Title

Towards a Stable Future: A Design Proposal for Cerrito Creek in Blake Garden, Kensington, California

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Publication Date

2010-12-01

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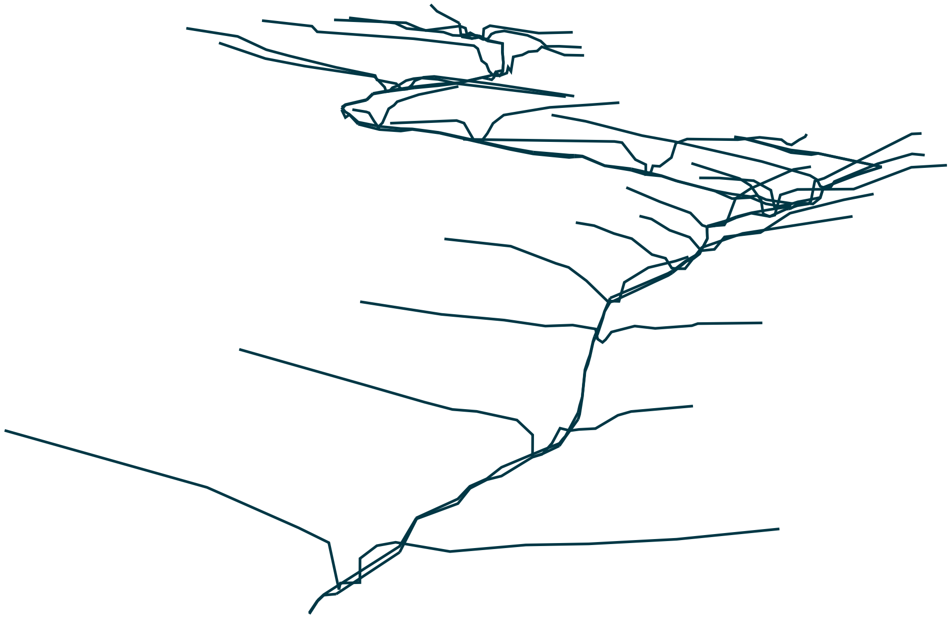

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LA 227/Spring 2010

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HEC-RAS modeling: Raymond Wong

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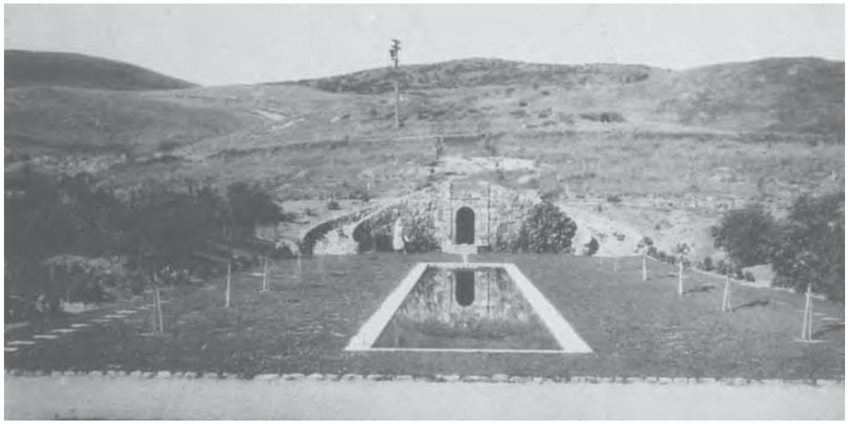
Fig. 1: Grotto at Blake Garden



Grotto 2008

Grotto 1924

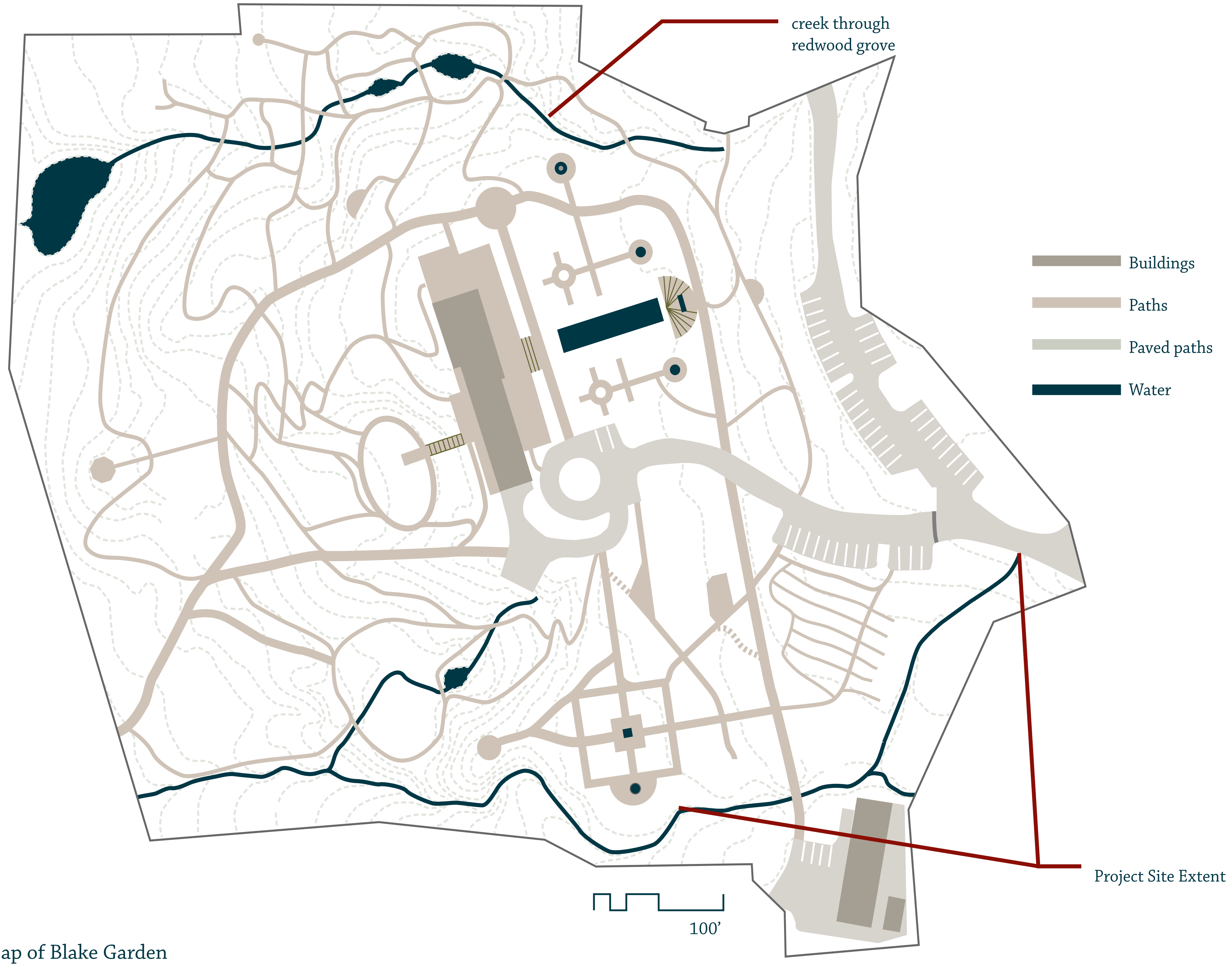
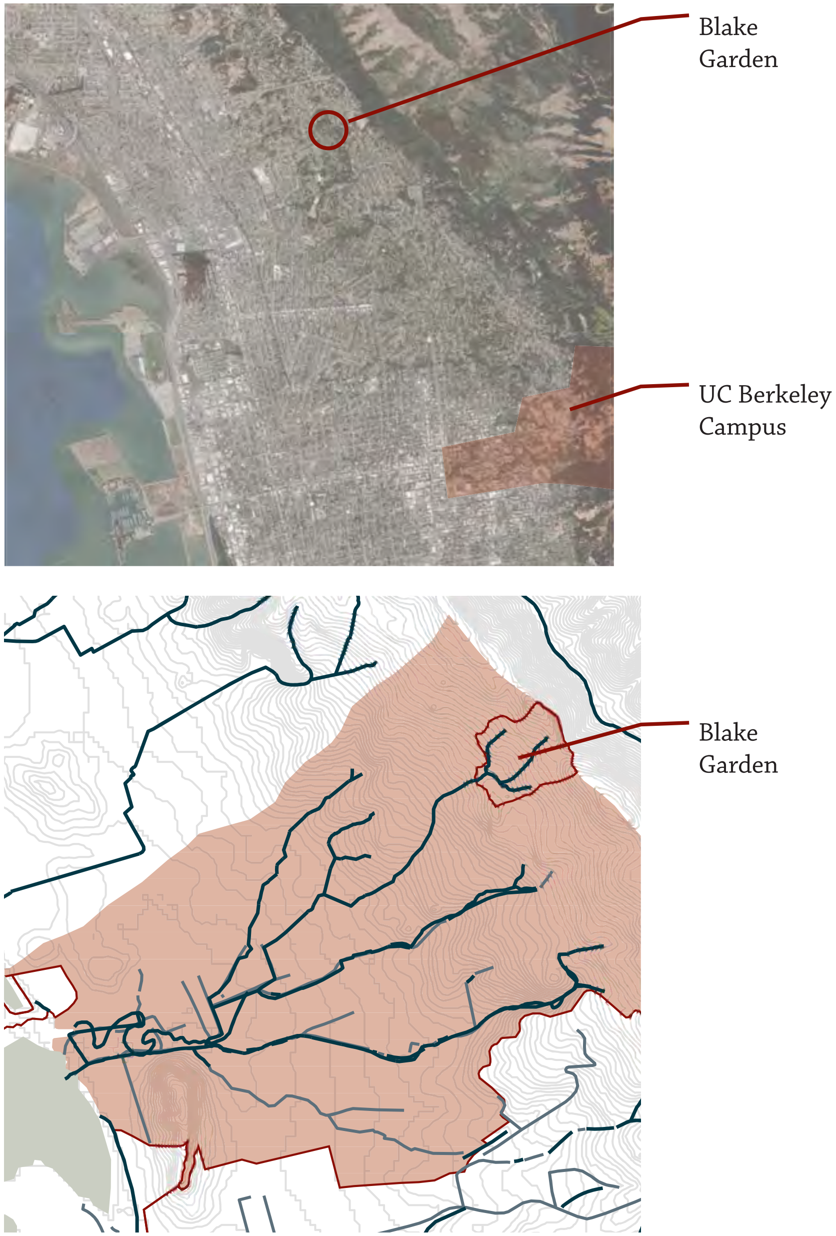


Fig. 2: Map of Blake Garden

Abstract

An upstream reach of Cerrito Creek, in Contra Costa County, California runs through Blake Garden, a 10.5-acre demonstration garden owned by the University of California, Berkeley (Fig 1 & 2). This study focuses on a 420-foot reach near the top of the garden that has a severely incised and undercut channel, undersized and deteriorating culverts, and failed bank armoring. In the spring of 2010 for LA222: Hydrology for Planners, the authors of this paper analyzed the hydrology of the watershed above the reach, in order to understand the flows that are likely causing incision, conducted extensive field surveys, and modeled flow in the creek. Continuing with last semester's work, we conducted a detailed facies map, and identified constraints and opportunities along the stream channel. Permanent monuments were placed on the site, and accurate mapping of the reach and cross-sections was generated. Based on our cumulative understanding of the site, we propose a stream design that will arrest incision and bank failure while allowing the 100-year flood to be conveyed through the channel by either reducing velocity below scouring or by protecting the banks. We achieve this by creating step-pool sequences in the actively incising sections, connecting the channel to a floodplain where possible, and proposing bank protection where the channel is more constricted. The design follows our goals of enhancing wildlife habitat, and serving as an attractive design element and educational focus within Blake Garden.

Fig. 3: Site Context



Problem Statement

Cerrito Creek suffers from many of the same problems that afflict small streams in urbanized areas worldwide: incision and undercutting, loss of riparian vegetation, high turbidity, and undersized and failing infrastructure (Dunne, 1978; Walsh, 2005; Brown, undated). Since the construction of Blake Garden in the 1920s, roads, driveways, parking lots, roofs, and other impervious surfaces upstream from the garden have increased the rate and amount of runoff. This same impervious surfaces arrested gravel recruitment, while runoff and dust from roads increased the pollutant load and suspended sediment. Constriction and armoring of the stream channel resulted in incision that has effectively cut off the channel from its former floodplain and riparian areas in many places, depriving the channel of roughness and natural filtration.

As a result, this reach of Cerrito Creek is currently in poor physical shape, and though little information is available about its condition prior to 2007, there is ample evidence that it has been incising for many years: the channel is littered with crumbling sack concrete walls and weirs from previous attempts at stabilization (Fig 6, 8).

We understood early in the project that the excessive erosion of the channel was mostly a consequence of the watershed's urbanization, and that intervention over the existing urban area could increase the area of pervious surfaces and improve its capacity to retain stormwater (Walsh, 2005). Nevertheless, the complexity of a large-scale proposal to retrofit the neighborhood with best management practices such as cisterns, retention ponds, vegetated swales, or pervious pavements, is certainly beyond the reach of what the Blake Garden management can control and would require large scale public involvement. On the other hand, Blake Garden is owned by UC Berkeley, and therefore restoration of this reach of the Cerrito Creek would likely be met with support from the university and has a greater likelihood of being implemented in a timely fashion. Some of the issues on this site are urgent, such as the need to stabilize and replace the undersized culvert that is currently threatened by a

Fig. 4: Term Project Goals

Based on the information gathered on the creek, as well as estimates of peak flow, we propose a creek restoration that:

1. prevents further incision and bank failure
2. enhances wildlife habitat
3. serves as an effective design element within Blake Garden.

Fig 5: Surveying

migrating headcut, which could easily undermine the stability of the public road above.

The goal of this project is to develop a more complex understanding of the processes at work in Cerrito Creek and come up with a conceptual design for an eventual in-stream restoration project (Fig 4). Our proposal recommends interventions such as measures for bank stabilization, regrading floodplains, and introducing step pools. These measures are expressed in redesigned cross-sections that address the specific issues of each reach.

Our work builds on research, survey and design ideas proposed by other students, namely a first survey of a smaller stretch of the creek, by Jessica Ludy and Kristen Podolak, and a preliminary step-pool design, by Nathaniel Behrends (Fig 43). This analysis was expanded by us, for LA222: Hydrology for Planners, where we conducted a full survey of the site and produced hydrological peak flow estimates. This project completes the analysis with facies mapping, pebble counts, map rectification, and the placement of monuments for future surveying. Drawing on this extensive analysis, we propose a design that prevents further incision, creates habitat, and integrates the creek more effectively into the botanical garden.

Typical small urban stream restoration projects are concerned with providing improved channel form, reducing flood risk, offering greater habitat value, and improving water quality (Purcell, 2002). This project, when complete, must accomplish much more: our site will become part of a designed, public garden. It is located near the garden's front gate; therefore creek stabilization measures must serve as part of the visual appeal and physical entry to the garden. Public safety, educational value, aesthetic appeal and circulation must become part of the design for this site. Our design proposal does not fully resolve all of these issues, but addresses the most pressing issues of stability and discontinuity with specific design solutions. As such, it leaves open the the opportunity to create a functional, attractive space in Blake Garden.

Methods

Our project site is located at the confluence of two small tributaries near the top of Blake Garden: the branch to the south, coming into the site from the fence that separates it from the neighboring property (here called the “South Branch”) meets the channel to the north, which emerges from the storm-drain culvert located near the entrance to the garden (the “North Branch”). Our fieldwork and analysis was conducted over two seasons. In April of 2010 we conducted interviews, field observations, and our initial creek survey including a longitudinal profile and 18 cross-sections, over three site visits. Additionally we completed our hydrologic calculations and initial modeling. In October and November of 2010 we added to our understanding of the creek by conducting facies mapping, pebble counts, detailed site mapping of the creek in its surroundings for our site design, and additional interviews over three site visits. With this combined data set and increased understanding of the creek we improved our modeling of the creek hydrology and were able to come up with a design proposal for restoration of our site. Overall our team interviewed, observed, documented, surveyed, calculated, and modeled data to provide a comprehensive understanding of this headwaters stretch of Cerrito Creek.

Inventory: Observations, Interviews, and Past Projects

To understand how past management decisions shaped the current conditions of Cerrito Creek and assess the rate of change in the channel, we conducted interviews and compared our results with previous survey work.

The manager of Blake Garden, Lauri Twitchell, collects monthly rainfall data for Blake Garden and observes the creek following rain events. She oversaw an ambitious and successful attempt to remove invasive weeds along the channel. In addition, she passively observes the creek. Kristen Podolak has firsthand knowledge of the creek from conducting research and surveying a portion of the same reach of Cerrito Creek in 2007. In the spring of 2010, we interviewed Twitchell and Podolak on-site about the physical condition of the creek.

Fig 6: Channel Conditions

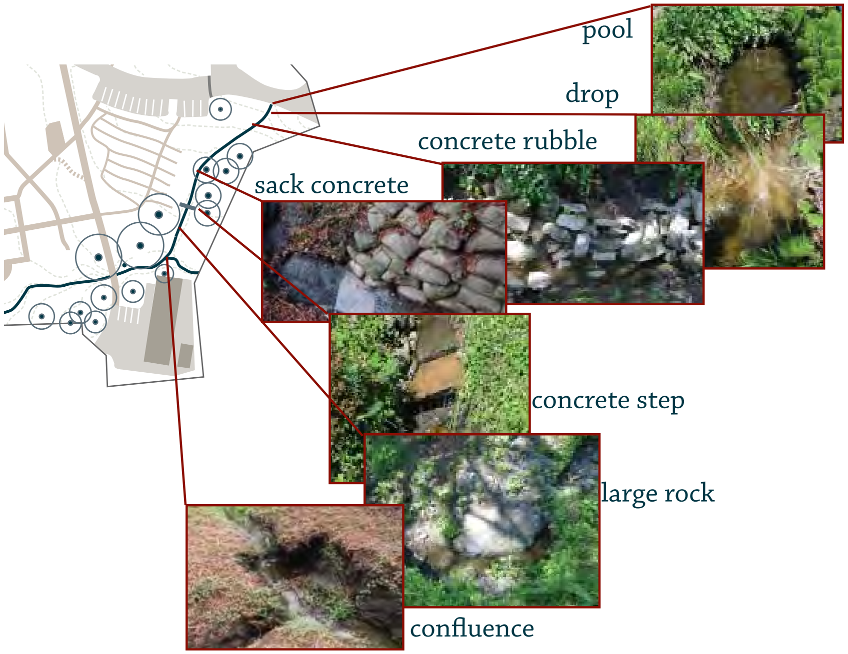


Fig 7: Trees

We examined two reports produced by former UC Berkeley students about the same reach of Cerrito Creek. The reports include research, survey, and design proposals that provide a basis for our project. Jessica Ludy and Kristen Podolak compiled a research report, Restoration with Reference: Rediscovering Cerrito Creek in Blake Garden, in the fall semester of 2007 (Podolak, 2007). This report includes channel survey and watershed analysis for a smaller portion of the reach of Cerrito Creek that overlaps with our project site. Nathaniel Behrends conducted a second survey in the fall of 2008 presented in Cerrito Creek Step-Pools: An Opportunity for Restoration and Education at Blake Garden (Behrends, 2008). He surveyed a portion of our site and proposed a preliminary step pool design. The cross sections and longitudinal sections Behrends, Ludy and Podolak surveyed provide an important basis of comparison to our work (Fig. 43).

We visited the site with Mark Tompkins, a geomorphologist and our professor for LA 227: River Restoration, and Raymond Wong, an engineer, second year doctoral student in Environmental Planning, and reader for LA 227. Kate Bolton and Tim Pine from UCB Capital Projects joined us. All of these people contributed their observations and knowledge.

Throughout the project, we referred to photographs taken of creek conditions, volunteer groups and garden staff working along the creek that showed previous conditions, projects and interventions.

We explored the channel conditions above and below Blake garden, and observed signs of water flow and overland flow into the natural detention pond on the neighboring property.

Creek Survey

Our team conducted surveys in late April of 2010, including over 400 feet of the longitudinal section of the North Branch, 75 feet along the South Branch, and eighteen cross sections, using compass readings and triangulation for spatial reference (Fig 5). In November of 2010, we re-marked our previous surveyed sections with permanent survey markers so that the survey may be reproduced in the future, and potential restoration activities monitored.

On October 31, during another field survey, we attempted to accurately map the thalweg using a laptop-plugged GPS antenna. The signal resolution was too poor to be useful, likely due to a heavy canopy cover. As an alternative we triangulated the stream, trees, buildings and other important constraints to the relative position of fixed points in our cross sections. With this information, we were able to generate an accurate referenced map of our site.

Watershed Delineation & Hydrology Calculations

The drainage area above our site is part of the much larger watershed of Cerrito Creek that flows into San Francisco Bay (Fig 3). To calculate runoff and flow, we used a combination of aerial photographs, USGS topographic maps, Google Earth and GIS data to determine the boundaries, the drainage area above Blake Garden, and impervious surfaces (Fig 23). We visually ground truthed our drainage assessment and made corrections to our hydrology calculations.

Because this reach of the creek is small and in an urban area, we used several methods to calculate peak flow. This gave us a good comparison in order to make informed decisions. Given the basic watershed data including area, land use, rainfall, surfaces, soil type, and slope, we estimated peak flow using the following methods: Haltiner, Rantz, Waananen and Crippen, and Rational.

Assessment of Channel Conditions and Bank Stability

Pebble Count: We completed four pebble counts to identify the amount and type of sediment in four different reaches of Cerrito Creek. We used the protocols from Wolman Pebble Count (Wolman, 1954) and Pebble Count Field Procedures. Given the narrow width of our creek (less than three feet wide in some places) and relatively short sections of the same facies, some of the counts were stopped at 50 samples and we used the zig-zag technique, walking heal to toe from downstream to upstream. We conducted pebble counts in the pool below the culvert at the upstream extent of the creek, in the pools below the main headcut, and immediately above the culverted road crossing (Fig. 11). These reaches were representative of the different channel conditions present within our site.

Facies Mapping and Visual Assessment: In order to understand how the geologic substrate affects the stream channel, major disturbances to the banks and bed, and the condition of the riparian vegetation, we mapped the facies along the creek (Buffington, 1999). Our facies map illustrates the bed substrate, including concrete rubble ("urbanite"), existing vegetation, the proximity of trees and structures to the banks, as well as areas of bank failure and scour (Fig 45). Our goal was to develop a detailed base map of conditions in and out of the channel, to understand processes leading to channel degradation and plan restoration actions.

Haltiner 'Order of Magnitude'(HOME): This is a simple method that provides a 'ballpark' figure and should be used mainly to identify blatant errors in calculations. By dividing the watershed area, in acres, by two, it is possible to make a rough estimate of the 100-yr recurrence interval peak flow.

Rantz: The Rantz method is a simple method of converting watershed area and mean annual precipitation (MAP), producing an estimate of peak flows.

Waananen and Crippen (W&C): This method is similar to Rantz, but also considers elevation and slope. The equation considers watershed area, MAP, and elevation at 15% and 85% of the distance along the creek's length. It is calibrated for each climate zone. We used the formula established by California's Central Coast Region. W& C provides peak flow estimates for the 2-year and 100-year recurrence intervals.

Rational: The Rational Method is the hydrologic analysis method used by Contra Costa County for planning and design. It is a simple method of converting watershed area, slope, time of concentration, and runoff coefficient (based on soil type and land use) to generate an informed estimate of peak flows. For the return interval under consideration, this method requires the determination of peak intensity, for a duration that coincides with the concentration time within the watershed. It also requires time of concentration estimated by a combined overland flow and time flowing through the channel.

Fig 8: Project Site & Degraded Channel

Modeling

AutoCAD/Rhinoceros: We drafted cross sections and long sections using Auto CAD, and then placed the 2D cross sections into the 3D spatial modeling program Rhinoceros. In Rhinoceros we were able to locate the cross sections along the longitudinal profile. Using triangulation, bearings and a USGS aerial map we oriented the longitudinal profile, creating a “base map” of our survey results, with a reasonable degree of accuracy (Fig 13).

HEC-RAS: Our hydrologic calculations and field survey allowed us to model flows in the creek using HEC-RAS. With the help of Raymond Wong, we used the peak flows estimated with the Rational method, for the 2, 5 and 100-year return interval as inputs, noting predicted bank overtopping. The choice of the Rational method’s results and these return periods is based on the comparison between the results of the several methods, produced on the previous semester in LA222, and identifying the Rational as the most consistent. It is also the method recommended the Contra Costa County Flood Control and Water Conservation District (CCCFCD). We tested the model for consistency against our field observations of high flows and bank overtopping during rain events. We then used HEC-RAS to model these flows through the channel using a modified, typical cross-section to see how it would respond to channel interventions (Fig 24-25).

Results

Our observations, measurements, calculations, and modeling are consistent with our theory that the reach of Cerrito Creek that flows through Blake Garden has become increasingly unstable.

Interview/Accounts

Interviews with Lauri Twitchell and Kristen Podolak revealed background information on alterations made to the stream, their concerns about stability, and goals for the future of this portion of the stream.

Kristen Podolak described her understanding of the flow of the two channel branches running through our site. She distinguished between the South Branch that enters Blake Garden from a neighboring private residence to the south, and the North Branch that enters through a culvert under the main garden entrance road. She described the South Branch as the "main branch" and the North Branch as residential storm runoff. She noted that prior to removal of the blackberries, it was difficult to know where water flowed on the site. Podolak noted a storm drain that carries water from a French drain in the parking lot onto the site, and flows into the North Branch (Fig 10). In the winter, Podolak explained, flow in the North Branch is high and fast, but in the summer this tributary nearly dries out; incision and undercutting are evidence of high flows. The low flows in the South Branch are more stable year-round than the North Branch, and the channel form is more consistent with a stable system.

Between 2007 and 2009, garden staff and volunteers removed blackberries that grew along the creek. This is an undesired invasive species that completely covered the channel (Fig 9). Staff continues to maintain low levels of vegetation by regularly cutting back new growth, but left blackberry roots within four feet of the channel intact to maintain bank stability. Twitchell's goals include making the creek more visible, conducting stream restoration, and integrating the creek into the designed garden.

Fig 9: Blackberry Removal

(source: Blake Garden website)

2007

2010

Fig 10: Culverts

When the creek was fully exposed, Twitchell observed that the stormdrain culvert at the upstream extent of the site was clogged with sediment, and water did not flow in a defined direction. She observed that during rain events, water flowed into a depressed wet area adjacent to the Blake property, and expressed concern about water leaving the Blake property. This was mitigated by digging out the deteriorating culvert, excavating a more defined channel, and regrading around the inlet. The excavated sediment was piled along the bank to create a berm, with the goal of preventing water from flowing towards the neighbor's property. These efforts were not sufficient to arrest all flow onto the neighboring property during high water events, though it still forms a berm at the edge of the channel.

Twitchell recounted a storm in January of 2010 that was the most intense storm she had witnessed in the garden since she began working at Blake in 2007 (Fig 44). The high water event had several dramatic results, including overbank flow, large debris mobilization, and backup behind the culverted road through the that came within inches of overtopping. In an effort to arrest overbank flow to the adjacent property, staff placed sandbags along the channel. Staff also removed substantial accumulated debris at the grate at the downstream extent of the garden.

In the last year since the stream has been exposed, Podolak and Twitchell agree that the channel has eroded substantially, and several locations noticeably downcut (Fig 8). As manager, Twitchell noted steep banks and bank failure is a growing concern for the safety of visitors to the garden.

One of Twitchell's long term goals is to remove the lower culvert and create a bridge for the road that crosses the stream, which she perceives as a more aesthetic and ecological solution than a culvert.

Field Observations

Field observations of the North Branch indicate long-term and ongoing channel instability. Scouring, headcuts, bank failure, undercutting and incision dominate this reach of the creek. There is a headcut six feet in height just 32 feet downstream from the culverted stormdrain that is the upstream extent of our site. In several locations banks are steep, undercut, and collapsing in on the channel (Fig 16, 18). At one location, unstable banks are causing a Blackwood Acacia to lean across the channel (Fig 7). We measured a 2.5 foot undercut at one location. The channel is intermittently walled with stone and concrete rubble, some of which has already collapsed while the remaining walls are threated by undercutting and scouring (Fig 8).

Keeping in mind our goal to propose structural and nonstructural interventions, we observed constraints and opportunities. Several areas of the creek were bare on one or both sides, with neither roads, culverts, buildings nor significant plants. These areas present the greatest opportunity for regarding a floodplain. In other areas, trees, roads and structures present constraints (Fig 28).

There are two culverts on our site (Fig 10). The first conveys stormwater from the residential neighborhoods above the site under the main entry road and into the garden at the upstream extent of our site; this is where the North Branch starts. This culvert is grossly undersized at 16” in diameter, structurally unsound, and visibly rusted through on the bottom six feet of the pipe. Water enters the garden underneath this culvert, indicating that it has holes and is undersized. At the base of this culvert is a large pool, followed by a 6’ headcut (described below). The second culvert is 30” in diameter, and conveys the stream underneath a gravel road that connects the greenhouse to the main entry of the garden. This culvert acts as a grade control point, indicated by the stable channel bed extending 50 feet upstream from the culvert with a slope of 2.5% and little evidence of incision. Similarly, for 40 feet downstream from this culvert the bed has a slope of 1.6% and appears stable until it reaches the first in a series of smaller headcuts migrating upstream. While the removal of this downstream culvert would certainly benefit the creek in terms of reestablishing longitudinal connectivity, such an intervention would have to be balanced with the removal of what is now in practical terms a very stable grade control.

Pebble Counts

The results of the four pebble counts showed fine sediment deposition at the top of the site with steadily decreasing fines and increasing size classes moving downstream. (Fig. 10) Specifically the pool at the out fall of the upstream culvert (count 1) contained 51% fines with 98% of the samples less than 16 mm in width, this indicates that the stormdrain is carrying almost exclusively fine sediment. The percent fines decreased moving downstream. The first scour pool below the largest headcut (count 2) revealed 40% fines and 70% <16 mm wide, while the second pool (count 3) contained 28% fines and 64% <16 mm. The riffle above the grade control culvert only contained 15% fines and 37% <16 cm, and is instead comprised 50% gravel and 20% cobble.

It is important to keep in mind that there hasn’t been a high water event since the extreme event in January 2010, which scoured most of the sediment from

Fig 11: Pebble Counts

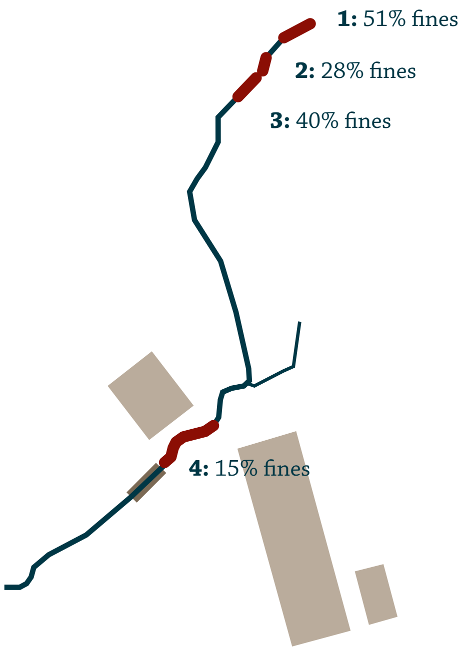
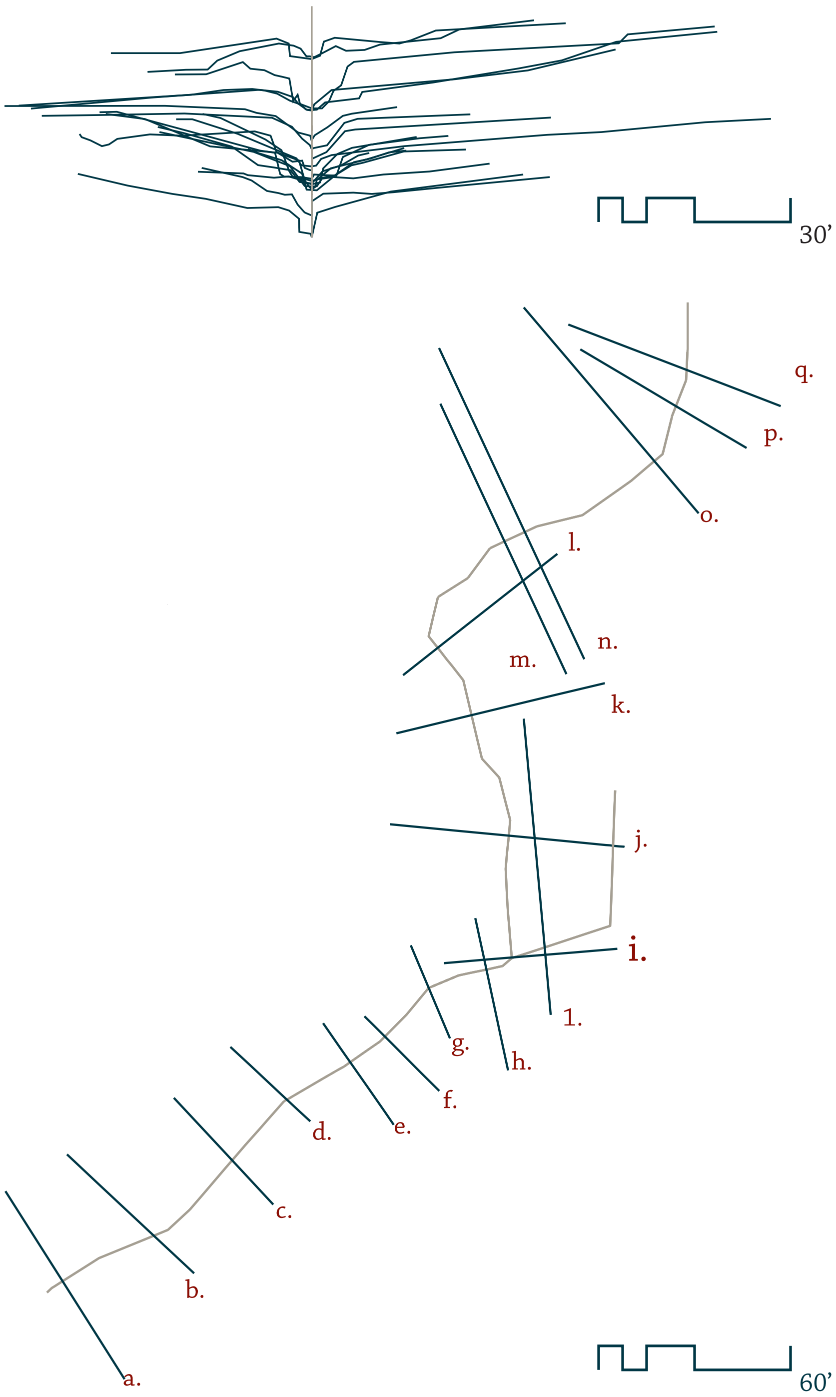


Fig 12: cross sections / april 2010



the site. Based on Twitchell’s observations, sediment of size classes up to 300 mm were moved in the January 2010 storm event, which may account for the current lack of larger size classes on-site. The fines that are present on-site were most likely deposited by small rain events that have occurred since last winter, as well as some recruitment from banks that have collapsed as a result of incision from the same high water event.

Most sections seem to be experiencing heavy scouring, and overall there is very little sediment present. There are some segments in which sediment entrapment appears to be occurring. Like many small, urbanized tributaries in the San Francisco bay area, this segment of Cerrito Creek appears to do most of its sediment transport in episodic storm events like the April 2010 event, moving surprisingly large stones and debris for such a small and intermittent stream.

Facies Mapping

The facies mapping identified distinct sub-reaches within the stream based on bed form and sedimentation. Blake Garden is located in an area with little native bedrock, instead the predominant (highly colloidal) clay substrate acts as a less rigid control, which when exposed appears to be stable in moderate high flows but erodible in the highest events. The pool at the culvert outfall is typified by fines sedimentation (mostly silt, sand, and 2-8 mm size class pebbles), demonstrating the small size of sediment moving down the stormdrain system and along the streets that lead to this culvert. Immediately below the 6 ft headcut are two scour pools with significantly coarser bed material and exposed clay substrate.

Apparent earlier attempts to stabilize the stream channel introduced broken concrete slabs and sack concrete (urbanite) into the channel. Reach 3, between cross-sections I and L is dominated by this urbanite used unsuccessfully for bank stabilization. Urbanite from collapsed walls may be helping to stabilize the bed in this reach, concentrating the energy on the banks. The bed of Reach 5, between sections b and d, consists of a clean clay substrate with very little sediment beyond the silt accumulated at the culvert outfall. (Fig 45)

We were able to clearly depict all site constraints and transferred this information to our composite map. This was used to delineate a corridor where channel regrading and creation of floodplains were feasible, and where bank protection was considered essential to constraints.

As well as illustrating the present condition of the channel in the facies map, we conducted a visual assessment of the habitat condition along the channel. In most sections, there is no continuous riparian corridor, the channel is cut-off from the floodplain due to heavy incision, and artificial materials, such as sack concrete, are present in the banks and bed at various points. The two stretches where there still is some level of lateral connectivity and less incision are the top-most section of reach 1, above the head-cut, and reach 5 where there is stable riparian vegetation and an active floodplain.

Assessment of Bank Stability

There are two segments within our site that show significant bank erosion. The first is reach 3, between sections I and K; despite past efforts, this segment has steepened banks with heights ranging from four to seven feet. There is evidence of recent bank failure and significant undercutting (up to 2.5ft in some places) (Fig 18). The second segment is reach 6, at the downstream end of our site, between sections A and C, here again there is active undercutting and steepened banks that follow the active head-cuts within the channel.

Additionally there are segments of our site that show signs of bank stability. Reach 2, between sections O and L, is relatively stable with a small floodplain forming on river right. The banks of reach 4 between sections I and E are stable due to the culvert which acts as a grade control structure (section E), a large boulder (section G) and mature trees along the banks. Below the culvert (sections D to below C) have an appropriately sized channel with a functional floodplain and thick riparian vegetation all leading to bank stability. However, this could change as the three head-cuts between sections a and c migrate up stream. (downstream sections highlight) The South Branch also exhibits a healthy channel configuration, for a stream of this size and location within the watershed, with a small low flow channel with riparian vegetation, stable banks and access to a small floodplain.

Survey

Long Profile: Our survey found that the average slope of the South Branch is 5.7% , and the average slope of the North Branch is 7.1%. The total surveyed reaches have an average slope of 6.7%. (Fig 15)

The channel slope from the upstream culvert where the North Branch enters Blake Garden to the downstream end of our long profile has six different reaches with distinct channel processes and slopes (Fig 15). Reach 1 begins at the culvert

Fig 13: Triangulation

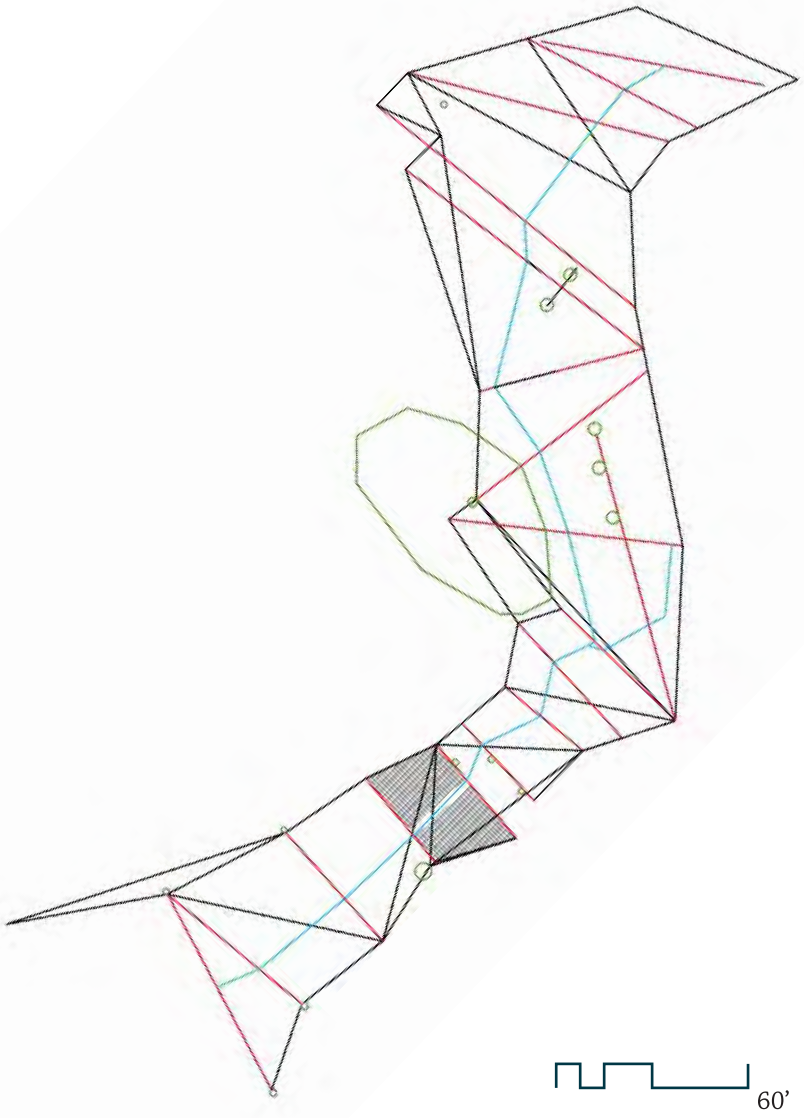
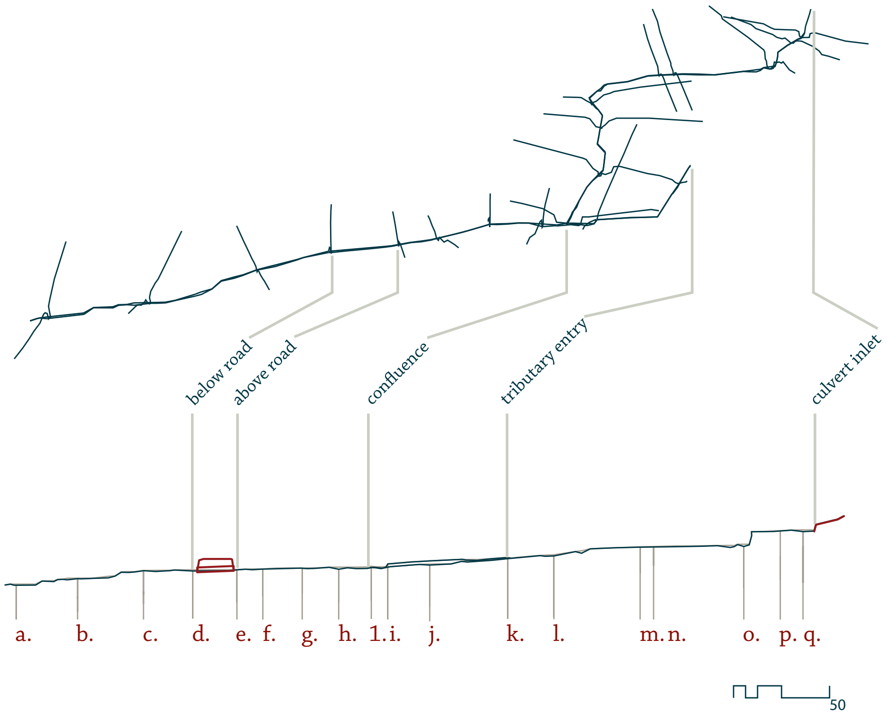


Fig 14: long profile / april 2010



at cross section Q and stretches to cross section O and has an average slope of 20%. Here water enters into a pool from the culvert and then heads down a drop of 8 ft to a second pool (Fig 16). This section is actively incising and threatens to cut back to the culvert outlet just below the road. Reach 2 extends from sections O to M, has a slope of 0.08%, and appears stable (Fig 17). Reach 3, between L to I (confluence) has a slope of 6%. Here the creek is deeply incised from past down-cutting and the banks are much less stable. Further downstream, the there is increased undercutting and bank failure. The stream bed appears relatively stable, perhaps because of the more resistant bed material, and side-cutting is the dominant process here (FIGURE 21). We delimit Reach 4 of the long profile from the confluence to the culvert crossing (sections H to E). Here the culvert is acting as a grade control structure, and the average slope is predictably low at 0.08% (image). Reach 5, from the bottom of the culvert to immediately downstream from section C, is stable and still maintains the lateral connectivity to a floodplain, in high flows, with an average slope of 1.6%. Reach 6, from there to the downstream end of our long profile (sections B and A), is much steeper (11.1%). There are active head cuts moving upstream toward the culvert.

Cross Sections: We surveyed a total of eighteen cross sections illustrating the changing channel morphology (Fig 14). Cross sections N and M depict a stable channel (Fig 17); section N has a channel and small floodplain. Section M is beginning to experience incision and shows a rubble wall on one side constricting the channel (Fig 17). Cross section O demonstrates the most dramatic pool and scouring along the stream banks, below the largest head cut in our survey area (Fig 16). Cross sections J and H demonstrate incision on the North Branch compared to the stable channel on the South Branch (Cross-section 1). The most dramatic undercutting and bank failure occurs at cross section H were both sides of the channel are undercut, one at .75ft and the other at 1.6ft (Fig 18).

Georeferencing: We measured on site the distance between several notable points along the creek, and we used these measurements to triangulate the location of constraints, such as trees and buildings, and correctly place the cross-sections on map, using AutoCad (Fig 13).

Hydrology Calculations

Our site drains a watershed area of roughly 61 acres. In our original calculations, from Spring 2010, we had tentativelly broken down the watershed into two parts, with 15.5 acres contributing flow to the North Branch and 44 acres for the South Branch. In our more recent field visits, we observed that almost all the stormwater in the watershed converges into the stormdrain system that culminates at the culvert located at the upstream end of the North Branch . As such, we will consider that all the peak flow will have to be conveyed through the North Branch in our design proposal. The watershed has an average slope of 12%. The Alameda County Hydrology and Hydraulics Manual (Alameda, 2003) defines a runoff coefficient (C) of 0.6, for a Type D soil with approximately 50% impervious surfaces (equivalent to a 1/8 acre residential plot configuration) which corresponds with the conditions of our site (Fig 23). Given the soil type D (CoE) and our estimated impervious surfaces at 47.7%, C=0.6 was selected for further calculations (Fig 21).

Using the four hydrologic calculation methods described above (Haltiner, Rantz, W&C, and Rational), we proceeded to make a series of peak flow estimates for comparison with each other and observations on site of approximate bank-full flow. For our watershed, peak flow calculations for Haltiner gave results of 31 cfs for Q100. Our calculations of Rantz resulted in a Q2 estimate of 4.4 cfs and Q50 of 49 cfs. The mean annual precipitation for our site identified from the Contra Costa County manual is 24.75 inches. This is comparable with the rainfall data collected at Blake Garden's gauging station over the past 44 years, giving a mean annual precipitation of 26.5 in.. (Fig 11) We calculated the altitude index for our site to be 0.6825. Thus the calculated peak flows using Waananen and Crippen were 3.7 cfs for Q2, and 42 cfs for Q100.

Lastly we ran calculations for the Rational method (indicated by the Contra Costa County as the preferred method for hydrologic analysis for planning and design). As mentioned before, the runoff coefficient selected, based on the Alameda County's manual, was C=0.6. The time of concentration was estimated through the combination of time overland and time in channel. The first, based on a headlands slope of over 15% and an approximate overland flow distance of 500ft, was calculated to be around 9.0 minutes. The time in channel, considering an average velocity of 5 fps and a total channel length of 2020 ft, was estimated at 6.7 minutes. This value is comparable with a time of concentration of 6.13 minutes obtained from the Kirpichs equation. Therefore, the total time of concentration that coincides with the precipitation event duration and that will consequentially generate the peak flow, is 15.7 minutes. Using the Contra Costa County Precipitation-Duration-Frequency-Depth charts, for such a duration, a depth of .41 in. was established for the 5-yr event, which corresponds to an intensity of 1.56 in/hr. Using the Rational equation Q=CiA, where C is the

Fig 15: reaches by dominant processes and slope

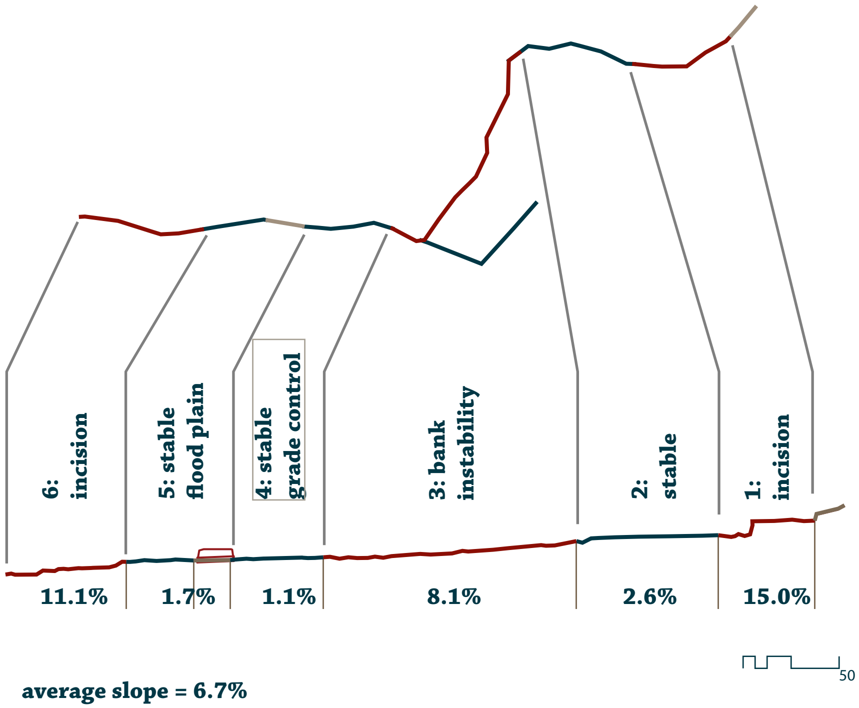
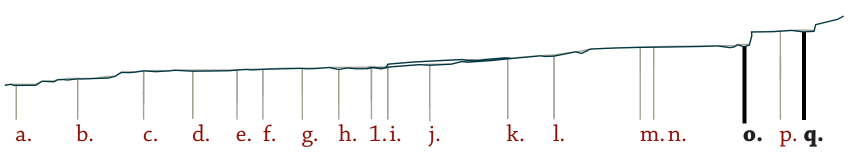
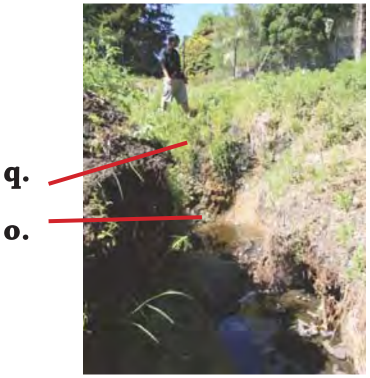
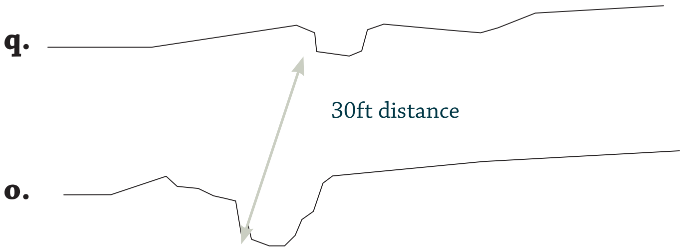


Fig 16: cross sections comparisson **o** and **q**







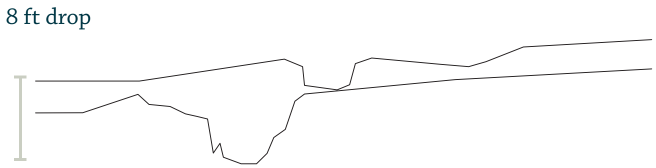
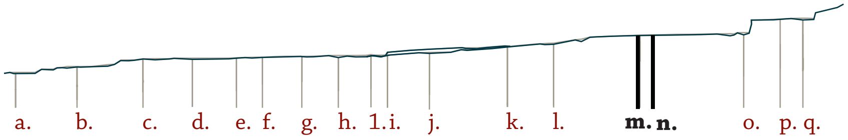
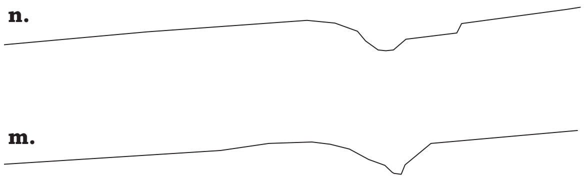


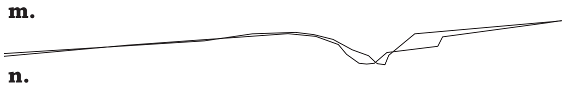
Fig 17: cross sections **n** and **m**



functional stream



section overlay at elevation



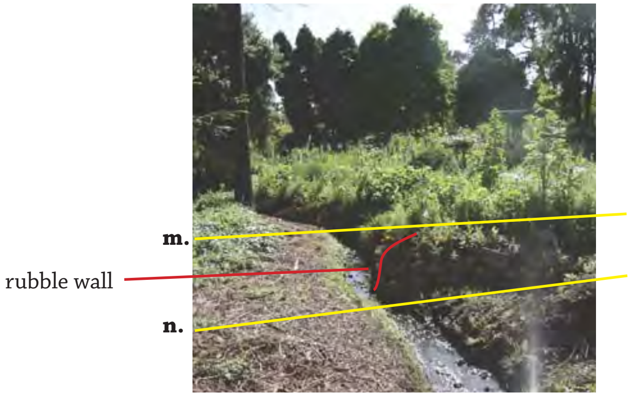


Fig 18: cross sections **j, h,** and **1.**

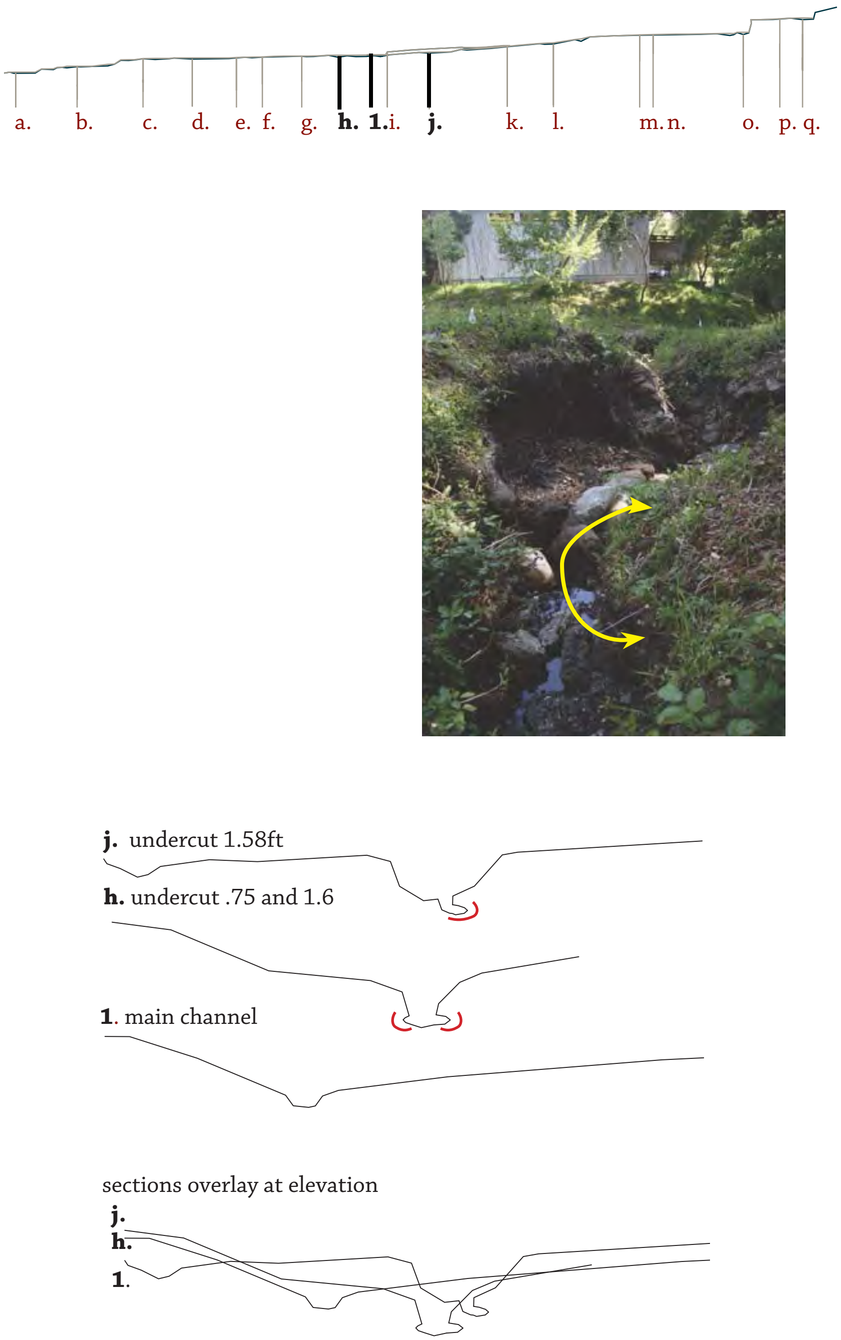


Fig 19: cross section comparison 2007-2010

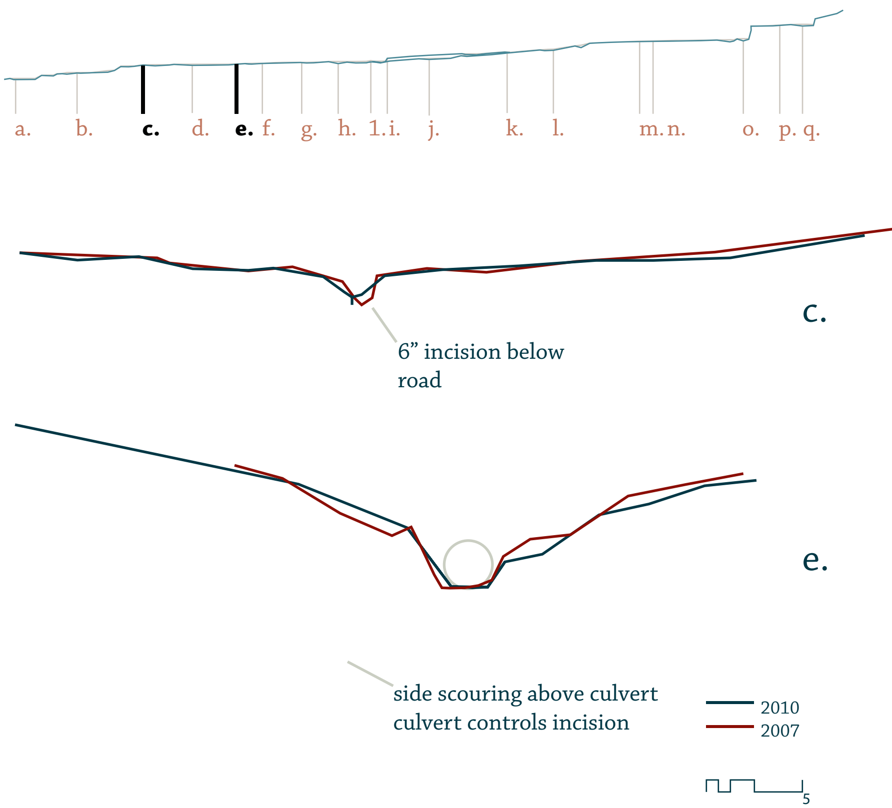


Fig 20: peak flow

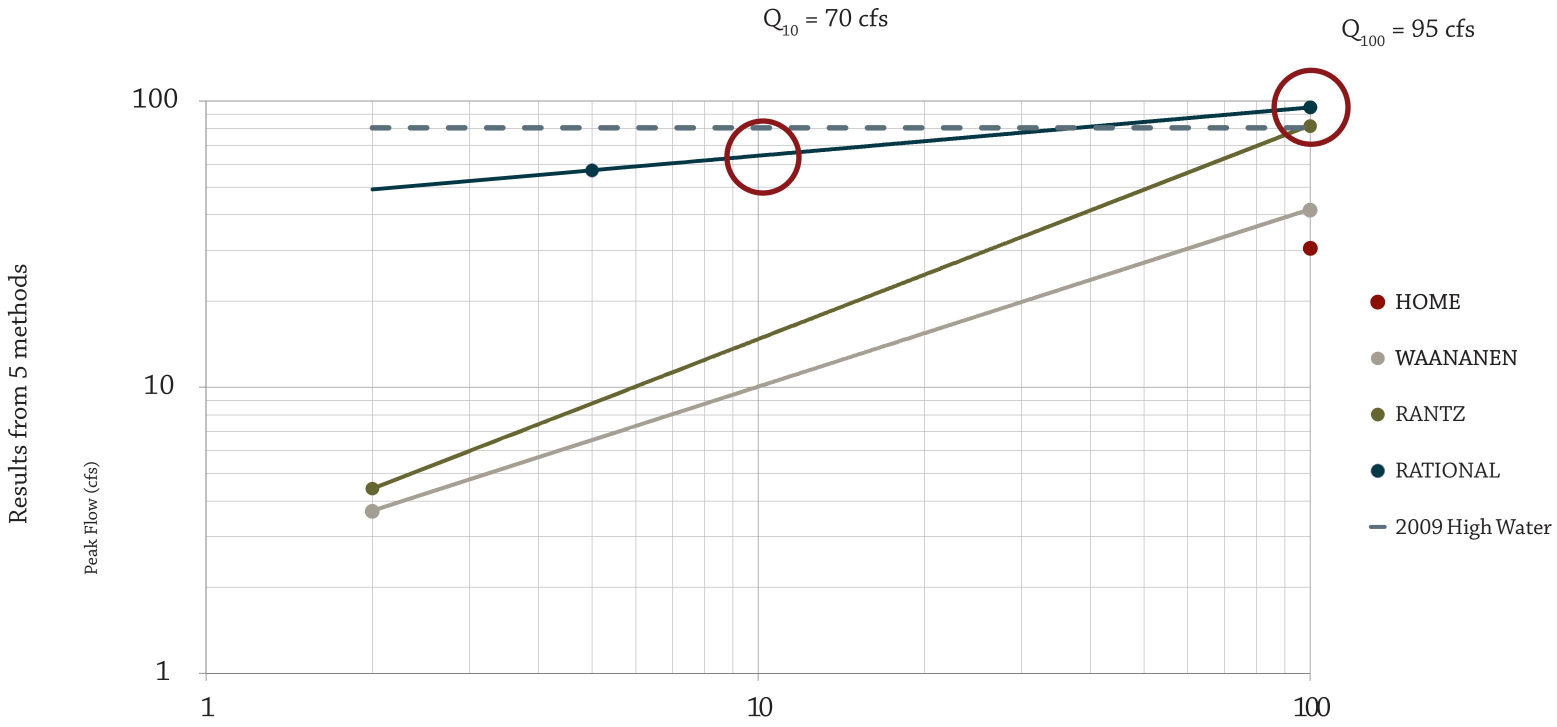


Fig 21: watershed analysis

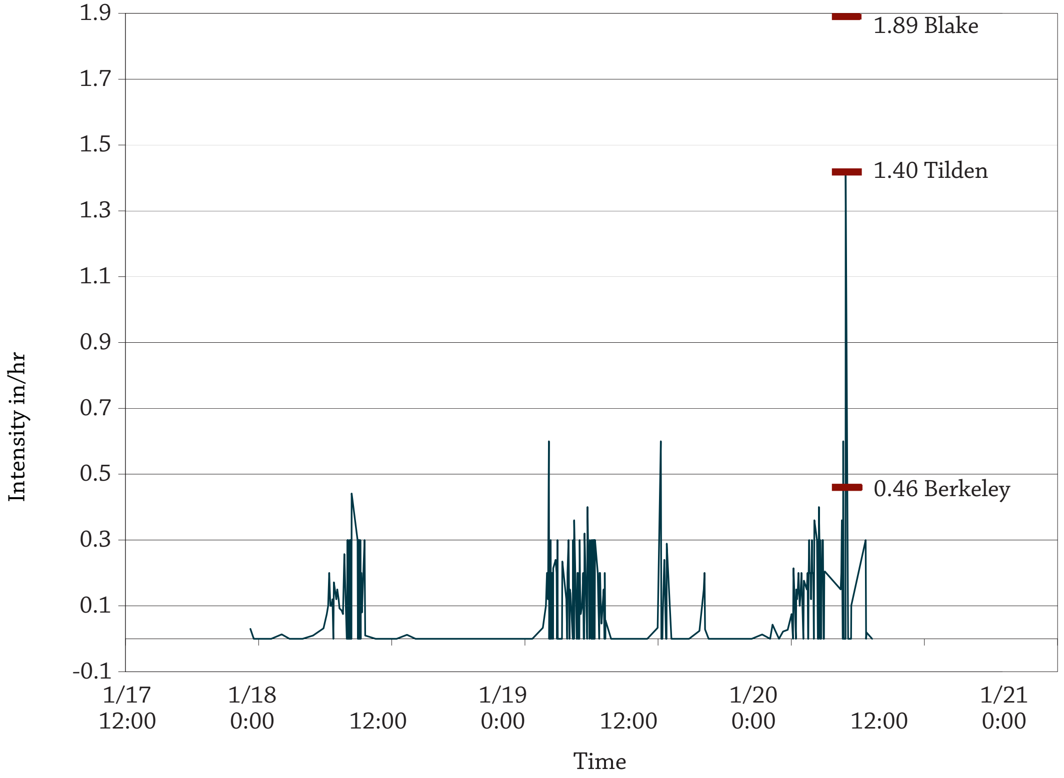
Slope at top 500'
21%

From Alameda County Hydrology and Hydraulics Manual	Soil Group	C-Factor
Residential 1/8 ac (50% impervious)	D	0.6

Time of Concentration:
15.7 min.

	Watershed Area acres	Paved Surfaces %	Buildings %	Total Impervious %	Rise ft	Run ft	Slope %
'Blake' branch	15.44	27.9%	26.6%	54.5%	110	1,338	8%
'Fence' branch	43.96	27.5%	19.4%	46.9%	282	2,247	13%
Below confluence	1.63	4.0%	3.0%	7.0%	9	191	5%
Total	**61.04**	**26.9%**	**20.8%**	**47.7%**	**309**	**2,520**	**12%**

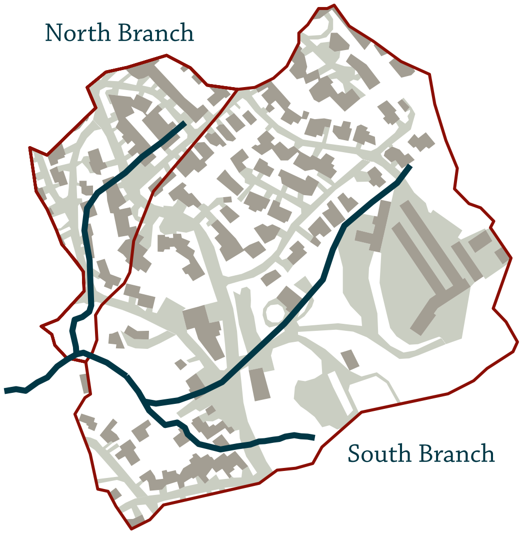
Fig 22: Jan 20, 2010 storm comparison



(data sources: Tilden Park Gaging Station, UC Berkely gaging staion)

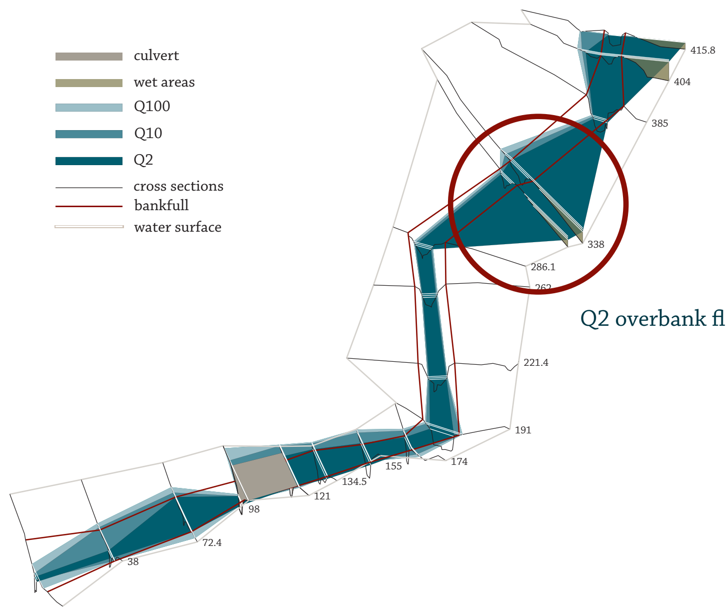
Fig 23: Watershed Above Blake Garden

aerial view



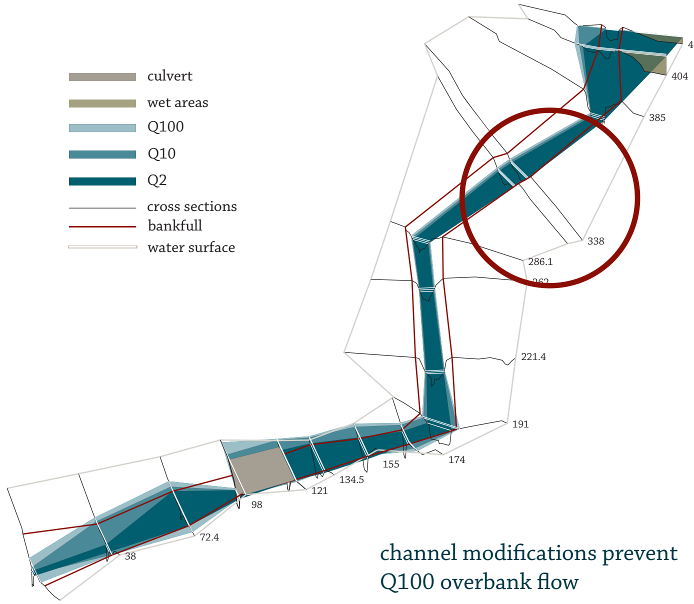
impervious surfaces = 50%

Fig 24: HEC-RAS model of current flow conditions



Q2 overbank flow

Fig 25: HEC-RAS model of flow with channel modifications



channel modifications prevent Q100 overbank flow

Modeling completed with the help of Raymond Wong

runoff coefficient, I the intensity, and A the watershed area, Q5 was calculated as 57.3 cfs. For the 10-yr event, depth was .5 in., intensity 1.91 in/hr and Q10 is 69.8 cfs. The Q100, corresponding to an intensity of 2.59 in/hr, is around 95.0 cfs (Fig 20).

Estimate based on 2010 high-water

On January 20th, 2010, a short, but very intense, precipitation event was registered in the Blake Garden watershed. The gage at Blake Garden collected 1.89 inches of rain in an hour. This seems to have been a very spatially concentrated event. This is demonstrated by the high intensity of 1.40 in/hr logged at the nearby Tilden gauging station, while the UC Berkeley gauging station only registered 0.46 in/hr for the same storm event. (Fig 22)

Using the Precipitation Duration Frequency Depth Curves for Contra Costa County (P-D-F-D), an event of this intensity registers at around a 100-year peak flow. Using Manning's equation, we determined what the flow could have been, for one of the more stable cross-sections (XS G), where the high-water mark had been pointed out by the staff at Blake Garden who were present during the storm. Our rough estimate puts the peak flow at 80.5 cfs, which when graphed with the peak flows for the rational method falls between a 20 and 50 year event. (Fig 20) Regardless of this discrepancy, it was obviously a very significant precipitation event.

Considering the very short times of concentration in the watershed, the rational method acknowledges (better than the other methods) that even a very short, but intense, precipitation event will generate very significant peak flows in stream. Comparing the results obtained with the different methods (Fig 20), it is observable that the somewhat random results observed for short recurrence intervals are not maintained for the longer recurrence intervals. Even if there is a significant variation for the Q100 obtained for the several methods, they tend towards the same order of magnitude. Given the observations by the staff at Blake Garden, the Rational estimates for higher frequency events seem to correspond much better to the creek's behavior. As such, we will use the Q100 estimated with the Rational method (95 cfs) as the design flow we used in dimensioning the channel in our proposal.

As mentioned before, most of the storm water seems to be converging into the upstream culvert, but there are indications that most of the low-flow is still entering the creek through South Branch. Unlike the seasonal North Branch, the South Branch is wet year-round, as reported by Twitchell and Podolak. An explanation would be the existence of the natural ponding area, that appears to be fed by spring water, although we were unable to verify this on site. Until recently, an unquantified portion of the peak flows from the North Branch (as will be analyzed later) also bypassed through the natural detention area located on the adjacent property (to the South), dampemning in part the concentrated peak flows.

Fig 26: in-channel interventions 2009-2010

Fig 27: Retention Area Flow Pattern


Normal flow conditions


Flood stage


Flood stage after interventions

Discussion/Analysis

Based on the results described above, it is clear that the reach of Cerrito Creek that runs through Blake Garden has degraded over time due to urbanization in the watershed above the creek, which increased the rate and amount of runoff entering the system. Many years of damaging flows degraded the channel over time. Past efforts to stabilize the channel with sack concrete and concrete debris are crumbling and failing, and structural intervention will be necessary to stabilize the channel.

Many changes on the study site have taken place over the last three years, most notably clearing of invasive weeds and exposure of the completely encroached creek. This work allowed students to use the site for field study (including the prior research described in this paper), and set the stage for the creek's restoration. These same interventions unintentionally resulted in changes to the hydrology and morphology of the system. We conclude that recent stream interventions had the consequence of modifying the local hydrology of the system, by increasing the peak flow conveyed in the North Branch, and accelerated the rate of channel degradation in our study site. These measures exacerbated ongoing processes of channel incision and bank failure.

Removal of the thicket of blackberries (Fig 9) in and around the creek channel also resulted in decreasing the roughness of the channel. Less roughness permits higher velocities in the channel during storm events, increasing the potential for water to scour and erode the stream banks, possibly resulting in more erosion on our site and downstream of our site.

Based on photographs and accounts, garden staff made an effort to direct all water that enters the garden through the North Branch into one defined channel, and prevent it from overtopping the bank and flowing into the natural detention area on the neighboring property during storm events. Field observations corroborate these accounts: we observed patterns of sediment and garbage buildup consistent with overland water flow towards the wet ponding

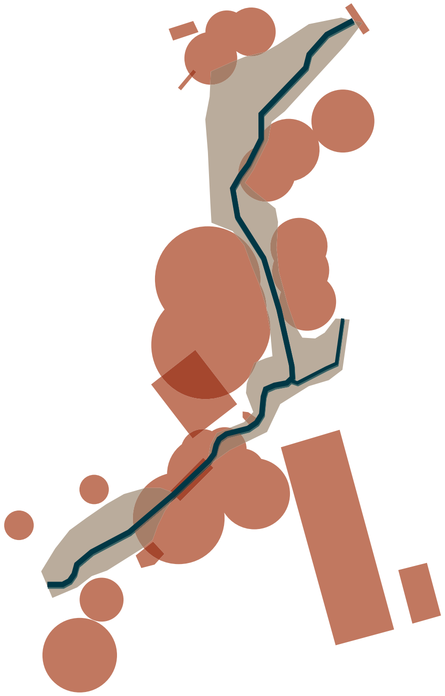


Fig 28: Constraints & Opportunities

area from past events, as well as new mounds of soil and sandbags situated to arrest overbank flow. We believe that the overbank flow into the adjacent wet ponding area served a critical role in maintaining the integrity of the channel by detaining water and releasing it slowly back into the system, effectively reducing peak flows following intense rain events (Fig 27). Given the very small lag time for the watershed above the garden, even a few minutes of ponding and spill over would have a very significant effect in reducing peak in-channel flow. The HEC-RAS model backs up our field observations. Based on our hydrologic calculations and field survey, this model indicates that overbank flow occurs in that same reach of the creek during the Q2 storm event, and demonstrates wet areas of low flow adjacent to the channel towards the detention area. That the HEC-RAS model reflects field observations and firsthand accounts is a good indication that our hydrology calculations and field data are somewhat accurate (Fig 24).

The effort to arrest bank overtopping, create a defined channel, and eliminate roughness increased the energy of the peak flows through the main channel. Increasing the energy of flows through a channel is known to cause erosion, and likely led to more rapid downcutting and bank failure.

Presently, the creek seems to be deprived of larger sediment inputs from the watershed upstream, which is a natural consequence of the urbanization. Most of the larger sediment found in-stream seems to be generated from the collapse and break-down of the bank material.

Although this reach of Cerrito Creek is currently physically disconnected from the lower sections of Cerrito Creek by long culverted sections and some significant drops, as a principal we will attempt to retain connectivity within our site that will not further impair the possibility of future reconnection efforts. Though the possibility of fish ever settling this reach is remote at best, given the seasonality of flows, maintaining a good level of longitudinal connection between the distinct pools and lateral connectivity to the banks and riparian corridor is still important for species of amphibians, macro invertebrates, and others (Purcell, 2002). As such the proposal should avoid excessive drops and should whenever possible work with the slope to provide the required breaks in velocity without compromising connectivity. The planting scheme should create a healthy riparian corridor that will encourage a higher diversity of animal species. For this, it should include a variety of, preferably native, plant species, and a density of canopy that creates diverse degrees of sunlight and shade exposure.

Design Proposal

Based on the above channel analysis and discussion, we were able to produce a design proposal that promotes the restoration of the creek in compliance with the goals expressed in the problem statement: prevent further incision and bank failure, enhance habitat, and serve as an effective design within Blake Garden.

Opportunities & Constraints

We identified areas along the banks where there is space to widen the channel and create terraced floodplains (Fig 28). In some places, regrading is not possible on one or both sides of the channel without disturbing large trees, paths, or built structures. Reaches with incision and a relatively narrow corridor available between trees suggests the need for a more structural approach to minimize shear stress from high flows (See Fig 30 - 39 for design approaches that address opportunities and constraints).

Blake Garden's trees are an integral part of the Garden, and our design proposal honors a general principle to not disturb trees or their root systems to the greatest extent possible. We consider trees as constraints to regrading when evaluating design alternatives. One exception is the blackwood acacia (Fig 7), that will be removed.

While keeping in mind that the site has several constraints, such as garden structures or functions that will have to be preserved, our proposal follows the principles of an ecologically successful restoration (Palmer, 2005). As such, the accomodation of the peak flow should be produced with the least possible artificial structures, and reproducing as close as possible a healthy, laterally and longitudinally connected, creek corridor. Armoring of banks, for instance, is proposed only where necessary to ensure channel stability, given the identified constraints.

Fig. 29: Sample Plant List

Douglas spirea	*(Spiraea douglasii)*
willow	*(Salix* spp.*)*
sedges	*(Carex* spp.*)*
rushes	*(Juncus* spp.*)*
mock-orange	*(Philadelphus lewisii)*
spicebush	*(Calycanthus occidentalis)*
Oregon-grape	*(Mahonia nervosa)*
redwood sorrel	*(Oxalis oregana)*
sword fern	*(Polystichum mutinum)*
ladyfern	*(Athyrium filix-femina)*
giant chain fern	*(Woodwardia fimbriata)*
redosier dogwood	*(Cornus sericea)*
snowberry	*(Symphoricarpos albus)*
vine maple	*(Acer circinatum)*
western azalea	*(Rhododendron occidentale)*
coast rhododendron	*(Rhododendron macrophyllum)*
wild ginger	*(Asarum caudatum)*
trillium	*(Trillium chloropetalum*
lemonade berry	*(Rhus integrifolia)*
bigleaf maple	*(Acer macrophyllum)*
ocean spray	*(Holodiscus discolor)*
California buckeye	*(Aesculus californica)*
coast redwood	*(Sequoia sempervirens)*
coast live oak	*(Quercus agrifolia)*

Design Solutions and Alternatives

Allowing Q2 overbank flow: Based on field observations and interviews, we have reason to believe that the North Branch is facing increased rates of incision. Until 2009, high flows overtopped the bank in Reach 1, and spilled over to the ponding area on the adjacent property. The recent construction of a small levee prevents Q2 overbank flow, and concentrates flows in the channel during peak storm events. By removing the recently improvised levee from the south side of the North Branch at cross sections P & Q, the lateral connectivity to the ponding area could be restored. Reestablishing a partial Q2 overbank flow would reduce in-channel peak flow during intense storm events, and thus reduce the shear stress in the channel. In adidition, maintaining historic flow patterns avoids possible legal issues (keeping all water in the Garden when it used to partially flow to the adjacent property). The concept of restablishing this surface flow to the neighboring property, though, is not fully resolved, both in tecnical or in legal terms. As such, we shy away from proposing any concrete solutions that might prove an even more serious liability issue for the garden management, and dimensioned the channel to convey all the estimated peak flow, as described below.

Channel configuration: Whenever possible, our design proposal employs lateral expansion of the channel and floodplain. Larger floodplains would reduce velocities below the scouring threshold (less than 5 cfs), and provide some retention capability in situ. Where necessary, we recommend an intermediate solution of dispersed step-pools, wood weirs, or bioretention to maintain velocities below the threshold for scouring the banks.

Reach 4 and the South Branch are currently stable, and we do not recommend any intervention beyond planting. Reaches 2 & 5 will require more extensive regrading of the banks so as to create a lateral floodplain that will accomodate the peak flow, while keeping velocity below scouring, thereby stabilizing the channel with non-structural solutions. Reach 3, which is constricted, may require hard structural solutions such as rock-lined step pools, and concrete or gabion walls. Likewise, hard structural interventions may be required in reaches where channel slope is excessively steep and widening the channel would not permit an effective stabilization, such as Reaches 1 & 6. Stabilization of Reach 1 is especially urgent because continued upstream migration of the large headcut could result in the collapse of the upstream culvert and possibly severe damage to the public road.

Although our design proposal does not address this, we recommend that future design of this site considers restoring the previous hydrologic conditions by allowing overbank flow to the adjacent wet area. Overflow to the adjacent wet area serves a critical role in the creek's hydrology, and contributes to channel stability. Because our site is near the headwaters of the watershed, the time of concentration is short (16 minutes) (Fig 21). The ability for this wet area to continue to functionally retain water for even a few minutes could substantially reduce the rate of flow in the channel for short, intense rain events such as the rainstorm recorded on Jan 20, 2010 (Fig 22).

In addition, we recommend planting for bank and floodplain stabilization. Though invasive weeds (such as blackberry) are undesirable for ecological reasons, native riparian plants, such as willow, redtwig dogwood, and rushes, among others, could be used to introduce a moderate aditional roughness and resistance, reducing velocities, stabilizing banks, improving infiltration, and significantly improving its aesthetics. This vegetated "floodplain" will not only provide hydrologic benefits and possibly reduce the energy of water flowing in the channel, but will also create a riparian area for wetland plants and wildlife habitat. The channel should, where possible, be regraded to increase access to the creek, from the garden, and avoid the possibility of serious injury arising from the presence of steep drops.

On the reaches with reduced slopes (around 2%) and sufficient space for channel reconfiguration, we propose introducing a widened channel with terraces that becomes active during storm events likely to occur a few times each winter (Figures 33, 34, 35 & 40). Using Manning's equation, we iterated the cross-sectional profile to convey flows at velocities below 5 fps for a 100 year flow. These velocities were estimated to not provoke bank erosion, taking into consideration the material: hard clay, strongly colloidal (Fortier and Scoby, 1926).

In addition to non-structural measures, our site on Cerrito Creek will require in-stream structures in order to stabilize the channel. Structural interventions are proposed that will dissipate the energy of high flows in several locations (Reach 1, 3 & 6). Considering the site constraints and the slope, simply setting back the banks of the creek will prove insufficient, especially in the upper section, where there is a 6 foot vertical drop. Given these constraints, the step-pool configuration was elected as the most viable solution especially for the steepest reaches 1 and 6 (Figures 30, 31 & 32). Step-pools are very effective in reducing shear-stress over unprotected banks and the creek bed. The rationale behind the

Fig 30: Step-pool longitudinal section

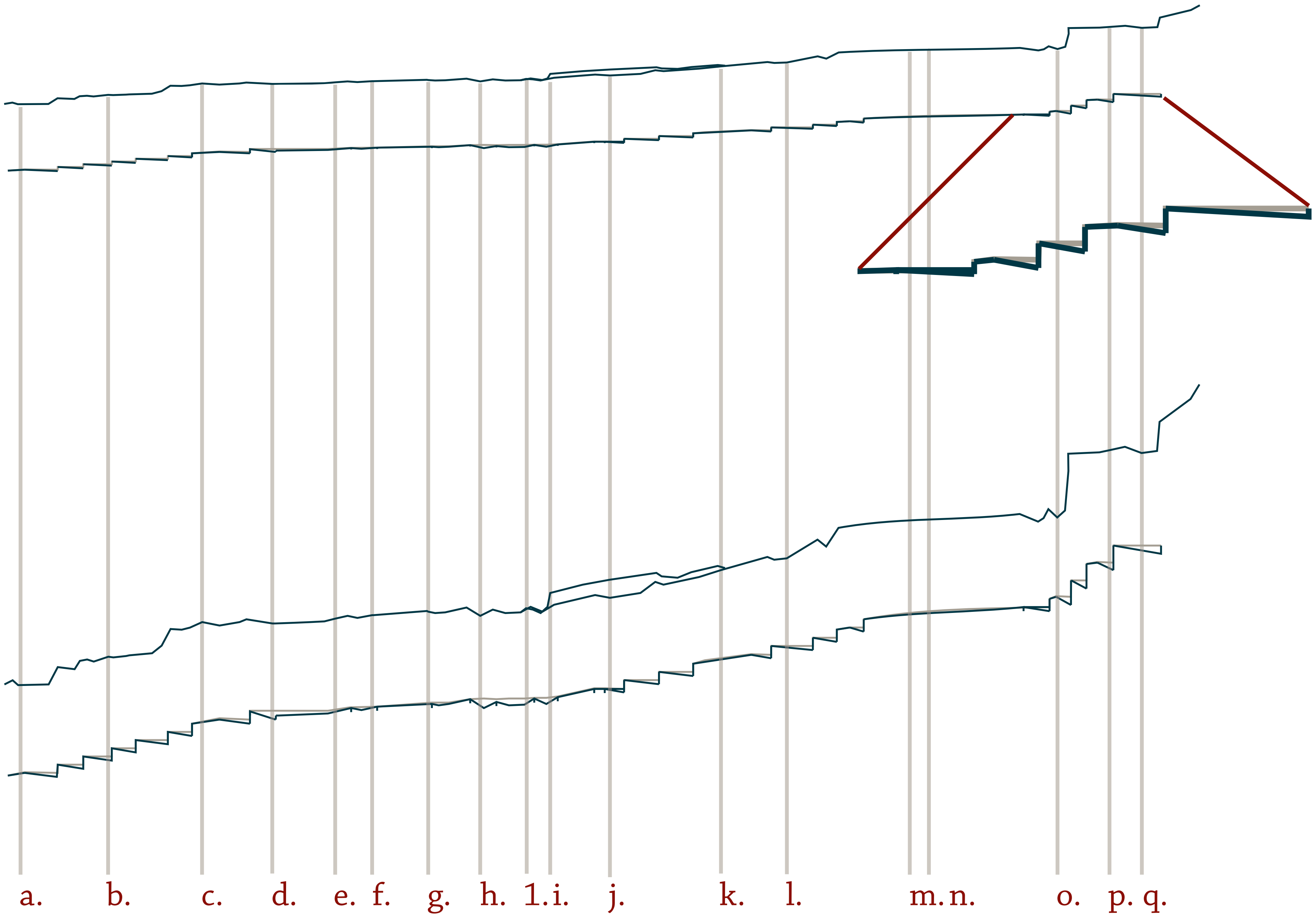


Fig 31: step-pool sequence
(Reach 1)

Fig 32: 2-foot step-pool
Section O (Reach 1)

A=15.05 sq ft
Q>95cfs
V>5.17 ft/sec

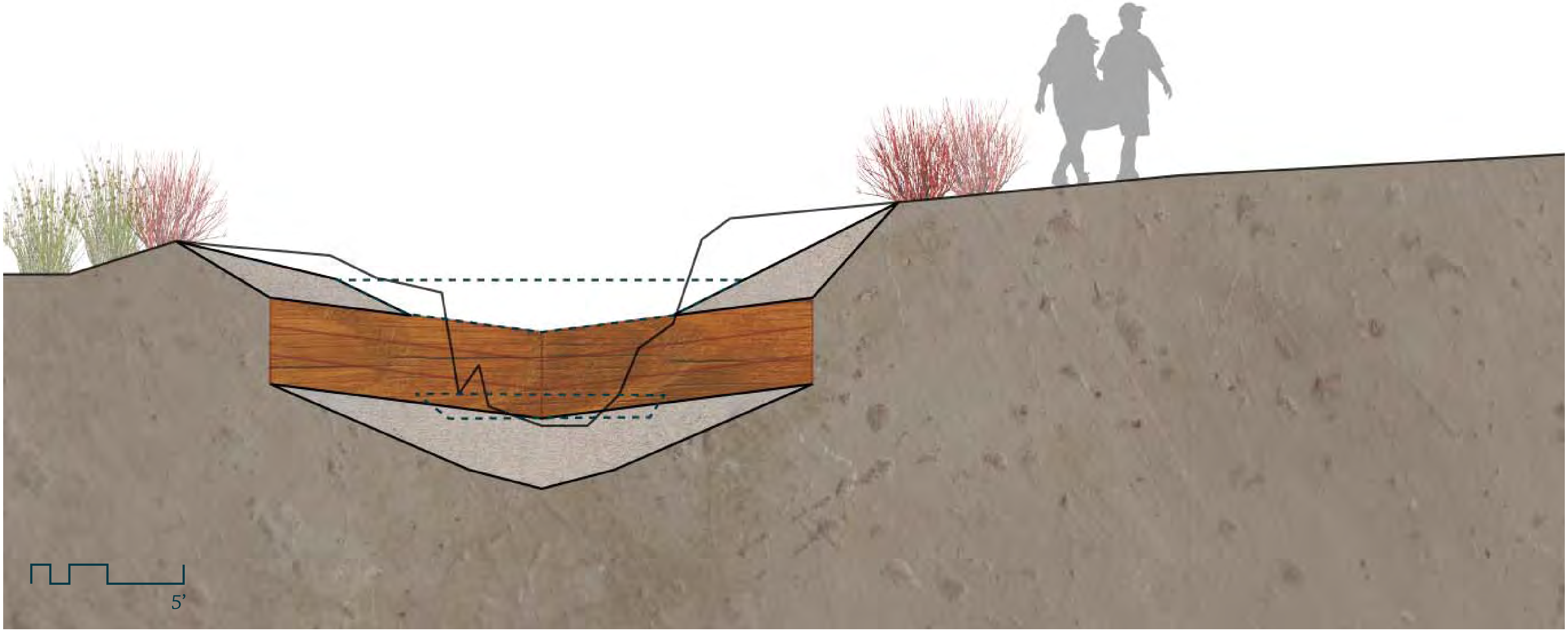


Fig 33: Creating Floodplain
Section N (Reach 2)

A=19.34 sq ft
Q=96.71cfs
V=5 ft/s

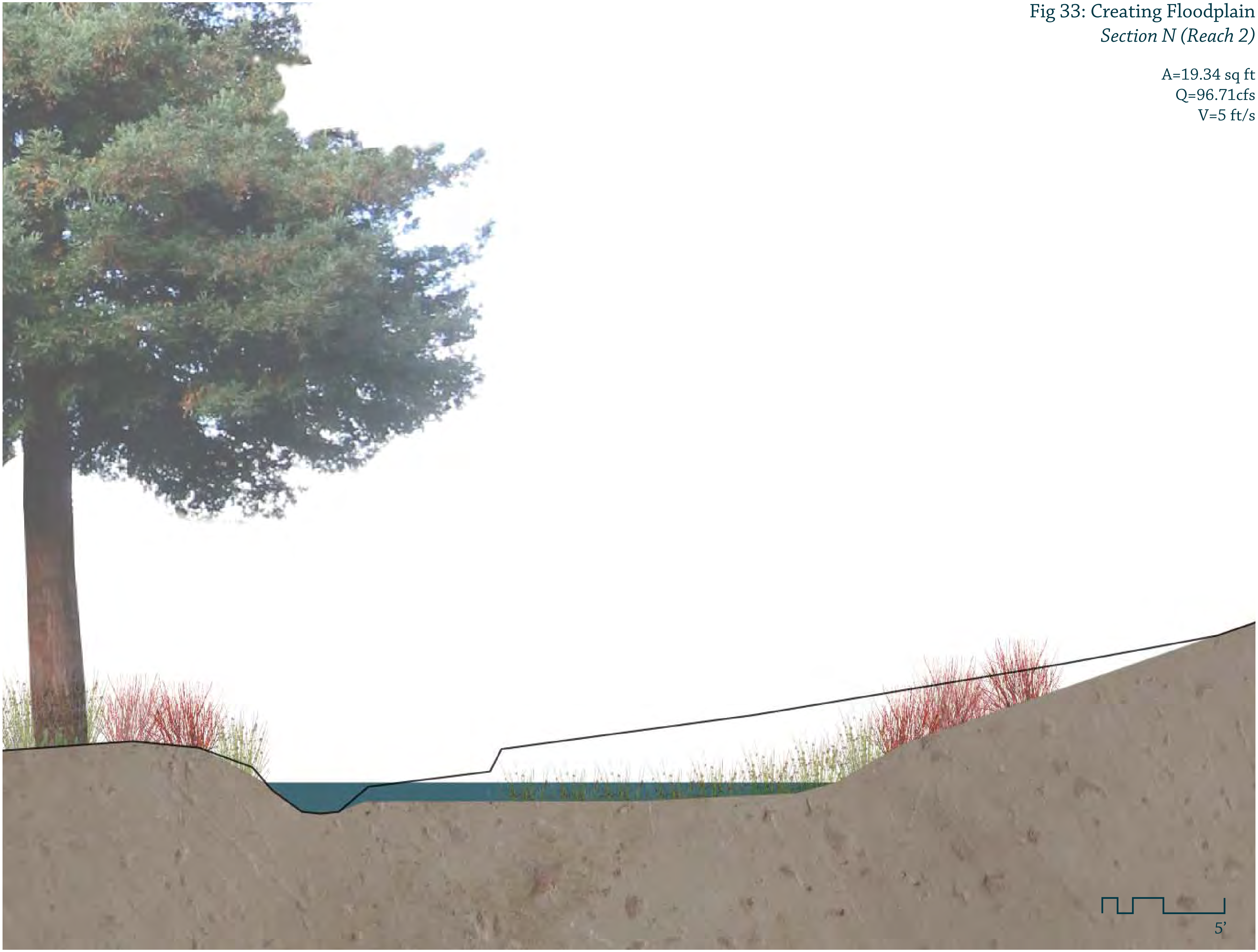


Fig 34: Creating floodplian

Section M (Reach 2)

A=18.95 sq ft
Q=94.25cfs
V=4.97fps

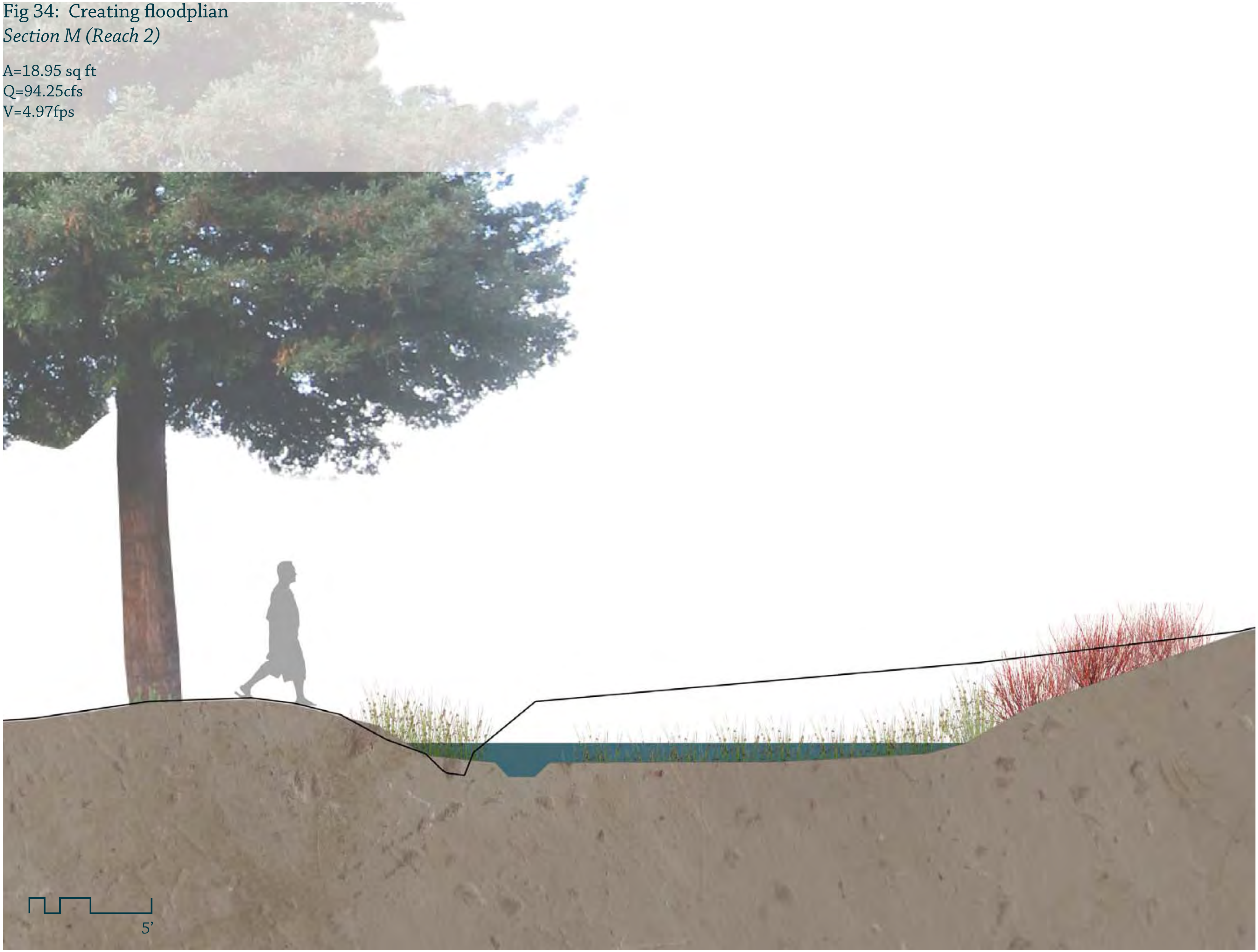


Fig 35: Stabilizing Banks With Mild Constraints
Section L (Reach 3)

A=18.86 sq ft
Q=94.78 cfs
V=5.03 ft/s

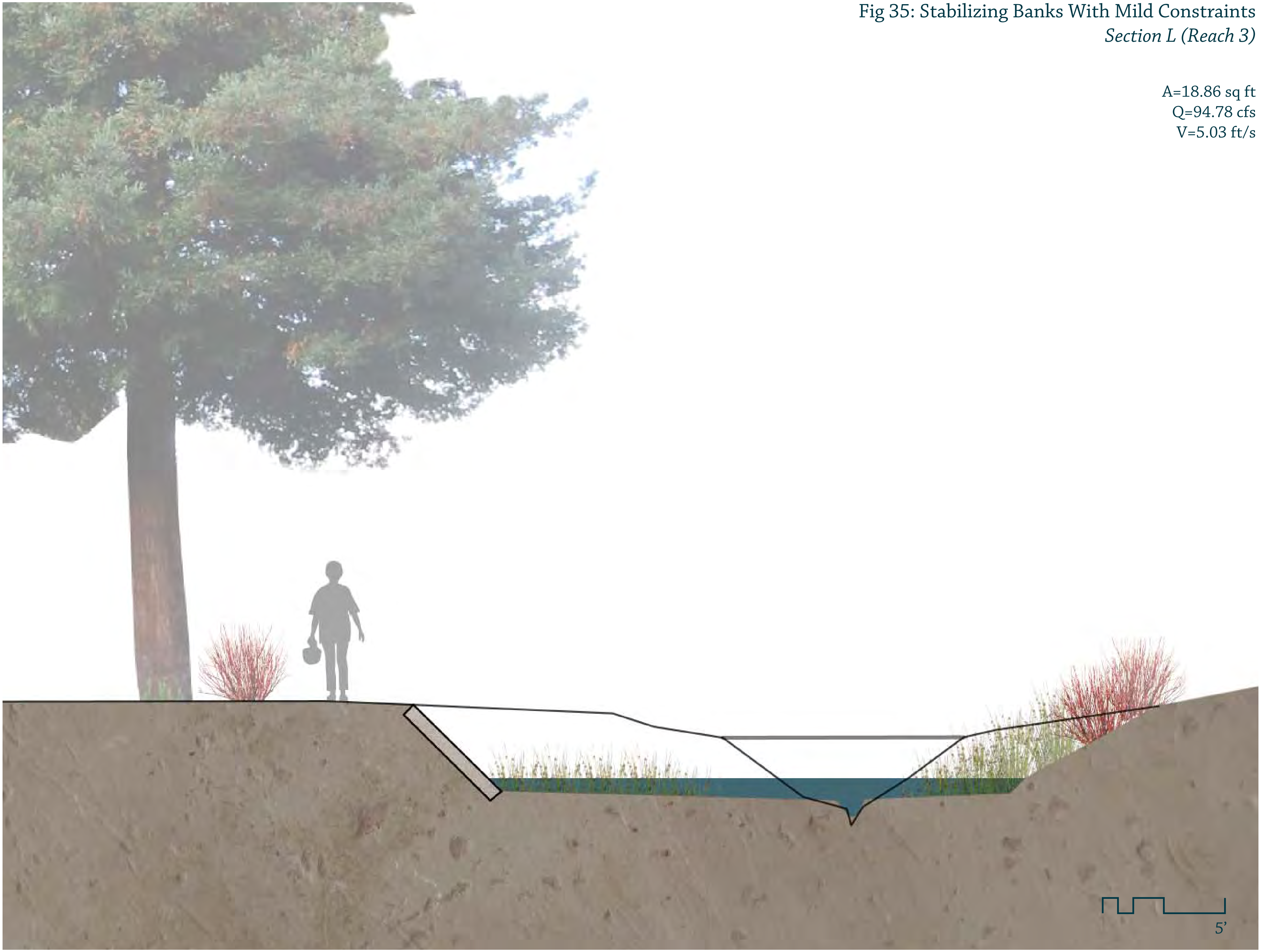


Fig 36: Stabilizing Banks With Significant Constraints

Section K (Reach 3)

A=12.98 sq ft
Q=95.16 cfs
V=7.33 ft/s

Fig 37: Protecting Garden Structures
Section H (Reach 4)

A=17.79 sq ft
Q=95.43 cfs
V=5.36 fps

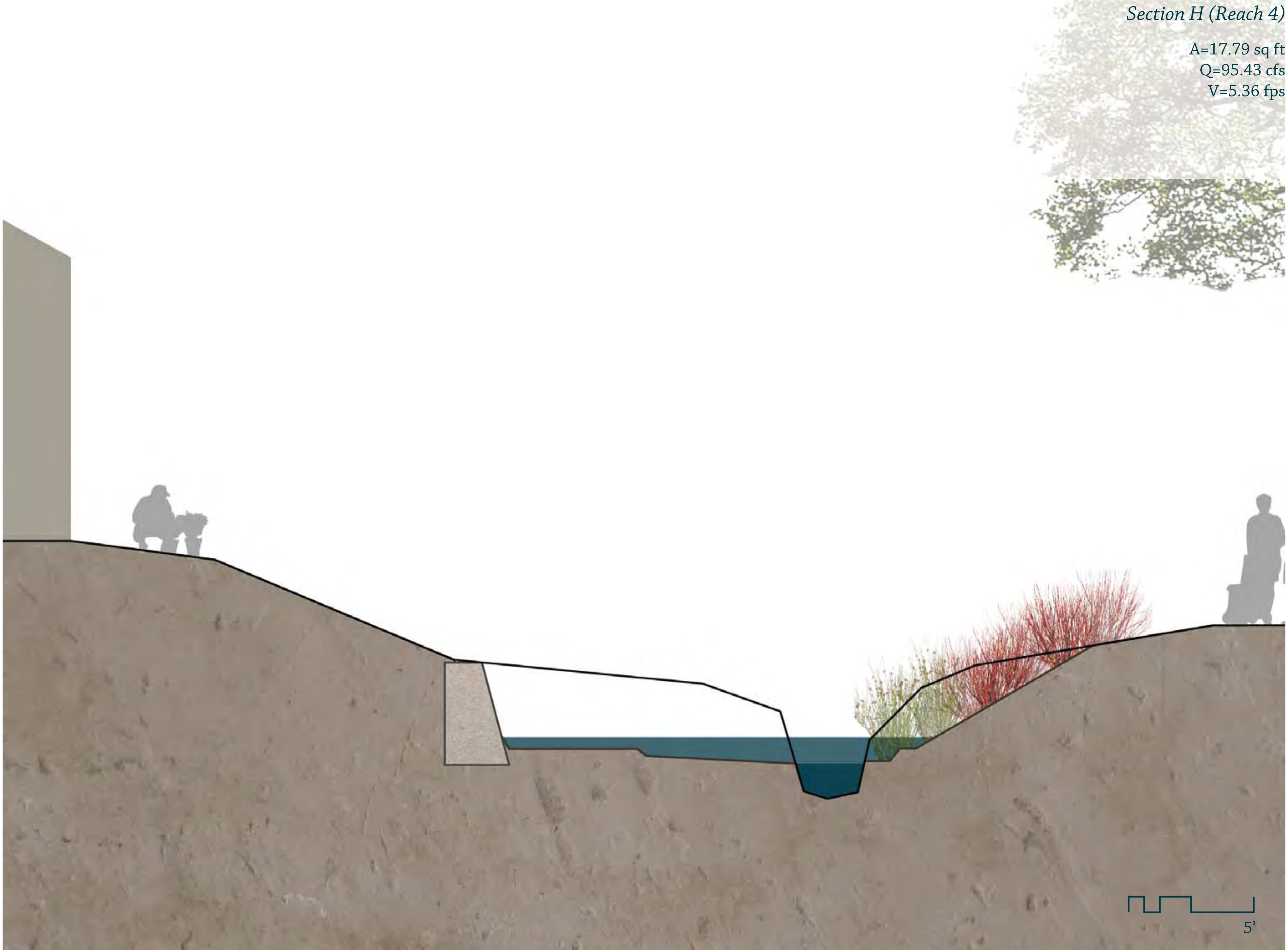


Fig 38: Protecting Garden Structures
Option 1, Section G (Reach 4)

A=14.27 sq ft
Q=96.48 cfs
V=6.76 fps

Fig 39: Protecting Garden Structures
Option 2, Section G (Reach 4)

A=14.27 sq ft
Q=96.48 cfs
V=6.76 fps

Fig 40: Engage Floodplain
Section C (Reach 5)

A=19.41 sq ft
Q=94.26 cfs
V=4.86 fps

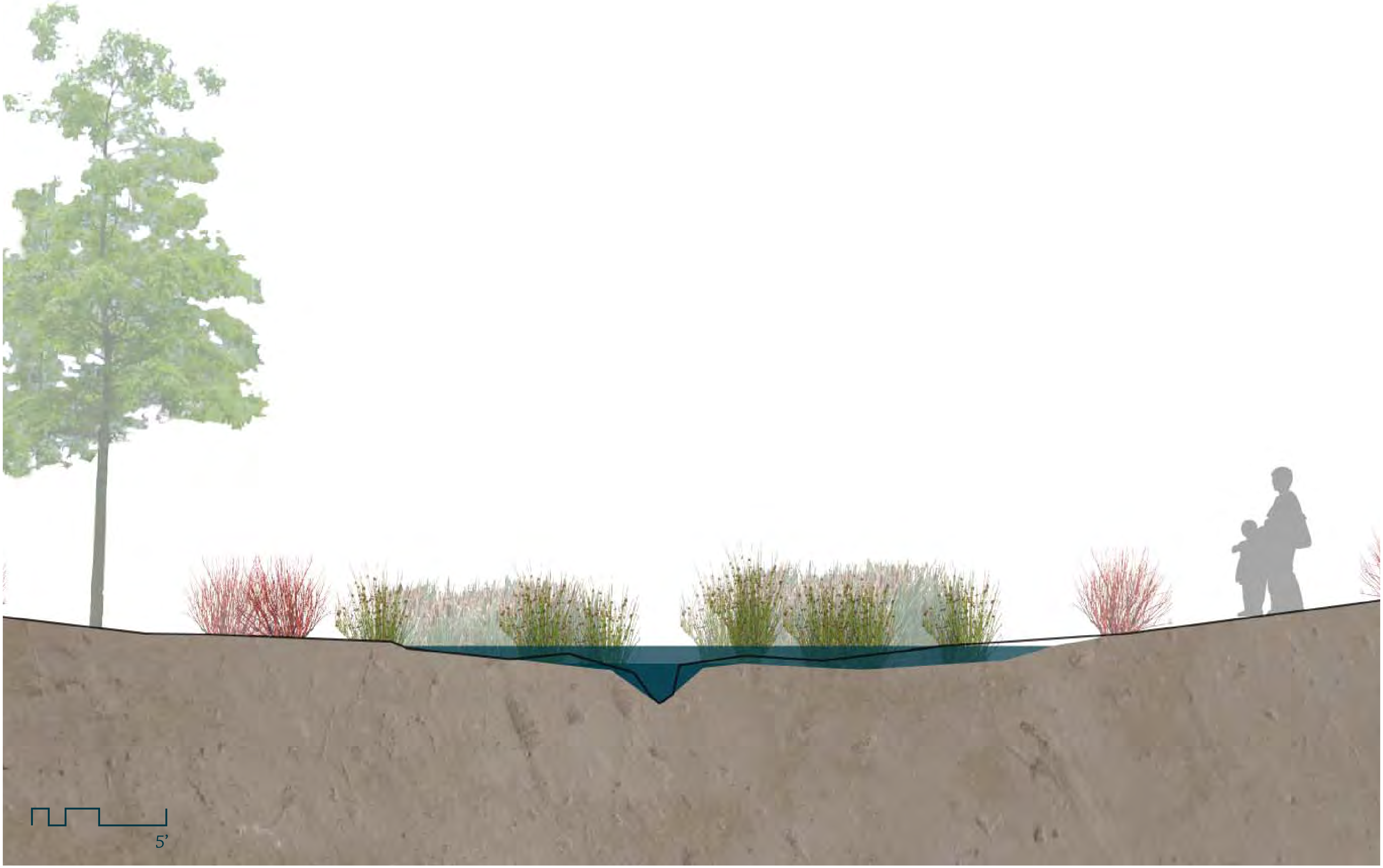


Fig 41: Plan Overview

Fig 42: Design Objectives

1. **convey Q100 (about 95 cfs)**
2. **stabilize banks and channel bed:**
    - a. widen channel and keep velocity below 5ft/sec
    - b. design step pool sequences
    - c. armor bed and banks where shear stress is excessive
3. **improve habitat:**
    - a. create a riparian corridor with native species
    - b. increase longitudinal and lateral connectivity
4. **integrate the creek with the garden:**
    - a. establish visual connections
    - b. create a valuable educational asset
    - c. introduce paths along the banks
    - d. increase safety by avoiding sharp drops

step-pool configuration is that energy can be dissipated over drops concentrated on steps that are armoured to withstand the added erosional energy (Chin, 2008). By dissipating energy in these specific sections, the remainder of the channel is subjected to less shear stress, as the water flows at reduced slopes in between steps. The steps should be anchored to prevent both undercutting and side-cutting on these areas of concentrated shear stress.

As we know little about the size or capacity of the retention pond on the adjacent property, and were unable to survey it, our proposed step-pool configuration is designed to stabilize all of the water entering the North Branch, without the added benefit of the adjacent retention area. As a result, the step pool design that we propose is quite robust and represents a significant intervention. If the final design incorporates overbank flow to the adjacent retention pond, construction of the step-pools proposed below may be scaled down, and the size of the drops could be reduced.

In our analysis of the long profile of the creek, we determined two critical areas for intervention. Reach 1 at the upstream extent of our site, where an initially flat area is succeeded by a six foot drop. The instability of the banks through undercutting and the continued incision is visible on both sides of the creek. The other area of concern is Reach 6, the downstream extent of our site, where where active headcuts are lowering the stream bed, as it tries to reach an equilibrium. In order to prevent further incision, the step-pool sequence for this reach, although not as dramatic in total drop as the upstream one, is essential for stabilizing the creek in a new equilibrium.

Chin et Al (2005;2009) and the author of the previous design proposal for the creek, Behrends (2007), describe an ideal range for step-pool dimensioning, a configuration that permits the greatest energy dissipation and provides the most stability. We recalculated the step-pool configuration taking into account the specific situation and average slope of Reach 1, and our design recommendation follows closely the design parameters suggested by these authors. We propose a standard step height of one foot, with a two foot drop solutoin being implemented only on the steepest sections (Figures 30, 31 & 32).

Our suggestion is consistent with the length-to-depth relation established as typical in Chin (2009), as for the average slope of .055, an average spacing of around 16.5 ft between steps will permit a H/L ratio of .061, that is, well within the .5 to 1 interval for the H/L to Slope ratio. Chin (2009) states this has been consistent with the proportions found to be the most stable and providing the best energy dissipation by various studies cited.

Given the uneven distribution of the steepest slopes along the creek, we suggest a sequence of 1 ft and 2 ft high steps in the upper reach, where the current 6ft drop as developed. Our step-pool typology could integrate unobtrusively into the landscape, using redwood logs, available on site, or stone steps combined with vegetating the banks above the normal water level (Fig 28).

All steps should be strongly anchored on the banks, through excavation of trenches to both sides of the step, installation of the logs and posterior stabilization of the banks with boulders. The side walls of the step and the bottom of the pool, right beneath them, should be stabilize with the installation of boulders and vegetation.

In Reaches 4 and 5, where the channel is narrowly constrained by trees and garden structures, bank stabilization through structural intervention is required. We propose retaining walls, that could be replaced with live staking on less vulnerable banks (Figures 36, 37, 38 & 39). Wherever possible, the use of materials that blend well with the garden's landscaping is preferrable.

Culverts: The culvert located upstream, where the North Branch enters the site (Reach 1) is undersized, shows extensive damage, and poses a threat to the road above. We recommended replacement in the near future. As mentioned before, the headcut immediately downstream should be stabilized in the near future, as it threatens to undermine the culvert and road.

The culvert under the bridge, between reaches 4 and 5, was identified in the modeling as acting presently as a dam in large storm events. The pipe is under-dimensioned, and peak flows back up behind the culvert. The culvert serves as a grade control, stabilizing the channel upstream. Therefore, removal of the culvert replacing it with a bridge must be preceeded by widening and stabilizing the channel, in reaches 4 and, especially, 5 and 6. Removing the artificial constriction caused by the culvert would drastically increase the in-channel peak flow downstream. Therefore, while replacing the culvert with a bridge is desirable, the reaches below the culvert should be carefully designed to withstand increased peak flows and restored before the culvert's removal.

Plantings

Blake Garden is maintained as a designed public garden and, as such, the goals of the design and the corresponding planting proposal will necessarily be distinct from many river restoration projects in several important ways. Plantings can expect to benefit from more care and long-term maintenance than other, more remote sites, including weeding, watering and pruning as necessary. Plant selection can reflect this. In addition, the planting plan must contribute to the ecological restoration goal.

Strategic planting design and plant selection should become a centerpiece of the design concept. As Cerrito Creek provides habitat and connects to other natural areas, we propose planting exclusively with native plants, and using this area of the creek as an exhibit of a native plant garden. Our design draws from the successful example of streamside plantings in the nearby Tilden Botanic Garden. The distinct microclimates on our site offer the opportunity to group plants reflecting different communities of native California vegetation.

The plants we propose will additionally support wildlife. Native plants provide shelter and food for the wildlife that live in the Garden and in the creek, including fish, amphibians, invertebrates, birds and mammals.

Planting in this area should contribute to the geomorphic goals of the restoration project. Red-osier dogwood (Cornus sericea) and willow (Salix spp.) grow aggressive root systems along waterways, and increase bank stability. In addition, plants on the banks and the floodplain increase roughness, slowing flows and retaining water on the constructed floodplains during high water events. (Fig 29)

Final Design

The proposed restored cross sections and plan view are reproduced in Figures 30 through 40.

We recommend replacing the top culvert, and introducing one- and two-foot armored step pools in the location of the large head cut just below the culvert in Reach 1. This should be followed by a gentle step pool sequence through Reach 2. In addition, we recommend incorporating a small channel that accomodates stormwater from the driveway, as well as an overflow breach that allows overflow to the adjacent property in a Q2 storm event. Throughout Reach 1 and Reach 2, we recommend widening the channel to create a terraced floodplain. (Fig 31 - 34)

In Reach 3, banks that are close to existing mature coast live oaks and coast redwoods should be stabilized with either rock or wood walls, combined with bioretention, small terraces, and step-pools where possible. (Fig 35, 36)

Reach 4 is stabilized by the culvert that serves as a grade control, and benefits from large, healthy trees. Because of the stability of this reach, we do not recommend regrading or bank reinforcement, and suggest establishing appropriate vegetation in this reach as soon as possible.

Below the culvert in Reach 5, the in-channel velocity appears slightly above the scouring limit, resulting in some incision and head-cutting. We recommend selecting a few points for one-foot step poools. In this area, there is an existing active floodplain, and we recommend regrading as necessary to maintain lateral connectivity. (Fig 40)

In Reach 6, the channel slope begins to increase. There is a large head cut that appears to be migrating upstream, though it is stablized in some places by large rock. We recommend a series of 1’-2’ step-pools to stabilize this section as needed.

Recommendations

Neighborhood Stormwater Retention

Because increased runoff from upstream development is the primary cause of strain to the system, reducing flows by increasing infiltration and retention within the watershed would be the ideal scenario. However, it is beyond this project's scope to propose changes in land use outside of our site. In the future, it may be possible to work with institutions and residents upstream to manage stormwater onsite, and thereby reduce peak flow.

Monitoring, Analysis and Design

Student Involvement/ Coursework Integration: Students in the Landscape Architecture and Environmental Planning Department and other UC Berkeley students are uniquely situated to participate in the design and implementation of restoration work in Cerrito Creek. The creek presents excellent design, monitoring and analysis opportunties for students in courses covering river restoration, planting design, topography and grading, hydrology, ecological factors, and structural engineering.

Monitoring: We identified with non-permanent markers the locations of all the suvey's cross-sections on site. We recommend placing permanent markers at these locations. This would allow others to replicate easily our survey, and determine the rate of change in the channel. In addition, we recommend developing a schedule for future surveys and photomonitoring to document conditions, and determine the rate of changes in the channel.

Adaptive Management

It will not be possible to implement design interventions throughout the creek immediately. Phases will likely be prioritized based on available funding, permitting, need, cost, and current risk to public safety. As phasing will likely occur over many years, we recommend adaptive management to determine whether interventions are working, and what could be improved. The first priority should be the stabilization of the headcut in Reach 1. The threat to a public road and storm drain underline the urgency of this intervention. Likewise, the headcuts in Reach 6 are rapidly migrating upstream, and will likely perturb the now-stable Reach 5. As such, a second priority should be the stabilization of these reaches. Other interventions could be scheduled according to the Garden's capabilities and should be accompanied by the redesigning of the adjacent areas of the garden, namely through the extension of the garden's footpaths along the banks of the restored creek.

Material Re-Use

Where possible, we recommend incorporating "urbanite" and sack-crete into the new channel design, with appropriate aesthetic integration or, depending on the funding available, removing this material and replacing it with another, more appropriate to a Botanical Garden.

Program and Circulation

Garden Entry: The creek enters the garden in close proximity to the main pedestrian entrance. We recommend coming up with a final design that effectively integrates the creek with visitor circulation, functioning as an attractive entrance to the garden. A thoughtful entry design will create a sense of arrival, and introduce visitors to the Garden through a path along the riparian corridor. A combination of attractive channel restoration and a thoughtful plant selection will draw visitors in.

Children's Play Area: Currently, the children's play area located around the large oak tree near Reach 3 is defined on the creek side by a steep bank that drops over 6 ft. This drop is identified only through a low row of rocks. These safety concerns should be addressed, by moving this play area to a safer location, introducing a secure barrier, or throughly reconfiguring the banks to reduce the slopes and create safer terraces and lower drops. This last option may be incompatible with the need to protect the mature oak's root system.

Transition: Reach 5 situated below the 'bridge' culvert is almost level with the formal area of the garden, the proposal should address further integration of the creek in the garden's design.

Planting

Master Plan: A good next step in the development of a master planting plan would be to list native plants appropriate for floodplain and bank areas, as well as sun and shade, and that meet other programmatic and design goals. Plants could be assigned to zones along the creek, floodplain, and upland areas in the initial planting master plan.

Initial Phase: Because we do not advise structural channel interventions or regrading in either Reach 4 or the South Branch, we recommend planting these reaches as soon as possible. Planting is relatively inexpensive compared to other channel interventions, will supress weeds, guard against future erosion, and provide a tangible example of the future possibilities of the restoration project as a whole. In addition, Reach 4 is in a visible location near the road crossing, and will draw attention.

Naming the Creek

Coming up with a name for the creek will work towards making the restoration project memorable, add to the public percpetion of its importance, and inspire future projects.

Conclusion

Determination, vision and hours of labor drove the ambitious project to clear blackberry around Cerrito Creek and spark interest in its restoration. Stabilizing the channel and restoring its ecologic function will require even more. A successful project will require creative engineering, thoughtful design, funding, and time.

Our project is only one step in this process, but it is a good start and we hope it will help the Garden's management gather support and funding for further detailed studies and eventual restoration.

Though this poses a challenge, it also presents an unparalleled opportunity for students in Landscape Architecture and other departments at UC Berkeley: the chance to see hydrology and hydraulic calculations completed in the classroom influence a design that will eventually lead to implemention of urban creek restoration is rare. The location of the site is not in a remote corner of the garden, but at the main pedestrian entryway. We hope that students in future classes take on this exciting design project, and keep it alive.

Sources

Alameda County Hydrology and Hydraulics Manual Hayward, CA (2003).

Behrends, Nathaniel Cerrito Creek Step-Pools: An Opportunity for Restoration and Education at Blake Garden. eScholarship, University of California (2008).

Brown, K. B. Urban Stream Restoration Practices: An Initial Assessment. Center for Watershed Protection.

Buffington, J. M. and D. R. Montgomery A procedure for classifying textural facies in gravel-bed rivers. Water Resources Research, 35(6): 1903–1914 (1999)

Chin, Anne, et al. Linking Theory and Practice for Restoration of Step-Pool Streams. Environmental Management (2008) 43:645-661.

Chin, Anne and Wohl, Ellen, Toward a theory for step pools in stream channels Progress in Physical Geography (2005) 29, 3:275-296.

Contra Costa County, “www.co.contra-costa.ca.us” (May 2010) <http://www.co.contra-costa.ca.us/index.aspx?NID=893>

Dunne, Thomas and Leopold, Lunna B. Water in Environmental Planning. W.H. Freeman and Company, New York, (1978) 687-710

Field Procedure: Pebble Count, 11th Ed.: http://www.clallam.net/streamkeepers/assets/applets/PebbleCt.pdf

Ludy, Jessica and Podolak, Kristen Restoration with Reference: Rediscovering Cerrito Creek in Blake Garden. eScholarshi, University of California (2007).

LAEP, “Blake Garden”, 2009. Berkeley, CA, (May 2010) <laep.ced.berkeley.edu/blakegarden/>

Purcell, A. H. et. al. An Assessment of a Small Urban Stream Restoration Project in Northern California. Restoration Ecology 10(4): 685–694. (2002)

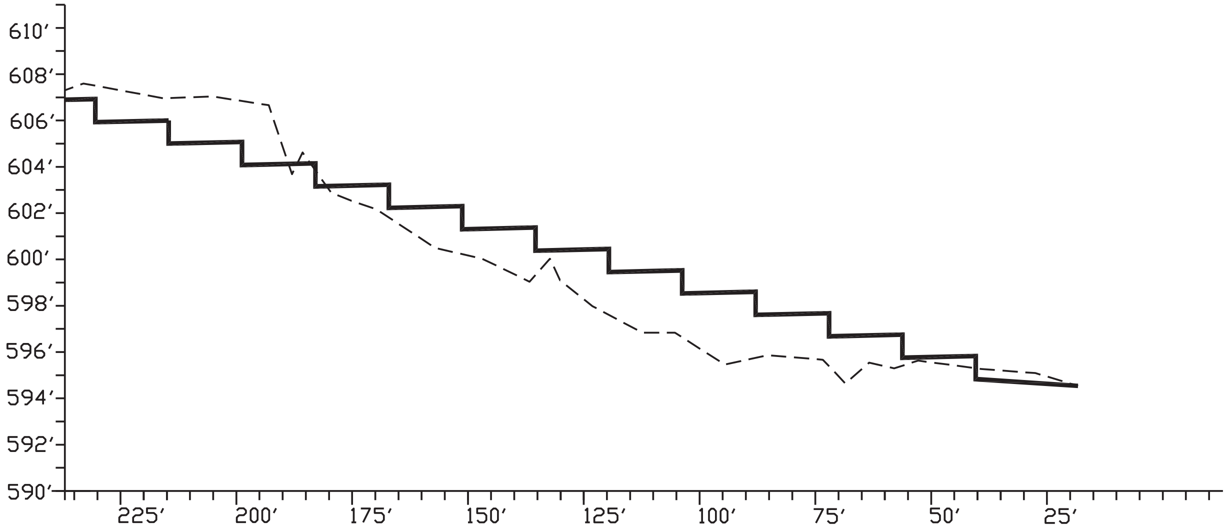
State of California, “cdec.water.ca.gov”. Department of Water Resources, CA (April 2010) <http://cdec.water.ca.gov/jspplot/jspPlotServlet.jsp?sensor_no=11196&end=01%2F20%2F2010+12%3A00&geom=medium&interval=3&cookies=cdec01>.

Walsh, C. J. et al. Stream restoration in urban catchments through redesigning stormwater systems: looking to the catchment to save the stream J. N. Am. Benthol. Soc., (2005), 24(3) : 690–705

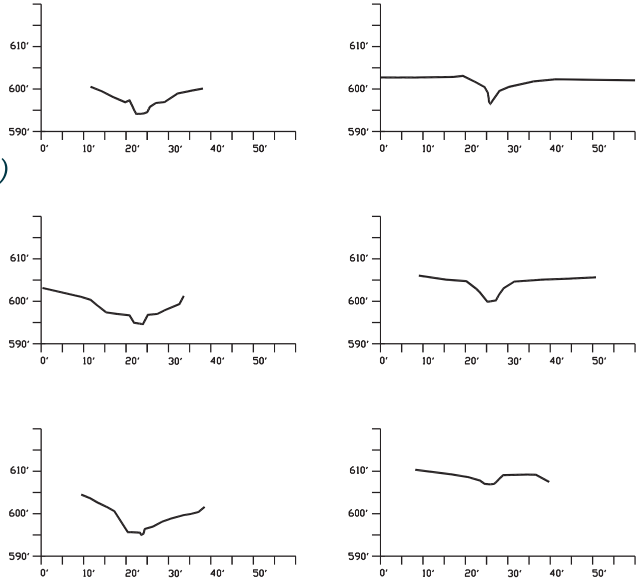
Wolman, M. G., 1954. A Method of Sampling Coarse River-Bed Material. Transactions of the American Geophysical Union 35(6):951-956.

Fig 43: What's Been Done So Far: Survey & Step-Pool Design

(source: Podolak & Ludy)



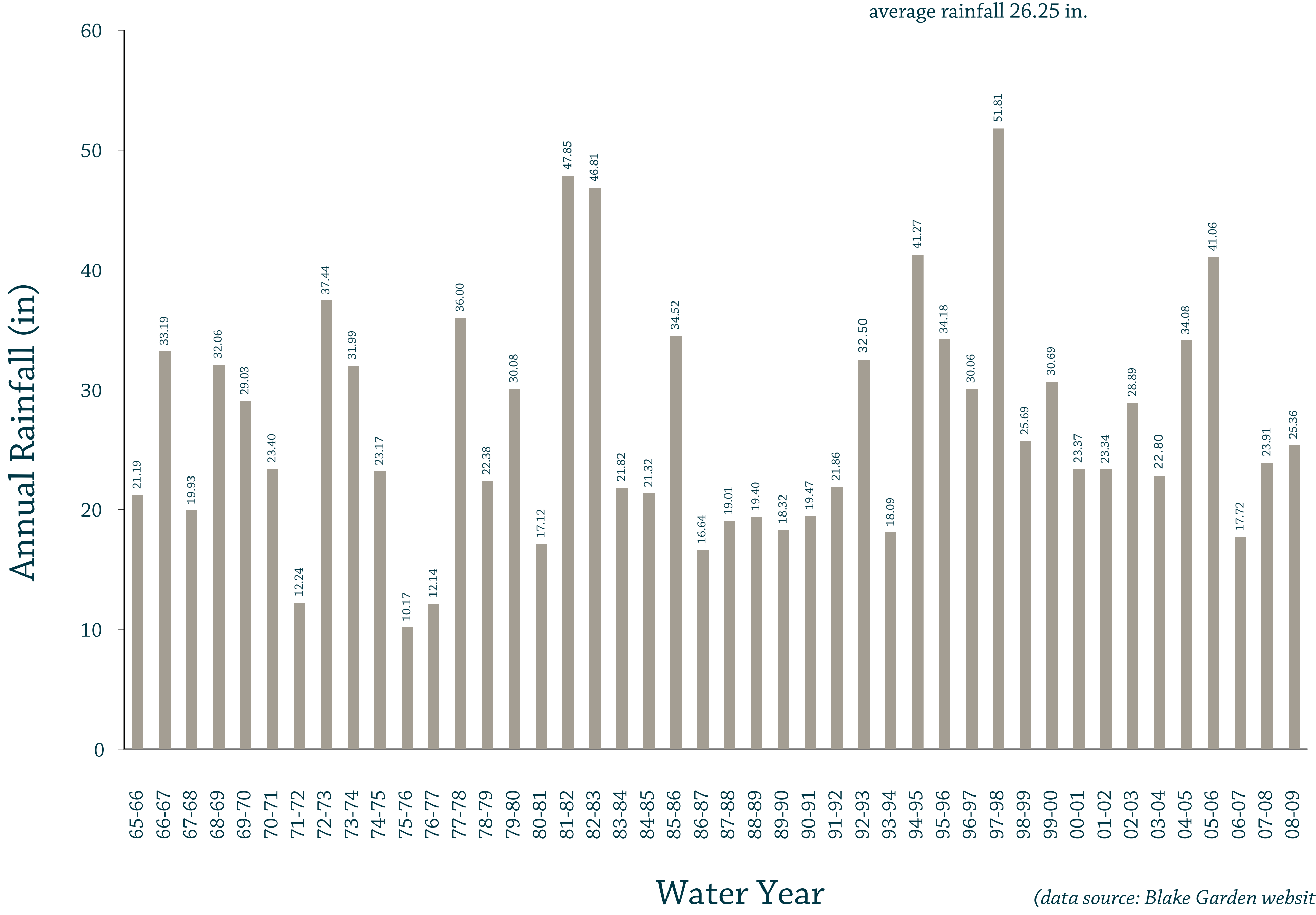
(source: Behrends)



(source: Behrends)

(source: Behrends)

Fig 44: annual precipitation @ Blake Garden, 1965-2009



(data source: Blake Garden website)