Restoration With Reference: Rediscovering Cerrito Creek in Blake Garden

FINAL DRAFT Final Project
LA 227 – Restoration of River and Streams
University of California, Berkeley



Jessica Ludy & Kristen Podolak

December 17, 2007

ABSTRACT

This investigation focuses on potential improvements to the Blake Garden section of Cerrito Creek for both ecological and social reasons. Cerrito Creek runs through an urbanized watershed from the East Bay Hills to San Francisco Bay. Garden staff recently cleared non-native invasive Himalayan blackberry (*Rubus discolor*) from several sections of the streambank, leaving it barren. We identified bank erosion and incision resulting from recent clearing and upstream urbanization as two issues to be addressed. The garden staff identified creek visibility and accessibility as their main concerns. To assess existing creek conditions and restoration objectives we completed longitudinal and cross sectional surveys, measured discharge from an on-site spring, and conducted interviews. We calculated creek discharge using the rational method, measured the surface area of two rooftops to estimate stormwater runoff, and measured discharge from a natural spring in the garden. Based on our assessment, we developed a creek restoration plan that addresses the hydrologic issues we identified, concurrently with those set by the garden staff. Our short-term recommendations include: jute netting and stream-bank plantings to stabilize the banks, constructing a step pool to reduce energy and provide an aesthetic water feature, and installing rain and stream gauges. Long-term recommendations include: geotextile reinforcement and regrading steep banks to improve access and safety, replacing downstream check dams with step pools, removing concrete (substituting alternative stabilization measures), reducing stormwater runoff onsite, and water harvesting from the natural spring. Future studies should monitor the rate of incision, evaluate the effectiveness of restoration measures, and assume an adaptive management approach.

INTRODUCTION

Rivers are highly constrained in urban areas; consequently, restoration of floodplain, hydrologic, and ecologic function is limited (Wohl et al. 2005). Despite the constraints, restoration in this context can be justified by its potential social benefits (Kondolf & Yang in press). This investigation focuses on potential improvements to the Blake Garden section of Cerrito Creek for ecological and social reasons. We identified incision and bank erosion as the main concerns resulting from upstream urbanization and recent stream bank clearing of non-native invasive Himalayan blackberry (*Rubus discolor*) by the garden staff. The garden staff expressed a desire to improve creek accessibility and visibility, and voiced support for restoration of creek functions to enhance educational and recreational opportunities for garden visitors. We propose a dual focus restoration plan that includes consideration of the creek's hydrologic and geomorphologic function, and improvement of the creek's aesthetic value. Currently, there is very little known about the creek. Data collection, interviews, analysis of creek processes, and establishing evaluation criteria provided a basis for our restoration plan. Throughout the project we worked with the garden staff and a local creek group to improve the restoration plan and begin implementation.

BACKGROUND INFORMATION

Cerrito Creek drains a 0.182 square mile urbanized watershed from the western slope of the East Bay Hills through flatland to debouch into San Francisco Bay. Cerrito Creek exhibits flows characteristic of a Mediterranean climate with dry summers and wet winters. Historically, the creek meandered toward the Bay (Figure 1) aboveground, but today several reaches are culverted underground (Figure 2). In the early 1900s, Cerrito Creek, once an asset to Native

Americans and to the first settlers, became a liability with cattle grazing, sewage discharges into the creek, and urbanization (Blake Garden Website). The Clean Water Act inspired some water quality improvements, and today Cerrito Creek has undergone small restoration projects including the section in El Cerrito Plaza (Berndt and Smith, 2005).

Blake Garden is a 10.6-acre garden located four miles north of the Berkeley campus in Kensington. The garden development began in the early 1920's when Mr. and Mrs. Anson Blake moved to the property (Blake Garden Website). Subsequently, Mable Symmes, a family friend, and Anson Blake designed the first garden plan taking advantage of the topography and various microclimates. The Blakes deeded the garden to the University of California for use as an educational resource in 1962.

We surveyed a 140 foot reach of Cerrito Creek within Blake Garden. This bedrock controlled steep reach is located in the headwaters of the watershed, at roughly 600 feet elevation. Single-family residences dominate land cover upstream and downstream of the garden. Towards the end of the study, the garden staff cleared blackberry from a section upstream of the study reach and we found a stretch of the right bank armored with concrete bags and concrete slabs in the streambed (Figures 20, 22). Downstream of the study reach, there are two check dams (five and ten feet tall) made of concrete spanning about 25 feet (Figures 18,19). We included these stretches of the creek in our long-term recommendations even though we did not survey them.

METHODS

We utilized a variety of field methods to assess current conditions in the creek and clarify the restoration objectives. We used this information to develop a restoration plan based on an understanding of the flow regime and water budget within the garden. We visited the site four times to collect hydrologic and water harvesting data, assess vegetation cover, and gain social comment and perspective by conducting interviews.

Hydrology: Since the stream is not gauged, we mapped the catchment above the garden using the USGS Richmond Quadrangle Map and calculated discharge using the Rational Method (Rantz, 1971). We surveyed a longitudinal profile (Figure 3) and six cross-sections (Figures 4-9) over a 140 foot reach from the greenhouse to the bridge (location of survey point and cross sections in figures 10, 11). We surveyed using an auto-level located on the bridge, stadia rod, and two 100 foot tape measures and marked the cross section locations with pins for future surveys. We took back shots to three structural locations, at the northwest corner of the greenhouse, the southwest corner of the shed fence, and the closest corner of the greenhouse box (Figure 10). We drew a facies map for the study reach (Figure 11). To better understand the processes affecting the creek, specifically urbanization, we reviewed historical maps and hydrologic studies on a nearby branch of Cerrito Creek (Leopold, 1991).

Water Collection: We calculated the contribution to flow from a spring located about 60 feet from the creek using a one-gallon bucket and a stopwatch (Table 1). The spring comes out of the ground as a trickle and drops roughly a foot, making it easy to measure. It then drains to the creek through a pipe. We also calculated the potential runoff from the roof of the main residence and greenhouse (Tables 2, 3). We estimated the financial savings as a result of reusing the harvested water.

Vegetation: We used photography to document clearing of the exotic Himalayan Blackberry (Figures cover, 20, 21). We researched appropriate vegetation for replanting streambanks.

Social & Educational: The social aspects of the project are important to assess; however, there are few well-established methods for assessment (Purcell, 2002), and time was a limiting factor in this project for social surveys. We conducted interviews with garden staff to discuss aesthetic and educational goals.

Interviews: We interviewed the Manager of Blake Garden, Lauri Twitchell, regarding her concerns and knowledge of existing creek and vegetation conditions, and her goals for the creek restoration project. We also interviewed other garden staff, Mike Frappier and Dawn Kooyumgian, who know the recent history of the creek, including a flood during the winter of 2005. Finally, we met with Susan Schwartz of 'Friends of Five Creeks' to discuss potential restoration strategies. She gave advice on permitting requirements, appropriate native vegetation, and rainwater harvesting.

RESULTS

Hydrology: The Rational Method calculations provided discharge estimates (Table 1). The two-year flood is estimated to have a discharge of eight cubic feet per second (cfs) and a fifty-year flood of 85 cfs. The twenty-five year flood (Q_{25}) value was 45 cfs for the Flow Frequency calculation versus 32 cfs for the Rational Method. There is one pool within the reach adjacent to the greenhouse at Station 32 (Figure 3). It is important to note the high water level in the Long Profile. This is because we surveyed the long profile during a storm event with high flows (cover photos). Cross-Section #2 (Figure 5) extends from the greenhouse to the tool shed across the creek, note the steepness of the left bank between seven and ten feet laterally. Sections #5 (Figure 8) shows the scour pool below the culvert, while Section #6 (Figure 9) shows incision.

Water Collection: Based on the calculations of runoff from the natural spring, the garden staff could harvest about 22,217 gallons during the wet season (Tables 3, 4). In addition, the smaller cistern can be connected to the greenhouse roof downspout and collect 13,701 gallons of stormwater runoff per year, with emptying. Potentially, if rainwater were harvested from the roof of the Residence on site and stored in a cistern, another 51,379 gallons could be saved during the year. Details for the cistern connection and overflow routes are presented (Figure 12, Lancaster, 2006). This amount of water reuse could save a total of $480 annually (Tables 2, 3, 4). We assessed the garden water bill from the East Bay Municipal Utilities District, which showed both the use and cost of water for the last two years. The lowest water use was from November through April, whereas the highest water use was from June through September (Table 4).

Vegetation: We narrowed down appropriate vegetation based on Susan Schwartz's suggestion for tough, shade-tolerant plants: Juncus afusis/afoites, Scorphularia californica, Ribes sanguineum, and Iris douglasiana, Tellima, and Hucara. She warned against dogwood as it is dense and tends to hide the creek.

Social & Educational: The partial removal of blackberries dramatically opened up the creek and improved scenic integrity. The garden staff discovered both a bridge and a trail upstream of the greenhouse.

RECOMMENDATIONS

The creek restoration goals are to mitigate the impacts of urbanization through bank stabilization and onsite water collection, and to enhance the creek experience by improving aesthetics for visitors and setting a stage for educational opportunities. We suggest both short and long term recommendations based on an adaptive management approach.

Short-Term: As a stopgap measure to prevent streambank erosion, we encourage the gardeners to install jute netting (brush mattress) as suggested by ‘Friends of Five Creek’ and other urban creek restoration precedents (Friends of Five Creeks, Riley, 1998). In response to incision near the greenhouse and culvert, we recommend building a one foot-tall step pool (Figure 12) to dissipate some of the energy and slow velocity roughly 80 feet upstream of the culvert. We chose this location to make use of the natural gradient and also because of the existing pool at this point. The step pool will also improve aesthetics by adding an interesting water feature easily seen from the road (Figure 10). Removing the remaining blackberry and re-vegetating the banks with native species will further enhance creek aesthetics, human access, and bank stabilization.

Long-term: To address the potential erosion from recently cleared streambanks, we recommend geotextile reinforcement on barren and steep sections of the reach. The garden layout and our observation of visitor circulation suggest the river right bank below the road is the best access point to the creek, but it is incised and steep, and should be regraded to improve access and safety. Considering longitudinal connectivity and habitat, we suggest removing the two concrete check dams downstream of the study reach and replacing them with alternative stabilization measures.

We recommend that Blake Garden collect water in the two on-site cisterns from the greenhouse rooftop and a natural spring. Considering that impervious surfaces upstream increase the discharge by about two times during average storms, attempts to store water locally can counteract the increased bank erosion associated with urbanization (Leopold, 1968 and Riley

1998, respectively). Water collection and reuse would also save the University money on the water bill. However, the greatest value may be educational. The project could increase garden visitor's awareness of the cheap price of water, water scarcity, and water conservation techniques. We propose collecting stormwater from the greenhouse rooftop from November through April when the garden uses the least amount of water, and the amount will not compromise the hydrologic functions of the creek. We also propose year-round irrigation using the natural spring. If these onsite water collection techniques prove effective, we suggest the garden staff add a cistern to collect rain from the main residence rooftop, which is a larger impervious surface.

CONCLUSION

Our investigation began with identification of Cerrito Creek's hydrologic condition, specifically the issues of bank erosion and incision, and the garden staff's motivation for creek restoration, to improve access and visibility. We coordinated with the garden staff to define restoration objectives and set criteria for evaluation. Our restoration plan is innovative in combining in-stream restoration with water collection to mitigate the impact of upstream urbanization. Blake Garden is well suited for this type of restoration project given the heightened awareness and support of creek restoration in the East Bay area, the availability of funding, and the educational focus of the garden. Monitoring the effect of creek restoration efforts and water harvesting will be fundamental to understanding how effective they are over time and space (Downs and Kondolf, 2002). We plan to install a stream and rainfall gauge to get a more accurate discharge measurement in next semesters 'Hydrology for Planners' class. Future studies should monitor the rate of incision, evaluate the effectiveness of restoration measures (post-project appraisals), and adopt an adaptive management approach.

REFERENCES

Berndt, Sarah and Fran Smith. Fall 2005. Post Project Appraisal of Cerrito Creek at El Cerrito Plaza. LA 227 Restoration of Rivers and Streams. University of California, Berkeley. http://repositories.cdlib.org/wrca/restoration/berndt/

Blake Garden: Landscape Architecture & Environmental Planning, College of Environmental Design, UC Berkeley. http://www.laep.ced.berkeley.edu/laep/blakegarden/history.html

Downs, P., and G.M. Kondolf. 2002. Post-Project Appraisals in Adaptive Management of River Channel Restoration. *Environmental Management* vol. 29 no.4:477-496

Friends of Five Creeks. 2007. http://www.fivecreeks.org/

Kondolf, G. Mathias and Chia-Ning Yang. 2008. Planning River Restoration Projects: Social and Cultural Dimensions. River Restoration: Managing the Uncertainty in Restoring Physical Habitat. John Wiley & Sons, Ltd.

Lancaster, Brad. 2006. Rainwater Harvesting for Drylands, Volume 1: Guiding Principles to Welcome Rain Into Your Life and Landscape. Rainsource Press, Tuscon, AZ.

Leopold, Luna B. 1991. Lag Times For Small Drainage Basins. Catena vol. 18, p. 157-171.

Purcell, Alison, Carla Friedrich, and Vincent H. Resh. 2002. An Assessment of a Small Urban Stream Restoration Project in Northern California. *Restoration Ecology*. 10:4 (685-694).

Rantz, S. E. 1971. Suggested Criteria for Hydrologic Design of Storm-Drainage Facilitied in the San Francisco Bay Region, California. United States Department of the Interior Geologic Survey, Water Resources Division. Menlo Park, CA.

Riley, Anne L. Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens. 1998. Island Press, Washington, D.C.

Wohl, Ellen. Paul L. Angermeier, Brian Bledsoe, G. Mathias Kondolf, Larry MacDonnell, David M. Merritt, Margaret A. Palmer, N. LeRoy Poff, and David Tarboton. 2005. River Restoration, Water Resour: Res, 41, W10301.

Figure 1: Historical Map of Cerrito Creek (Friends of Five Creeks).

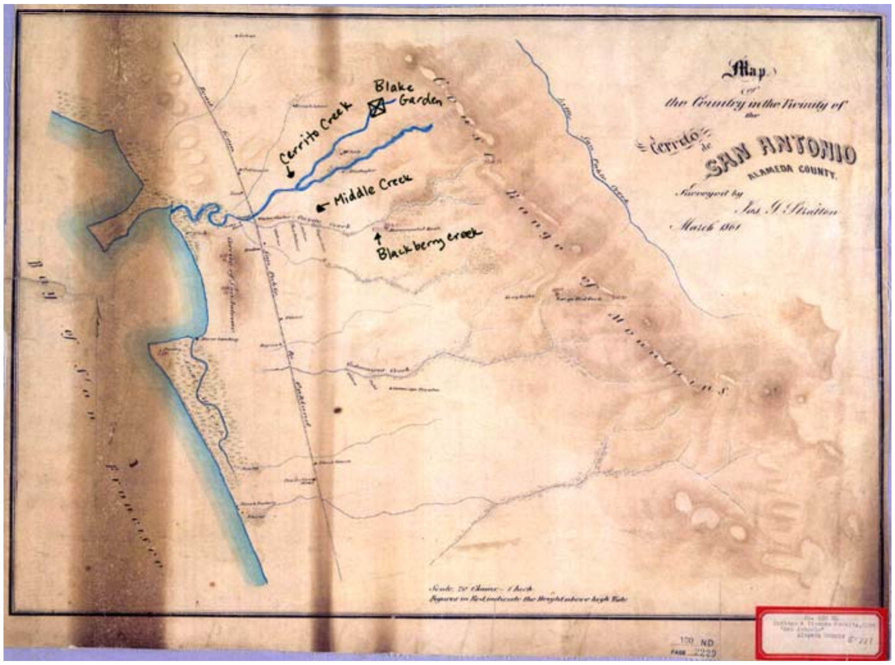


Figure 2: Location of site and watershed contribution to creek reach in Blake garden outlined in blue. Blake Residence marked with a green star. (Janet Sowers, Robin Grossinger, Peter Vorster. 2006. Creek & Watershed Map of Richmond Vicinity. Oakland Museum of California)

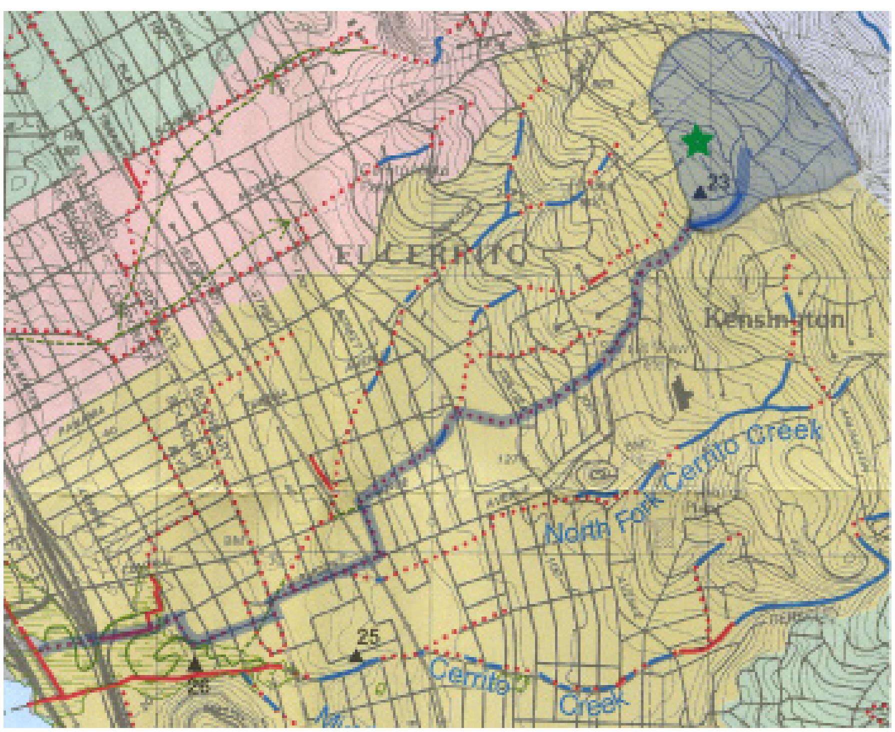


Figure 3: Longitudinal Profile (no vertical exaggeration)

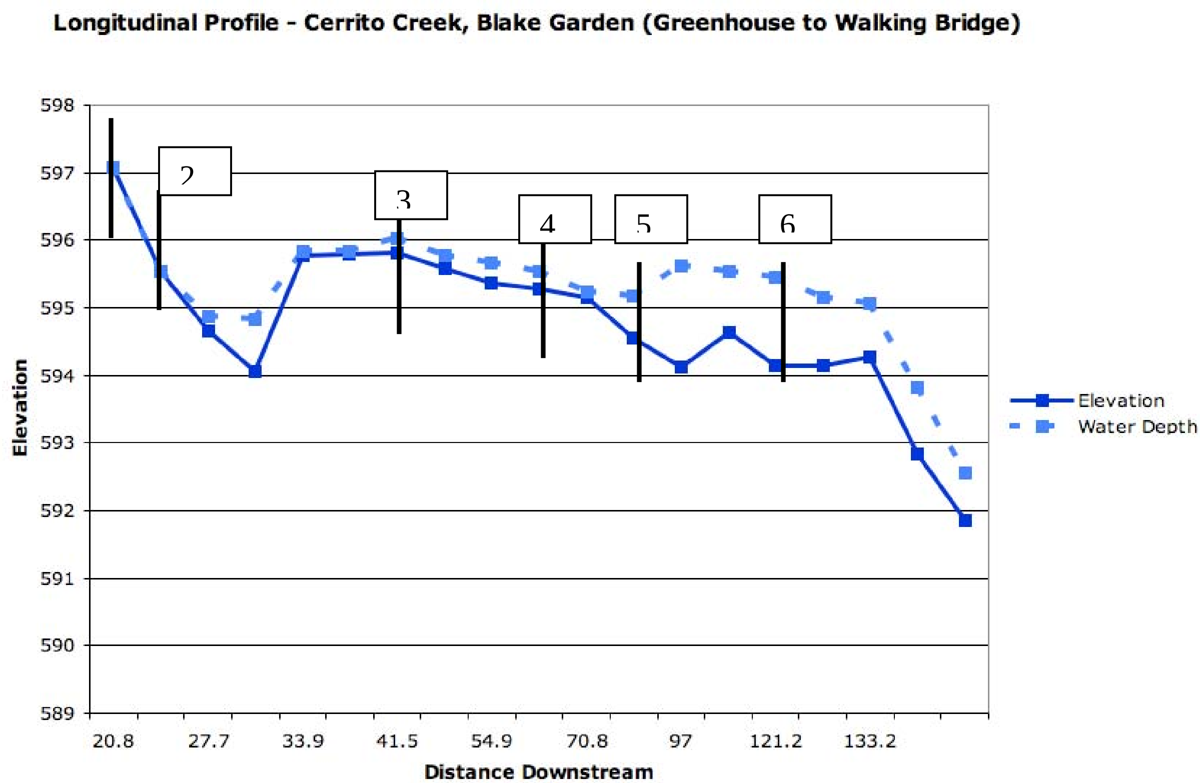


Figure 4: Cross Sections (looking downstream)

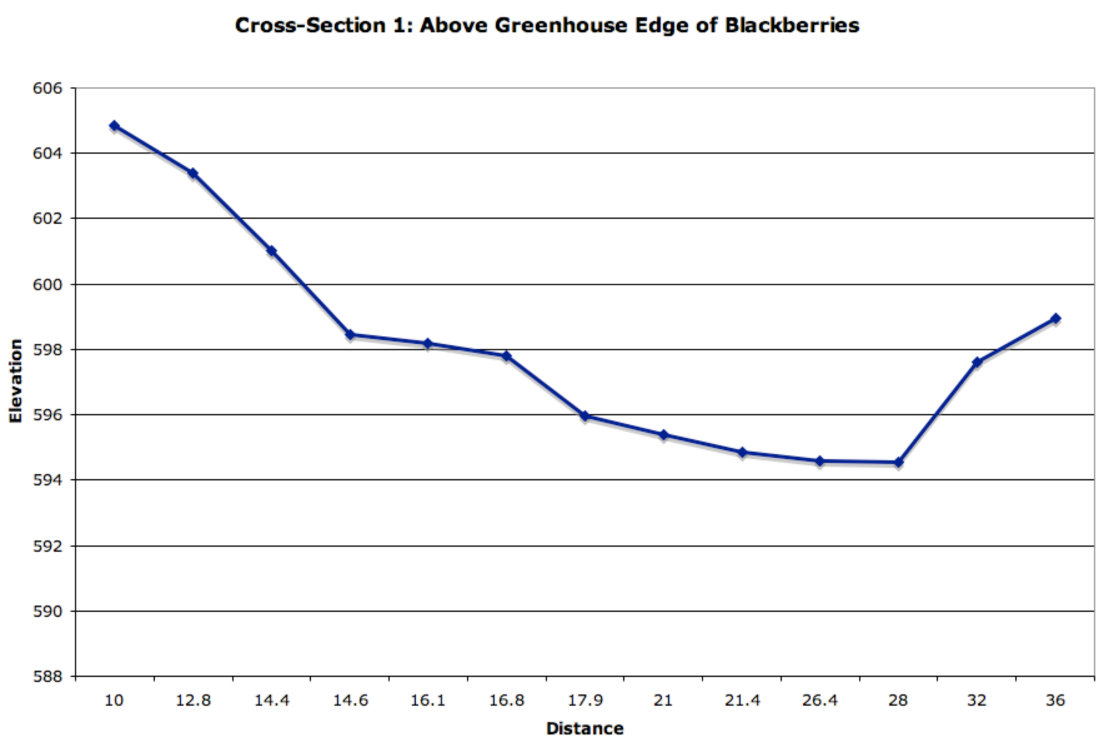


Figure 5:

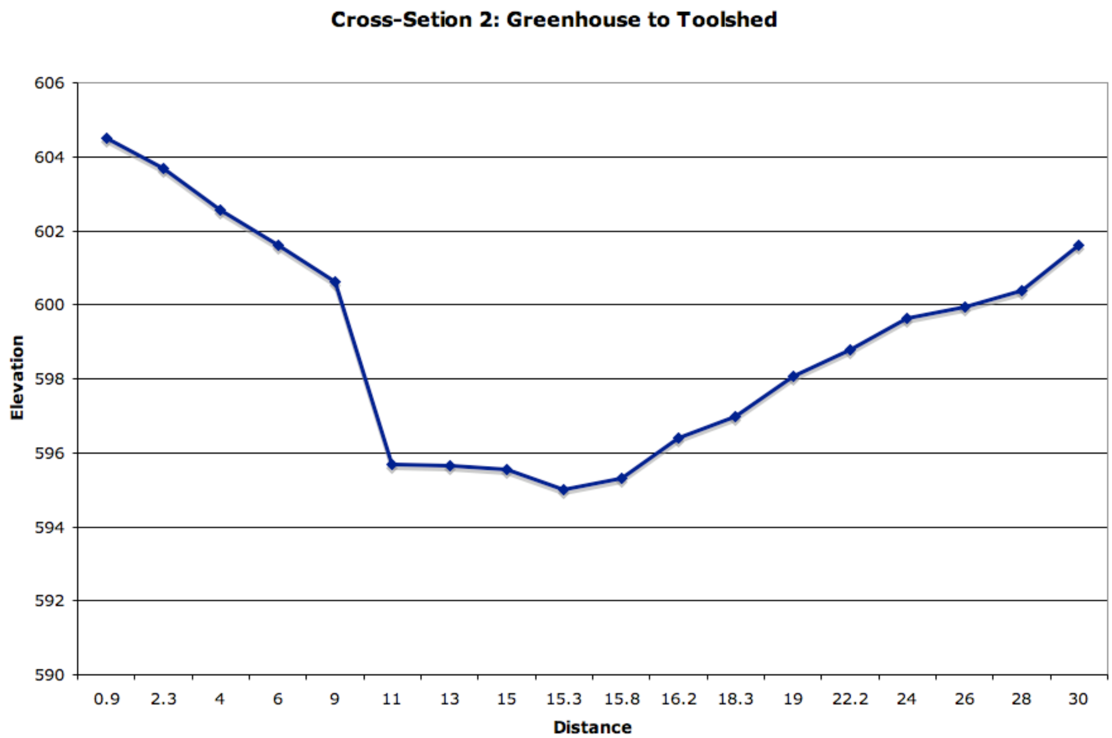


Figure 6:

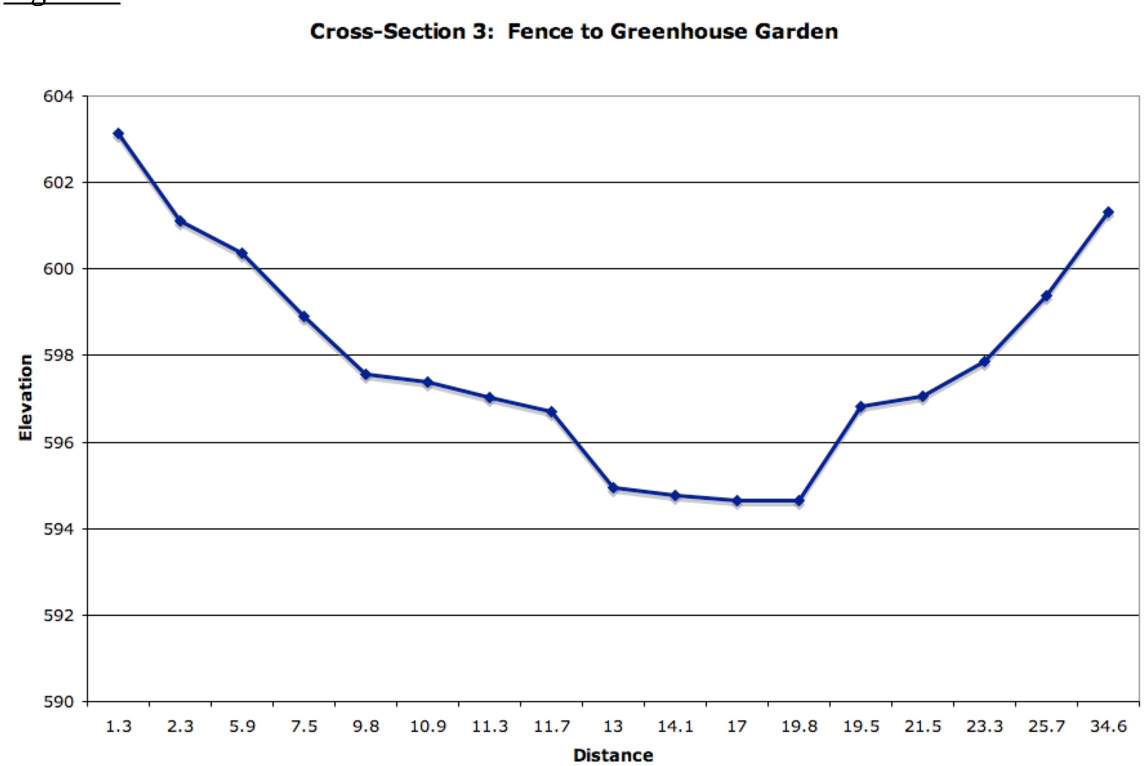


Figure 7:

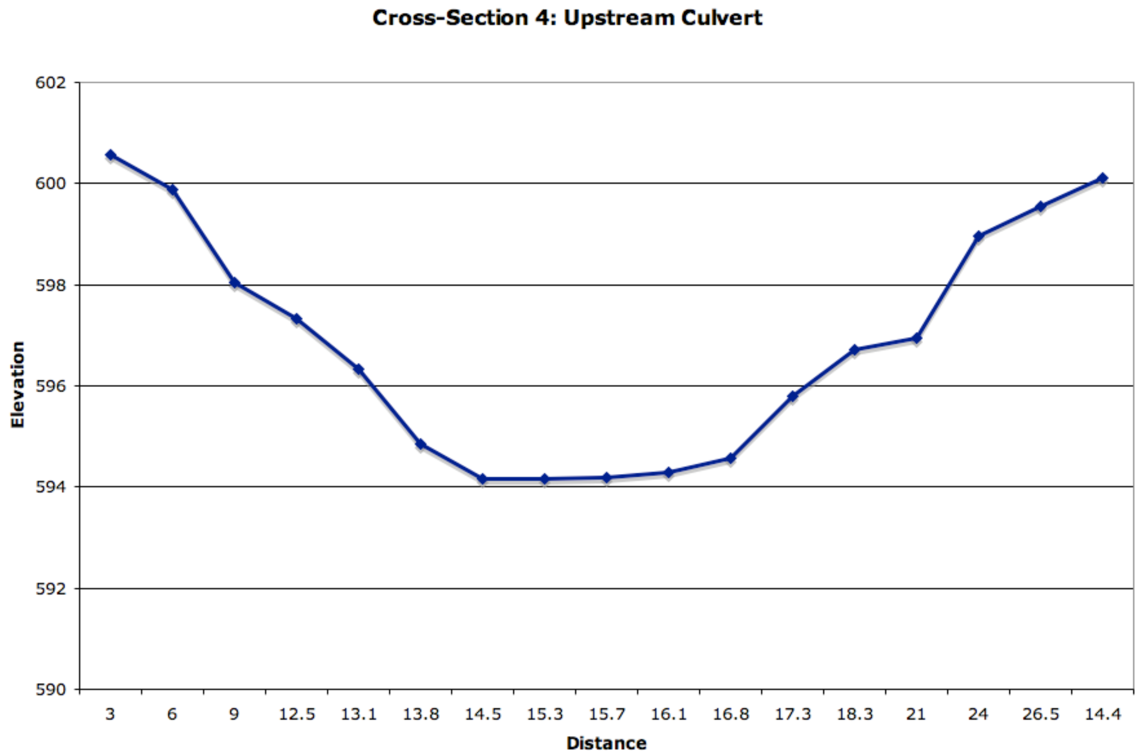


Figure 8:

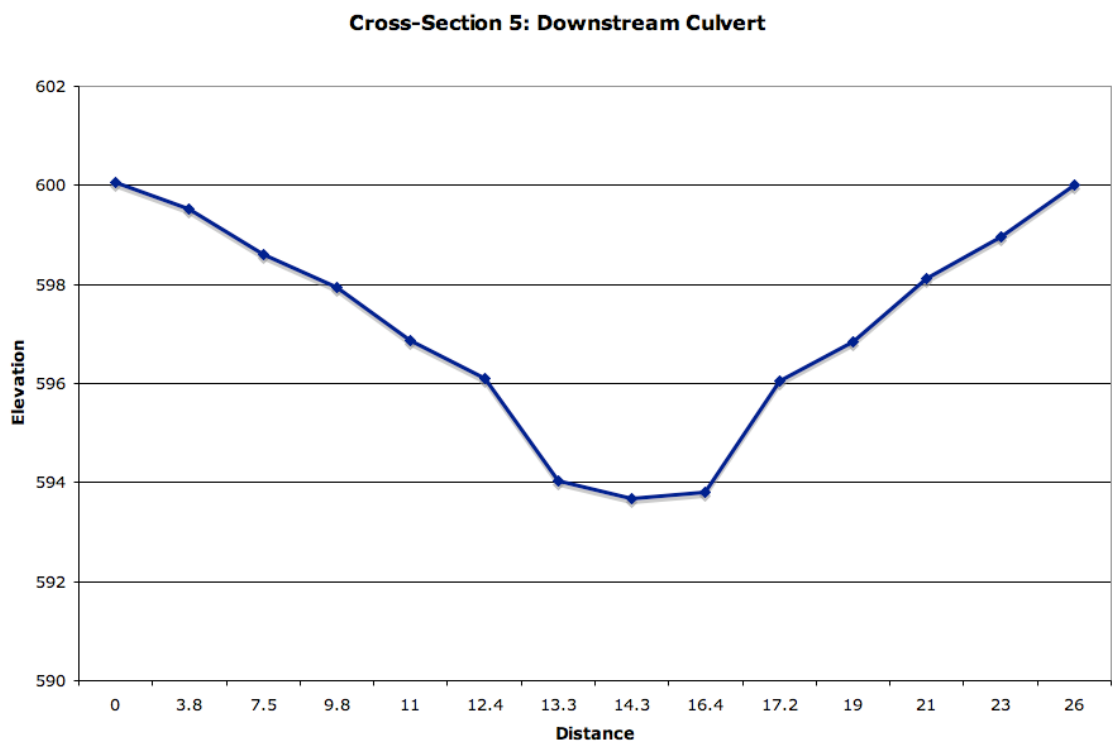


Figure 9:

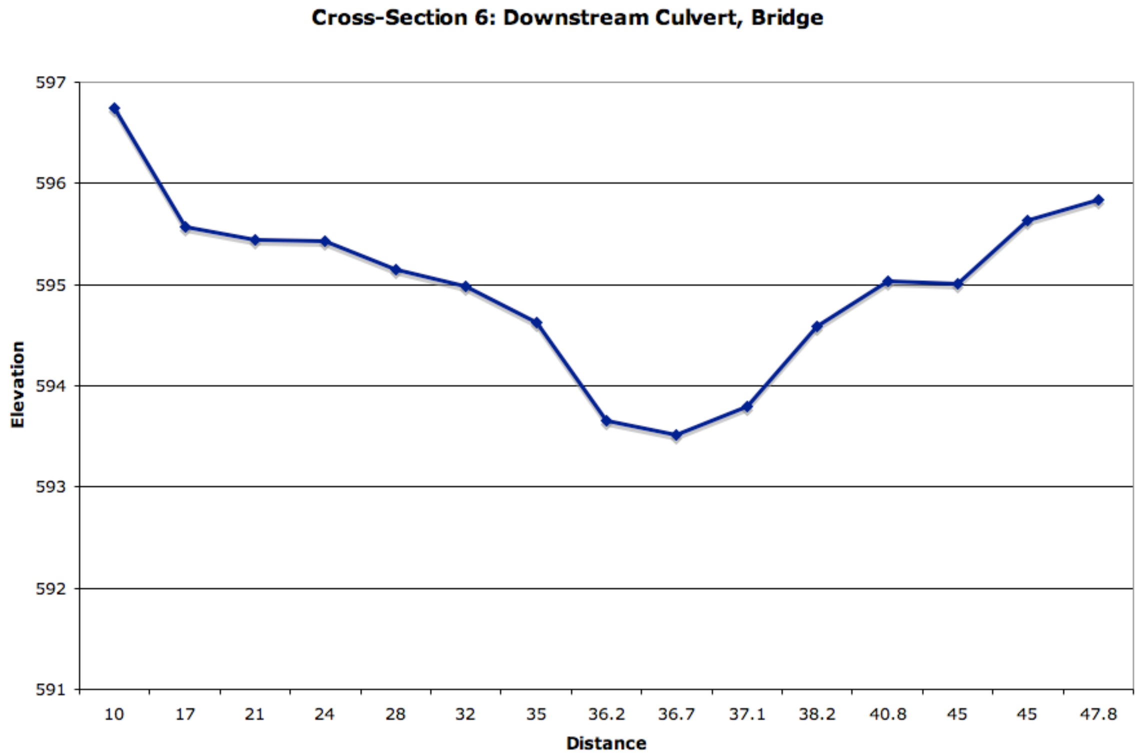


Figure 10: Map of survey location

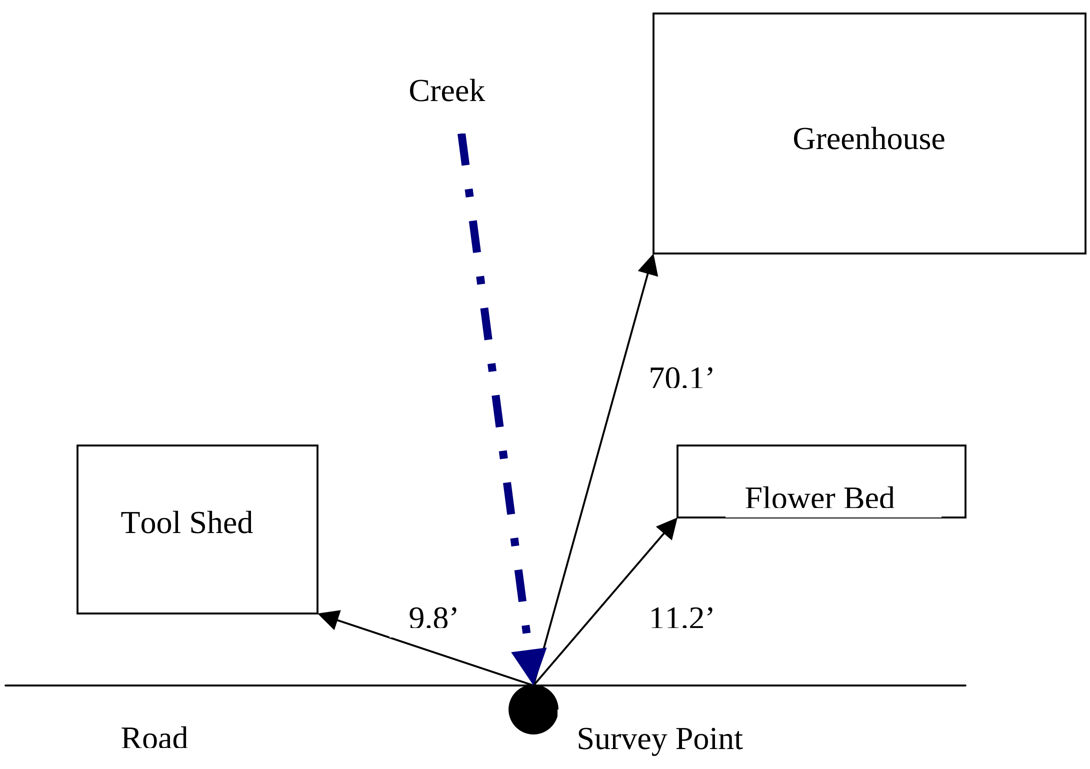


Figure 11. Facies Map for restoration reach of Cerrito Creek with cross section locations

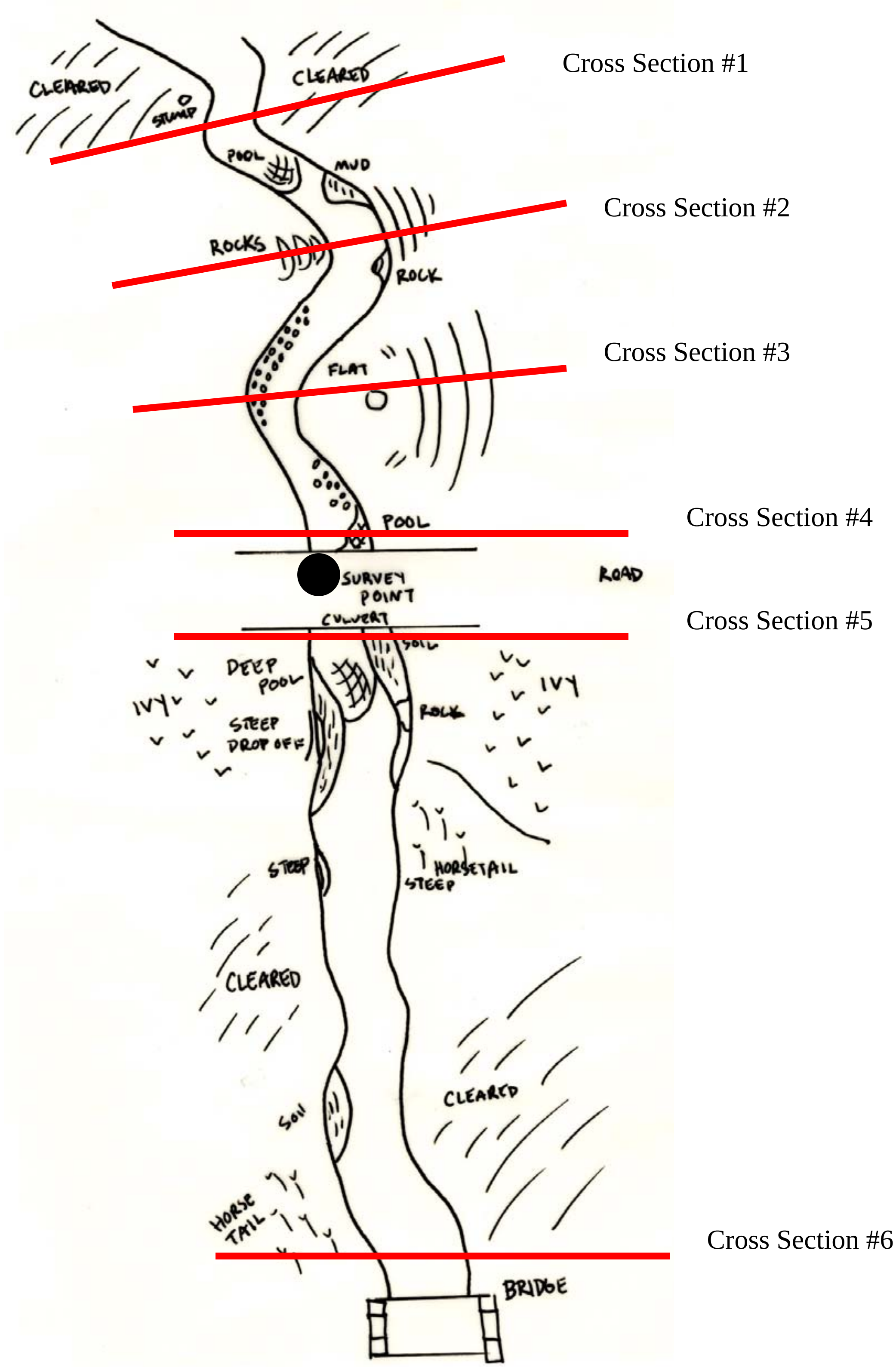


Figure 12: Map of site and proposed water collection from natural spring and rooftops.

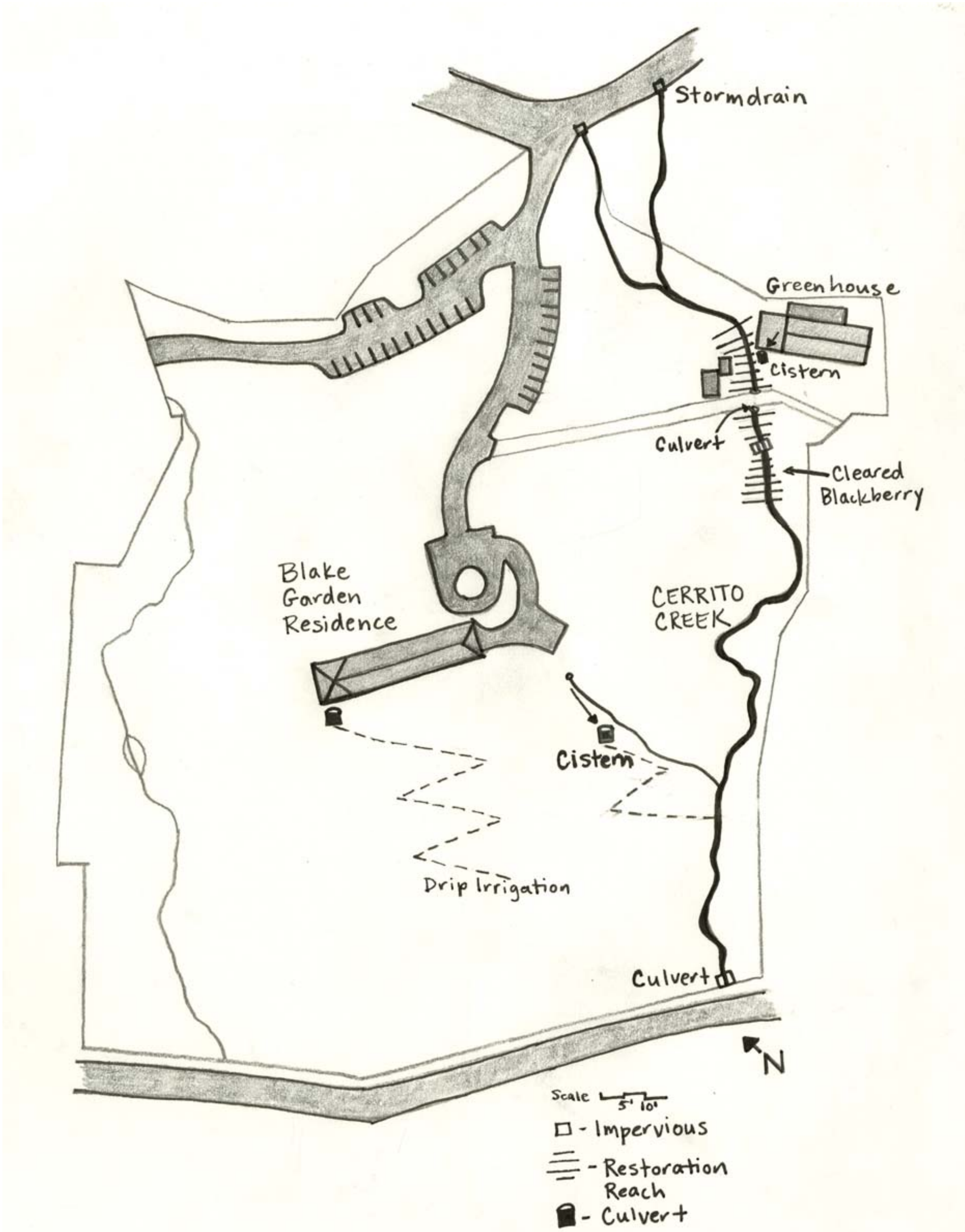
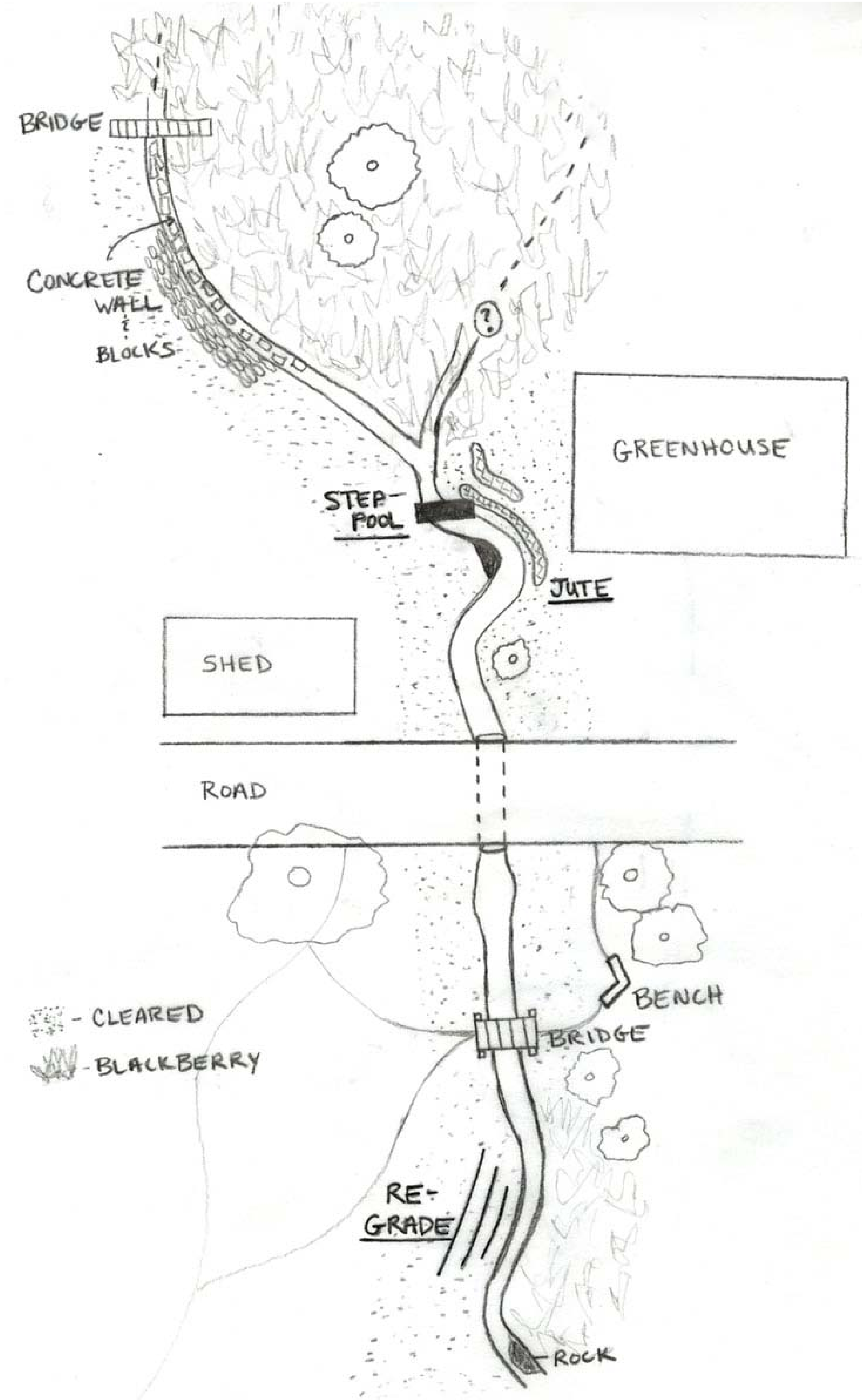


Figure 13: Restoration Suggestions Map



Site Photos

Figure 14: Lauri Twitchell looks at debris on the stormdrain upstream of the garden where runoff flows into Cerrito Creek

Figure 15: Jess prepares survey equipment on the road

Figure 16: The creek goes into an underground culvert at the downstream end of the study reach

Figure 17: On-site Large Cistern approximately 1,600 gallons


Figures 18-19: Check dams downstream of surveyed reach


Figures 20-21: View of blackberry clearing above tool shed and armored right bank

Figure 22: New bridge revealed and concrete slabs in streambed

Table 1: Discharge Calculations

FLOOD FREQUENCY (Rantz, 1971)		
Drainage area	**0.182 square miles**	
Mean ppt	**25 inches**	
Development	70% urbanized (check with Leopold study)	
	70% sewered?	
Recurrence	Equation	Discharge (cfs)
Q2	0.69*A^0.913P^1.965	**8.13**
Q5	2.00*A^0.925P^1.206	**20.1**
Q10	7.38*A^0.922*P^0.928	**30.4**
Q25	16.5*A^0.912*P^0.797	**45.4**
Q50	69.6*A^0.847*P^0.511	**85.2**

RATIONAL METHOD (Rantz 1971)		
Q=CIA		
Drainage area	0.182 square miles	
Mean ppt	25 inches	
Development	70%	
Overland Travel Distance	900 ft	
Slope	13%	120 ft/900 ft
Mannings 'n'	0.2	
Cross sectional area	3.56 ft^2	
Wetted perimeter	3.3 ft	
Computation of Overland Travel Time		
C	25	0.32
C to impervious	0.52	
Travel time	19 min	
Computation of Channel Travel Time		
V=(1.49/n)(A/WP)^2/3 * S^1/2		
V=(1.49/0.2)(3.56/3.3)^2/3 *0.13^1/2		
2.83 ft/second		
Travel Time	L/60V	
	900/(60*2.83)	
	169.8	
	5.30	minutes
Tc (minutes)		
19+5.30		
24.3		
I		
.49-.56		
0.49+0.07*(12/20)		
0.532		
Q25	**32.09**	

Table 2: Spring Calculation

Spring Calculations	
1 gallon bucket	
Time to Fill (seconds)	350
gallons/sec	0.00286
gallons/day	246.8571429
cfs	0.0038
small cistern (gallons)	200
big cistern (gallons)	1600

Table 3: Rainfall Harvesting

Potential Rainfall Harvesting Per Year Catchment area X average rainfall = Rainfall Volume (ft^3) Average Annual Rainfall Berkeley, California: 25.40" = 2.12 feet/year **Greenhouse roof**
32 feet X 27 feet X 2.12 feet/year = 1,831.68 ft^3 (x 7.48 gal/ ft^3) = 13,701 gallons rainfall/year **Residence**
108 feet X 30 feet X 2.12 feet = 6,868.8 ft^3/year (x 7.48 gal/ ft^3) = 51,379 gallons rainfall/year Average price/gallon water = $0.0055/gallon If collected water from the greenhouse , could save $75.35 annually. If collected water from the residence, could save $282.58 annually. If collected water from the the spring for 90 days a year (22,217 gallons), could save $122.19
Total Savings of $480.12 annually

Table 4: Blake Garden Water Bill (East Bay Municipal Utility District)

Date	Amount (gallons)	Days	Average gall/day	Suggested Use	Cost
6/29/07-8/29/07	401676	61	6584	593164	2078.94
last year	569976	64	8905		
3/6-5/3 2007	77044	58	1328	379984	472.5
last year	415636	61	6830		
missing 2/06/07					
11/2/06-1/06/07	100980	65	1553	130152	590.9
last year	172788	63	2786		
9/05/2006-11/2/2006	461516	58	7957	261800	2374.3
last year	329120	63	5224		
7/3/06-9/5/06	569976	64	8905	636548	2910.8
last year	358292	60	5971		
5/3-06-7/3/06	303688	61	4978	601392	1541.48
last year	232628	60	3877		

Table 5: Survey Raw Data

Longitudinal Profile

Station	Forshot	HI	Elevation	Water Rod Ht	Water elevation	Description
		604.85	600			
0	7.78		597.07	0.01	597.08	riffle
20.8	9.32		595.53	0.01	595.54	first curve
24.4	10.2		594.65	0.22	594.87	top pool
27.7	10.8		594.05	0.77	594.82	mid pool
32	9.08		595.77	0.06	595.83	bottom pool
33.9	9.06		595.79	0.05	595.84	current
37.2	9.03		595.82	0.2	596.02	current
41.5	9.28		595.57	0.2	595.77	current
48.1	9.48		595.37	0.3	595.67	current
54.9	9.58		595.27	0.26	595.53	current
63.3	9.71		595.14	0.1	595.24	current
70.8	10.31		594.54	0.64	595.18	edge pipe
70.8	7.84		**597.01**			**top culvert**
72.3	6.65		**598.2**			**cement**
86.1	4.41		**600.44**			**Road- base station**
89.3	4.9		**599.95**			**culvert top**
90.5	10.72		594.13	1.5	595.63	culvert bottom
97	10.21		594.64	0.9	595.54	creek 1
106.6	10.71		594.14	1.3	595.44	edge of horsetails
121.2	10.71		594.14	1	595.14	edge of bridge
121.5	8.39		**596.46**	2.1	598.56	bridge
132.2	10.58		594.27	0.8	595.07	below bridge
133.2	12.02		592.83	1	593.83	top of waterfall
141.2	12.99		591.86	0.7	592.56	below waterfall

Benchmarks	Forshot	Distance		
		Greenhouse Corner	Tool Shed Fence	Greenhouse Garden
Day 1	23.01	70.1	9.9	11.2
Day 2	23.94	70.1	9.9	11.8

Cross-section 1: Above greenhouse edge of blackberries (15.6 ft on profile)

Station	Forshot	HI	Elevation	Flip left bank	water rod	water elevation	notes
10	4.79	604.85	600.06	604.85			bank
12.8	5.9		598.95	603.4			bank
14.4	7.24		597.61	601.02			edge bank
14.6	10.31		594.54	598.44	1.05	599.49	waters edge (6"eroded undercut)
16.1	10.28		594.57	598.18	1.08	599.26	see picture
16.8	10.01		594.84	597.82	0.7	598.52	pool
17.9	9.46		595.39	595.95	0.18	596.13	waters edge (6"eroded undercut)
21	8.9		595.95	595.39			mudbank
21.4	7.03		597.82	594.84			(see picture)
26.4	6.67		598.18	594.57			bank
28	6.41		598.44	594.54			hill
32	3.83		601.02	597.61			uphill bank
36	1.45		603.4	598.95			rod at 0

Cross Section 2: Greenhouse corner to toolshed corner (23 ft on profile)

Station	Forshot	HI	Elevation	Flip left bank	water rod	water elevation	notes
0.9	3.25	604.85	601.6	604.49			edge of tool shed
2.3	4.45		600.4	603.69			base of retaining wall
4	4.9		599.95	602.55			
6	5.23		599.62	601.61			
9	6.07		598.78	600.61			start of bank
11	6.78		598.07	595.7			
13	7.86		596.99	595.64			on rock
15	8.45		596.4	595.54			
15.3	9.55		595.3	595.02	2.8	597.82	rt bank start of water
15.8	9.83		595.02	595.3			middle
16.2	9.31		595.54	596.4			left bank
18.3	9.21		595.64	596.99			
19	9.15		595.7	598.07			base of steep hill
22.2	4.24		600.61	598.78			top of steep hill
24	3.24		601.61	599.62			flat
26	2.3		602.55	599.95			bank
28	1.16		603.69	600.4			
30	0.36		604.49	601.6			
33.6	?						greenhouse-no shot

Cross Section 3: Fence to bottom of garden below greenhouse (43.7 ft. on profile)

Station	Forshot	HI	Elevation	Flip left bank	water rod	water elevation	notes
1.3	3.52	604.85	601.33	603.15			rock wall
2.3	5.46		599.39	601.11			bottom of rock wall
5.9	6.99		597.86	600.38			bank

7.5	7.8		597.05	598.9			edge of flood plane
9.8	8.03		596.82	597.56			top of bank
10.9	10.2		594.65	597.38			waters edge
11.3	10.19		594.66	597.02	?		thalweg
11.7	10.09		594.76	596.71			waters edge
13	9.91		594.94	594.94			right bank edge
14.1	8.14		596.71	594.76			top of bank
17	7.83		597.02	594.66			edge of tree
19.8	7.47		597.38	594.65			flood plain
19.5	7.29		597.56	596.82			other side of tree
21.5	5.95		598.9	597.05			middle of bank
23.3	4.47		600.38	597.86			top of bank
25.7	3.74		601.11	599.39			top of bank
34.6	1.7		603.15	601.33			edge of garden

Cross Section 4: Upstream culvert, end of tape at stump roll at culvert (59.3 ft on profile)

Station	Forshot	HI	Elevation	Flip left bank	water rod	water elevation	notes
0	4.73	604.85	600.12	596.63			end of tape
3	5.29		599.56	600.56			
6	5.89		598.96	599.87			
9	7.91		596.94	598.05			bank
11.1	8.14		596.71	596.89			top of erosion WC line
12.5	9.05		595.8	597.34			concrete slab
13.1	10.28		594.57	596.33			rim of culvert
13.8	10.56		594.29	594.85			waters edge rt side
14.5	10.67		594.18	594.17	0.14	594.31	mid culvert
15.3	10.7		594.15	594.15	0.15	594.3	mid water
15.7	10.68		594.17	594.18	0.11	594.29	left edge of culvert, erosion 1.53 ft
16.1	10		594.85	594.29			left waters edge
16.8	8.52		596.33	594.57			left bank on cement
17.3	7.51		597.34	595.8			top bank
18.3	7.96		596.89	596.71			top top bank
21	6.8		598.05	596.94			up bank
24	4.98		599.87	598.96			
26.5	4.29		600.56	599.56			end of tape
14.4	8.22		596.63	600.12			top of culvert

Cross Section 5: Downstream of culvert (78.5 ft on profile)

Station	Forshot	HI	Elevation	Flip left bank	water rod	water elevation	notes
0	4.79	604.85	600.06				left side of path
3.8	5.33		599.52				bank/veg
7.5	6.24		598.61				bank/veg
9.8	6.92		597.93				start of wall
11	7.97		596.88				wall
12.4	8.74		596.11				top of bank (eroded)
13.3	10.81		594.04		0.2	594.24	edge of water
14.3	11.18		593.67		0.6	594.27	center of water
14.6	8.61		596.24				middle of cement
14.8	5.26		599.59				top of cement structure
16.4	11.04		593.81		0.5	594.31	left waters edge
17.2	8.8		596.05				bank
19	8.02		596.83				edge of flat
21	6.72		598.13				bank
23	5.89		598.96				bank

26	4.84		600.01				

Cross Section 6: Downstream of culvert , bridge (109.9 ft on profile)							
Station	Forshot	HI	Elevation	Flip left bank	water rod	water elevation	notes
10	8.11	604.85	596.74				
17	9.28		595.57				
21	9.41		595.44				
24	9.42		595.43				
28	9.7		595.15				edge of bridge
32	9.87		594.98				
35	10.22		594.63				land side of vert bridge post
36.2	11.2		593.65				water surface
36.7	11.33		593.52		0.03	593.55	center of water
37.1	11.06		593.79				left waters edge
38.2	10.26		594.59				bank
40.8	9.81		595.04				waters edge vert. Bridge
42.1	9.93		594.92				land other side of vertcle br. Post
45	9.84		595.01				
47.8	9.21		595.64				gravel pad meets wood structure
51	9.4		595.45				mid pad
54	9.01		595.84				edge of bench