Title

Post-Project Appraisal of Arroyo Viejo Creek Improvement Project, Oakland, California

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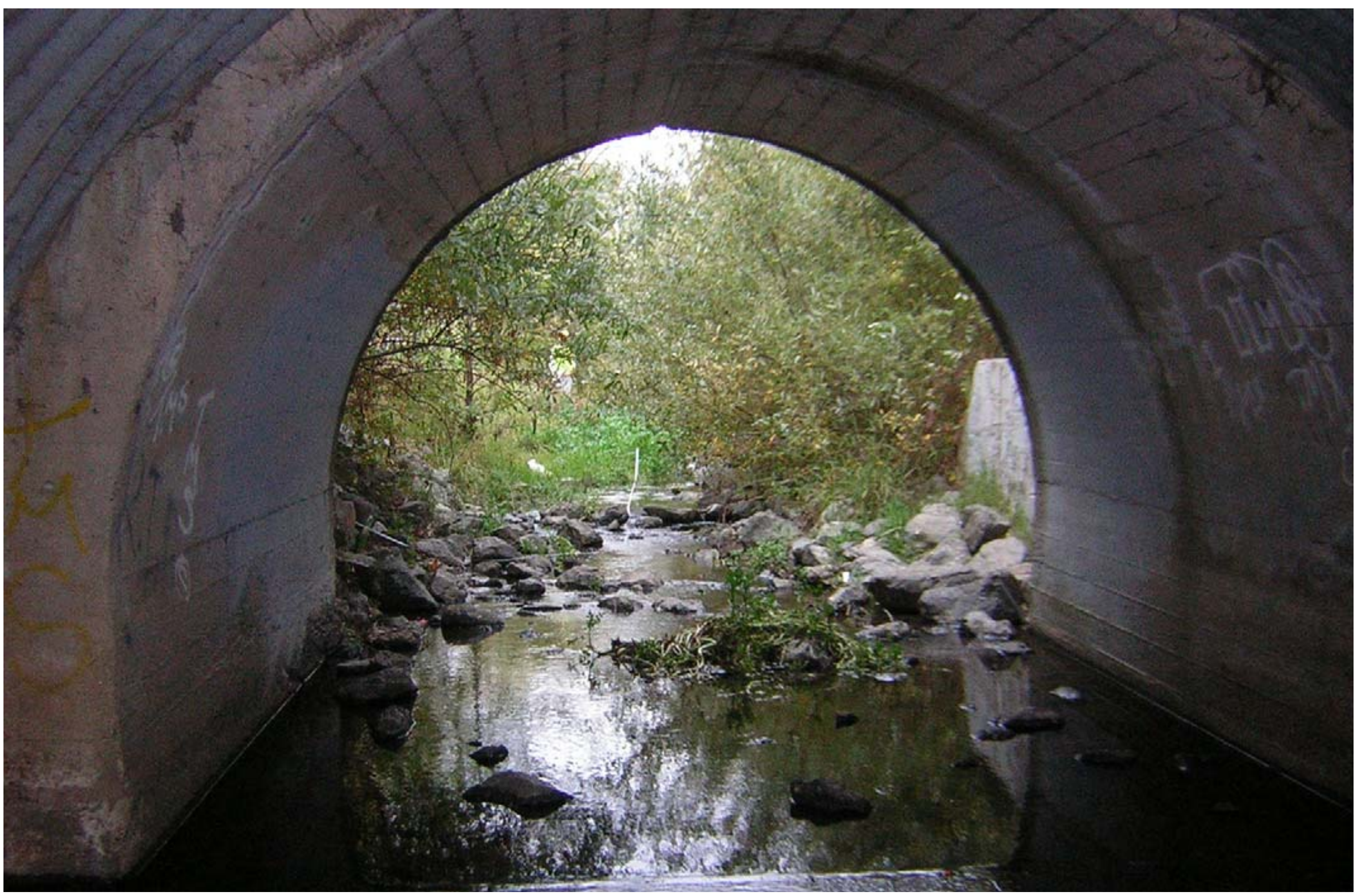

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Abstract

Our Post-Project Appraisal assesses the performance of the Arroyo Viejo Creek Improvement Project, located in Oakland, Alameda County, California. We evaluated the project based on seven goals identified by the lead design firm Wolfe Mason Associates in project planning documents, though most of the goals did not have identified targets and/or quantifiable metrics. Two clear goals evaluated in this Post-Project Appraisal were geomorphic streambank stability and riparian habitat enhancement through the replacement of non-native plant species with native species. To assess geomorphic stability, we surveyed the site and compared current conditions to designed and constructed conditions. Also, we conducted a vegetation survey to quantify the success of planted native vegetation. Three years after its completion, the Arroyo Viejo Creek Improvement Project has a mixed outcome. One of the key goals of the project was habitat enhancement; there seems to be an unstated assumption that native vegetation recovery alone would signal this improvement. The assemblage of native vegetation is well established and represents about 50% of the vegetative cover, but its growth lags behind the target level of 70% cover after three years, and invasive non-natives are a continuing threat. Another key goal, channel stability, is being met throughout most of the site, but there are regions of localized scouring that indicate insufficient bank protection. Finally, invasive aquatic vegetation on the site (primarily watercress) is capturing trash, potentially degrading water quality as a result.

Introduction

Background

The Arroyo Viejo Creek Improvement Project was implemented in 2001-2002 by the City of Oakland and Alameda County Public Works Agency to enhance an approximately 750-foot stretch of urban creek in Arroyo Viejo Park. The project included partial removal of concrete channel walls in the eastern half of the project area, re-grading and re-vegetation of channel banks, and installation of park enhancement features. These modifications were intended to provide environmental benefits like habitat improvement, long-term bank stability, and improved water quality, as well as enhancing public safety and access.

Arroyo Viejo Creek originates in the East Bay hills near the Oakland Zoo, and flows to San Francisco Bay (Figure 1). Oakland has a Mediterranean climate with an average annual rainfall of about 23 inches (WRCC, 2005). The stream is not gauged, but the Waterways Restoration Institute estimated a 1.5-year return period flow ($Q_{1.5}$) of 440 ft^3/s using regional regression analysis (WRI, 2000). At the restoration site in Arroyo Viejo Park in the Elmhurst neighborhood of the East Oakland flatlands, the creek has a drainage area of approximately 5.6 mi^2 (WRI, 2000). Arroyo Viejo Creek is an integral part of the city's storm water conveyance system, so its ability to safely transmit peak flows is important.

Prior to its 2001 rehabilitation, this reach was fully contained by a concrete channel east of Krause Avenue and partially contained west of Krause Avenue (WMA, 2001; see Photos 1 and 2). These creek containment structures were constructed by the Works Progress Administration in the 1930's. However, modifications to the creek likely predated that era. For example, a topographic map from 1897 (Figure 2) shows the creek disappearing underground, instead of reaching San Francisco Bay. The Arroyo Viejo Park area was rapidly urbanized in the early 1940's, as evidenced by aerial photography from 1937 and 1946 (Figure 3). As a result of this development, some of the mature tree canopy was lost to create space for home construction. However, by 1981, trees planted in Arroyo Viejo Park had provided a new canopy, which was partially removed during construction (Figure 4).

Problem Statement

Monitoring the performance of urban creek restoration projects is important for the maintenance of individual projects, but it is even more important for the field of stream restoration to advance as a whole. To assess the outcome of the Arroyo Viejo Creek Improvement Project, we must first understand the intent of the project. The project had the following seven objectives, according to the design concept document (WMA, 2001):

- Restore native riparian plant species;
- Enhance and restore habitat for terrestrial and aquatic species;
- Restore hydrologic function to Arroyo Viejo Creek for safe storm-water conveyance, sediment transport (dynamic equilibrium), and improved sediment quality;
- Restore a stable channel profile and meander sequence which transitions smoothly and safely between the reaches upstream and downstream of the restoration site;
- Re-establish a stable channel and banks (including removal of sections of existing WPA-era concrete and mortared stone walls);
- Provide long-term erosion control;
- Incorporate appropriate recreational amenities such as trails, footbridges, overlooks, and interpretive signage.

Although project planning documents state that post-construction monitoring "will be an important component to the Arroyo Viejo Creek restoration project" (WMA, 2001), formal monitoring efforts have been limited to native vegetation survival and re-planting due to grant-related funding restrictions (A. Schwarz, City of Oakland, personal communication, Oct. 2005). The lack of a comprehensive monitoring program makes the task of assessing the performance of the project design and overall success of achieving the project goals difficult, limiting the project's learning benefits for future restoration efforts.

To capture field data that can be used to measure the attainment of the project goals and validate the performance of the designed renovated creek system, we conducted a Post-Project Appraisal (PPA) of the Arroyo Viejo Creek Improvement Project. Our appraisal, which is presented in this report, includes a comparison of the site's current physical condition with the designed and constructed physical conditions.

Methods

We collected documents from the planning, design, and construction phases of the project, and then compared the planned outcomes described therein with post-project conditions as established by a field survey conducted in November 2005. We used the project goals and constraints as the criteria for interpreting success. Details of the methods utilized to collect data for the project are presented in this section.

Document Collection

We compiled existing documentation for the project to gain an understanding of its development, design, construction, and monitoring. Ali Schwarz with the City of Oakland provided documents related to project vision, design, and monitoring. James Yoo with the Alameda County Public Works Agency provided as-built documentation. Additional documentation, collected as part of a previous LAEP 227 student project, was available at the Water Resources Center Archives at U.C. Berkeley. We reviewed survey data collected by Jesse Kupers (2001) during project construction. These background documents were the basis for establishing our field data collection program. A summary of the data used in formulating our field data collection program is presented in Table 1, below.

Table 1: Available Data to compare with Post-Project Appraisal Survey

Data Type	**Sources of Information**
Long Profile	• Pre-project: Long profile in hydrology report (WRI, 2000) • Pre-project & Design: Long profile in project plans (WMA, 2001) • As-Built: Long profile in student project report (Kupers, 2001)
Cross Sections	• Pre-project & Design: 6 cross sections in project plans (WMA, 2001) • As-Built: 6 cross sections, 4 at different locations than plans (Kupers, 2001) • Post-project: 5 cross sections from Kupers (2003)
Pebble Counts	• Post-construction: Pebble counts at 6 locations (Kupers, 2001)
Feature Mapping	• Design: Rock riffles and bank protection included as construction change order (WRI, 2001a) • As-Built: Narrative description in Kupers (2001)
Vegetation	• Pre-project: Tree survey in project plans (WMA, 2001), Aerial Photography (1981), photos in Kupers (2001) • Design: Re-vegetation plan description and project plans (WMA, 2001) • Post-construction: Vegetation survival monitoring data (City of Oakland, 2005)

Survey Methods

Our field data collection program consisted of surveying a long profile and cross sections, pebble counts, feature mapping, and a vegetation survey. We selected these methods based on the identified project goals and the availability of comparison data. We did not collect macroinvertebrate or hydrologic data because there was no reliable basis for comparison with pre-project or as-built conditions.

We surveyed the longitudinal profile and nine cross sections using a theodolite and stadia rod. The primary benchmark used during the field survey was the southeast corner of the concrete amphitheater structure, which is at elevation of +101 feet according to the (apparently arbitrary) datum of +100 feet used in the design drawings. (WMA, 2001). We surveyed a longitudinal profile of the project reach by collecting points and measuring water depth along the middle of the wetted channel, and we identified station locations along the long profile and cross sections using a measuring tape. Trends for the cross section were noted using a hand-held compass and are shown in Figure 6.

Each of our pebble counts consisted of a random sample of approximately 100 grains along a cross section or bar. We followed the method described by Kondolf (2005), measuring the size of the b-axis in half-phi classes down to 4 mm.

We performed a vegetation survey by dividing the site into seven planting areas and identifying the percentage cover by natives and non-natives. The planting lists provided in the design drawings and by the City of Oakland served as the native plant guide.

Performance Measures

Most of the project performance measures originate within the project permits, not the design documents. For example, the Army Corps of Engineers (USACE) permit required erosion control during construction, monitoring of vegetation survival and channel stability for five years after construction, and annual reports with color photos (USACE, 2001). Similar monitoring requirements are echoed in the Regional Water Quality Control Board permit (CRWQCB, 2005) and in the California Department of Fish and Game permit (CDFG 2001), which in addition sets a target of 70% native vegetation cover after three years. Other than these permit conditions, the overall goals for the project were qualitative, not quantitative. An example of a qualitative goal presented in the project overview is the opportunity for "comprehensive hydrological, habitat, and native plant restoration" (WMA, 2001). Metrics for assessing the impact of the restoration activities were not presented. The planning documents do not define the difference between habitat and native plant restoration; instead, there seems to be an assumption that the two are equivalent. The performance measures that we used to evaluate the project are listed in Table 2.

Table 2: Performance Measures

Objectives (WMA, 2001)	**Performance Measure**
Restore native regional riparian plant species	Percentage cover of restored native vegetation. CDFG requires 70% cover after 3 years.
Enhance and restore habitat for terrestrial and aquatic species	Qualitative assessment
Restore hydrologic function to Arroyo Viejo Creek for safe storm-water conveyance, sediment transport, and improved sediment quality	Conduct pebble counts to quantify changes in sediment characteristics, and qualitatively assess others
Restore a stable channel profile and meander sequence which transitions smoothly and safely between the reaches up and downstream of the restoration site	Evaluate change in long profile over time
Re-establish a stable channel and banks	Evaluate change in cross sections over time to assess stability
Provide long-term erosion control	Evaluate change in long profile and cross sections
Incorporate appropriate recreational amenities such as trails, footbridges, overlooks, and interpretive signage	Qualitative assessment of recreational uses and signage

Results and Discussion

Long Profile

Over the project reach in Arroyo Viejo Park, the bottom elevation dropped from + 92.8 feet to +87.2 feet, which corresponds to an elevation drop of 5.6 feet over a distance of approximately 800 feet and yields a slope of 0.7 percent. Our study was in agreement with previous surveys performed at the project site, as Figure 5a shows. We had difficulties matching the exact elevations between our study and previous studies completed by others, we believe that this is mainly due to alignment errors between the different surveys. The bottom of creek elevation is controlled at the west end of the project area by a culvert, so no significant loss of elevation is anticipated.

The vertical scale shown in Figure 5a is exaggerated in relation to the horizontal scale, which overly emphasizes the elevation change of the creek along the alignment. The project creek elevations are constrained as a result of structural culverts at Krause Ave. and 78th Avenue. Thus, the overall creek gradient is unlikely to vary from pre-project conditions. When viewed at true scale (vertical scale equivalent to horizontal scale), the overall creek gradient was not modified, as shown in Figure 5b. Figure 5c highlights features along the long profile from the east end of the project area to the west end of the project area.

The long profile surveys shown for comparison in Figures 5a, 5b and 5c are based on a pre-project survey (WRI, 2000), the design drawings (WMA, 2001), and two post-project student surveys (Kupers, 2001, 2003). Due to the lack of reliable stationing information in the field, a direct comparison of all long profiles should be performed with caution, as differences in readings may have occurred as a result of misaligned stationing along the alignment of the creek and/or inconsistent measurement locations within the creek watercourse channel.

The eastern half of the project reach experienced significant earthwork grading and channel restoration enhancements, while the western reach (west of Krause Avenue) was modified to a lesser degree. Perhaps due to these differences, the eastern half showed greater water depth variability, greater substrate variability, and more pools compared to the western half (Figure 5c). East of Krause Avenue, the substrate varied between silty sands to sandy gravels with cobbles. West of Krause Avenue, the substrate consisted primarily of sandy gravel with cobbles and boulders. In addition, there were not many pools in the steeper, western stretch of the creek. The overall stream course complexity within the eastern half of the project was substantially more than the western half. Our pebble count results and features mapping further reinforce these observations.

Cross Sections

We surveyed nine cross sections as part of our field data collection program, as shown in Figures 6 and 7a-7i. Cross sections identified by roman numeral (II, III, and V) are intended to match the cross sections surveyed by Kupers (2001). Those identified alphabetically (A, B, C, D, E, G, H) are intended to match sections from the project plans (WMA, 2001). We adjusted our results to obtain the most probable match-up between the various cross sections. All sections are plotted looking downstream. Each of the nine cross sections is discussed below in greater detail.

A-A' – This cross section was located at the east end of the project area. Project plans called for the removal of an existing concrete retaining wall and replacement with 2:1 (horizontal to vertical) earthen stream bank slopes and native vegetation. During construction, existing utilities were reinforced and stabilized. These utilities were not included in the design documents. Rock riprap was added on the creek bank slopes to prevent scour-induced erosion and potential damage to the utilities during a flood event (Photo 3). The as-constructed slope was 2:1 in this area, as specified on the project plans.

B-B' – This cross section was located just west of the steel-framed pedestrian bridge. The project plans called for 2:1 side slopes and native vegetation planting. The pre-existing concrete-lined channel was removed and the steel-framed pedestrian bridge was constructed. A gravel bar (Photo 4) was located in this area, and we conducted a pebble count on the bar. Our survey indicated that the channel width had increased slightly from the designed channel width. Creek bank slopes were approximately 2:1 and we observed stabilization fabric covering these slopes. In addition, logs were installed along the north edge of the stream to provide protection against scour-induced erosion. Some erosion was observed immediately under the steel-framed pedestrian bridge, as shown in Photo 5.

C-C’ – This cross section was located near the end of the first meander that begins under the pedestrian bridge. The project plans called for 2:1 side slopes, native vegetation planting, and the initiation of a log revetment on the southern edge of the creek bank. Our survey indicated that the channel width had increased and become deeper than the designed channel depth, especially on the north edge of the cross section. The stream channel was heavily vegetated with watercress and cattails at this location. The log revetments were partially covered by vegetation cascading down the eroding right bank. Photo 6 presents a view of the location surveyed for section C-C’.

D-D’ (II-II’) – This cross section was located south of the new amphitheater. As part of the restoration project, the old amphitheater and pedestrian bridge were removed; the abutments can be seen in Cross Section D-D’. The new amphitheater was constructed north of the creek (Photo 7) to allow more community interaction with the creek. Log revetments were called out on the project plans to be installed all along the outside of the meander bend, but we observed these log revetments only on the western (downstream) edge of the meander. Conceptual drawings (WRI, 2001b) also indicate that boulders were installed on the northern creek bank (south of the amphitheater) to provide scour protection. We did not observe these boulders during our field visit. We noted significant scour and slope instability along the southern creek bank in this area as shown on Photo 8. Project plans specified the creek bank slopes to be a maximum of 2:1 in this area; however, we measured the slope to be on the order of ¾ to 1, far above the acceptable slope. The log revetments installed to mitigate bank erosion appear to have shifted and moved during past high flow creek events. Photo 9 provides another view that shows the movement of the log revetments away from the creek bank. In addition, because these log revetments do not extend further up the slope, they do not provide sufficient scour protection during high flow events. The creek width is significantly larger than the design channel. The creek width has also widened since the survey by Kupers (2003).

This location also demonstrates the impact of vegetation on water velocities within the creek channel. We observed fresh scour along the northern creek bank, which probably occurred within a week of our field visit and resulted from the thick stand of watercress nearby. The water located the path of least resistance, in this case the northern creek bank. The narrowed water passage increased velocities and resulted in erosion. Overall, this area is not statically stable and further future bank instability should be anticipated.

III-III' – This section was surveyed in an area of the creek that did not undergo significant modifications during the restoration construction. The section is located immediately east of the existing concrete retaining wall, as shown in Photo 10, and upstream of the Krause Avenue bridge shown in Photo 11. This area appeared to be geomorphically stable, since our cross section agreed fairly well with the previous post-project cross section survey (Kupers, 2003).

E-E' – This section is located west of the Krause Avenue bridge. This area of the project did not undergo significant channel modifications. The existing conditions appear to conform to the pre-project grade, not the design grade, which implies that no grading activities were undertaken in this area.

V-V' - This section is located west of the Krause Avenue bridge. This area of the project did not undergo significant channel modifications. Our surveyed cross section was very similar to the previously surveyed section (Kupers, 2003). Photo 12 presents a view looking eastward where cross sections V-V' and E-E' were performed. The creek banks appeared to be stable in this area.

G-G' - This section is located west of the Krause Avenue bridge. The creek did not undergo significant channel modifications during construction. Our surveyed cross section was consistent with the proposed grades outlined in the project design documents. Both creek banks appeared to be stable. Although the creek did not undergo significant alterations and the existing concrete retaining wall was left in place, this area provided abundant riparian habitat and substrate complexity within the creek channel.

H-H' - This section is located west of the Krause Avenue bridge. Our surveyed cross section was consistent with the proposed grades outlined in the project design documents. All creek banks appeared to be stable. As seen in the area of G-G', this area was not significantly modified and offered abundant riparian habitat and substrate complexity.

Pebble Counts

We conducted four pebble counts that approximately matched the locations used by Kupers (2001). Figure 8 shows the cumulative size distribution for these four pebble counts, plus one additional pebble count conducted at the only large bar onsite, just downstream of the pedestrian bridge. Three of the four pebble counts showed significant sediment fining since 2001, and one showed minor coarsening. One possible explanation for the fining is that the boulders and cobbles placed in the channel during construction have been mobilized and/or covered by finer sediments originating upstream.

Vegetation Survey

The results of our vegetation survey, shown in Figure 9, indicate that the site had a strong and growing community of native vegetation, but the total percentage of native cover lagged behind the target value of 70%. By our estimate, about 25% of the site was covered by bare soil and tanbark. Of the remaining ground, about 50% was native and 50% was non-native (Stella Cousins, personal communication, November 2005). This is generally consistent with the monitoring performed by the City of Oakland, which indicates that some species, like *Baccharis pilularis* (coyote brush) and *Rosa californica* (California rose) have had a 100% survival rate since planting, while others, like *Mimulus aurantiacus* (Sticky monkeyflower) and *Rhamnus californica* (Coffeeberry) have had survival rates less than 1% and 7%, respectively. Many of the non-natives are low-growing common weeds that will likely be crowded out as the native vegetation continues to mature. Others pose a more serious threat; invasive plants like scotch broom, pampas grass, and watercress may continue to re-appear at the site even if they are periodically removed. Thus, the site will likely require maintenance after the planned 5-year monitoring period; even after that time, native vegetation may not be able to out-compete the most invasive species.

Two specific concerns are the watercress (*Rorippa nasturtium-aquaticum*) and cattails (*Typha spp*.) that were growing in the creek bed. Watercress covered much of the creek bed in early November 2005, though most of it had scoured away by late November 2005 due to increased flows from the first large storm of the 2006 water year (Photos 13-16). Watercress is common in quiet waters in much of California (Faber & Holland, 1988). We do not know all of the effects of the watercress on aquatic habitat, but it appeared to significantly slow the water velocity, trapping fine sediments and garbage (see Photos 17-19), and thereby degrading water quality. On the other hand, the watercress also shades the creek and removes nutrients, both of which would benefit water quality. The watercress may be a seasonal and temporary invasion caused by the current lack of a tree canopy, which was removed during construction but will grow back over the next decade as the willows, alders, maples, and coast live oak reach maturity. The cattails were not as wide-spread as the watercress, but they may be a more serious problem since they are much more firmly rooted and are therefore more likely to affect channel hydraulics under high flow conditions. The progress of both species should be monitored in the coming years.

In certain areas of the site, soil type may be impeding the success of the re-vegetation effort. For example, across from the amphitheatre, very little vegetation has established. The design calls for willows to provide bank protection, but they have been unable to grow in the heavy clay soil. This problem is not surprising, since the site contains soils from the Clear Lake complex, which is characterized by deep and poorly drained clay and silty clay, with poor potential for certain types of vegetation to succeed (USDA, 1981).

Feature Mapping

Figure 10 shows the dominant streambed features that we observed during our survey. Watercress and other large aquatic vegetation covered much of the streambed during our survey, so we could not see the substrate for at least half of the reach. There is no comparable map for the designed and/or constructed streambed, because many of the features were added as change orders during construction (James Yoo, ACPWA, personal communication, November 2005). Therefore, our interpretation of the intended outcome for streambed features is based on the design plans, interviews with Ali Schwarz at the City of Oakland, and documentation of design changes made during the construction phase.

We observed recent evidence of sediment transport and erosion at the site, especially upstream of the car bridge. A point bar has developed at Meander #1, and the sediments appeared to have been recently reworked. There is also a point bar at Meander #2, though it is less well developed. The outside bank at Meander #2 shows active signs of erosion, as discussed for Cross Section D-D'.

The project plans called for log revetments to be installed and tied down to the outer bank of the two significant meanders upstream of the car bridge (WMA, 2001). Figure 10 shows that at least portions of these log revetments remain. However, at Meander 2, erosion is occurring behind the logs revetments, so they are only partially protecting the bank (see Photo 8). At Meander 1, willows are better established and offer significantly more bank protection, so the potential loss of logs is not as great a concern.

During construction, excavators discovered a concrete apron below the existing channelized streambed. In response to this discovery, vortex weirs ("rock riffles") were quickly designed and added in two locations (WRI, 2001a). The first weir was installed upstream of the amphitheatre bend, and the second about 100 feet upstream of the downstream culvert. Remnants of the second weir were evident at the site (see Photo 20), but the first weir seems to have been broken apart or covered by finer sediment and vegetation. The partial loss of the first weir may be another factor contributing to the erosion at Meander #2.

Conclusions

The first project objective was to restore native regional riparian plant species, and indeed native vegetation is taking hold at the site. However, it seems likely that continued maintenance, past the planned 5-year maintenance period, will be necessary to keep certain invasive plants at bay. In particular, the invasive aquatics (cattails, watercress) may be altering the intended streambed by retaining fine sediment and adding a significant amount of roughness.

Habitat improvement was the second project objective. Compared with the adjacent stretches of creek, as in Photo 21, the Arroyo Viejo Park stretch of Arroyo Viejo Creek offers rich habitat value. We observed evidence of wildlife such as tree frogs, raccoons (Photo 22), and ducks using the site, and there is a complex assemblage of vegetation. We cannot determine whether the habitat that is now present matches the envisioned habitat value, since the latter was not specified in project documents. Furthermore, we do not have reference for the habitat value before the implementation of the restoration activities. Despite these problems, we can conclude that there has been some improvement in habitat, especially at the east end of the project where the concrete retaining walls were removed.

Four of the project objectives dealt with geomorphology, like improving sediment transport, re-establishing a stable channel and banks, and providing long-term erosion control. Although most of the western reach of the project appears to be stable, there are multiple locations where the creek banks are unstable. Active erosion at the outside of the two meander bends appears to be inconsistent with the stated goal of bank stability. Log revetments are not fully protecting the bank from scour, and vegetation is not succeeding at the outside bank of the meander bend near the amphitheatre. If cutting of these banks is deemed problematic by the City or County, whose park and flood control facility are being affected, then additional protection will become necessary. Additional protection could consist of log revetments that are constructed one to two feet above the current top of creek to prevent scour and stabilize the slope.

The final project objective concerns recreational amenities. The results of this project objective have been mixed. The community uses the site; we observed children and pets playing in the creek and families using the trails and pedestrian bridges. However, the signage that was envisioned in project planning documents is not present, as shown in Photo 23. As a result, the site may give the impression of having "gone wild" and being in urgent need of maintenance. Permanent signage would help explain the project's purpose and features to the community. The abundant vegetation alongside and in the channel is serving as an informal trash filter (Photos 17-19), and the situation is not only unaesthetic, but also has the potential to seriously degrade water quality by trapping toxic chemicals.

In conclusion, riparian vegetation cover appears to have been improved, but the desired level of stream bank stability has not been achieved. Future studies within Arroyo Viejo Creek should continue to monitor the progression of the native riparian habitat and identified zones of bank instability.

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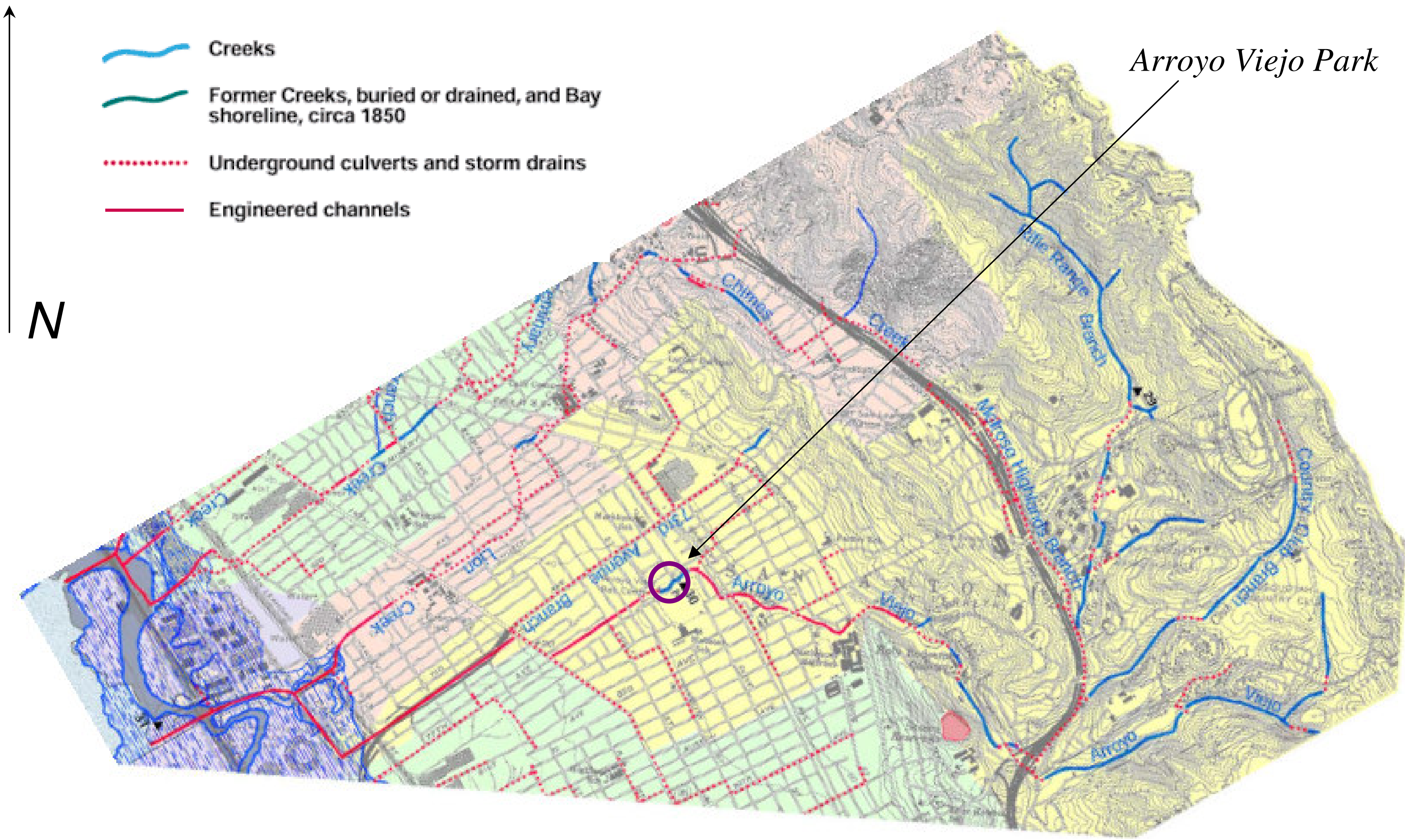


Figure 1: Arroyo Viejo Creek Watershed

The watershed (yellow shading) stretches from the steep East Bay hills through Oakland's flatlands to San Francisco Bay. The lower part of the watershed, including the project site, is mostly urbanized.

(Source: Sowers, 2000)

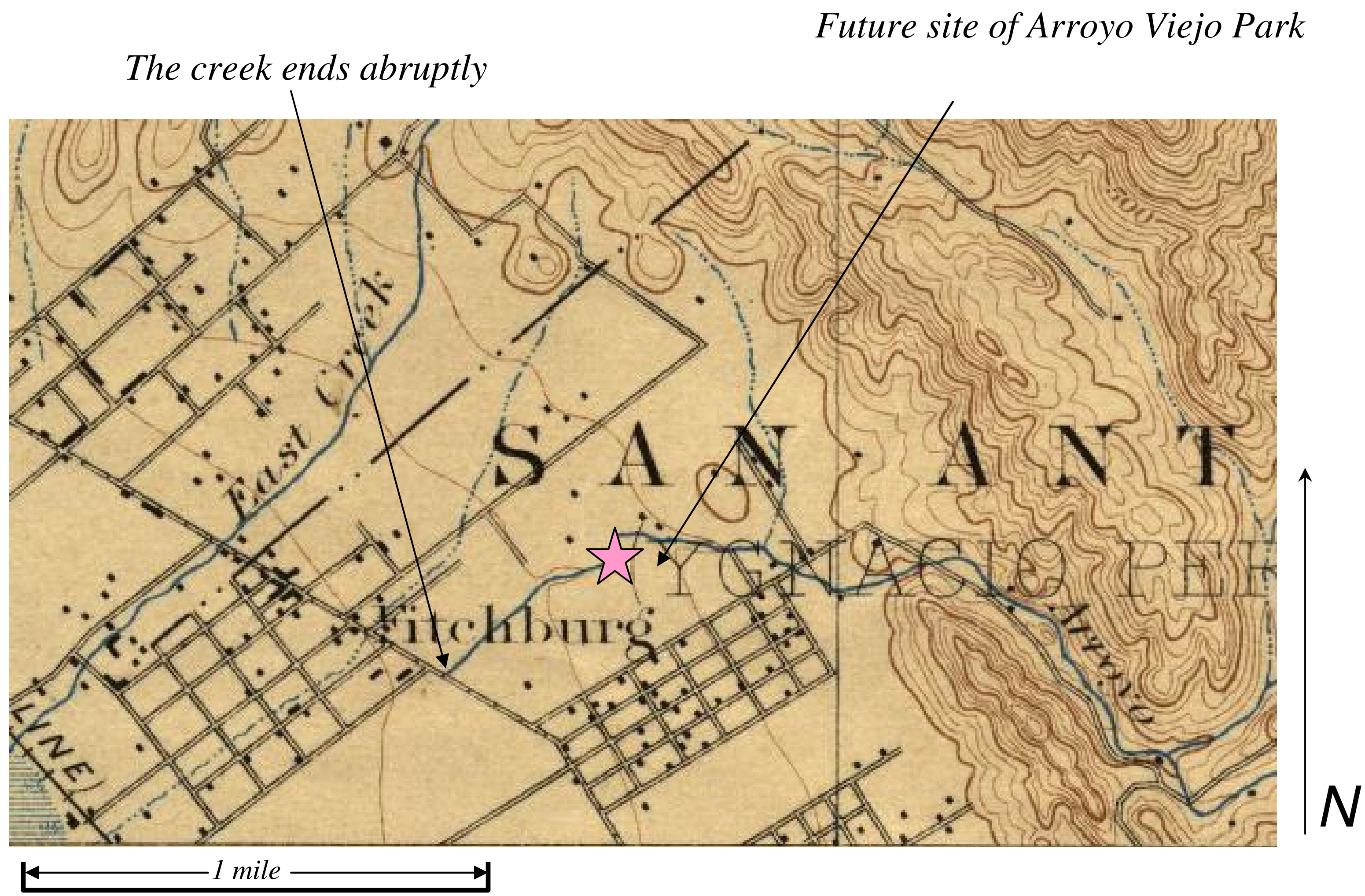


Figure 2: Arroyo Viejo Creek on the Topographic Map of 1897

As early as 1897, Arroyo Viejo Creek seems to be re-routed before it reaches San Francisco, and the early signs of urbanization are apparent.

(Source: U.S. Geological Survey topographic map, original scale 1:62,500, available online from the Earth Sciences and Map Library, University of California, Berkeley)

Figure 3a: Aerial Photo, 1937

(Source: Fairchild Aerial Surveys, Inc.)

Figure 3b: Aerial Photo, 1946

(Source: Jack Ammann Photogrammetric Engineers)

The restoration site lost some of its tree canopy to accommodate the new design for native vegetation

Figure 4a: Aerial Photo, 1981

(Source: WAC Corp.)

Figure 4b: Aerial Photo, 2002 (post-project)

(Source: WAC Corp.)

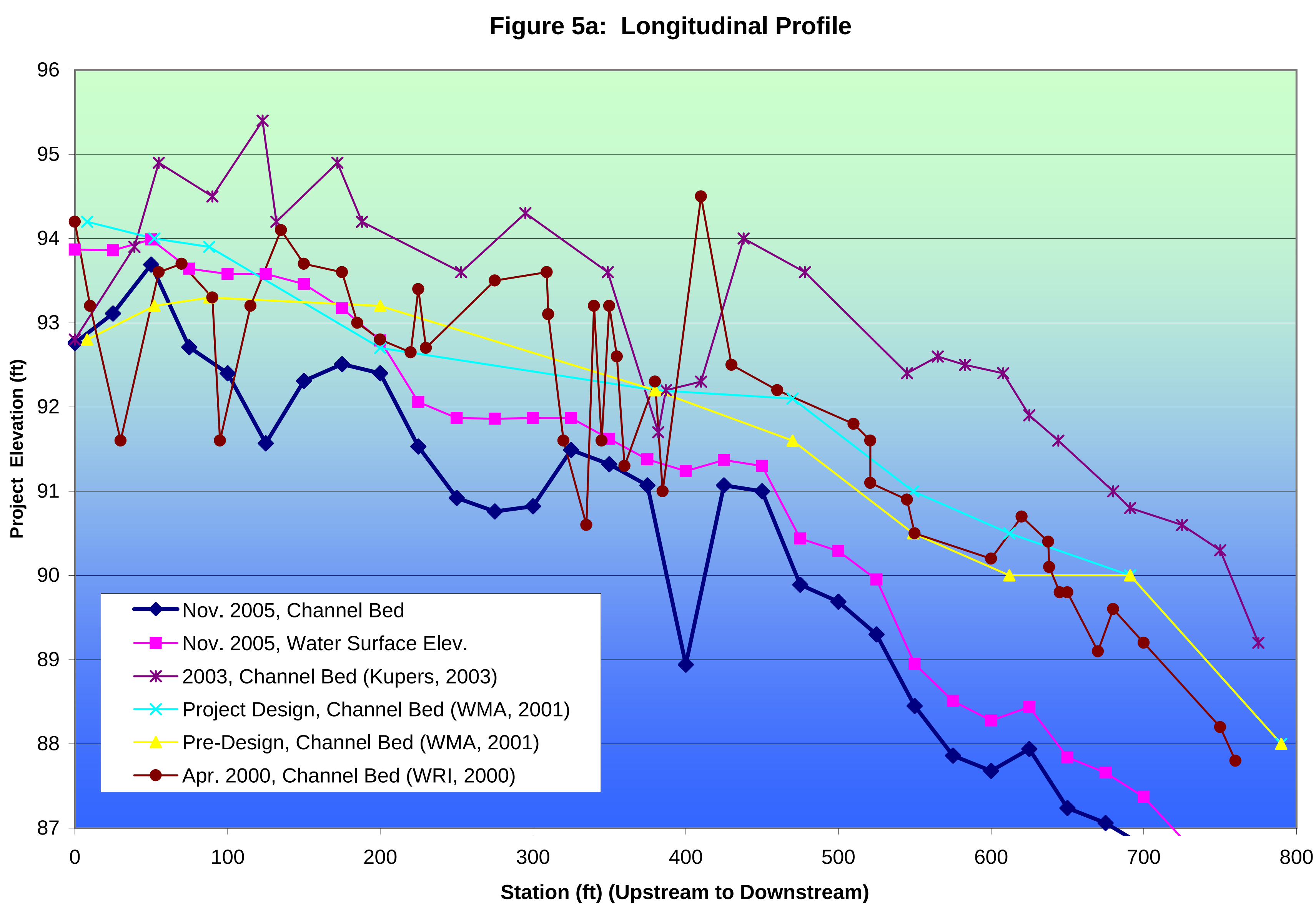
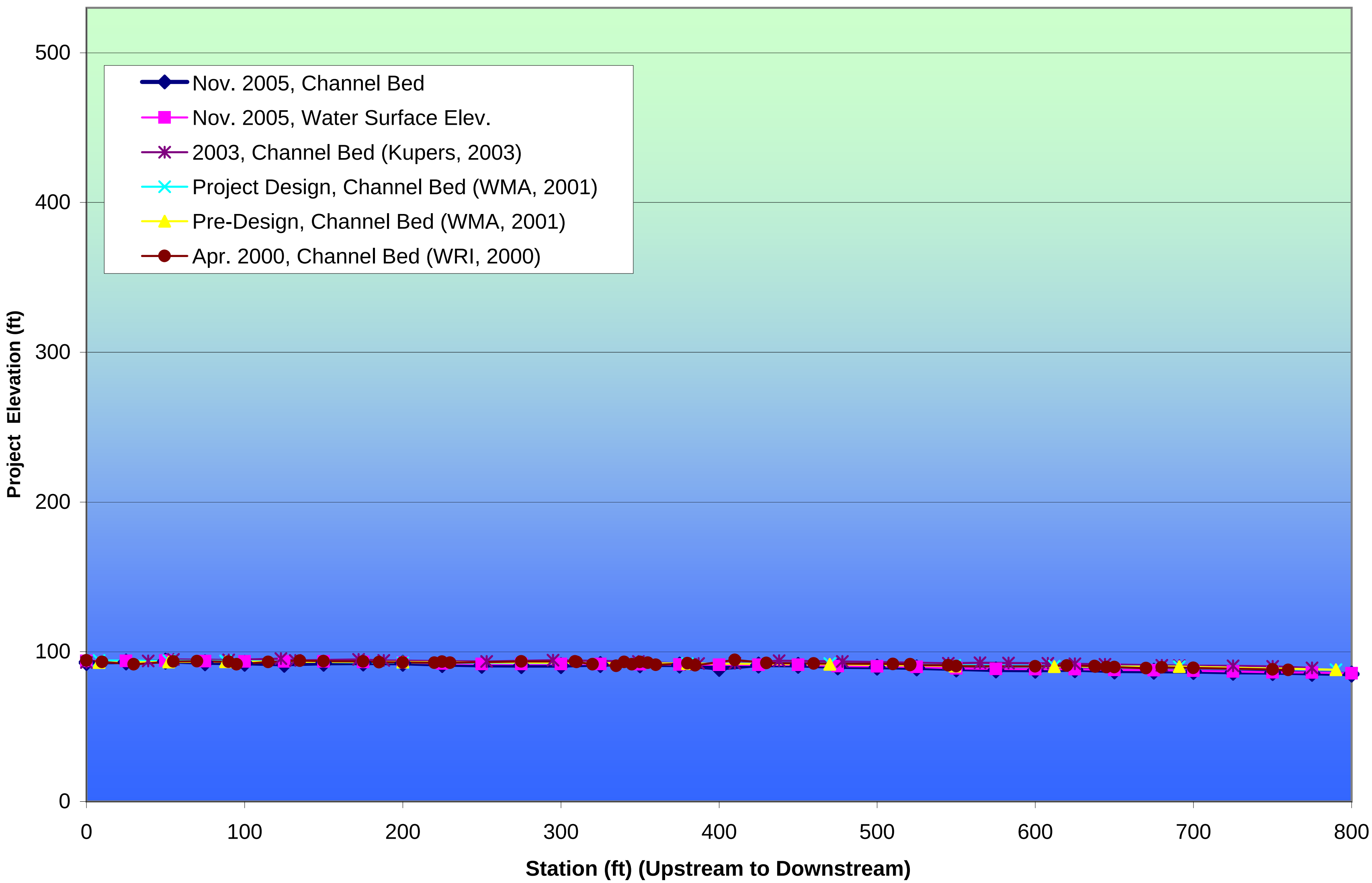


Figure 5a: Longitudinal Profile
Project Elevation (ft)
Station (ft) (Upstream to Downstream)
96
95
94
93
92
91
90
89
88
87
0
100
200
300
400
500
600
700
800
Nov. 2005, Channel Bed
Nov. 2005, Water Surface Elev.
2003, Channel Bed (Kupers, 2003)
Project Design, Channel Bed (WMA, 2001)
Pre-Design, Channel Bed (WMA, 2001)
Apr. 2000, Channel Bed (WRI, 2000)

Figure 5b: Longitudinal Profile at True Scale



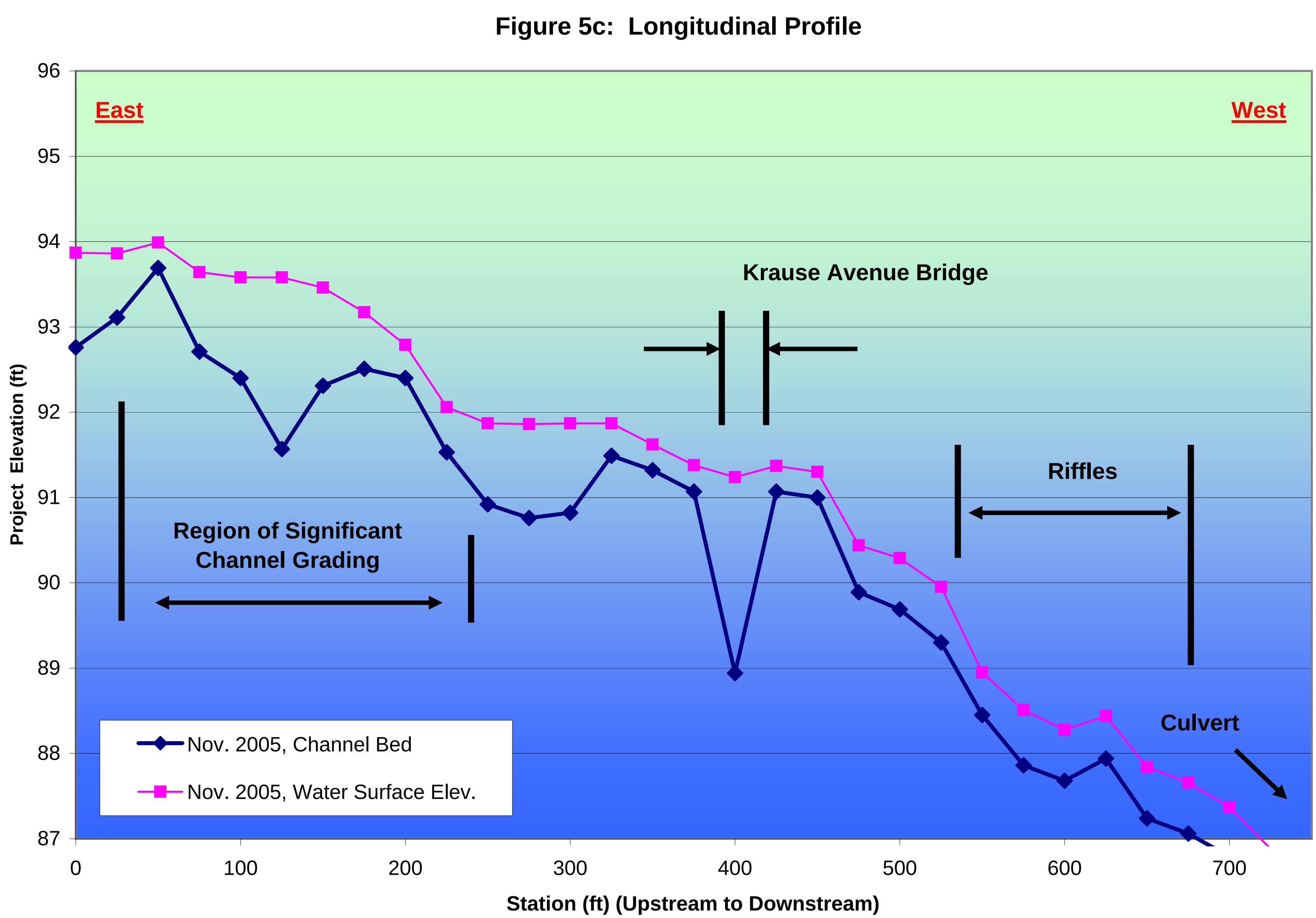
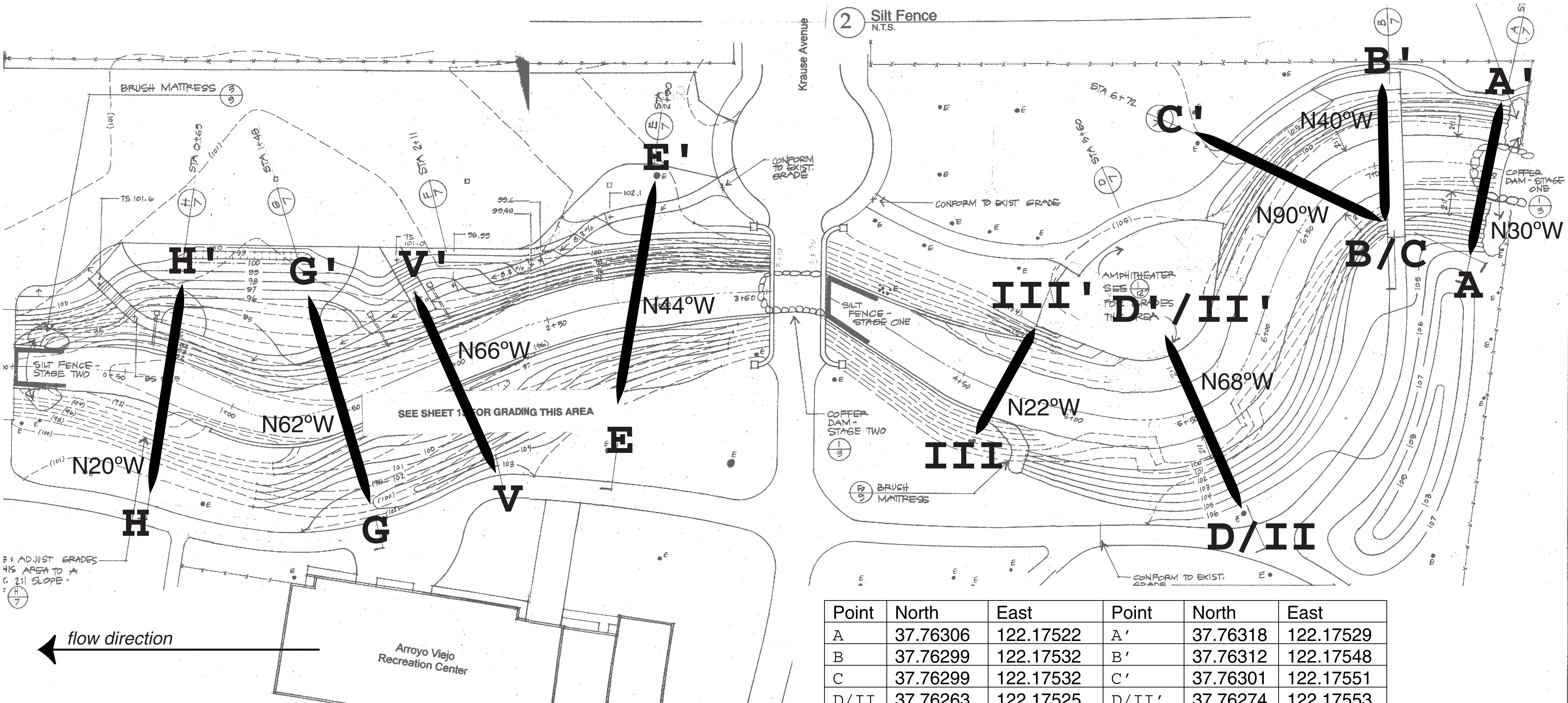


Figure 5c: Longitudinal Profile
East
West
Krause Avenue Bridge
Riffles
Region of Significant
Channel Grading
Culvert
Nov. 2005, Channel Bed
Nov. 2005, Water Surface Elev.
Project Elevation (ft)
Station (ft) (Upstream to Downstream)
96
95
94
93
92
91
90
89
88
87
0
100
200
300
400
500
600
700



Point	North	East	Point	North	East
A	37.76306	122.17522	A′	37.76318	122.17529
B	37.76299	122.17532	B′	37.76312	122.17548
C	37.76299	122.17532	C′	37.76301	122.17551
D/II	37.76263	122.17525	D/II′	37.76274	122.17553
III	37.76249	122.17550	III′	37.76268	122.17566
E	37.76223	122.17612	E′	37.76246	122.17625
V	37.76206	122.17622	V′	37.76221	122.17650
G	37.76195	122.17632	G′	37.76212	122.17663
H	37.76180	122.17660	H′	37.76209	122.17671

Notes:
- All compass headings are based on magnetic north.
- GPS locations for endpoints for cross sections were identified using a Garmin GPS Map76S model handheld GPS unit. This unit has a built-in Quad Helix antenna, 12-channels, and Differential GPS Wide Area Augmentation System (DGPS - WAAS) capabilities. Accuracy for the GPS unit, when in WAAS mode, is 3 meters (10 feet) with a confidence interval of 95%.
- All locations were identified with the GPS unit in WAAS mode.
- The datum for the GPS coordinates is WGS84.

Figure 6
Locations of Cross Sections

Figure 7(a): Cross Section A-A'

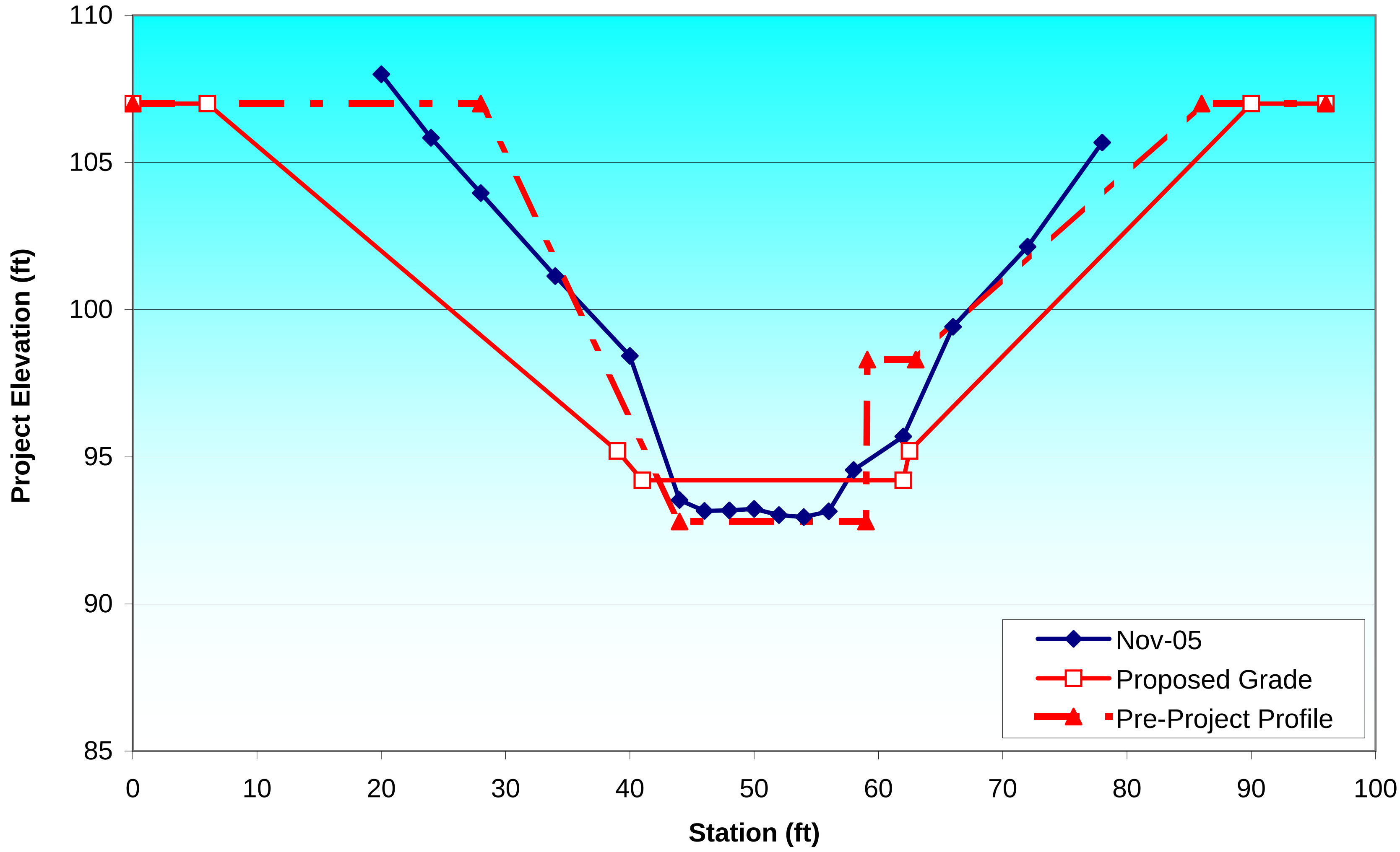


Figure 7(b): Cross Section B-B'

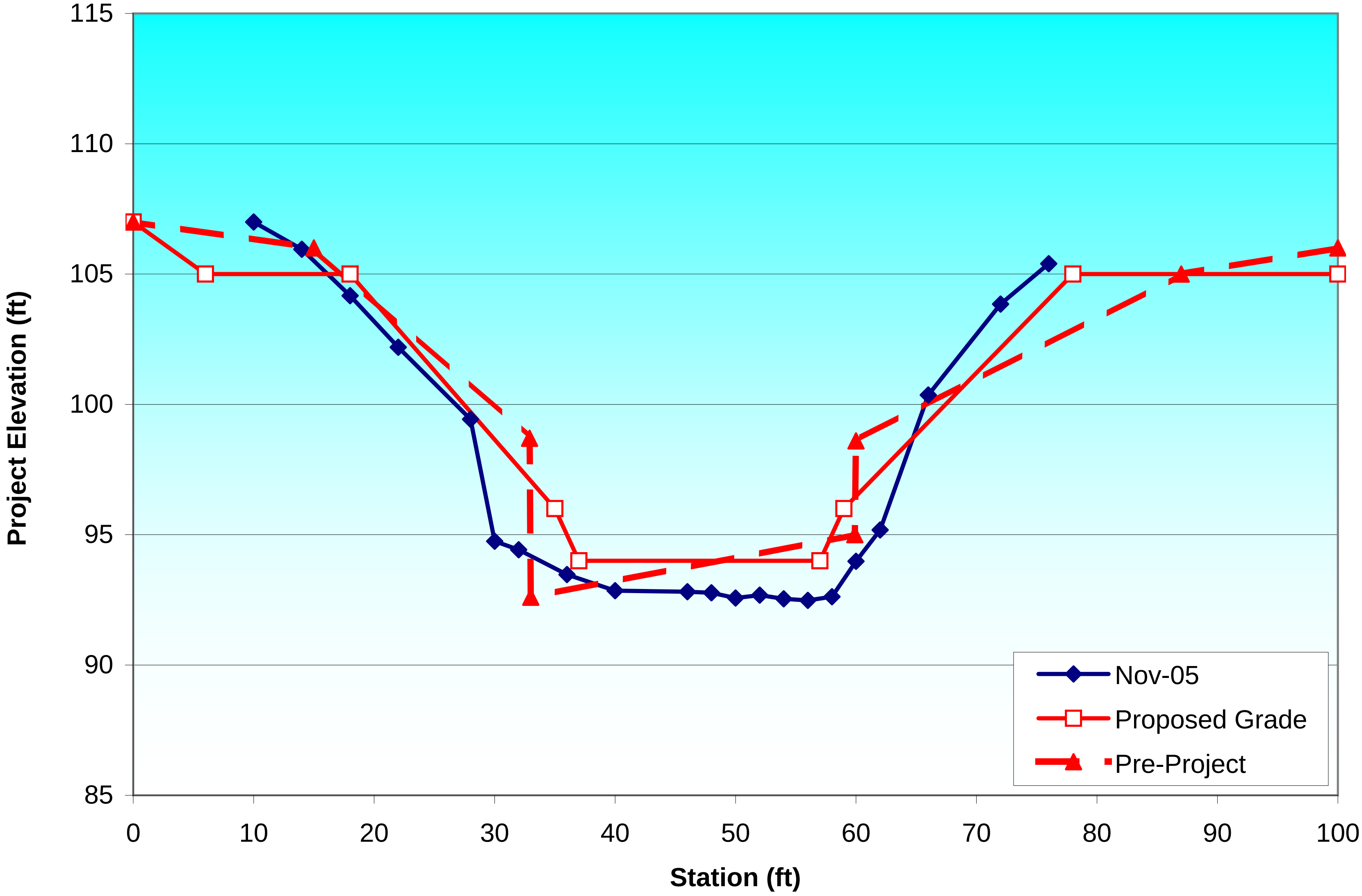


Figure 7(c): Cross Section C-C'

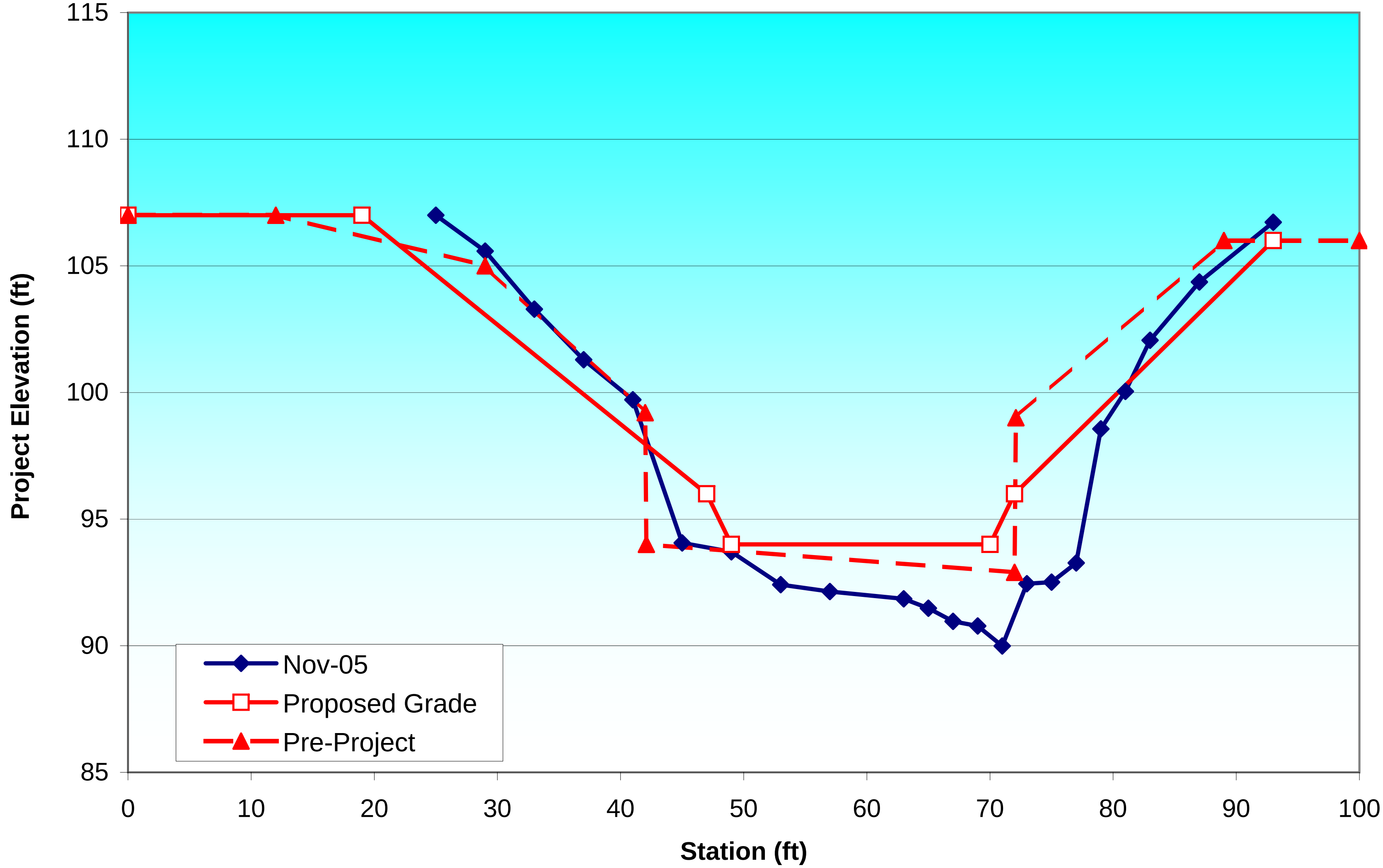


Figure 7(d): Cross-Section D-D'

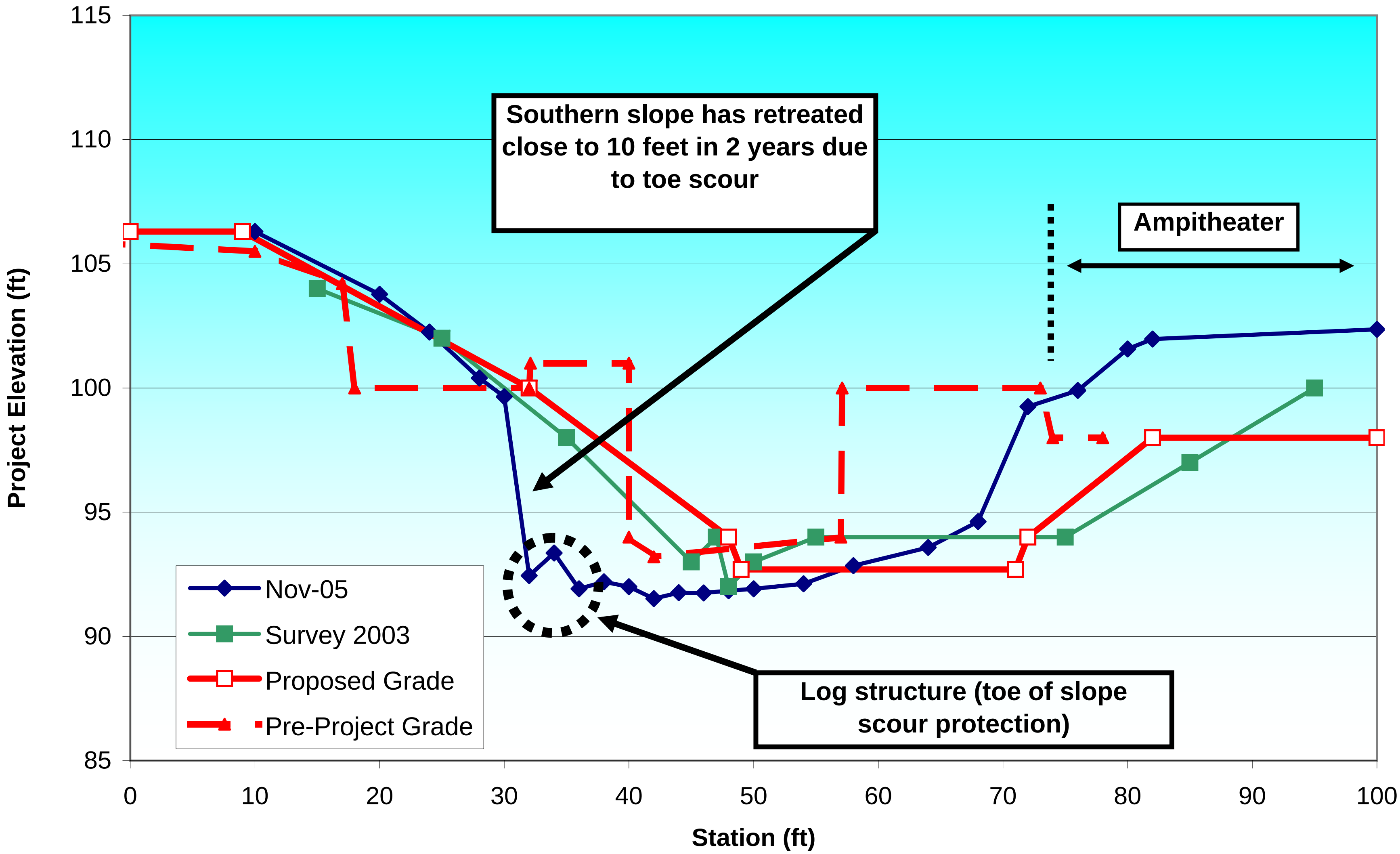


Figure 7(e): Cross Section III-III'

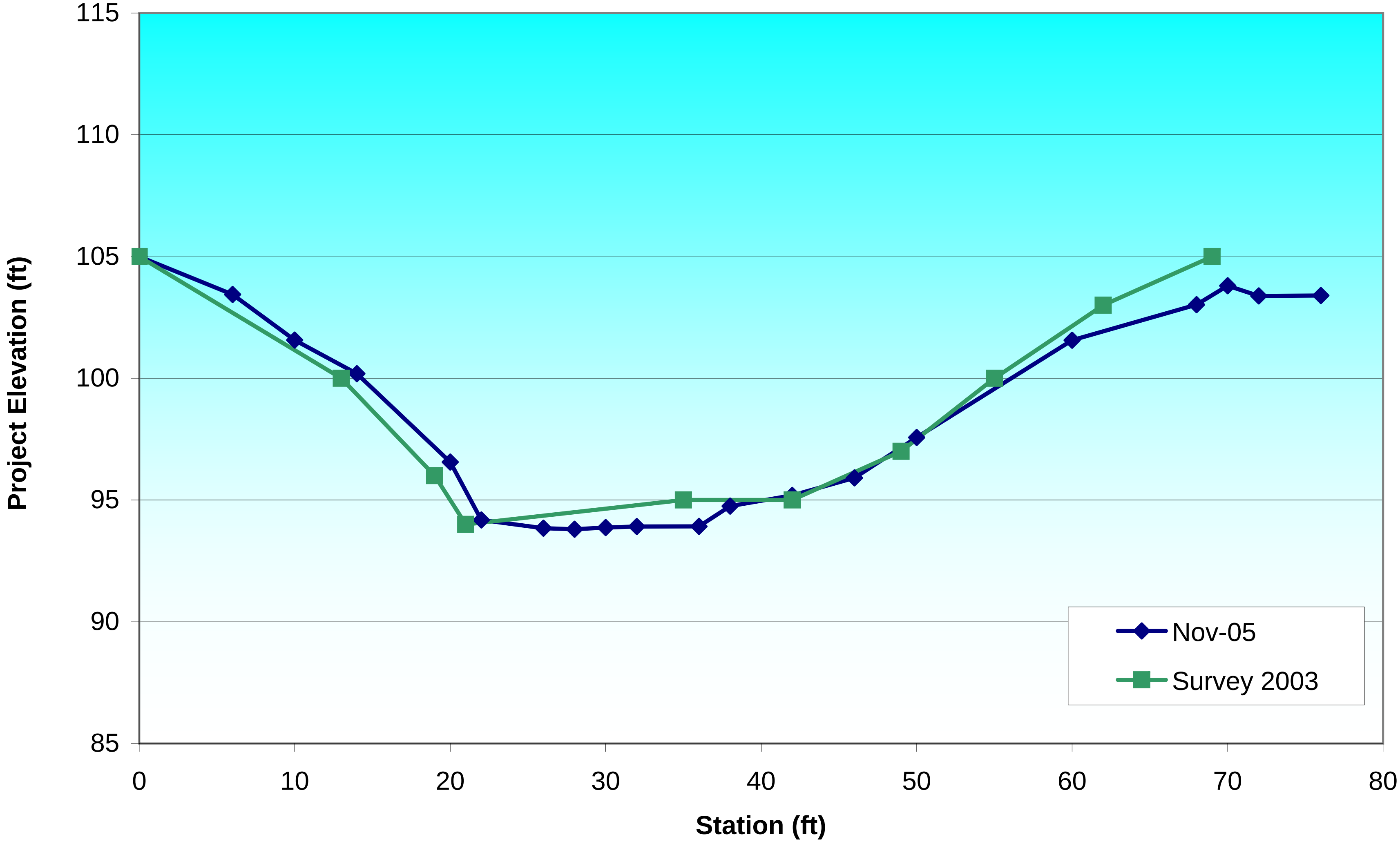


Figure 7(f): Cross Section E-E'

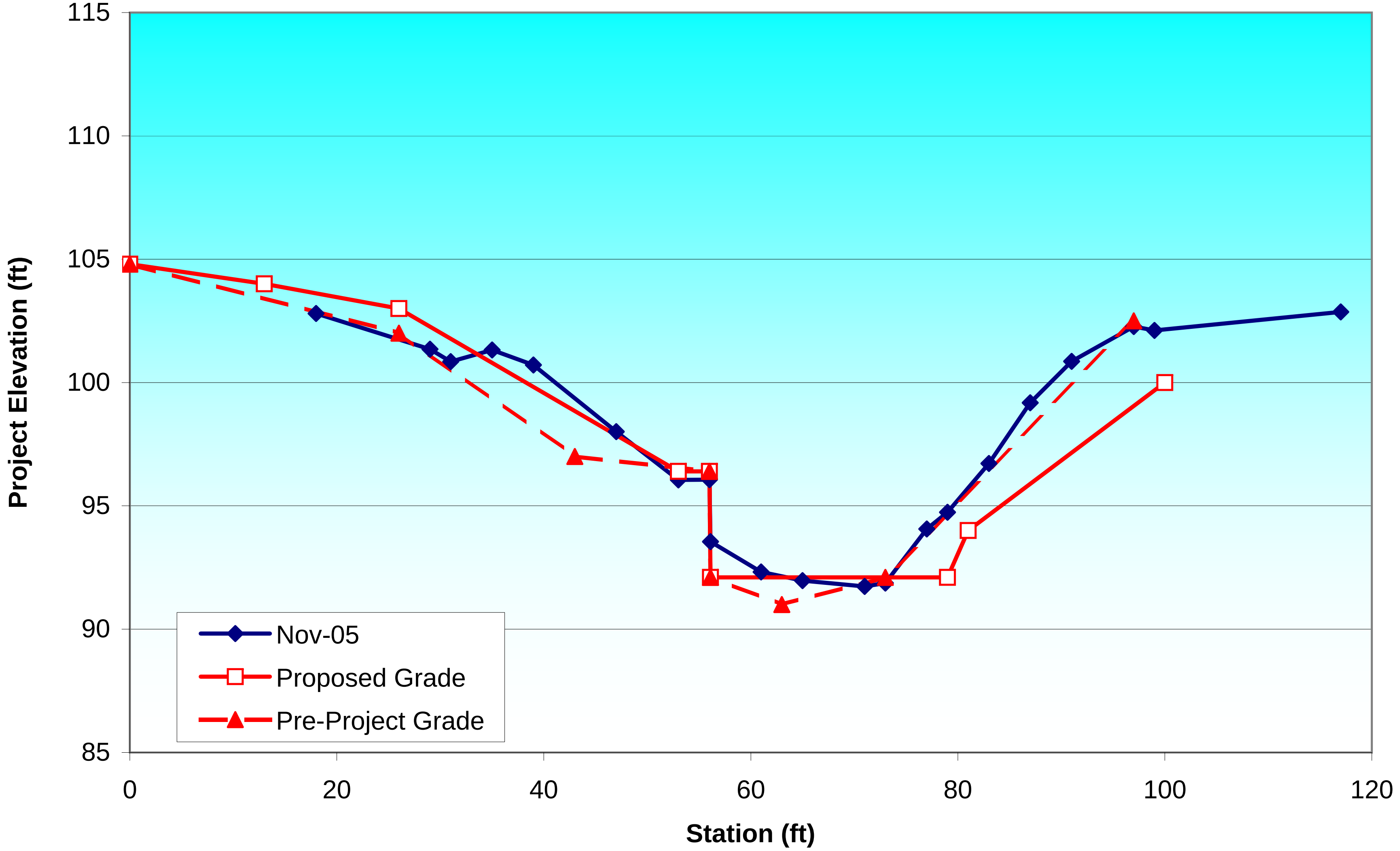


Figure 7(g): Cross-Section V-V'

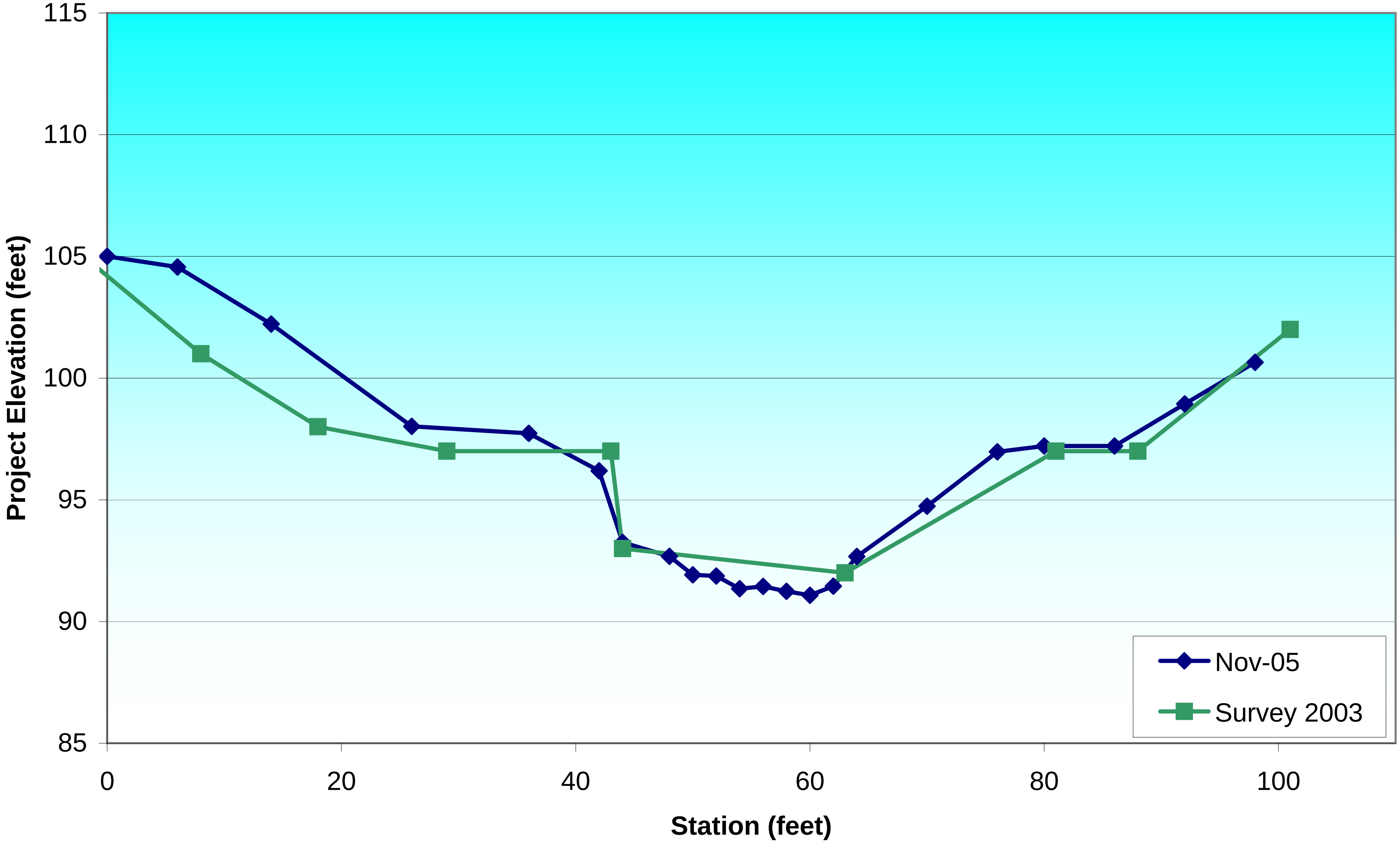


Figure 7(h): Cross-Section G-G'

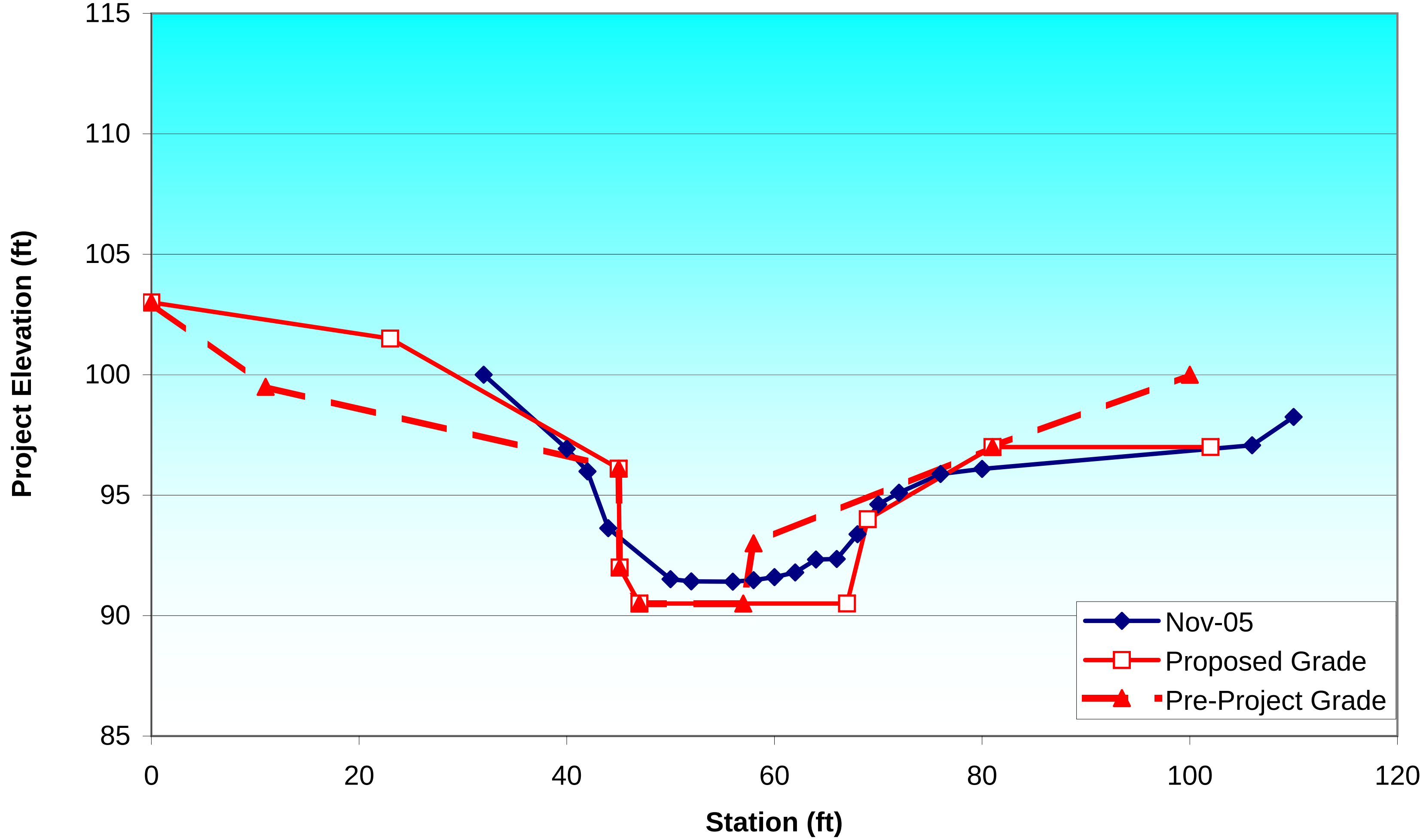
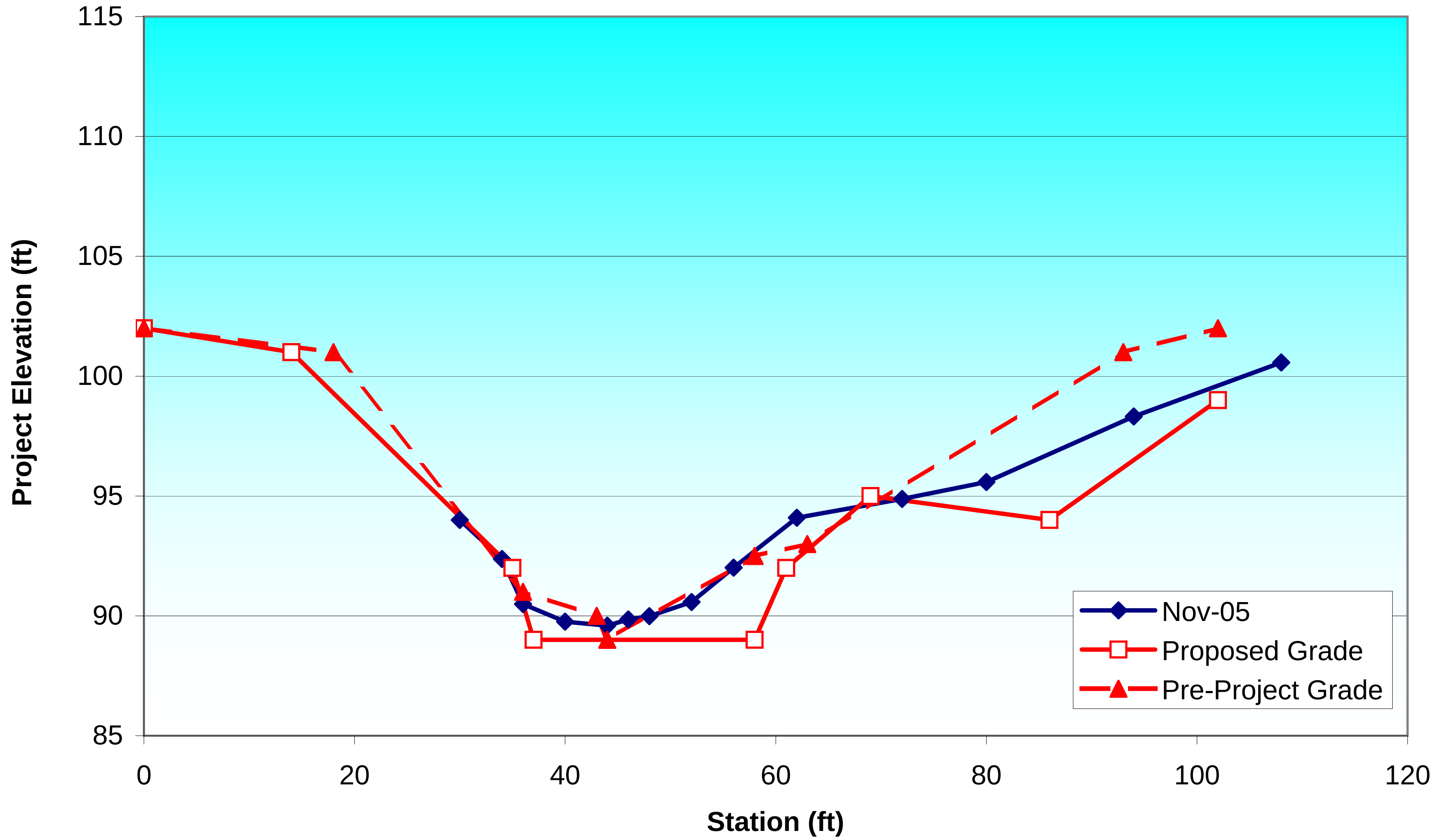
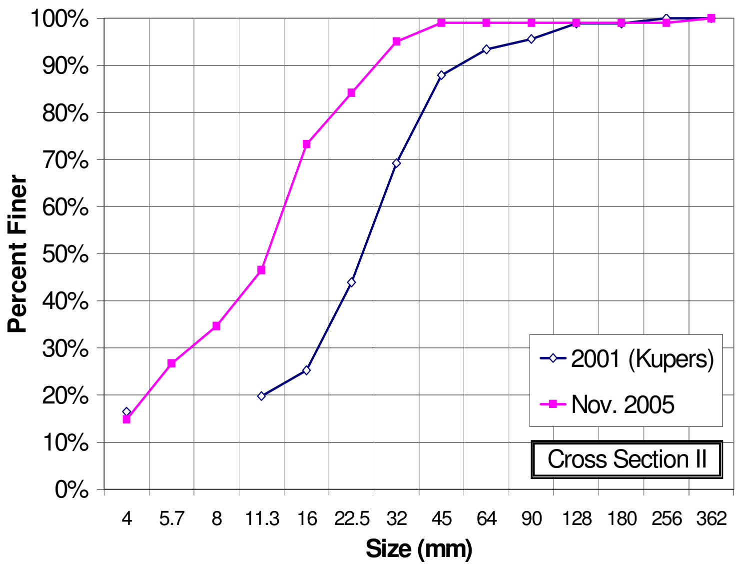
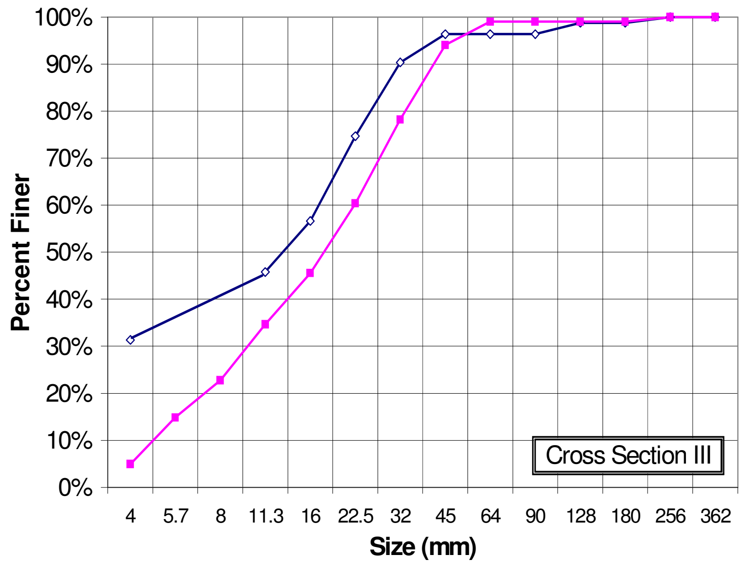
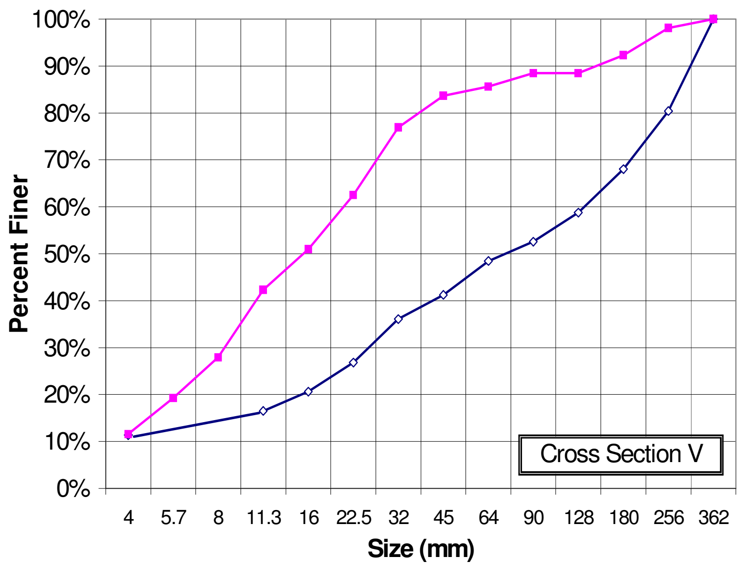


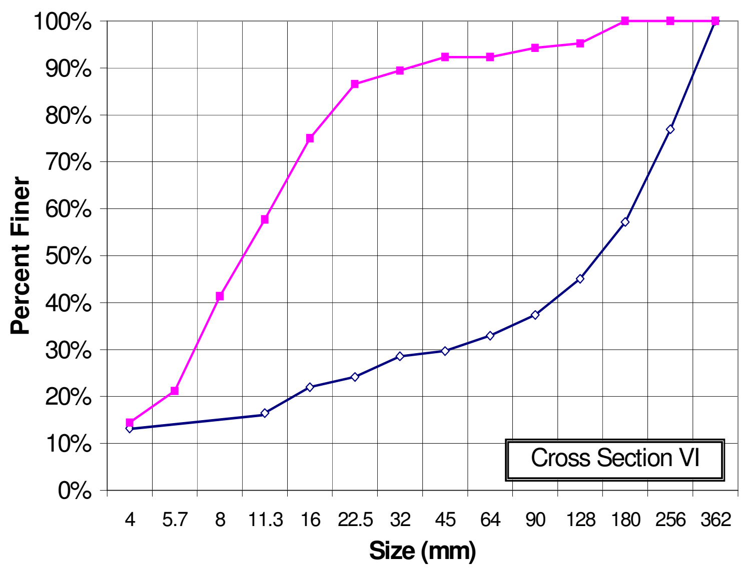
Figure 7(i): Cross-Section H-H'











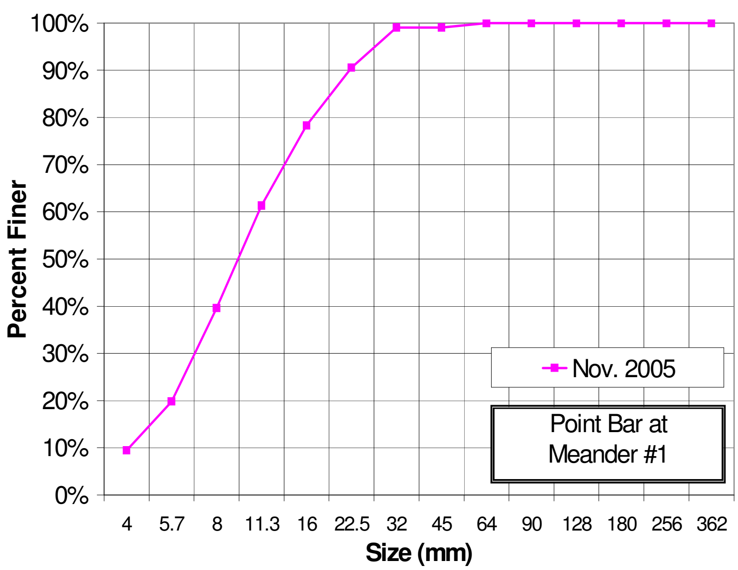


Figure 8:
Results of Pebble Counts

Significant fining is evident at cross sections II, V, and VI, where deposition has probably filled in larger rocks placed during construction.

Note: Kuper's results have been slightly rounded to conform to the metric system, and the silt fraction has been removed.

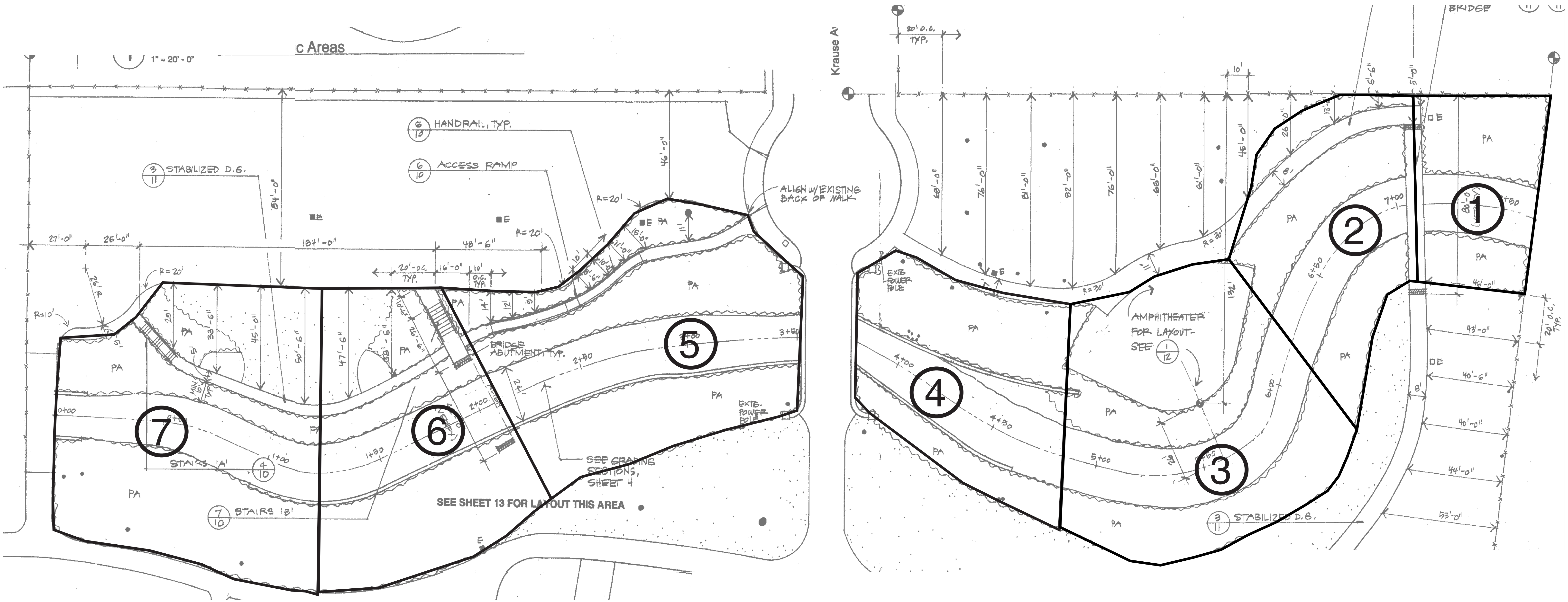
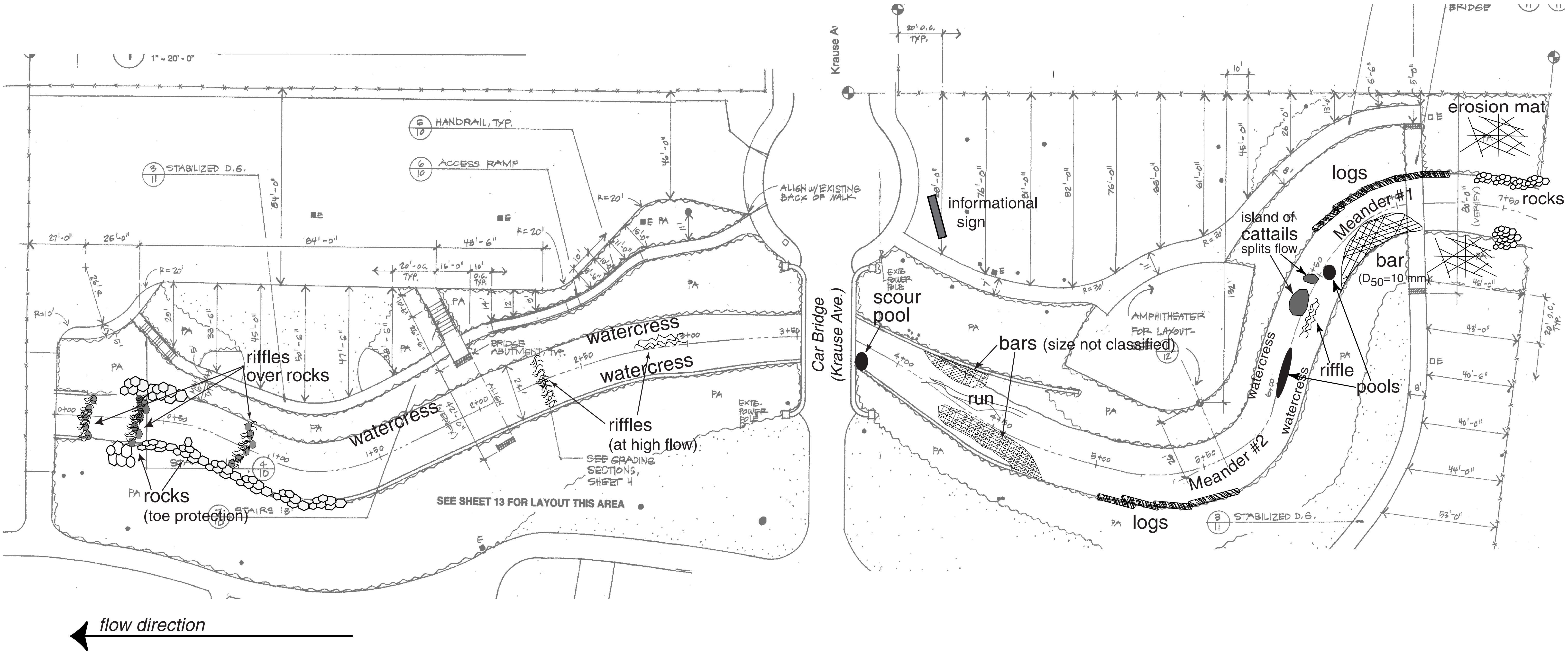


Table ___: % Cover by Native Vegetation

Area #	Relative Area	% Native	% Non-Native
1	0.08	38%	62%
2	0.12	76%	24%
3	0.15	22%	78%
4	0.13	40%	60%
5	0.19	52%	48%
6	0.15	48%	52%
7	0.18	80%	20%
	Weighted Average:	52%	48%

Note: Bare soil, tanbark, lawn, paths, bare rock and open water are not included in percent cover estimates. Watercress is included.

Figure 9
Vegetation Survey



Notes:

1. The bars shown east of Krause Ave. were submerged under the moderate storm flows observed on 11/29/05 (after 0.7" rain).
2. The riffles shown were present during the storm flow of 11/29/05. Only the riffles at the downstream end were also present under low flow conditions.
3. The watercress is shown where it persisted along the sides of the channel under storm flow conditions. Prior to the storm it was also present in these areas, but across the whole channel.

Figure 10
Feature Map

Photo 1. This pre-construction photo from Kupers (2001) shows the eastern stretch of the project reach, specifically the masonry and concrete channel walls that were targeted for removal. The view is upstream from the amphitheatre.

Photo 2. Another pre-construction photo from Kupers (2001) shows the western stretch, which was re-graded and re-planted during the restoration project. The view is upstream from the end of the project reach.

Photo 3. Looking west from the eastern end of the Project site, near the location of cross section A-A'. Utilities (not identified on the design documents) were protected and concrete rip rap was added to minimize scour-induced erosion of the stream bank. Vegetation growth can be seen through the placed rip rap boulders.

Photo 4. Location of cross section B-B' under the steel-framed pedestrian bridge. A gravel bar formed and log protection was added along the northern edge of the stream (outside the picture to the left). This was the location of our gravel bar pebble count.

Photo 5. Erosion is evident immediately under the steel-framed pedestrian bridge as a result of the over-steepened creek bank in the vicinity of cross section B-B'. Active erosion is occurring behind the willow stakes.

Photo 6. The location of cross section C-C' is towards the right of this photo. Note the growth of cattails and watercress within the creek.

Photo 7. Reconstruction of the amphitheatre was one of the major components of the project. The amphitheatre, which formerly covered the creek with its stage, now transitions naturally into it, while providing a small floodplain for the creek.

Photo 8. Significant scour is evident as a result of oversteepened creek bank slopes. The log revetments installed to mitigate bank erosion have shifted and moved during high flow creek events. In addition, these log revetments do not provide scour protection during high flow events.

Photo 9. The installed log revetments have shifted and “floated” downstream as a result of inadequate restraint. Additionally, these logs do not provide significant scour protection during high flow events.

Photo 10. Looking toward the location of cross section III-III’, which crossed the creek at the far end of the concrete retaining wall (along the right-hand side of the picture). Vegetation can be seen growing both on top of and at the base of the concrete retaining wall.

Photo 11. View looking west through the Krause Avenue bridge. We deduced that watercress is not attracted to deep water locations with little or no sunlight.

Photo 12. View looking east toward the Krause Avenue bridge. Cross sections E-E' and V-V' were performed across this stretch of creek. Vegetation was very thick along this stretch.

Photos 13 and 14. Two views looking upstream from the amphitheatre, one before the first storm of the season (11/11/2005) and the other immediately after the storm (11/29/05). The watercress (foreground) has been washed out of the middle of the channel, but the cattails upstream remain firmly rooted.

Photos 15 and 16. Two similar views looking downstream from the car bridge at Krause Avenue, one before the first storm of the season (10/21/2005) and the other immediately after the storm (11/29/05). Nearly all of the watercress has been washed out of the channel.

Photos 17-19: Aquatic vegetation is serving as an informal trash filter.

Photo 20: The last 100 feet of the site contains a long, continuous riffle. The vortex weir that was installed near this location here may be buried, or it may have broken up. We observed a number of appropriately sized rocks, but not in a vortex weir shape.

Photo 21: Downstream of the project reach, Arroyo Viejo creek is channelized and devoid of vegetation.

Photo 22: The site is used by both pets and wildlife, as indicated by these dog and raccoon prints.

Photo 23: This is the only informational sign about the project on the site.

Appendix I

Survey Data

Cross Section A-A' (Survey by Cousins and Storesund, November 2005)

Station	BS (ft)	FS (ft)	HI (ft)	EL[1] (ft)	Notes
0+00	3.49	3.49		108.0	
0+02					
0+04		5.65		105.8	
0+06					
0+08		7.53		104.0	
0+10					
0+12					
0+14		10.35		101.1	
0+16					
0+18					
0+20		13.06		98.4	
0+22					Edge of channel at 0+23 feet
0+24		17.96		93.5	
0+26		18.33		93.2	
0+28		18.31		93.2	
0+30		18.26		93.2	
0+32		18.47		93.0	
0+34	6.51	18.54		93.0	
0+36		18.34		93.2	
0+38		16.94		94.6	Edge of channel at 0+38
0+40				111.5	
0+42		15.80		95.7	
0+44				111.5	
0+46		12.07		99.4	
0+48				111.5	
0+50	-1.44			111.5	
0+52		9.35		102.1	
0+54				111.5	
0+56				111.5	
0+58		5.81		105.7	
0+60				111.5	

[1]Vertical datum based on project datum

For Graph

OFFSET	station	Measured height		Converted Elevation
20	0	3.49	20	108.00
20	4	5.65	24	105.84
20	8	7.53	28	103.96
20	14	10.35	34	101.14
20	20	13.06	40	98.43
20	24	17.96	44	93.53
20	26	18.33	46	93.16
20	28	18.31	48	93.18
20	30	18.26	50	93.23
20	32	18.47	52	93.02
20	34	18.54	54	92.95
20	36	18.34	56	93.15
20	38	16.94	58	94.55
20	42	15.80	62	95.69
20	46	12.07	66	99.42
20	52	9.35	72	102.14
20	58	5.81	78	105.68

Proposed Grade

station	Elevation	Un-converted Station
96	107	0
90	107	6
62.5	95.2	33.5
62	94.2	34
41	94.2	55
39	95.2	57
6	107	90
0	107	96

Pre-Project Grade

station	Elevation	Un-converted Station
96	107	0
68	107	28
52	92.8	44
37	92.8	59
36.9	98.3	59.1
33	98.3	63
10	107	86
0	107	96

Cross Section B-B'' (Survey by Cousins and Storesund, November 2005)

Station	BS (ft)	FS (ft)	HI (ft)	EL[1] (ft)	Notes
0+00		5.06			
0+02					
0+04		6.11			
0+06					
0+08		7.89			
0+10					
0+12		9.87			
0+14					
0+16					
0+18		12.63			
0+20		17.31			
0+22		17.64			
0+24					
0+26		18.59			
0+28					
0+30		19.21			
0+32					
0+34					
0+36		19.25			
0+38		19.29			
0+40		19.49			Gravel bar at 0+41
0+42		19.38			
0+44		19.52			
0+46		19.58			
0+48		19.44			
0+50		18.08			Log at creek bank
0+52		16.88			
0+54					
0+56		11.70			
0+58					
0+60					
0+62		8.21			
0+64					
0+66		6.66			

[1]Vertical datum based on project datum

For Graph

OFFSET		station	Converted Elevation	Measured height
10	0	10	107.00	5.06
10	4	14	105.95	6.11
10	8	18	104.17	7.89
10	12	22	102.19	9.87
10	18	28	99.43	12.63
10	20	30	94.75	17.31
10	22	32	94.42	17.64
10	26	36	93.47	18.59
10	30	40	92.85	19.21
10	36	46	92.81	19.25
10	38	48	92.77	19.29
10	40	50	92.57	19.49
10	42	52	92.68	19.38
10	44	54	92.54	19.52
10	46	56	92.48	19.58
10	48	58	92.62	19.44
10	50	60	93.98	18.08
10	52	62	95.18	16.88
10	56	66	100.36	11.70
10	62	72	103.85	8.21
10	66	76	105.40	6.66

Proposed Grade

Station	Elevation	Uncorrected Station
100	105	0
78	105	22
59	96	41
57	94	43
37	94	63
35	96	65
18	105	82
6	105	94
0	107	100

Pre-Project Grade

Station	Elevation	Uncorrected Station
100	106	0
87	105	13
60	98.6	40
59.9	95	40.1
33	92.6	67
32.9	98.7	67.1
15	106	85
0	107	100

Cross Section C-C' (Survey by Cousins and Storesund, November 2005)

Station	BS (ft)	FS (ft)	HI (ft)	EL[1] (ft)	Notes
0+00		5.04			
0+02					
0+04		6.46			
0+06					
0+08		8.75			
0+10					
0+12		10.75			
0+14					
0+16		12.33			
0+18					
0+20		17.98			
0+22					
0+24		18.33			
0+26					
0+28		19.63			Edge of gravel bar
0+30					
0+32		19.90			
0+34					
0+36					
0+38		20.19			Edge of gravel bar & water
0+40		20.56			
0+42		21.08			
0+44		21.26			
0+46		22.05			
0+47		19.59			Top of log
0+48		19.53			Edge of water
0+50		18.77			
0+52		13.48			
0+54		12.00			
0+56		9.98			
0+58					
0+60					
0+62		7.68			
0+64					
0+66					
0+68		5.32			
0+70					

[1]Vertical datum based on project datum

For Graph

Offset	Unconverted Station	station	Elevation	Unconverted Elevation
25	0	25	107.00	5.04
25	4	29	105.58	6.46
25	8	33	103.29	8.75
25	12	37	101.29	10.75
25	16	41	99.71	12.33
25	20	45	94.06	17.98
25	24	49	93.71	18.33
25	28	53	92.41	19.63
25	32	57	92.14	19.90
25	38	63	91.85	20.19
25	40	65	91.48	20.56
25	42	67	90.96	21.08
25	44	69	90.78	21.26
25	46	71	89.99	22.05
25	48	73	92.45	19.59
25	50	75	92.51	19.53
25	52	77	93.27	18.77
25	54	79	98.56	13.48
25	56	81	100.04	12.00
25	58	83	102.06	9.98
25	62	87	104.36	7.68
25	68	93	106.72	5.32

Proposed Grade

Station	Elevation	Unconverted Station
	107	0
	107	19
	96	47
	94	49
	94	70
	96	72
	106	93

Pre-Project Grade

Station	Elevation	Unconverted Station
	107	0
	107	12
	105	29
	99.2	42
	94	42.1
	92.9	72
	99	72.1
	106	89
	106	100

Cross Section D-D' (Survey by Cousins and Storesund, November 2005)

Station	BS (ft)	FS (ft)	HI (ft)	EL[1] (ft)	Notes
0+00		6.50			
0+02					
0+04					
0+06					
0+08					
0+10		9.03			
0+12					
0+14		10.55			
0+16					
0+18		12.40			
0+20		13.15			
0+22		20.35			
0+23		19.44			
0+24		20.88			Edge of water at 0+23.5
0+26		20.60			
0+28		20.80			
0+30		21.28			
0+32					
0+34		21.04			
0+36		21.05			
0+38		20.96			
0+40		20.88			
0+42					
0+44		20.68			Edge of water
0+46					
0+48		19.95			
0+50					
0+52					
0+54		19.22			
0+56					
0+58		18.18			
0+60					
0+62		13.55			
0+64					
0+66		12.90			
0+68					
0+70		11.23			
0+72		10.83			
0+74					
0+76					
0+78					
0+80					
0+82					
0+84					
0+86					
0+88					
0+90		10.44			

[1]Vertical datum based on project datum

For Graph

OFFSET	field station	Modified station	Elevation	Unconverted Elevation
10	0	10	106.30	6.50
10	10	20	103.77	9.03
10	14	24	102.25	10.55
10	18	28	100.40	12.40
10	20	30	99.65	13.15
10	22	32	92.45	20.35
10	24	34	93.36	19.44
10	26	36	91.92	20.88
10	28	38	92.20	20.60
10	30	40	92.00	20.80
10	32	42	91.52	21.28
10	34	44	91.76	21.04
10	36	46	91.75	21.05
10	38	48	91.84	20.96
10	40	50	91.92	20.88
10	44	54	92.12	20.68
10	48	58	92.85	19.95
10	54	64	93.58	19.22
10	58	68	94.62	18.18
10	62	72	99.25	13.55
10	66	76	99.90	12.90
10	70	80	101.57	11.23
10	72	82	101.97	10.83
10	90	100	102.36	10.44

Proposed Grade

station	Elevation
0	106.3
9	106.3
32	100
48	94
49	92.7
71	92.7
72	94
82	98
100	98

Existing Grade

OFFSET	Original Station	Converted Station	Elevation
-20	0	-20	106.3
-20	30	10	105.5
-20	37	17	104.2
-20	38	18	100
-20	52	32	100
-20	52.1	32.1	101
-20	60	40	101
-20	60	40	94
-20	62	42	93.2
-20	77	57	94
-20	77.1	57.1	100
-20	93	73	100
-20	94	74	98
-20	98	78	98

Kupers' Section

offset	field station	modified station	Elevation	
15	0	15	104	41
15	10	25	102	39
15	20	35	98	35
15	30	45	93	30
15	32	47	94	31
15	33	48	92	29
15	35	50	93	30
15	40	55	94	31
15	60	75	94	31
15	70	85	97	34
15	80	95	100	37

Cross Section III-III' (Survey by Cousins and Storesund, November 2005)

Station	BS (ft)	FS (ft)	HI (ft)	EL[1] (ft)	Notes
0+00	4.16	4.16		105.0	
0+02					
0+04					
0+06		5.72			
0+08					
0+10		7.59			
0+12					
0+14		8.97			
0+16					
0+18					
0+20		12.60			
0+22		14.98			Edge of water'
0+24					
0+26		15.32			
0+28		15.36			
0+30		15.29			
0+32		15.25			
0+34					
0+36		15.24			Edge of water at 0+37
0+38		14.41			
0+40					
0+42		13.97			
0+44					
0+46		13.25			
0+48					
0+50		11.59			
0+52					
0+54					
0+56					
0+58					
0+60		7.60			
0+62					
0+64					
0+66					
0+68		6.14			
0+70		5.36			Top of curb
0+71		5.78			Edge of curb
0+72					
0+74					
0+76		5.76			

[1]Vertical datum based on project datum

For Graph			Proposed Grade		Existing Grade	
station	Elevation		station	Elevation	station	Elevation
0	105.00	4.16				
6	103.44	5.72				
10	101.57	7.59				
14	100.19	8.97				
20	96.56	12.60				
22	94.18	14.98				
26	93.84	15.32				
28	93.80	15.36				
30	93.87	15.29				
32	93.91	15.25				
36	93.92	15.24				
38	94.75	14.41				
42	95.19	13.97				
46	95.91	13.25				
50	97.57	11.59				
60	101.56	7.60				
68	103.02	6.14				
70	103.80	5.36				
72	103.38	5.78				
76	103.40	5.76				

Jesse's Survey			
uncorrected station	corrected station	Elevation	Uncorrected Station
0	69	105	41
7	62	103	39
14	55	100	36
20	49	97	33
27	42	95	31
34	35	95	31
48	21	94	30
50	19	96	32
56	13	100	36
69	0	105	41

Cross Section E-E' (Survey by Cousins and Storesund, November 2005)

Station	BS (ft)	FS (ft)	HI (ft)	EL[1] (ft)	Notes
0+00					
0+01		5.19			Fence line
0+02					
0+04					
0+06					
0+08					
0+10					
0+12		6.64			Top of curb
0+14		7.14			Sidewalk
0+16					
0+18		6.67			Top of curb (6 inches wide)
0+20					
0+22		7.28			
0+23					
0+24					
0+26					
0+28					
0+30		9.98			
0+32					
0+34					
0+36		11.94			
0+38					
0+39		11.93			Top of wall
0+39.1		14.44			Bottom of wall
0+40					
0+42					
0+44		15.67			Edge of water
0+46					
0+48		16.02			
0+50					
0+52					
0+54		16.26			
0+56		16.12			Edge of water
0+58					
0+60		13.93			
0+62		13.25			
0+64					
0+66		11.27			
0+68					
0+70		8.81			
0+72					
0+74		7.13			
0+76					
0+78					
0+80		5.72			
0+82		5.88			
0+84					
0+86					
0+88					
0+90					
0+92					
0+94					
0+96					
0+98					
1+00		5.13			

[1]Vertical datum based on project datum

	For Graph			
Offset	**Unconverted Station**	Converted Station	Elevation	Unconverted Elevation
17	1	18	102.80	5.19
17	12	29	101.35	6.64
17	14	31	100.85	7.14
17	18	35	101.32	6.67
17	22	39	100.71	7.28
17	30	47	98.01	9.98
17	36	53	96.05	11.94
17	39	56	96.06	11.93
17	39.1	56.1	93.55	14.44
17	44	61	92.32	15.67
17	48	65	91.97	16.02
17	54	71	91.73	16.26
17	56	73	91.87	16.12
17	60	77	94.06	13.93
17	62	79	94.74	13.25
17	66	83	96.72	11.27
17	70	87	99.18	8.81
17	74	91	100.86	7.13
17	80	97	102.27	5.72
17	82	99	102.11	5.88
17	100	117	102.86	5.13

Proposed Grade	
Station	Elevation
0	104.8
13	104
26	103
53	96.4
56	96.4
56.1	92.1
79	92.1
81	94
100	100

Pre-Project Grade	
Station	Elevation
0	104.8
26	102
43	97
56	96.4
56.1	92.1
63	91
73	92.1
97	102.5

Appendix II

Pebble Count Data

Appendix, Table 1

Cumulative Size Distribution for Pebble Counts on Arroyo Viejo Creek (% Finer) November 12, 2005					
	Location of Pebble Count				
Size (mm)	Bar below Pedestrian Bridge	XS II	XS III	XS V	XS VI
362	100%	100%	100%	100%	100%
256	100%	99%	100%	98%	100%
180	100%	99%	99%	92%	100%
128	100%	99%	99%	88%	95%
90	100%	99%	99%	88%	94%
64	100%	99%	99%	86%	92%
45	99%	99%	94%	84%	92%
32	99%	95%	78%	77%	89%
22.5	91%	84%	60%	63%	87%
16	78%	73%	46%	51%	75%
11.3	61%	47%	35%	42%	58%
8	40%	35%	23%	28%	41%
5.7	20%	27%	15%	19%	21%
4	9%	15%	5%	12%	14%
D_{50} (mm):	10	12	18	15	10

Notes:
For locations of pebble counts, see Figures 6 and 10.
XS II, etc. refers to cross sections II, III, V, and VI as reported by Kupers (2001).
Cross section VI is near cross section H.