Codornices Creek Restoration Project

2016 Monitoring Report

Phase 3 Vegetation Monitoring
Phase 3 Geomorphic Monitoring
Phase 1-3 Benthic Macro Invertebrate Sampling
Phase 1-3 Stream Habitat Condition Survey

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City of Albany / City of Berkeley

Appendices:
Appendix A: *2016 Habitat Assessment*
Appendix B: *Phase 3 Cross Section Locations*
Appendix C: *Photopoint Locations*
Appendix D: *2016 Site Images*

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Codornices Creek Monitoring 2016

1. Overview

This report presents the 2016 monitoring results for Phase 3 of the Codornices Creek Restoration Project and follows the December 2015 Monitoring Report that summarized that year's monitoring of Lower Codornices Creek.

To date, three phases of Codornices Creek restoration have been completed. Phase 1 was completed in 2005, Phase 2 in 2006 and Phase 3 in 2010. Table 1 below is a calendar of scheduled monitoring activities for the three phases of the Codornices Creek Restoration Project for 2016. Geomorphic and vegetation surveys were completed for Phase 3 and benthic macroinvertebrate sampling and a stream condition survey, assessing the suitability of the three phases of restoration for Steelhead, were completed for all three phases.

Table 1: Monitoring Calendar

Calendar Year 2014				
Phase	*Geomorphic Survey*	*Vegetation Survey*	*BMI Survey*	*Fish Survey*
I	Complete	Complete	Fall 2016	Fall 2016
II	None (Yr. 9)	None (Yr. 10)	Fall 2016	Fall 2016
III	Fall 2016 (Yr. 6)	Fall 2016 (Yr. 6)	Fall 2016	Fall 2016

2. Vegetation Monitoring Results (Phase 3 Only)

Year 6 / Fall 2016

2.1. METHODS:

The project monitoring was performed in accordance with the elements of the Monitoring and Mitigation Plan (MMP) prepared by FarWest Restoration Engineering (FRE) dated April 16, 2006. The MMP describes the project goals, monitoring questions, performance criteria and monitoring protocols required to evaluate the success of the restoration project towards achieving project objectives. The vegetation monitoring was broken down into four separate tasks. Monitoring for each task was conducted separately using distinct methods:

MMP Task 2.1: Task 2.1 monitors the soil bioengineering components of the project. Table 2 below summarizes the monitoring criteria for the soil bioengineering by year. For year 6, soil bioengineering monitoring was not required, but was performed anyway to evaluate the success of more recent infill planting completed since the project was initially constructed. The entire riparian canopy is evaluated for percent cover using the same methodology as in year 5. This

was done using the Line Intercept Transect Along Banks method (Center for Forestry, UC Berkeley, 2005). Both sides of the creek (along bankfull channel) within the project area were measured in a linear fashion for gaps 1-foot or more in riparian cover. Total gaps were compared to total project area reach length (both sides) to quantify a percent of riparian canopy cover.

Table 2: Soil Bioengineering Success Criteria

Year	Criteria
Year 1: 2011	**Sprouts**
Year 2: 2012	**2-feet tall**
Year 3: 2013	**4-feet tall**
Year 4: 2014	**6-feet tall**
Year 5: 2015	**Evaluate entire canopy for percent cover**
Year 10: 2020	**Evaluate entire canopy for percent cover**

MMP Task 2.2: This task evaluates the success of the live staking of dogwood outside the active channel bank. See Table 3 below for success criteria of the live staking. For year 6, the entire riparian canopy is evaluated for percent cover. See Task 2.1 for method of measurement.

Table 3: Dogwood Stake Success Criteria

Year	Criteria
Year 1: 2011	**Survival**
Year 2: 2012	**Survival**
Year 3: 2013	**1-foot tall**
Year 4: 2014	**2-feet tall**
Year 5: 2015	**Evaluate entire canopy for percent cover**
Year 10: 2020	**Evaluate entire canopy for percent cover**

MMP Task 2.3: Container plants are monitored under this task. The entire site was surveyed and all living plants from the original list of species planted, including additional plants installed by volunteers since the project completion, were tallied and compiled on a per species basis. Native species planted by volunteers or growing as volunteers but not on the original plant list were not tallied. Dead plants were noted but not compiled.

MMP Task 2.4: The final task measures percent cover of native and non-native plants in 10 randomly sampled 3 foot by 3 foot plots using the Daubenmire method as detailed in the USFS Technical Reference: Sampling Vegetation Attributes, 1996.

2.2. RESULTS

2.2.1.MMP Tasks 2.1 and 2.2: Soil Bioengineering and Live Stakes

Soil Bioengineering and live stakes are almost completely covering the channel and floodplain. Along both banks of the project area, there were 16 linear feet of gaps in riparian cover. Compared to 1,260 linear feet of channel (along both banks), the total measures over 98% riparian cover.

2.2.1.MMP Task 2.3: Container Planting

Table 4: Phase 3 Container Planting Results

		2011 as-built		2012		2013		2014		2015		2016	
Species	**Spec'd**	#	*% survival from previous period*	#	*% survival from previous period*	#	*% survival from previous period*	#	*% survival from previous period*	#	*% survival from previous period*	#	*% survival from previous period*
Acer macrophyllum	6	6	*100%*	7	*117%*	8	*114%*	7	*88%*	4	*57%*	6	*150%*
Acer negundo	3	3	*100%*	3	*100%*	3	*100%*	3	*100%*	2	*67%*	4	*200%*
Aesculus californica	18	17	*94%*	16	*94%*	17	*106%*	17	*100%*	13	*76%*	14	*108%*
Alnus rhombifolia	40	37	*93%*	37	*100%*	36	*97%*	33	*92%*	24	*73%*	26	*108%*
Heteromeles arbutifolia	18	15	*83%*	17	*113%*	20	*118%*	19	*95%*	18	*95%*	15	*83%*
Mimulus aurantiacus	15	1	*7%*	3	*300%*	5	*167%*	3	*60%*	0	*0%*	1	*NA*
Populus fremontii	20	18	*90%*	19	*106%*	21	*111%*	18	*86%*	20	*111%*	15	*75%*
Quercus agrifolia	23	28	*122%*	29	*104%*	29	*100%*	34	*117%*	28	*82%*	28	*100%*
Rhamnus californica	14	13	*93%*	22	*169%*	19	*86%*	21	*111%*	18	*86%*	11	*61%*
Ribes sanguineum	8	8	*100%*	8	*100%*	9	*113%*	3	*33%*	1	*33%*	1	*100%*
Rosa californica	11	8	*73%*	15	*188%*	16	*107%*	14	*88%*	9	*64%*	8	*89%*
Sambucus mexicana	11	13	*NA*	14	*108%*	14	*100%*	12	*86%*	7	*58%*	7	*100%*
TOTAL # OF INDIV.	**187**	**167**	*89%*	**190**	*114%*	**197**	*104%*	**184**	*93%*	**144**	*78%*	**136**	*94%*

2.2.2. MMP Task 2.4: Percent Cover

The 2016 survey of percent cover indicates a slight increase in bare soil (14% currently, 11% in 2015). Now that the willows are nearing mature size, there is an increasing amount of shade on the floodplain, which may contribute to the increase in bare soil. Also, native plant establishment on the Phase 3 floodplain is better than the previous two phases. *Salix spp., Leymus triticoides, Bromus carinatus, Hordeum brachyantherum, Baccharis douglasii,* and *Equisetum* have successfully established and account for the majority of the native cover on the floodplain. Even with the limited initial container plant palette, ongoing maintenance by the City of Albany and maintenance / follow up planting by volunteer groups has been successful at adding further native cover and limiting the colonization of many of the invasive species typical of urban restoration areas.

Table 5: Percent Cover Results using Daubenmire Method

2014		Species		Species		Species		Species	
		Native		Exotic Forbs		Exotic Grasses		Bare Soil	
Cover Class	Mid-point	Number	Product	Number	Product	Number	Product	Number	Product
1-5%	2.5	0	0	0	0	2	5	0	0
5-25%	15	1	15	3	45	3	45	2	30
25-50%	37.5	0	0	3	112.5	3	112.5	3	112.5
50-75%	62.5	2	125	1	62.5	0	0	0	0
75-95%	85	1	85	1	85	0	0	0	0
95-100%	97.5	6	585	0	0	0	0	0	0
Total Canopy			810		305		162.5		142.5
Number of Samples			10		10		10		10
% Canopy Cover			81%		31%		16%		14%
Species Composition			**61%**		**23%**		**12%**		**11%**
Frequency			100%		80%		80%		50%

2.3. DISCUSSION

2.3.1.MMP Task 2.1 and 2.2: Soil Bioengineering and Live Stakes

The riparian canopy is providing almost 100% cover to the creek and floodplain. In previous years, the willow and other plants were struggling to establish at one meander at the upstream end of the project; the willows in this area have almost completely filled in. Dogwood stakes are establishing well and have formed thickets in various areas.

2.3.2. MMP Task 2.3: Container Planting

As summarized in Table 4 above, fewer container plants (94%) were observed in 2016 than in 2015. However, the 94% does not take into account species that were planted by volunteers or natural colonization. There were specimens of Oregon ash, Rush, California Sagebrush, Mugwort, Bee plant, Douglas Iris, Ocean-spray, Coyote Brush, Ceanothus and Ninebark noted during the survey. Baccharis pilularis are self-colonizing aggressively, and have appeared throughout the site. One volunteer Fremont poplar was observed in the channel. Overall, the dense cover of vegetation made locating all of the container plants challenging.

Four alders were noted as dead but the remaining ones are looking healthy with vigorous growth. Overall the container plants are exceeding the 60% survival threshold.

2.3.3. MMP Task 2.4: Percent Cover

The goal for the sixth year of monitoring is to have less than 20% exotic species cover. There is currently 31% cover non-native species detected in the random selected sample plots. Multiple aggressive exotic species are still colonizing within the Phase 3 reach. Acacia seedlings, bristly ox-tongue, fennel, pampas grass, curly dock, bindweed, and wild onion are found scattered throughout the site and should continue to be addressed through on-going maintenance. Additional effort should continue with removing these and other invasives.

2.4. General Notes

Overall the vegetation in Phase 3 is performing well. Previous reports have noted that site soil preparation and compaction mitigation improved over techniques employed during the prior two phases, and that this may be reason for better reason colonization of native plants. This theory still seems to hold true, along with the more consistent maintenance and irrigation programs.

Colonization of the site by invasive plant species continues to be an ongoing challenge. City maintenance and the additional planting and maintenance efforts by volunteers has played a significant role in getting native species to colonize this urban site, which in turn decreases invasive plant infestations.

2.5. Maintenance Recommendations

2.5.1. Mulch: Hand weed area around container plants/trees and mulch around the base of the plants for weed suppression and water retention.

2.5.2. Weed: Locate and remove acacia seedlings, bristly ox-tongue, fennel, pampas grass, curly dock, Himalayan blackberry, bindweed, ivy, ripgut brome, wild oat grass and nasturtium.

2.5.3. Prune:

a. Phases 1-3: Selectively prune willows and other vegetation that are growing into the multi-use path. Perform structural and aesthetic pruning on oak and other trees near public use areas to ensure healthy ongoing growth.

b. Phase 1: Remove 3-4 large (~6" DBH) willows touching 4th Street bridge to avoid damage to the bridge structure. Willows can be cut at base to not disturb soil and root structure.

2.5.4. Weed 6th Street Rain Gardens: Remove Fennel and bristly ox-tongue and other invasive species.

2.5.5. Remove and dispose of sediment from Rain Garden entry points.

2.5.6. Pick up trash and cigarette butts in Rain Garden and adjacent walks.

2.5.7. Prune roses in Rain Garden.

2.5.8. Test irrigation system regularly and fix any issues promptly. Turn off the irrigation for all areas except for the rain gardens and monitor the health of the trees and shrubs. Turn on irrigation if vegetation appears significantly stressed.

2.5.9. Empty trash cans on-site more frequently

2.5.10. Clean or paint over graffiti on USPS wall along multi-use trail

3. Geomorphic Survey

Phase 3 – Year 6

3.1. Methods

Profile and cross section surveys were completed in 2016 for Phases 3. Cross sections are from established and monumented locations.

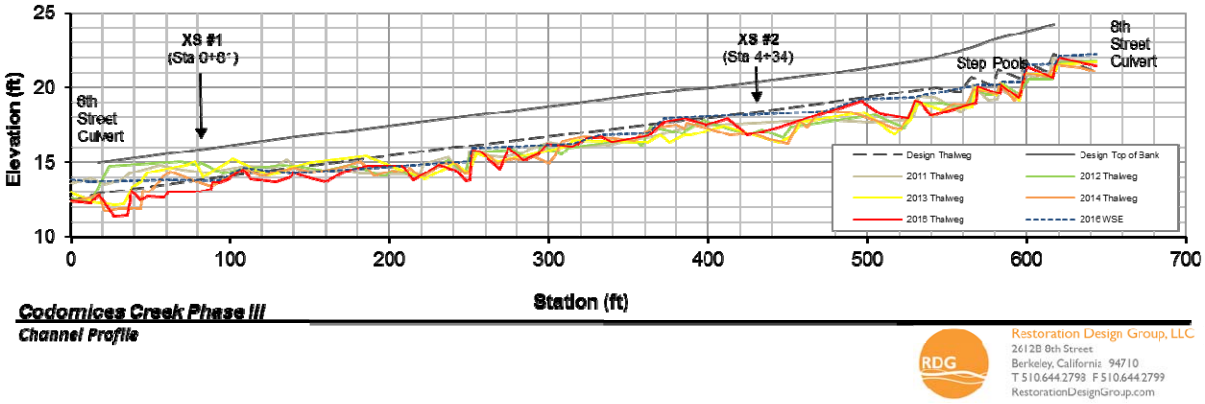
3.2. Results

3.2.1.Channel Profile Phase 3

The end of the drought and the return of channel forming flows in the 2015/2016 winter resulted in some changes to Phase 3, particularly in the lower third of the project. The channel continues to incise and narrow slightly immediately upstream of the 6th Street culvert. This part of the channel has adjusted the most since construction, having abandoned its original meander form in favor or a more direct route to the culvert. It is possible that the channel has broken though a thin lens of hardpan in the lower channel allowing for additional scour. The extent of downcutting is not of concern but we will continue to observe it.

The profile of the upper two thirds of Phase 3 experienced little change where much of the bed has maintained a consistent elevation. The upstream step pools have remained stable.

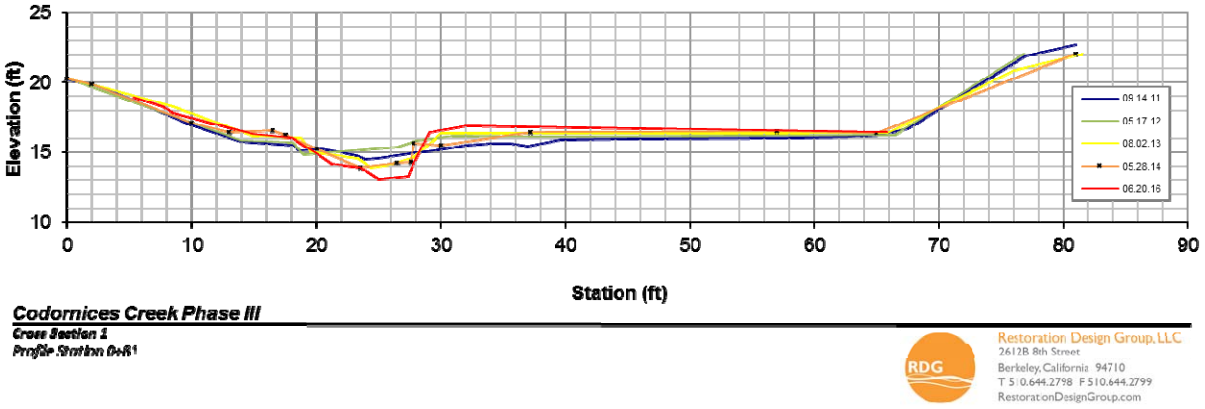
Riffle and pool morphology continue to develop within the channel with the exception of areas scoured to hardpan. The hardpan is hampering sediment deposition in these areas and limiting development of depositional feature such as point bars.



3.2.2.Cross Sections Phase 3

The two riffle cross sections were resurveyed in 2016. Cross section #1 is in the lower portion of the creek and is influenced by the culvert backwater. Cross section #2 is upstream in the location adjacent to the hardpan bed. Cross section 1 shows continued adjustment of the channel above

the 6th street culvert, with active narrowing of the channel. Cross section 2 continues to build its inner depositional bench formed in 2012, while maintaining a consistent thalweg elevation.



Codornices Creek Phase III
Cross Section 1
Profile Station 0+81

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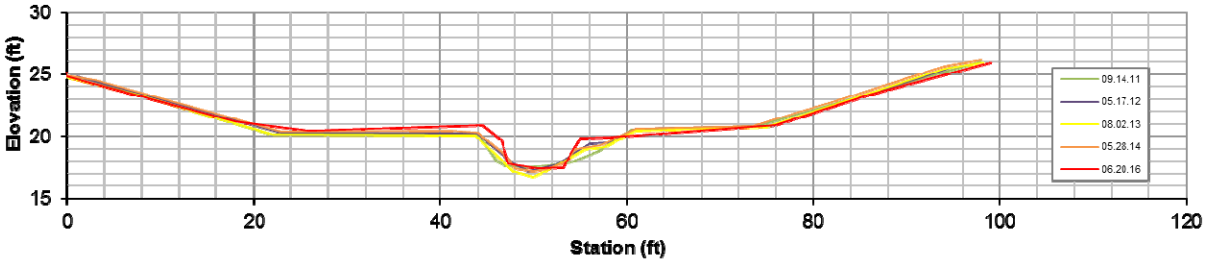

Codornices Creek Phase III
Cross Section 2
Profile Station 4+34

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3.3. Discussion

Phase 3 continues to mature. We have been monitoring two areas closely since the project was constructed. The first area is immediately upstream of the 6th Street culvert, where the channel adjusted immediately after construction. The second area is the upper half of the restoration reach, where the channel has exposed hardpan. The following provides an update for each of these areas.

Above 6th Street Culvert – The hydraulics of the culvert backwater resulted in deposition of sediment in the channel upstream of the culvert and a near immediate evulsion and straightening of the channel leading into the culvert. For the next five years, the changes to the channel in this area have slowed as the channel approaches an equilibrium condition. The

resulting changes to the channel have increased the channel capacity in this area. Competency was increased due to the increased channel slope resulting from the evulsion and with continued deposition of the floodplain at the culvert. As a result, the channel has reached a more stable configuration and no adaptive management is required at this time.

Expose Hardpan –The exposed hardpan upstream continues to persist. This hardpan substrate excludes any opportunity for hyporheic flow and does not provide ideal habitat for benthos. This condition is not unique to the restoration areas. A similar condition exists upstream of the project site between 8th and 9th street.

Monitoring of this condition began during the first winter after construction and has not shown any indication of improvement. The channel has incised up to 1-foot below the design grade resulting in increased stream power near bankfull flows. In addition, the floodplain is no longer inundated at the designed frequency.

In the lower part of the hardpan, the creek seems to have eroded through the hardpan down to a softer substrate. We will continue to monitor this development.

As mentioned in previous years, there is an opportunity to provide high quality habitat in this newly restored reach by rebuilding three riffles in the middle to upper section of Phase 3. These riffles would restore the appropriate bankfull channel dimensions. They would be sized with material that could be moved by hand, yet persist during larger storm events. This rock would not require excavation in the channel for placement and would effectively raise the channel at the riffles up to 1.5 to 2-ft to reduce channel entrenchment. Although Codornices Creek is an urbanized watershed it does transport a significant amount of sandy gravel as bedload. This bedload can be expected to deposit in the channel between the constructed riffles, effectively burying the hardpan overtime.

Over the last few years we have also observed willows collapse into the channel as they mature in size. This is particularly common in Phase 1, which is the oldest of the three restored reaches. These collapsed willows often fall into and across the channels, creating debris jams. These jams are backwatering the channel and allowing sediment to drop out into the resulting pools. If this process were to occur throughout Phase 3, we could see a similar affect as to what is being proposed by rebuilding the riffles, where backwater caused by the debris jams could bury the hardpan with deposited sediment. This process has already occurred within Phase 3 at station 3+08, where a mature willow that was preserved during construction partially collapsed into the channel in 2013 and trapped sediment upstream. This observation indicates that this process should continue to be encouraged as a strategy to mitigate for the exposed hardpan.

3.4. Maintenance Recommendations

3.4.1. Install riffle material in the upper half of Reach III to restore the beneficial channel dimensions and passively bury the hardpan.

3.4.2. Allow vegetation to remain in the channel to encourage minor debris jams and backwatered pool habitat.

4. Benthic Macroinvertebrate Survey

4.1. Methods

RDG collected benthic macroinvertebrates following the California Stream Bioassessment Procedure in October 2016. This protocol is consistent with past sampling conducted by Kier Associates in 2006 and RDG in 2012 and 2014. Each of the three phases of restoration were sampled separately and were composed of three randomly selected riffle locations for a total of nine (9) collection sites. Each of the three samples was evaluated in the laboratory by Tom King of BioAssessment Services, Folsom, Ca.

4.2. Results

The results continue to show a general impairment of Codornices Creek in each of the three phases of restoration. The results show consistency over time, however 2016 does show slightly more impaired condition compared to previous years. These changes are not seen as significant and may be due to timing of the survey or natural variability expected from these survey methods. The 2016 surveys were conducted in October.

Table 6: BMI Survey Results[1]

Metrics	2016			2014			2012			2006	
	Phase I	Phase II	Phase III	Phase I	Phase II	Phase III	Phase I	Phase II	Phase III	Phase I	Phase III[2]
Richness:											
Taxonomic	16	19	20	21	18	23	17	17	16	13	14
EPT	3	2	2	2	3	4	2	1	2	2	2
Composition:											
EPT Index (%)	2.1	4.0	0.4	3.4	5.7	8.8	14	1.3	2.0	6	9
Sensitive EPT Index (%)	1.9	4.0	0.2	3.1	3.3	3.1	14	1.3	0.7	0.0	0.0
Shannon Diversity	1.8	2.1	1.7	2.2	2.0	2.1	2.3	2.0	2.2	0.92	0.89
Dominant Taxon (%)	31	24	52	23	39	43	23	24	29	66	77
Non-Insect Taxa (%)	44	53	45	43	44	43	47	59	50		

[1] Metrics based on SAFIT level I standard taxonomic effort except chironomids identified to subfamily/ tribe. Standard taxonomic effort source: Southwest Association of Freshwater Invertebrate Taxonomists (http://www.waterboards.ca.gov/swamp/docs/safit/ste_list.pdf).

[2] 2006 survey occurred in the Phase III reach prior to construction.

Metrics	2016			2014			2012			2006	
	Phase I	Phase II	Phase III	Phase I	Phase II	Phase III	Phase I	Phase II	Phase III	Phase I	Phase III[2]
Tolerance:											
Tolerance Value	4.6	5.2	4.8	5.4	5.6	5.6	5.5	6.2	5.8	5.43	5.58
Intolerant Organisms (%)	2.1	4.0	0.4	3.1	3.3	3.1	14	1.3	0.7		
Intolerant Taxa (%)	19	11	10	4.8	11	13	12	5.9	6.3		
Tolerant Organisms (%)	3.9	6.7	3.0	19	9.6	12	28	24	21		
Tolerant Taxa (%)	13	26	25	19	22	26	29	29	31		
Functional Feeding Groups:											
Collector-Gatherers (%)	38	29	65	64	66	69	46	46	64		
Collector-Filterers (%)	0.7	2.0	2.3	10	1.7	1.0	1.3	2.2	1.4		
Scrapers (%)	35	27	15	12	5.2	10	25	23	11		
Predators (%)	24	38	18	11	24	14	15	27	22		
Shredders (%)	1.9	4.0	0.2	3.3	3.3	3.1	14	1.3	0.7		
Other (%)	0.0	0.4	0.0	0.0	0.0	3.1	0.0	0.0	1.4		
Estimated Abundance:	1068	506	845	697	2168	1360					

The three samples contained a total of 25 discrete taxa, up from 22 in 2012 and down from 30 in 2014. 26 discrete taxa were observed during the 2006 survey which included a total of 6 sample sites between Albina Street and Second Street.

4.3. Discussion

The 2012 and 2016 surveys were both conducted in the month of October. The 2014 survey was conducted in the spring when macroinvertebrates are typically more abundant. This is likely the reason that the 2014 survey results show slightly greater health than the other two surveys. All surveys indicate that Codornices Creek remains impaired and no trends can be discerned from the survey; however, this collection of BMI surveys now offers a robust snapshot of existing stream health through the restoration reach and provide a baseline for continued measurement of stream health as Berkeley and Albany continue to implement green infrastructure projects within Codornices Creek Watershed.

4.4. Maintenance Recommendations

As noted above, there is a large portion of channel that has hard pan clay substrate and does not provide suitable habitat and likely contributes to the elevated stream temperatures seen within Phase 3. Addressing this condition should be considered if there is interest from the regulatory agencies.

5. References

Carter, K. (2008). *Effects of Temperature, Dissolved Oxygen/Total Dissolved Gas, Ammonia, and pH on Salmonids* (p. 53).

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Sloat, M. R., & Osterback, A. K. (2013). *Maximum stream temperature and the occurrence, abundance, and behavior of steelhead trout* Oncorhynchus, *73* (October 2012), 64–73.

Technical Memorandum

Prepared for: **Restoration Design Group**

Prepared by: **Hagar Environmental Science**

2016 Codornices Creek Post-Project Habitat Reconnaissance, UPRR to 8th Street

The reaches of Codornices Creek between the Union Pacific Railroad (UPRR) right-of-way and 8th Street were surveyed on October 24, 2016 to assess the general stream habitat condition following a series of stream restoration projects. The restoration project between the UPRR and 5th Street was initiated with grading in 2004 and completed with re-vegetation in 2005. The project between 5th Street and 6th Street was completed in 2006. The reach between 6th Street and 8th Street was completed in 2010. A habitat assessment was also conducted for the entire reach in 2014 (HES 2014) and 2012 (HES 2012); and for the reaches between the UPRR and 6th Street in 2009 (HES 2009). The UPRR to 8th Street habitat reconnaissance was conducted with the following objectives:

- estimate the frequency and relative extent of pool and riffle habitat types in the study reach and measure pool depths;
- evaluate the extent of cover in the study reach and characterize the habitat in terms of ability to support steelhead in comparison to other Central Coast streams;
- note the presence of any fish migration passage obstacles;
- provide a qualitative assessment of macro-invertebrate populations that are visible at the time of the survey; and
- record any observations of trout or steelhead (*Oncorhynchus mykiss*), California red-legged frog (CRLF), or other aquatic life visible during the time of the survey

The three reaches evaluated continued to show significant differences in habitat conditions as a result of the restored channel structure and planform, riparian plantings, and the time elapsed since restoration project completion (Figure 1). The stream channel of Codornices Creek in the reach between the UPRR and 5th Street has high sinuosity and is lined with dense riparian vegetation including willows to a height of 12 to 18 feet and a few alder and sycamore saplings. The trees provide a canopy of 90% to 95% coverage in most of the stream reach. This canopy provides extensive shade throughout the day and is expected to result in cooler stream temperature than would occur in its absence. This reach has been relatively stable with respect to habitat features since the 2012 survey.

The reach of Codornices Creek between 5th Street and 6th Street has much lower sinuosity than downstream of 5th Street but is also lined with dense riparian vegetation. This reach is relatively shallow and has significantly less pool habitat than downstream of 5th Street. Gravel has accumulated in this reach and provides some potential spawning habitat for resident or anadromous *O. mykiss*. Conditions in this reach were little changed from the 2014 survey.

The reach from 6th Street to 8th Street has lower sinuosity than the reach downstream of 5th Street but more than the reach between 5th Street and 6th Street. The reach has continued to evolve since the 2012 survey. Tree cover has greatly increased since the 2014 survey with greater extent of shading and less extensive growths of rooted aquatic macrophytes compared to the previous survey. The channel has deepened in many areas with increased pool formation and riffle development.

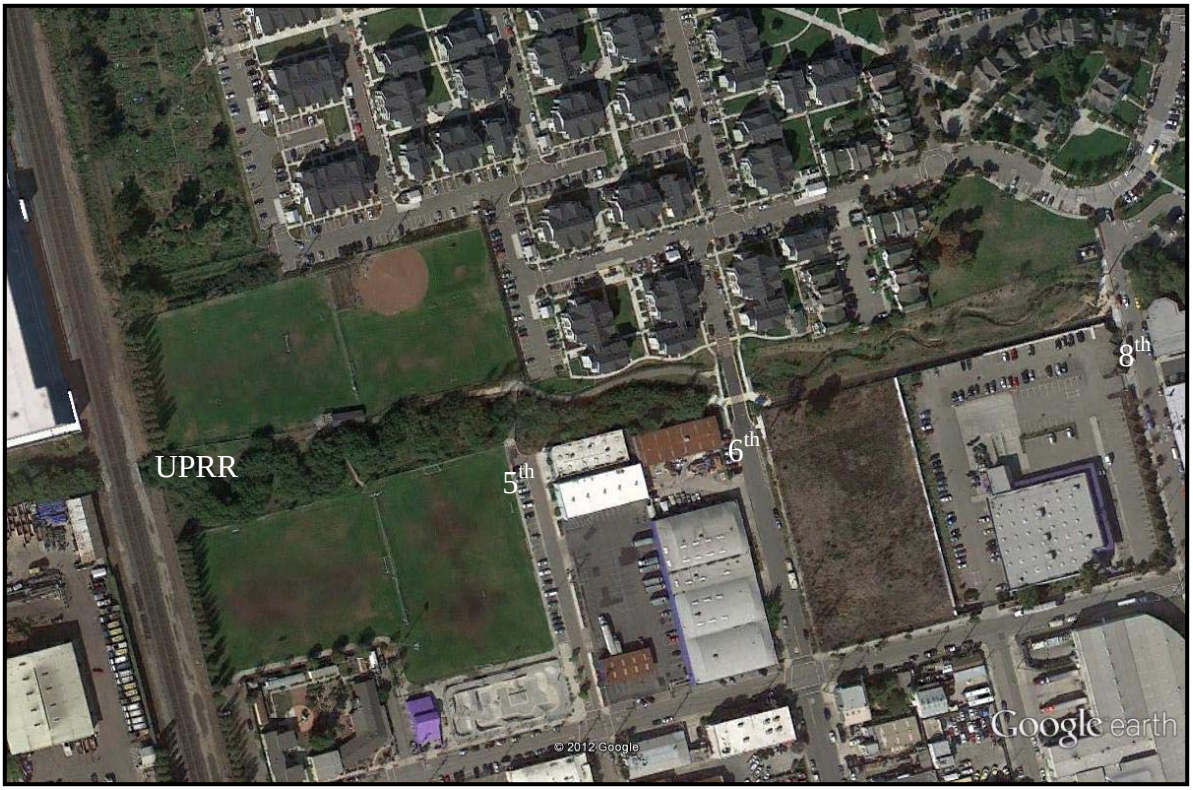

Figure 1. Project location showing three project reaches.

UPRR to 5th Street

The reach was relatively unchanged from previous surveys in 2009, 2012, and 2014 in terms of channel position and channel cross-section. Small debris jams caused by accumulations of small woody debris were a more common feature than in previous surveys (Figure 2). These small accumulations of wood are not extensive enough to cause flooding or bank erosion and they provide shelter for fish. There is passage under and through the debris for smaller fish and passage for larger fish would be possible at higher flows, when fish are more likely to be moving. Stream wetted width ranged from 2 to 9 feet. The reach is dominated by pool habitat (62% by length), with riffles making up 25% by length. Runs and glides comprise 8% and 5%, respectively. In comparison, previous surveys found pools comprised 70% of the reach length in 2014 compared to 49% of the surveyed length in 2012 and 56% in 2009. Riffles were only 16%

of the surveyed length in 2014 compared to 22% in 2012 and 23% in 2009. Run and glide habitat were 10% and 3% of the reach in 2014, respectively. It appears that pools were deeper since the last survey. Pool maximum depth ranged from 1.1 to 2.6 compared to 1.0 to 2.3 feet in 2014, 1.3 to 2.2 feet in 2012, and 1.1 to 2.3 feet in 2009. Maximum pool depths averaged 1.89 feet in 2016 compared to 1.61 feet in 2014, 1.69 feet in 2012 and 1.56 feet in 2009. In 2016 half of the pools were 2 feet deep or greater whereas only 6% were that deep in 2014. Cover complexity was consistent with previous surveys.

Figure 2. Small debris jam between UPRR crossing and 5th Street.

Riffles were relatively short, ranging from 4 to 20 feet and averaging 12 feet. Eighty percent of riffles were 15 feet or less in length. As noted in the previous surveys, many of the riffles were over the entwined fine roots of the riparian willows and these root mats formed much of the substrate in the riffles. Substrate in this reach was predominantly sand and small gravel with some areas of silt in the lower part of the reach. Substrate suitable for steelhead or rainbow trout spawning was relatively scarce. Spawning substrate was of moderate quality with relatively small gravel and not much silt, but fairly sandy.

There were no significant migration obstacles in the survey reach, although due to the stream's small size, passage through riffles would be limited under baseflow conditions. Debris collected at the mouth of the culverts at the UPRR crossing may be a hindrance to fish migration and should be cleared (Figure 3). Pool tail crest depths ranged from 0.1 to 0.3 feet and averaged 0.2 feet. These conditions are to be expected in a stream the size of Codornices Creek during the dry season. Adult steelhead migration passage is limited to periods of storm runoff. The relatively

narrow width and steep banks of the low-flow channel should result in a relatively large increase in flow depth with increases in streamflow at these riffles.

Figure 3. Debris blocking UPRR culvert mouth.

No benthic macro-invertebrates were observed in the study reach although crayfish were present and water striders (Family Gerridae) were present on the water surface. The low abundance of benthic invertebrates is likely a result of the small substrate size, high substrate mobility, or water quality issues. It was also late in the season, when productivity is lower, and there had been recent runoff. The small gravel/sand substrate does not have large pore spaces to support benthic macro-invertebrates and is easily mobilized under high flows. The extensive willow root mats likely provide good habitat for certain types of benthic invertebrates but none were observed on the surface of the mats.

No fish were observed in the UPRR-5th Street reach. It is difficult to observe fish in this section due to the dense shade and ample cover. The habitat appears adequate to support all life stages of resident rainbow trout and rearing juvenile steelhead. There is a potential for steelhead to spawn in Codornices Creek during the winter (December through March). Although steelhead can hold over during the summer in the streams where they spawn, there is little habitat to support over-summering in Codornices Creek. Codornices Creek supported rainbow trout in this reach before the restoration project (HES 2005, HES 2006). Most of the fish were in the relatively deep scour pool and culvert at 5th Street and in an overgrown concrete box culvert in the lower part of the original reach.

5th Street to 6th Street

Compared to the downstream reach, this reach has larger substrate with more gravel-sized elements, less channel sinuosity, and fewer pools. There were only two pools in the 300 foot reach. Habitat conditions were little changed from the 2014 survey.

Pool habitat was more extensive than in past surveys with pools comprising 31% by length compared to 20% in 2014. Riffles and glides made up 29% and 27% by length, respectively, while runs were 13%. Runs made up 19% of this reach in 2012 but were not classified in 2014, possibly due to the lower depth of flow during the drought conditions of 2014. There was very little cover in the extensive glide and riffle habitat in this reach but both pools had high shelter complexity.

This reach had relatively extensive potential spawning habitat with relatively clean and non-compacted gravel substrate although depth of flow was limited. Willow root mats were less prevalent in this reach compared to the reach below 5th Street. The extensive shallow riffle habitat in this reach hinders migration during summer low flow conditions. Only a small portion of the habitat is deep enough and with good enough cover to support trout in the summer. The culvert under 6th Street at the upper end of the reach was backwatered and appeared to have reasonable depth throughout its length. The culvert could not be surveyed due to insufficient height but may provide good habitat for *O. mykiss*.

6th Street to 8th Street

Restoration work was completed in this reach during the summer and fall of 2010. During the survey in August 2012, the project was still in the early stages of recovery. Riparian plantings were still small and there was very little shade along the stream. Watercress and other emergent aquatic plants were established in the stream channel to the extent that open water was not visible in much of the project. Most of the project was characterized as "marsh" (496 out of 596 total feet or 83% of the project length). The remaining habitat consisted of small pockets of glide (13%) and run (3%) type habitat.

By 2014, there had been some growth of the willows and other riparian vegetation providing additional shading. Although still present in some areas, the extensive growth of emergent aquatic vegetation had been reduced and a defined channel was present through most of the reach. The channel had cut down through the wedge of sediment upstream of the 6th Street culvert, noted in the 2012 survey, improving passage through this section.

In 2016, riparian vegetation had matured further and most of the reach had good canopy. Average percent canopy increased from 27% in 2014 to 63% in 2016. Floating and emergent vegetation was present along the channel margins in places but the channel was well defined. Macrohabitat features shifted significantly between 2014 and 2016. In 2014 the reach consisted of pools and glides (each at 37% of the total by length) with smaller amounts of run (15% by length) and riffle (11% by length). In 2016, the extent of pools had increased to 48% by length

and riffles were the next most extensive habitat type at 25%. Glides and runs comprised 14% and 13% of habitat by length, respectively. Pools below the rock weirs in the upper part of the reach had increased in depth and areal extent and provided improved habitat. This was reflected by an increase in depth of pools to an average depth of 1.8 feet in 2016 (range 1.3 ft. to 3.2 ft.) compared to 1.4 feet in 2014 (range 1.2 ft. to 1.9 ft. Glides and runs were deep enough to provide rearing habitat for younger *O. mykiss* with maximum depths averaging 0.65 and 1.1 feet, respectively. The substrate was dominated by silt and clay in much of the reach. A hard pan of clay was exposed in many areas in this reach. Gravel had been deposited in a few areas.

Cover was moderate to high and was composed of floating and rooted aquatic vegetation and overhanging terrestrial vegetation with smaller amounts of root mass and undercut banks. Boulders included in the constructed rock weirs at the upper end of the reach provided some additional cover. No *O. mykiss* were seen in this reach though conditions for observing fish were poor due to the narrow width and extensive cover.

Conclusions

The two reaches downstream of 6th Street have recovered well following the restoration projects. Riparian vegetation is well established and the channel appears to be stable. Plantings downstream of 5th Street are relatively dense and may somewhat limit aquatic productivity due to lack of sunlight. Habitat conditions are suitable for trout and rearing juvenile steelhead. The 5th Street to 6th Street reach has limited rearing potential due to lack of pool development but has potential spawning habitat. The reach downstream of 5th Street has good pool development and cover providing good potential rearing habitat. The habitat is maturing with larger trees, more extensive root systems and formation of habitat through collection of small woody debris.

The reach between 6th Street and 8th Street is also maturing. Growth of riparian trees and shrubs is providing more shading and cover and mitigating any tendency for excessive temperature conditions. Previous monitoring has indicated that high temperature is not likely to be a problem in this reach (HES 2014). There are still a few scattered areas with open canopy that allow greater insolation and enhance aquatic productivity. Continuing growth of riparian vegetation including developing root masses and interaction with higher winter flows appears to be resulting in development of pools and undercut banks. The rock weirs also appear to be instrumental in these processes. The pan of clay substrate in many areas of the reach may be the biggest limiting factor for *O. mykiss*, although this reach supported a relatively abundant population before the project and certainly has that potential now (HES 2010).

References

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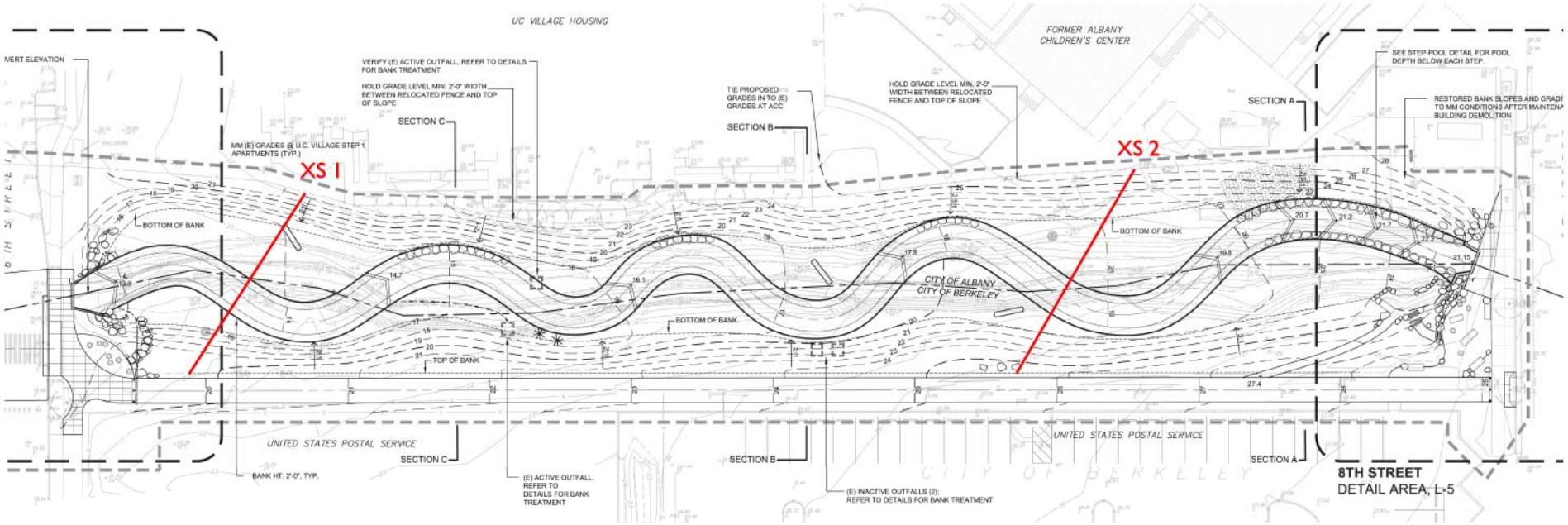

Codornices Creek Phase III

Cross Section Locations

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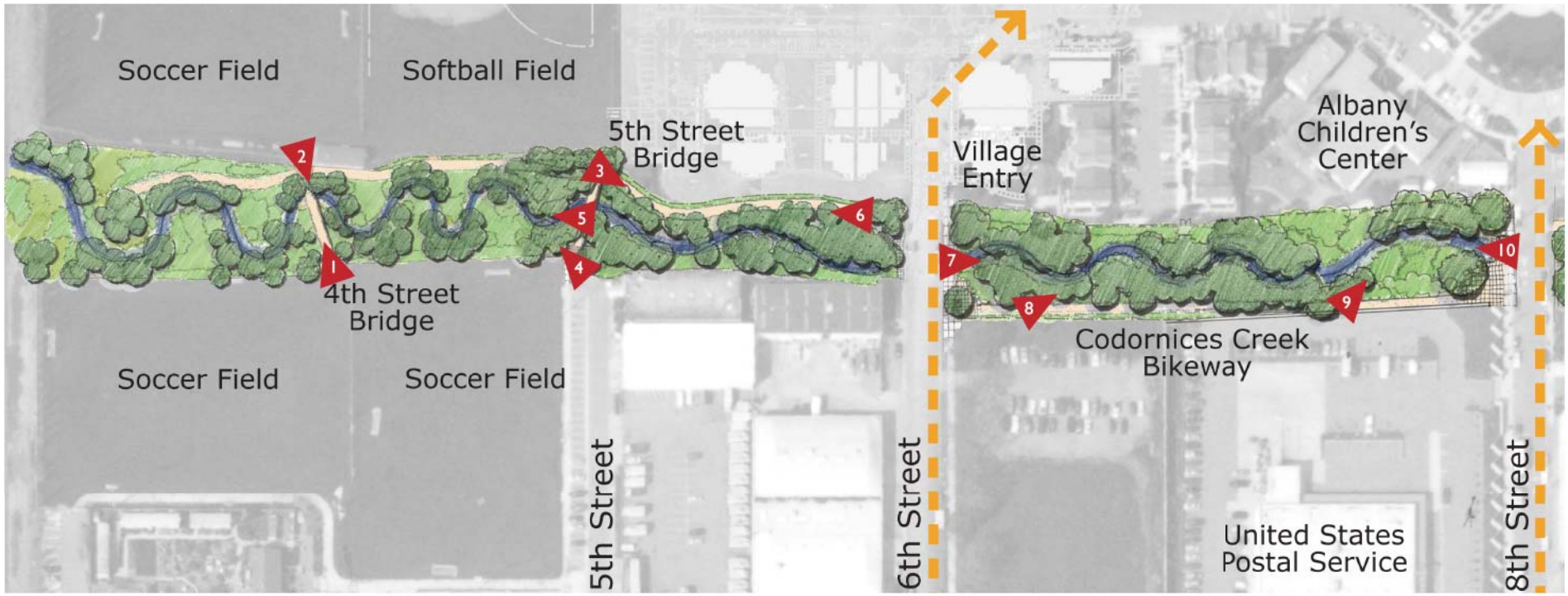

Codornices Creek Phase III

Photo Point Locations

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12/14/2012

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10/20/2015

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Codornices Creek Phase 2

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Codornices Creek Phase 2

Photo Point #5

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12/14/2012

4/18/2014

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Codornices Creek Phase 2

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2/17/2011

2/21/2011

10/22/2012

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Codornices Creek Phase 3

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2/17/2011

3/7/2012

12/14/2012

11/8/2016

Codornices Creek Phase 3

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3/7/2012

12/14/2012

11/8/2016

Codornices Creek Phase 3

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Technical Memorandum

Prepared for: **Restoration Design Group**

Prepared by: **Hagar Environmental Science**

2016 Codornices Creek Post-Project Habitat Reconnaissance, UPRR to 8th Street

The reaches of Codornices Creek between the Union Pacific Railroad (UPRR) right-of-way and 8th Street were surveyed on October 24, 2016 to assess the general stream habitat condition following a series of stream restoration projects. The restoration project between the UPRR and 5th Street was initiated with grading in 2004 and completed with re-vegetation in 2005. The project between 5th Street and 6th Street was completed in 2006. The reach between 6th Street and 8th Street was completed in 2010. A habitat assessment was also conducted for the entire reach in 2014 (HES 2014) and 2012 (HES 2012); and for the reaches between the UPRR and 6th Street in 2009 (HES 2009). The UPRR to 8th Street habitat reconnaissance was conducted with the following objectives:

- estimate the frequency and relative extent of pool and riffle habitat types in the study reach and measure pool depths;
- evaluate the extent of cover in the study reach and characterize the habitat in terms of ability to support steelhead in comparison to other Central Coast streams;
- note the presence of any fish migration passage obstacles;
- provide a qualitative assessment of macro-invertebrate populations that are visible at the time of the survey; and
- record any observations of trout or steelhead (*Oncorhynchus mykiss*), California red-legged frog (CRLF), or other aquatic life visible during the time of the survey

The three reaches evaluated continued to show significant differences in habitat conditions as a result of the restored channel structure and planform, riparian plantings, and the time elapsed since restoration project completion (Figure 1). The stream channel of Codornices Creek in the reach between the UPRR and 5th Street has high sinuosity and is lined with dense riparian vegetation including willows to a height of 12 to 18 feet and a few alder and sycamore saplings. The trees provide a canopy of 90% to 95% coverage in most of the stream reach. This canopy provides extensive shade throughout the day and is expected to result in cooler stream temperature than would occur in its absence. This reach has been relatively stable with respect to habitat features since the 2012 survey.

The reach of Codornices Creek between 5th Street and 6th Street has much lower sinuosity than downstream of 5th Street but is also lined with dense riparian vegetation. This reach is relatively shallow and has significantly less pool habitat than downstream of 5th Street. Gravel has accumulated in this reach and provides some potential spawning habitat for resident or anadromous *O. mykiss*. Conditions in this reach were little changed from the 2014 survey.

The reach from 6th Street to 8th Street has lower sinuosity than the reach downstream of 5th Street but more than the reach between 5th Street and 6th Street. The reach has continued to evolve since the 2012 survey. Tree cover has greatly increased since the 2014 survey with greater extent of shading and less extensive growths of rooted aquatic macrophytes compared to the previous survey. The channel has deepened in many areas with increased pool formation and riffle development.

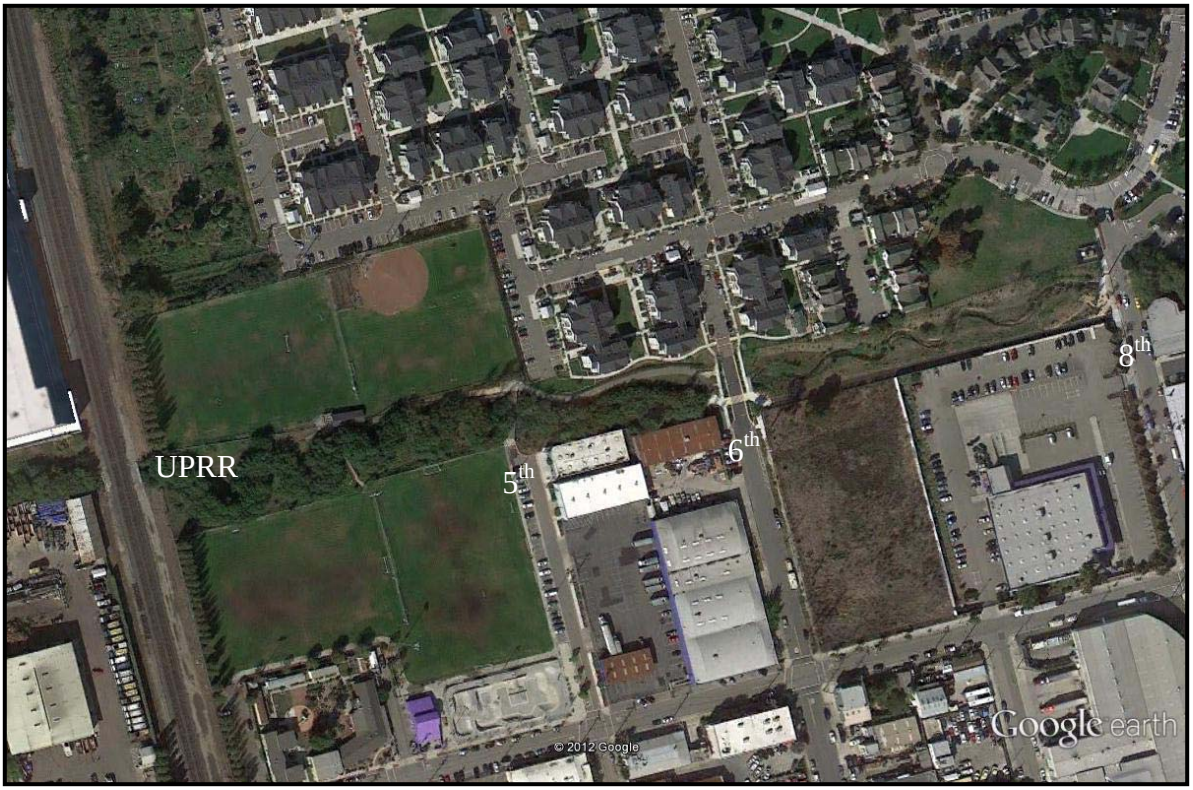

Figure 1. Project location showing three project reaches.

UPRR to 5th Street

The reach was relatively unchanged from previous surveys in 2009, 2012, and 2014 in terms of channel position and channel cross-section. Small debris jams caused by accumulations of small woody debris were a more common feature than in previous surveys (Figure 2). These small accumulations of wood are not extensive enough to cause flooding or bank erosion and they provide shelter for fish. There is passage under and through the debris for smaller fish and passage for larger fish would be possible at higher flows, when fish are more likely to be moving. Stream wetted width ranged from 2 to 9 feet. The reach is dominated by pool habitat (62% by length), with riffles making up 25% by length. Runs and glides comprise 8% and 5%, respectively. In comparison, previous surveys found pools comprised 70% of the reach length in 2014 compared to 49% of the surveyed length in 2012 and 56% in 2009. Riffles were only 16%

of the surveyed length in 2014 compared to 22% in 2012 and 23% in 2009. Run and glide habitat were 10% and 3% of the reach in 2014, respectively. It appears that pools were deeper since the last survey. Pool maximum depth ranged from 1.1 to 2.6 compared to 1.0 to 2.3 feet in 2014, 1.3 to 2.2 feet in 2012, and 1.1 to 2.3 feet in 2009. Maximum pool depths averaged 1.89 feet in 2016 compared to 1.61 feet in 2014, 1.69 feet in 2012 and 1.56 feet in 2009. In 2016 half of the pools were 2 feet deep or greater whereas only 6% were that deep in 2014. Cover complexity was consistent with previous surveys.

Figure 2. Small debris jam between UPRR crossing and 5th Street.

Riffles were relatively short, ranging from 4 to 20 feet and averaging 12 feet. Eighty percent of riffles were 15 feet or less in length. As noted in the previous surveys, many of the riffles were over the entwined fine roots of the riparian willows and these root mats formed much of the substrate in the riffles. Substrate in this reach was predominantly sand and small gravel with some areas of silt in the lower part of the reach. Substrate suitable for steelhead or rainbow trout spawning was relatively scarce. Spawning substrate was of moderate quality with relatively small gravel and not much silt, but fairly sandy.

There were no significant migration obstacles in the survey reach, although due to the stream's small size, passage through riffles would be limited under baseflow conditions. Debris collected at the mouth of the culverts at the UPRR crossing may be a hindrance to fish migration and should be cleared (Figure 3). Pool tail crest depths ranged from 0.1 to 0.3 feet and averaged 0.2 feet. These conditions are to be expected in a stream the size of Codornices Creek during the dry season. Adult steelhead migration passage is limited to periods of storm runoff. The relatively

narrow width and steep banks of the low-flow channel should result in a relatively large increase in flow depth with increases in streamflow at these riffles.

Figure 3. Debris blocking UPRR culvert mouth.

No benthic macro-invertebrates were observed in the study reach although crayfish were present and water striders (Family Gerridae) were present on the water surface. The low abundance of benthic invertebrates is likely a result of the small substrate size, high substrate mobility, or water quality issues. It was also late in the season, when productivity is lower, and there had been recent runoff. The small gravel/sand substrate does not have large pore spaces to support benthic macro-invertebrates and is easily mobilized under high flows. The extensive willow root mats likely provide good habitat for certain types of benthic invertebrates but none were observed on the surface of the mats.

No fish were observed in the UPRR-5th Street reach. It is difficult to observe fish in this section due to the dense shade and ample cover. The habitat appears adequate to support all life stages of resident rainbow trout and rearing juvenile steelhead. There is a potential for steelhead to spawn in Codornices Creek during the winter (December through March). Although steelhead can hold over during the summer in the streams where they spawn, there is little habitat to support over-summering in Codornices Creek. Codornices Creek supported rainbow trout in this reach before the restoration project (HES 2005, HES 2006). Most of the fish were in the relatively deep scour pool and culvert at 5th Street and in an overgrown concrete box culvert in the lower part of the original reach.

5th Street to 6th Street

Compared to the downstream reach, this reach has larger substrate with more gravel-sized elements, less channel sinuosity, and fewer pools. There were only two pools in the 300 foot reach. Habitat conditions were little changed from the 2014 survey.

Pool habitat was more extensive than in past surveys with pools comprising 31% by length compared to 20% in 2014. Riffles and glides made up 29% and 27% by length, respectively, while runs were 13%. Runs made up 19% of this reach in 2012 but were not classified in 2014, possibly due to the lower depth of flow during the drought conditions of 2014. There was very little cover in the extensive glide and riffle habitat in this reach but both pools had high shelter complexity.

This reach had relatively extensive potential spawning habitat with relatively clean and non-compacted gravel substrate although depth of flow was limited. Willow root mats were less prevalent in this reach compared to the reach below 5th Street. The extensive shallow riffle habitat in this reach hinders migration during summer low flow conditions. Only a small portion of the habitat is deep enough and with good enough cover to support trout in the summer. The culvert under 6th Street at the upper end of the reach was backwatered and appeared to have reasonable depth throughout its length. The culvert could not be surveyed due to insufficient height but may provide good habitat for *O. mykiss*.

6th Street to 8th Street

Restoration work was completed in this reach during the summer and fall of 2010. During the survey in August 2012, the project was still in the early stages of recovery. Riparian plantings were still small and there was very little shade along the stream. Watercress and other emergent aquatic plants were established in the stream channel to the extent that open water was not visible in much of the project. Most of the project was characterized as "marsh" (496 out of 596 total feet or 83% of the project length). The remaining habitat consisted of small pockets of glide (13%) and run (3%) type habitat.

By 2014, there had been some growth of the willows and other riparian vegetation providing additional shading. Although still present in some areas, the extensive growth of emergent aquatic vegetation had been reduced and a defined channel was present through most of the reach. The channel had cut down through the wedge of sediment upstream of the 6th Street culvert, noted in the 2012 survey, improving passage through this section.

In 2016, riparian vegetation had matured further and most of the reach had good canopy. Average percent canopy increased from 27% in 2014 to 63% in 2016. Floating and emergent vegetation was present along the channel margins in places but the channel was well defined. Macrohabitat features shifted significantly between 2014 and 2016. In 2014 the reach consisted of pools and glides (each at 37% of the total by length) with smaller amounts of run (15% by length) and riffle (11% by length). In 2016, the extent of pools had increased to 48% by length

and riffles were the next most extensive habitat type at 25%. Glides and runs comprised 14% and 13% of habitat by length, respectively. Pools below the rock weirs in the upper part of the reach had increased in depth and areal extent and provided improved habitat. This was reflected by an increase in depth of pools to an average depth of 1.8 feet in 2016 (range 1.3 ft. to 3.2 ft.) compared to 1.4 feet in 2014 (range 1.2 ft. to 1.9 ft. Glides and runs were deep enough to provide rearing habitat for younger *O. mykiss* with maximum depths averaging 0.65 and 1.1 feet, respectively. The substrate was dominated by silt and clay in much of the reach. A hard pan of clay was exposed in many areas in this reach. Gravel had been deposited in a few areas.

Cover was moderate to high and was composed of floating and rooted aquatic vegetation and overhanging terrestrial vegetation with smaller amounts of root mass and undercut banks. Boulders included in the constructed rock weirs at the upper end of the reach provided some additional cover. No *O. mykiss* were seen in this reach though conditions for observing fish were poor due to the narrow width and extensive cover.

Conclusions

The two reaches downstream of 6th Street have recovered well following the restoration projects. Riparian vegetation is well established and the channel appears to be stable. Plantings downstream of 5th Street are relatively dense and may somewhat limit aquatic productivity due to lack of sunlight. Habitat conditions are suitable for trout and rearing juvenile steelhead. The 5th Street to 6th Street reach has limited rearing potential due to lack of pool development but has potential spawning habitat. The reach downstream of 5th Street has good pool development and cover providing good potential rearing habitat. The habitat is maturing with larger trees, more extensive root systems and formation of habitat through collection of small woody debris.

The reach between 6th Street and 8th Street is also maturing. Growth of riparian trees and shrubs is providing more shading and cover and mitigating any tendency for excessive temperature conditions. Previous monitoring has indicated that high temperature is not likely to be a problem in this reach (HES 2014). There are still a few scattered areas with open canopy that allow greater insolation and enhance aquatic productivity. Continuing growth of riparian vegetation including developing root masses and interaction with higher winter flows appears to be resulting in development of pools and undercut banks. The rock weirs also appear to be instrumental in these processes. The pan of clay substrate in many areas of the reach may be the biggest limiting factor for *O. mykiss*, although this reach supported a relatively abundant population before the project and certainly has that potential now (HES 2010).

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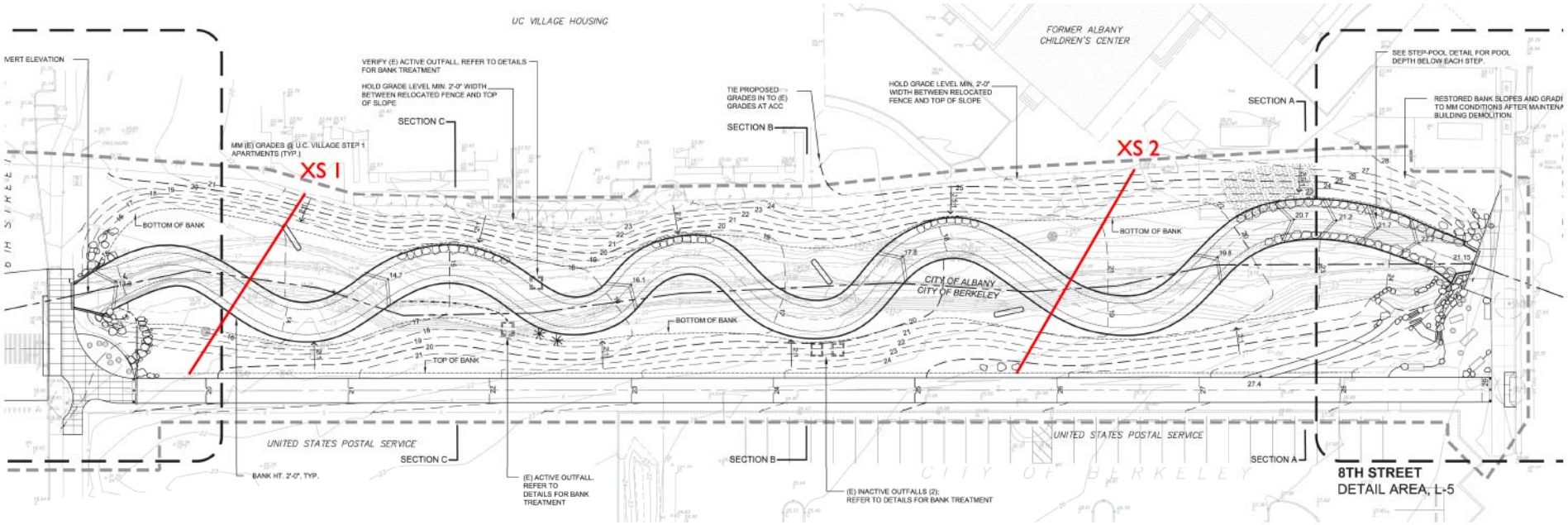

Codornices Creek Phase III

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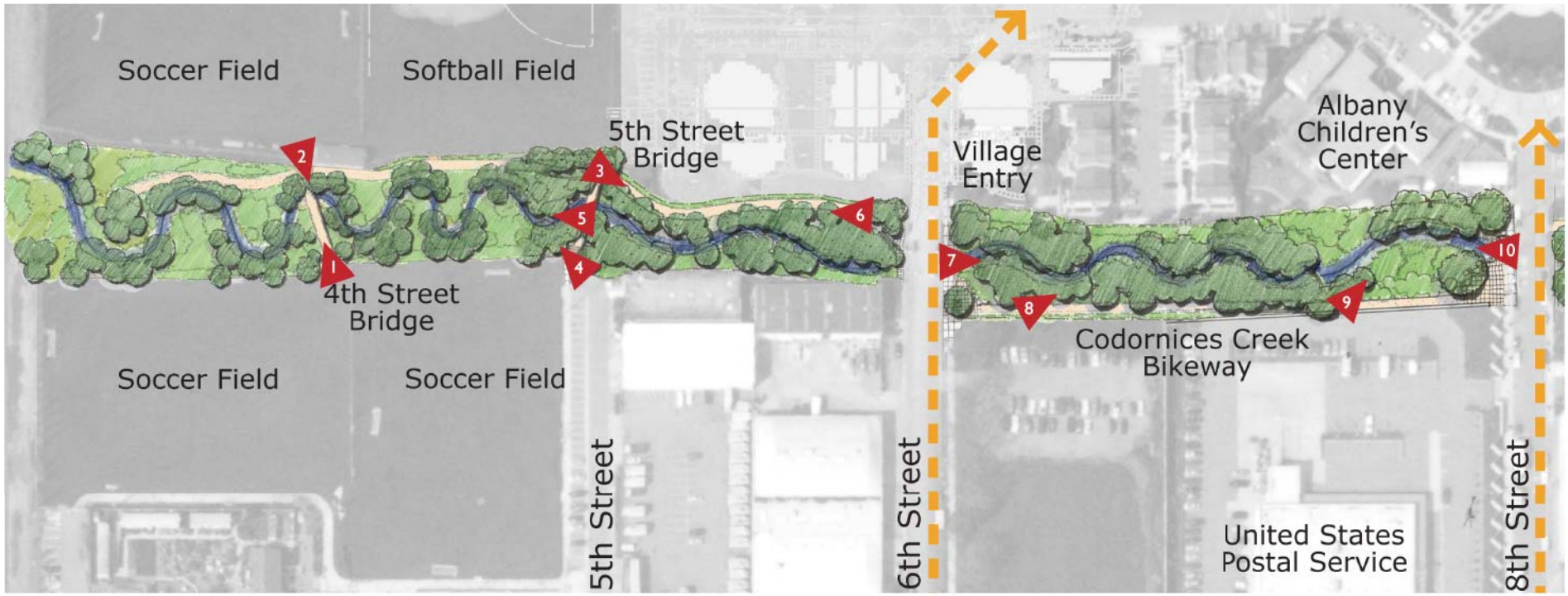

Codornices Creek Phase III

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4/20/2006

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Codornices Creek Phase 1

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7/31/2009

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4/18/2014

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2/17/2011

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2/17/2011

3/7/2012

12/14/2012

11/8/2016

Codornices Creek Phase 3

Photo Point #8

Restoration Design Group, Inc
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1/23/2012

3/7/2012

12/14/2012

11/8/2016

Codornices Creek Phase 3

Photo Point #9

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2/17/2011

3/7/2012

12/14/2012

11/8/2016

Codornices Creek Phase 3

Photo Point #10

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