	12.9	68.1					
3105-1	8.5	7.43	14	70.4					
3105-2	6.6	7.16	15.1	67.8					
3105-3	7.2	7.14	13.5	68.2					
3106-1	1.7	6.81	13.7	71.3					
3106-2	2.5	6.89	13.5	72					
3106-3	2.5	6.82	13.6	66.4					

River water	8.2	7.41	15.9	67.9					
Sacramento Bar									
5101-1									
5101-2	1.1	6.71	15.3	68.1	90				
5101-3	1.3	6.63	14.9	63.3	85				
5102-1	8.2	6.92	15.2	61.7	7.5				
5102-2	7.5	6.82	13.7	62.4	0.7				
5103-1	7.8	7.11	13.9	62.7	0.7	0.67	0.89		
5103-2	6.1	7.03	13.9	64.5	0.7				
5103-3	5.6	6.97	15	63.7	2.1				
5104-1	6.1	6.98	14.1	63.8	32				
5104-2	5.6	6.94	13.5	64.1	22				
5104-3	5.2	6.93	13.7	64.3	16				
5105-1	9.4	6.96	14.8	62.1					
5105-2	7.7	6.92		63.2					
5105-3	7.4	6.89	9.4	63					
5106-1	9.7	7.39	14.5	62	6				
5106-2	8.2	6.93	13.5	63					
5106-3	9.4	6.95	13.7	63.1					
5107-1	8.2	7.13	14.9	62.9					
5107-2	6.1	6.33	18	63					
5107-3	6.4	6.95	16	63.1					
River water #1	9.5	8.64	16.9	62.2	16				
River water #2	9.5	7.9	13.7	63.1	1.3				
River water #3		7.9		63.1	1.3				

Table 30: Field parameters were measured in April/May to characterize Spring conditions in spawning gravels. . Numbers after each sample number tell depth in gravel. Ex: 5101-1 is the 30 cm mini-piezometer tip, 5101-2 is the 60 cm sample tip, and 5101-3 is the 90 cm mini-piezometer tip.

Site	Dissolved oxygen (mg/l)	pH	Temperature (°C) in flow-through cell	Electrical Conductivity (uS/cm)	Turbidity (NTU)	Stream depth (m)	Average Stream Velocity (m/s)	Gradient direction	Gradient magnitude (cm)
	December 2002 sampling event- field parameters								
Sailor Bar									
1101-1	8.7	7.18	11	60	1.6				
1101-2	1.3	6.97		63	3.2				
1102-1	8.9	7.23	11.1	60	1.8				
1102-2	0.3	6.97		85	55	0.33	0.53		
River water	10.6								
Sacramento Bar									
5101-1						0.24	0		
5101-2	0.5	6.43		72	0.3			down	1.1
5102-1								up	4.6
5102-2								up	4.9
5104-1	5.6	6.69		66	0.4	0.33	2.3	up	3.5
5104-2	5	6.6		64	120			up	3.3
5106-1	5.6	6.63		65	6.2	0.24	0.72	none	0
5106-2	3.6	6.56		63	3.6			down	0.2
River water	9.7	7.52		69	6.22				

Table 31: Field parameters were measured in December to characterize physical and geochemical conditions near the end of the Fall Chinook Salmon run. . Numbers after each sample number tell depth in gravel. Ex: 5106-1 is the 30 cm mini-piezometer tip, and 5106-2 is the 60 cm deep sample tip.

Appendix C: Additional figures- Field parameters

Lower Sunrise Access
Dissolved oxygen in river water and stream gravel
April 2003 @ 2000 cfs

D.O. at 30 cm depth (mg/L)
D.O. at 60 cm depth (mg/L)
D.O. at 90 cm depth (mg/L)
Stream D.O. = 8.2 mg/L

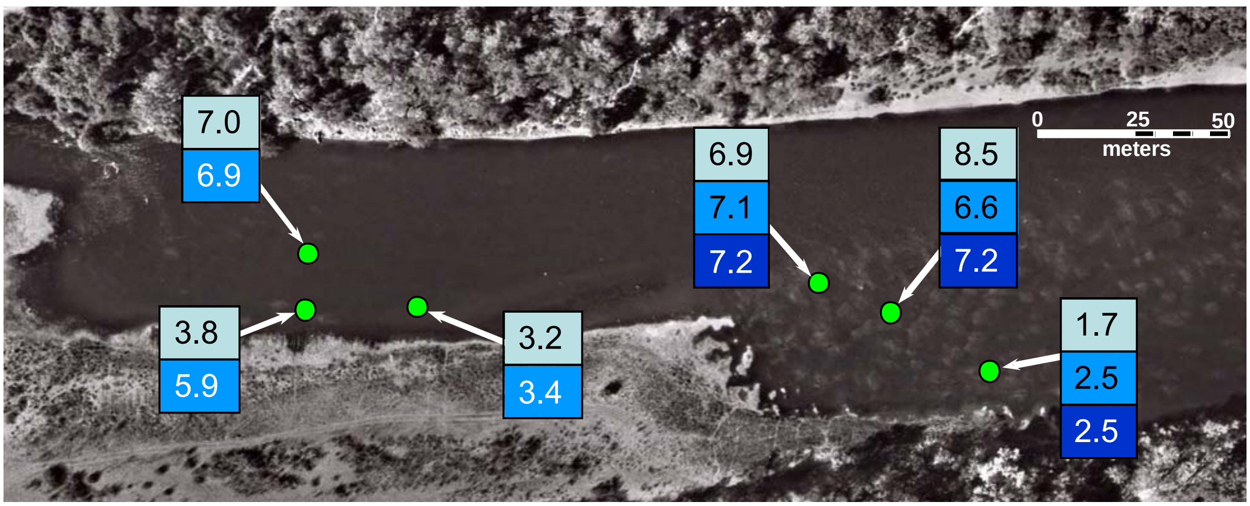


Figure 36: Dissolved oxygen levels in April, 2003 reflect differences in permeability and pore water residence time. Mid-channel sites are in riffles and high velocity flow areas, and oxygenated surface water is flushed rapidly through the gravel. Sites near the bank have higher organic and silt content and lower permeability. Dissolved oxygen is consumed because of longer pore water residence times at these less permeable sites.

Sacramento Bar
Dissolved oxygen in river water and stream gravel
August 2003 @ 2100 cfs

D.O. at 30 cm depth (mg/L)
D.O. at 60 cm depth (mg/L)
D.O. at 90 cm depth (mg/L)
Stream D.O. = 7.9 mg/L

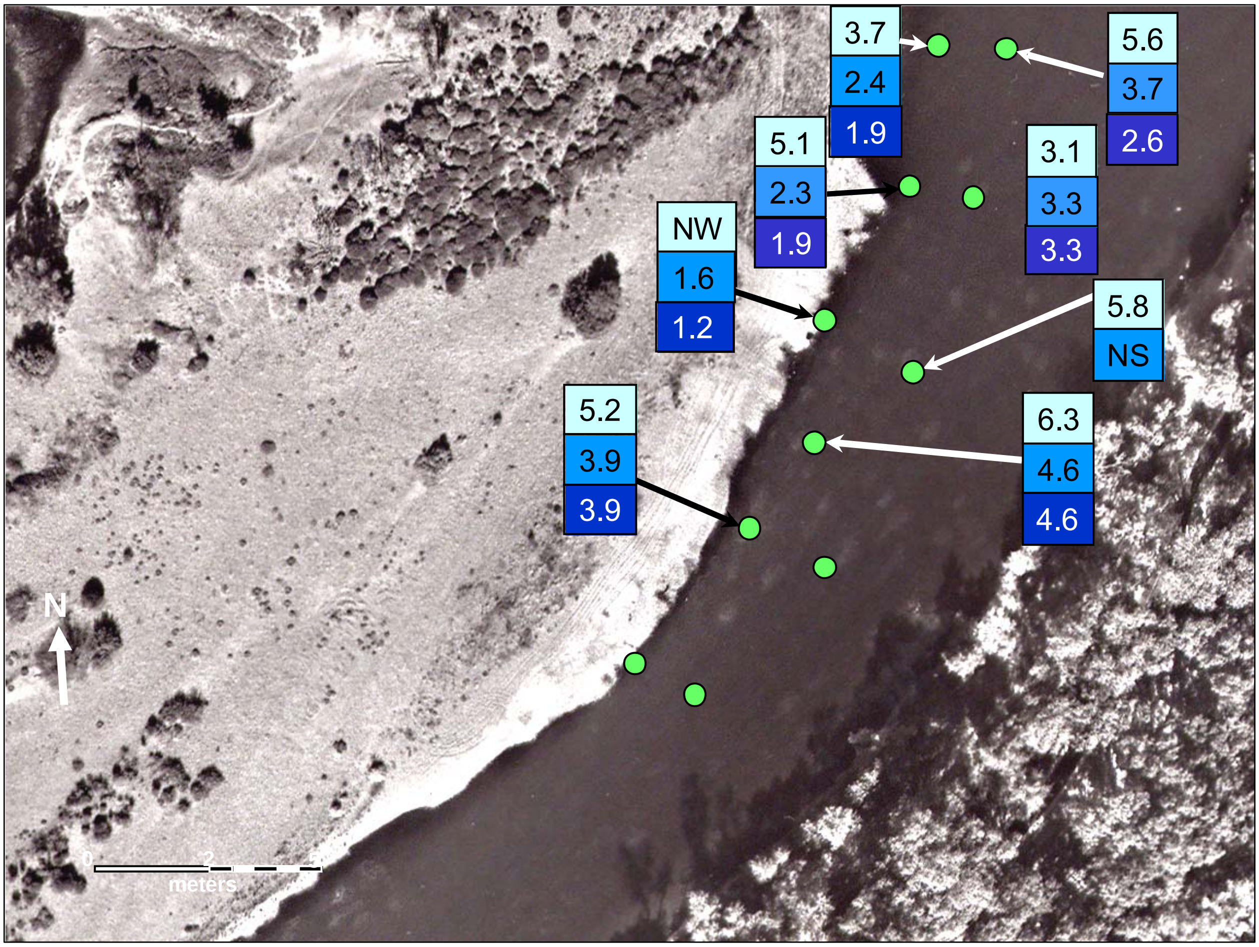


Figure 37: Dissolved oxygen levels at Sacramento Bar in August, 2003 reflect differences in permeability and pore water residence time. Downstream (bottom left) and mid-channel sites are in riffles and high velocity flow areas, and oxygenated surface water is flushed rapidly through the gravel. Sites near the bank tend to have lower surface water velocity, resulting in lower pore water exchange. Dissolved oxygen is consumed because of longer pore water residence times at these sites.

Sacramento Bar
Dissolved oxygen in river water and stream gravel
April 2003 @ 2000 cfs

D.O. at 30 cm depth (mg/L)
D.O. at 60 cm depth (mg/L)
D.O. at 90 cm depth (mg/L)
Stream D.O. = 9.5 mg/L

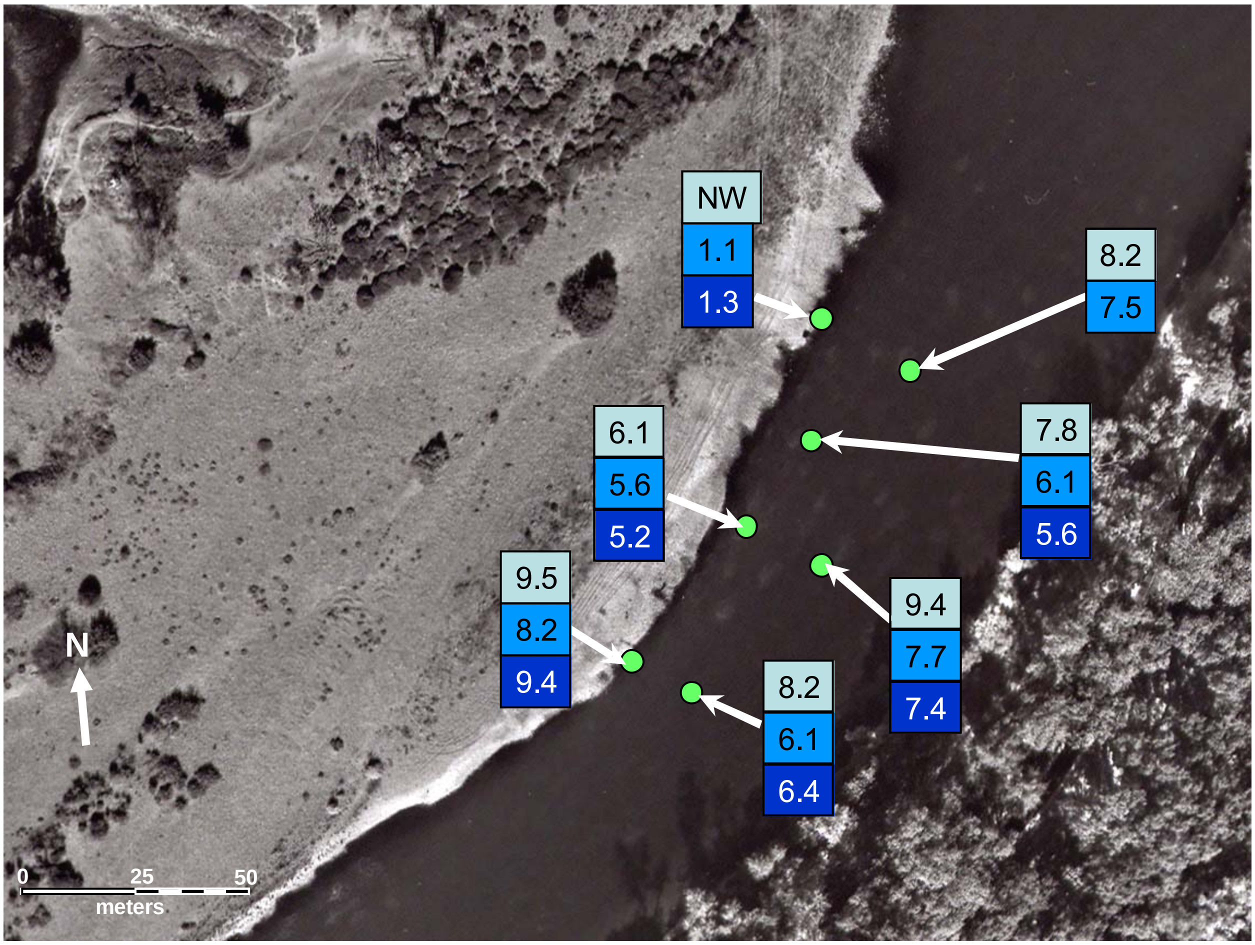


Figure 38: Dissolved oxygen levels at Sacramento Bar in April, 2003 reflect differences in permeability and pore water residence time. Downstream (bottom left) and mid-channel sites are in riffles and high velocity flow areas, and oxygenated surface water is flushed rapidly through the gravel. Sites near the bank tend to have lower surface water velocity, resulting in lower pore water exchange. Dissolved oxygen is consumed because of longer pore water residence times at these sites.

Sacramento Bar
Dissolved oxygen in river water and stream gravel
December 2002 @ 1500 cfs

D.O. at 30 cm depth (mg/L)
D.O. at 60 cm depth (mg/L)
D.O. at 90 cm depth (mg/L)
Stream D.O. = 9.7 mg/L

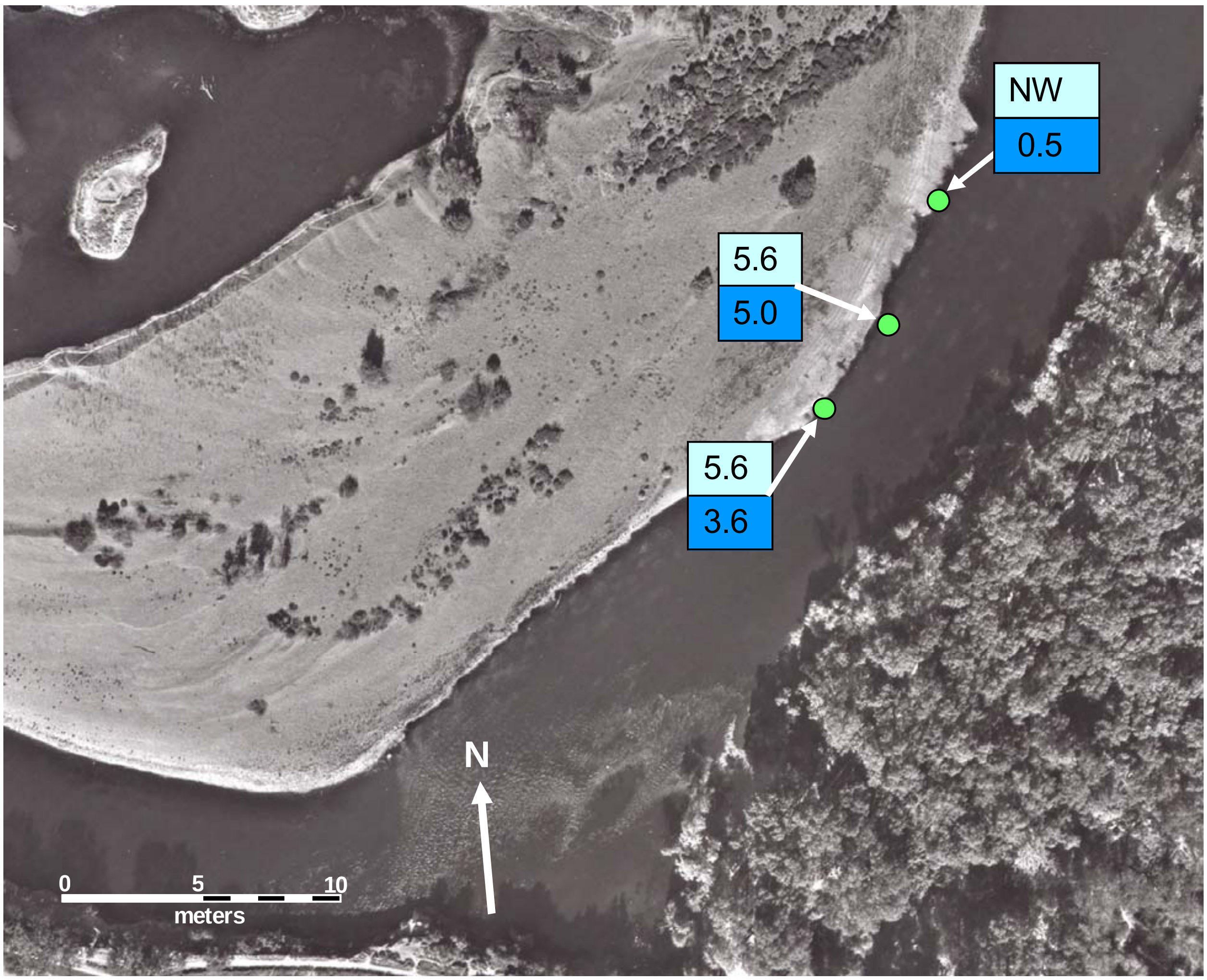


Figure 39: Dissolved oxygen in gravel pore waters at Sacramento Bar, December 2002 sampling run. The upstream (top right) sample sampling tips do not produce water, and may be installed in a clay plug or ash layer of the Mehrten Formation. Downstream sites have higher surface D.O. than at depth.

Lower Sunrise Access
Temperature Measurements (°C)
Measured through flow-through cell
August 2003

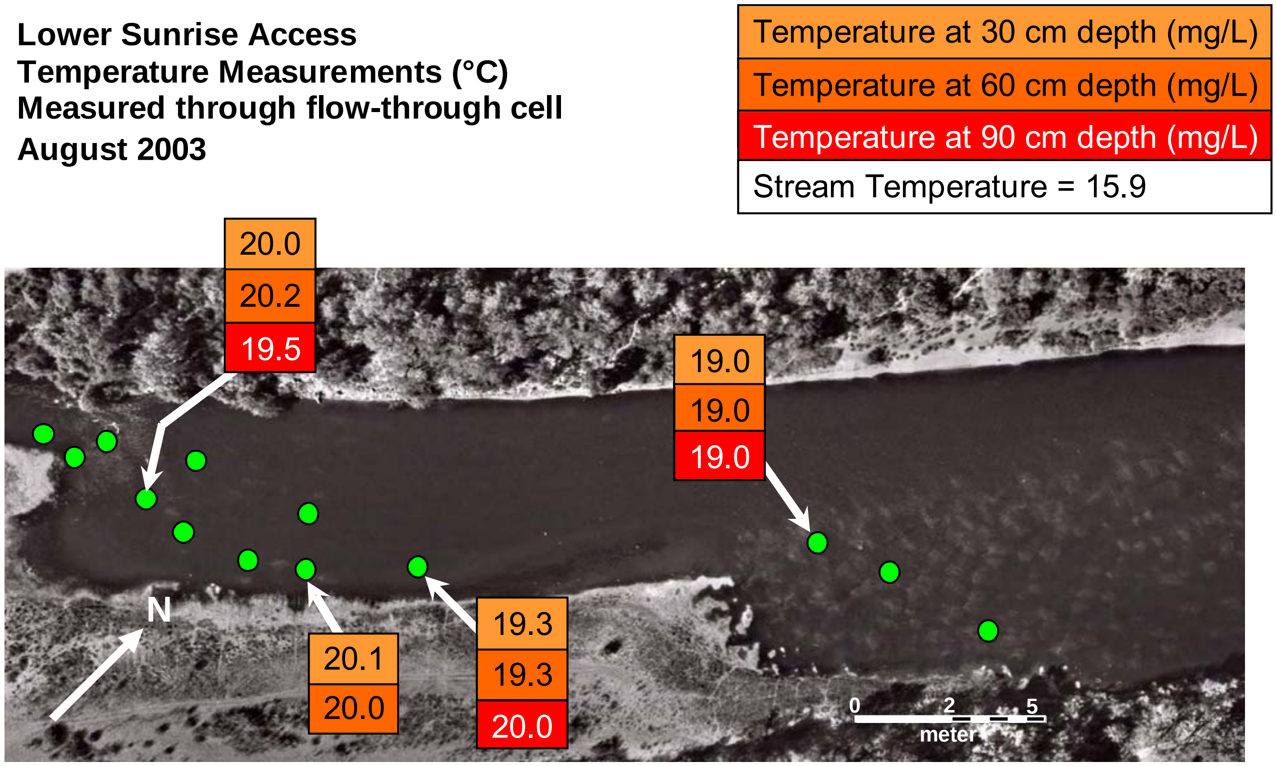


Figure 40: Temperature measurements from Lower Sunrise Access, collected when river temperature = 15.9°C. Field parameters (including temperature) are measured in a flow-through cell, and temperature may not be representative of conditions in the gravel.

PERMEABILITY							
Location:	1201 (Sailor Bar)						
Tested By:	T. Horner and E. Morita						
Date:	20-Nov-02						
2.54 cm Drawdown at 1 Foot Depth							
Time (sec)	**Discharge (mL)**	**Time to Equilibrium (sec)**	**Volume of Water at 1 inch (mL)**	**Lab Time (sec)**	**Lab Discharge (mL)**	**Inflow (cm3/ sec)**	**Permeab ility (cm/sec)**
45	1380	2.5	12.87	42.5	1367.13	32.168	16.084
45	1470	3	12.87	42	1457.13	34.694	17.347
2.54 cm Drawdown at 2 Foot Depth							
60	550	2	12.87	58	537.13	9.261	4.630
60	560	2	12.87	58	547.13	9.433	4.717

PERMEABILITY							
Location:	*1202*						
Tested By:	*T. Bishop, T. Horner, and E. Morita*						
Date:	*November 21, 2002*						
2.54 cm Drawdown at 1 Foot Depth							
Time (sec)	**Discharge (mL)**	**Time to Equilibrium (sec)**	**Volume of Water at 1 inch (mL)**	**Lab Time (sec)**	**Lab Discharge (mL)**	**Inflow (cm3/sec)**	**Permeab ility (cm/sec)**
60	*100*	*1*	12.87	59	87.13	1.477	0.738
60	*100*	*1*	12.87	59	87.13	1.477	0.738
2.54 cm Drawdown at 2 Foot Depth							
60	*995*	*0.5*	12.87	59.5	982.13	16.506	8.253
60	*1065*	*1*	12.87	59	1052.13	17.833	8.916

PERMEABILITY							
Location:	*3201*						
Tested By:	*T. Bishop, T. Horner, and E. Morita*						
Date:	*November 21, 2002*						
2.54 cm Drawdown at 1 Foot Depth							
Time (sec)	**Discharge (mL)**	**Time to Equilibrium (sec)**	**Volume of Water at 1 inch (mL)**	**Lab Time (sec)**	**Lab Discharge (mL)**	**Inflow (cm3/sec)**	**Permeab ility (cm/sec)**
60	*760*	*0.5*	12.87	59.5	747.13	12.557	6.278
60	*815*	*0.5*	12.87	59.5	802.13	13.481	6.741

60	815	1	12.87	59	802.13	13.595	6.798
2.54 cm Drawdown at 2 Foot Depth							
60	325	1	12.87	59	312.13	5.290	2.645
60	325	0.5	12.87	59.5	312.13	5.246	2.623
PERMEABILITY							
Location:	*3202 (Lower Sunrise Access)*						
Tested By:	*T. Bishop, T. Horner, and E. Morita*						
Date:	*November 22, 2002*						
2.54 cm Drawdown at 1 Foot Depth							
Time (sec)	**Discharge (mL)**	**Time to Equilibrium (sec)**	**Volume of Water at 1 inch (mL)**	**Lab Time (sec)**	**Lab Discharge (mL)**	**Inflow (cm3/sec)**	**Permeab ility (cm/sec)**
30	995	2	12.87	28	982.13	35.076	17.538
30	1098	2	12.87	28	1085.13	38.755	19.377
30	1135	2	12.87	28	1122.13	40.076	20.038
30	1060	2	12.87	28	1047.13	37.398	18.699
		2.54	cm Drawdown at 2 Foot Depth				
20	1315	8	12.87	12	1302.13	108.511	54.255
25	1545	9	12.87	16	1532.13	95.758	47.879
25	1540	9	12.87	16	1527.13	95.446	47.723
PERMEABILITY							
Location:	*4201*						
Tested By:	*T. Bishop, T. Horner, E. Morita, and Steve Rounds*						
Date:	*December 13, 2002*						
2.54 cm Drawdown at 1 Foot Depth							
Time (sec)	**Discharge (mL)**	**Time to Equilibrium (sec)**	**Volume of Water at 1 inch (mL)**	**Lab Time (sec)**	**Lab Discharge (mL)**	**Inflow (cm3/sec)**	**Permeab ility (cm/sec)**
26	1685	5	12.87	21	1672.13	79.625	39.813
28	1695	3	12.87	25	1682.13	67.285	33.643
28	1680	4	12.87	24	1667.13	69.464	34.732

Table 32: Permeability measurements from spawning gravels. Results seem anomalously high, and will be compared to other methods of permeability measurement during the upcoming year.