POST-PROJECT APPRAISAL OF THE SAUSAL CREEK RESTORATION PROJECT, OAKLAND, CALIFORNIA

FINAL DRAFT

BY

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Abstract

Sausal Creek originates in the Oakland Hills of California, runs through the city of Oakland, and terminates at the San Francisco Bay. The lower half of the riparian corridor is channelized or culverted and the upper half is natural and free flowing. Dimond Canyon Park is located in this transition area and the steep banks experience erosion and landsliding. The proximity of the corridor to development makes it a focus of attention. In the 1930's, the Works Progress Administration installed extensive concrete and steel structures in the creek to control erosion and stabilize the banks. In 2001, the City of Oakland, the California Coastal Conservancy, and the Alameda County Flood Control and Water Conservation District sponsored the restoration of an 825-foot reach of the creek with the help of the Friends of Sausal Creek. The project's stated objectives were to remove six in-stream structures, improve water quality, stabilize the channel and banks, control erosion, improve access, and additionally to restore hydrologic function, sediment transport, native vegetation, and habitat for aquatic and terrestrial species. By 2002, the structures were removed from the channel, six rock weirs installed, 20,000 plants planted, bank stabilization installed, and 600 feet of the channel realigned and regraded.

We conducted a post-project appraisal (PPA), based on water quality, aquatic insect, and vegetation monitoring data collected by the Friends of Sausal Creek. These data indicated no change in water quality or aquatic insects since the project. However, percent cover of vegetation increased from zero to 50 percent in the first 18 months of the project. FoSC found that 74% of the vegetation in the riparian corridor is native and using the Simpson's Diversity Index, found that diversity has dramatically increased since the restoration. We surveyed nine cross-sections and the long profile of the restored channel. We compared our data to pre-project design information from Wolfe Mason and Associates and the as-built data from the Restoration Design Group and detected no changes in the channel. The rock weirs appeared to successfully create riffles and deep pools. We conducted a qualitative community survey and found that the trail is highly used by park visitors who are excited about the restoration. However, we found evidence that dogs and people are eroding the banks in accessing the creek, which could cause future failure. We recommend evaluation of sediment transport and hydrologic function, continued monitoring, implementation of dog management guidelines, permanent survey markers, and continued invasive plant removal.

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Introduction

This study is a post-project evaluation of the Sausal Creek restoration project, which is located in Dimond Park, Oakland, California (Figure 1). The watershed drains an area of 2,656 acres (4.15 mi^2), flows through a tidal canal that separates Oakland and Alameda, and then flows into the San Francisco Bay (Figure 2). Sausal Creek begins in the Oakland Hills just below Highway 13 at the confluence of the headwater tributaries, Shepard and Palo Seco Creeks (Figure 3). These creeks have spring-fed baseflow and also carry storm runoff. The upper half of Sausal Creek is free flowing; the lower half is culverted or channelized through an urban area. About eighty percent of the watershed is developed, and the undeveloped area includes all of Joaquin Miller Park (Lowe, 1998) (FoSC Website, 2005).

Seismic activity, channel incision, and landslides define the topography of the Sausal Creek watershed. The Hayward fault cuts through the watershed, and east of the fault, the Oakland hills are rapidly uplifting, resulting in the convergence of Shepard and Palo Seco Creeks. Near this intersection, average slopes range from 30-75%; downstream, slopes flatten out. In the steep areas of the watershed, landslides and debris flows are common, and deliver increasing amounts of sediment to the creek. Also, post-wildfire sediment pulses and headwater channel incision contribute to increased sediment loads (Lowe, 1998) (Barry Hecht, personal communication, July 12, 1999).

The Works Progress Administration (WPA) installed concrete and steel structures in the channel for unknown reasons, but Goetting (personal communication, July 6, 1999) speculated that the structures were built to stabilize the banks and prevent channel incision. However, the structures did not prevent landslides, and started to fail. In 1995, flooding in Dimond Canyon raised community awareness about the creek’s problems. Consequently, the Friends of Sausal

Creek (FoSC) formed in 1996 and began to focus on native revegetation, erosion control, bank stabilization, and monitoring (Chanse et al., 2003). FoSC's mission is "to promote awareness and appreciation of the Sausal Creek watershed, and to inspire action to preserve and protect the creek and its watershed as both a natural and a community resource" (FoSC website, 2005).

After the flood, it became clear to the community that the concrete structures were in disrepair and possibly detrimental to channel stabilization. With the assistance of FoSC, the City of Oakland, the California Coastal Conservancy, and the Alameda County Flood Control and Water Conservation District identified Sausal Creek as a priority river restoration project and sponsored an effort to restore the creek and remove the structures (Oakland DPW website, 2005) (Drew Goetting, Memo, July 6, 1999).

In 1999, the city of Oakland replaced a sewer line that runs through the canyon by a non-invasive slip-line procedure. This installation resulted in higher streamflows because water had been infiltrating into the old pipes (Emma Brown, FoSC, personal communication, November 8, 2005). In 2000, Wolfe Mason and Associates (WMA) designed a restoration project for a 597-linear foot section of Dimond Canyon beginning at about 825 feet upstream of El Centro Avenue and FoSC planned a native plant revegetation project for the entire reach (Figure 4).

By 2002, one five-foot concrete check dam and spillway and two metal and concrete debris racks had been removed. The channel was realigned and re-graded, and six vortex rock weirs were installed in the creek (Figure 4). These rock weirs were installed to control the profile, to define and maintain the thalweg, and to create pools for aquatic diversity (WMA, 2000).

During the construction, the banks were cleared of mostly non-native vegetation, reconstructed, and stabilized with erosion control matting and large boulders. After the construction, FoSC continued invasive plant removal, planted 17,000 native plants by March 2002, and planted another 3,000 plants by March 2003.

WMA (2000) stated the key objectives of the restoration project as:

- Removal of three (3) structures from the active channel: Two (2) three foot debris racks which span the creek and one (1) five foot concrete check dam;
- Restoring hydrologic function to Sausal Creek for safe storm-water conveyance, sediment transport (dynamic equilibrium), and improved water quality;
- Restoring a stable channel profile and meander sequence which transitions smoothly and safely between the reaches up and downstream of the restoration site;
- Re-establishing a stable channel and banks (this work will include removing sections of existing WPA era concrete and mortared stone walls);
- Restoring native regional riparian plant species;
- Enhancing and restoring habitat for terrestrial and aquatic species;
- Providing long-term erosion control; and
- Incorporation of appropriate recreational amenities such as a multi-use trail (pedestrian and maintenance vehicles), footbridges, overlooks, and interpretive signage (WMA, 2000, p. 3).

This post-project appraisal (PPA) assesses the degree to which the project has met these objectives and evaluates the effectiveness of the project based on systematic data collections. The experience gained from this project can guide and improve the success of future river restoration projects (Downs et al., 2002).

Methods

The first aspect of this project involved gathering information and plans from the Friends of Sausal Creek, Wolfe Mason and Associates, and other individuals involved with the project. We obtained pre-project plans and documents from WMA and an as-built survey from Drew Goetting with the Restoration Design Group. Also, we conducted research and reviewed previous Berkeley projects from LAEP 222 and LAEP 227. Since the Friends of Sausal Creek currently monitor vegetation, water quality, and aquatic insects, we used their data in this study.

Vegetation

FoSC monitored the vegetation in the revegetated area on both sides of the creek in May

2003. They placed a one square meter plastic frame (or quadrant) every forty feet and estimated the percent cover by species and counted the plants. For each monitoring interval, FoSC collected data in the riparian area and the upland area, which was collected one to two meters east of the trail. They separated the data from the east side of the trail (upland) from the west side of the trail (riparian) because these areas received different treatments during the construction phase. Their control data for the percent cover study was collected 40 feet upstream of the restoration project, which was representative of the pre-project vegetation. Their control data for their species counts evaluations was taken from monitoring information that was collected before construction started. With their plant counts, FoSC measured diversity by calculating the Simpson Diversity Index. The following formula was used: $\Delta = (n/N)^2$, where n is the number of individuals of each species and N is the total number of plants in the sample. Lower numbers represent greater diversity (Paulsell, 2005).

Aquatic Insects

For Sausal Creek aquatic insect monitoring, FoSC collects their samples from the restored reach and Palo Seco Creek, which is the control site. Their samples are collected using a D-frame net with a 0.5mm mesh. The net is placed below a riffle and the 12”x12” area above the net is disturbed so that the organisms will float downstream and into the net. Then, the net is emptied into a white tub by rinsing it with stream water. This mix is sorted into countable portions using a screen that is the same size as the net and the organisms are sorted by species. After the organisms are counted, they are released back into the creek (Emma Brown, personal communication, November 22, 2005).

Community Survey

We conducted an informal community survey on November 4, 2005 and November 13, 2005. During the 15 hours we spent in the field, we counted the number of people walking along the trail. We asked ten trail users how they felt about the restoration at Dimond Canyon and if access to the canyon has improved.

Water Quality

FoSC began water quality monitoring in Sausal Creek in February 1998. Water quality monitoring is performed upstream of, downstream of, and within the project reach. The upstream sampling location is Palo Seco creek, which is approximately 2,500 feet from the restoration site. The downstream location is where Sausal Creek meets El Centro Avenue, which is approximately 1000 feet downstream from the restoration site. Water quality monitoring at the restoration reach was initiated in 2002.

We reviewed the water temperature, dissolved oxygen, pH, and conductivity data compiled by the FoSC. We compared the temporal trends of water quality parameters in an attempt to elucidate the effect of the restoration project on water quality. We created the temporal trends by plotting the water quality parameters versus sampling date. The upstream, downstream, and restoration site data were plotted on the same graph for comparison purposes (Figures 5-8).

Additionally, we analyzed the baseflow water quality data. The baseflow water quality values, which were assumed to occur from May through October, were determined by averaging the sampling data (Table 6). The purpose of the baseflow analysis was to isolate the stream conditions from the effects of stormwater inputs. Because no pre-project sampling data was available at the restoration, the baseflow data was analyzed from 2002 to 2005 and the restoration site data was compared to the upstream and downstream data.

Channel Morphology

In order to determine the effect of the stream restoration project on the channel morphology, channel stability, and bank stability, we surveyed a longitudinal profile and eight cross-sections along the restored reach. We used a self-leveling level and a survey rod to gather elevation data and adjusted the elevations by tying into a manhole cover east of the trail about 600 feet upstream from El Centro Avenue, which has an elevation of 240.2 feet (WMA, 2001). We could not locate the cross-section pins, so we used the horizontal distances indicated on the pre-project plans (WMA, 2001) and referenced these distances to the rock weirs or existing in-stream structures to locate our cross-sections. We marked our cross-sections with redwood stakes and pink tie-tape so further monitoring can be performed. Our zero point for the longitudinal survey was the debris rack, which was 234.25 feet upstream of the rock weir at cross-section J.

We then compared our survey with the pre-project data and the as-built survey (Drew Goetting, personal communication, 2001). Because we had difficulty with locating the cross-sections, our surveys may not have been in exactly the same places as the previous surveys. In order to compare our cross-section survey data with the as-built data, we horizontally shifted cross-sections B, C, D, and E to match the as-built points on the left bank. Cross-sections A, I, J, and K were not shifted and no elevations were changed. In addition, the zero point was not indicated on the as-built longitudinal survey, so this data was not collected in the same place. We adjusted the as-built data to our longitudinal profile by matching the points at rock weir 4. Since it was difficult to compare our longitudinal profile data with the as-built data, we decided to analyze the effects of the constructed rock weirs on the longitudinal profile. We were able to identify and compare five of the six rock weirs identified in the as-builts by matching the elevation at the top of the rock weir and we plotted the longitudinal profile immediately upstream and downstream of each weir.

Results

Vegetation

The FoSC results of the understory vegetation survey performed in the spring of 2003 are reported in Tables 1-4. Table 1 shows the percent cover of vegetation and includes the percentage of bare ground, whereas Table 2 outlines the percent cover excluding bare ground. In these two tables, the percent cover of natives and non-natives were calculated for the riparian, upland, and control areas. For this study, the control data was collected upstream of the restoration project and represents pre-project conditions.

FoSC used their 2003 plant count data to calculate the percentages of natives and non-natives (Table 3) and the Simpson's Diversity Index (Table 4).

Aquatic Insects

FoSC has conducted monthly aquatic insect studies since 1998 and the results are shown in Table 5. The table highlights the data collected from March through May because spring counts are the most significant in finding trends (Emma Brown, personal communication, November 8, 2005).

Community Survey

During the two days spent collecting field data we observed about 100 people walking through the project reach on the trail. Approximately 75% of the observed people had dogs. Of the ten people surveyed, nine believed that the restoration project improved Dimond Canyon and has increased their use of the corridor since the restoration project was completed.

Water Quality

The water quality trends are shown in Figures 5-8. The baseflow water quality results are shown in Table 6. The complete results of water quality monitoring are presented in Appendix 1.

Channel Morphology

Our longitudinal profile data is compared to the as-built data in Figures 9-10 and the locations of the rock weirs or riffle starters (RF) are noted. In some locations the data does not correspond, but the overall channel slope of 0.02 has remained relatively constant.

In Figures 11-16, we plotted the channel profile at the rock weirs and compared our data to the as-built data. A summary of the change in pool depth at the rock weirs can be found in Table 7. It should be noted that we could not definitively locate rock weirs three and five.

The locations of the cross-sections are marked on the longitudinal profile in Figure 17 and on the project plan in Figure 4. We compared our cross-section data to the pre-project data and the as-built survey in Figures 18-27.

Discussion

Vegetation

In April 2003, FoSC began monitoring vegetation to evaluate the native and non-native understory vegetation and to guide future vegetation efforts (Paulsell, 2005). We can use the results from the monitoring survey to compare the pre-project vegetation (control) with the vegetation condition in 2003.

The total percent cover for the riparian, upland, and control areas was 52%, 53%, and 90%, respectively. The riparian and upland areas had similar percent cover, but the riparian area had a significantly higher percent cover of native vegetation. Neglecting the percent cover of bare ground clearly demonstrates that the riparian cover was mostly native and the control cover was mostly non-native (Paulsell, 2005). Even though the control area had less bare ground cover, it was mostly non-native. Paulsell (2005) noted that the bare ground might have been due to trampling by dogs and people, slow-growth of native shrubs, invasive plant removal, channel scouring, and the natural spacing of plants in the understory. We observed many dogs running off the designated trail and on the banks of the creek, and observed evidence of erosion (Figure 28). Also, people use rock weirs to cross the creek, causing erosion on the slopes leading to the weirs. Pausell (2005) reported possible causes for the varying coverage results in the riparian and upland areas:

- The upland area was infested with more deep-rooted invasives before the project.
- During construction, more deep-rooted invasives were removed in the riparian area.
- Algerian Ivy, which was not removed during the project, was growing into the upland area.
- Hydroseeding of upland banks post-construction produced grasses that out-competed native plants.
- The upland zone was drier, which increased native outplanting mortality.
- Mulch applied in the riparian area assisted the new plants with water retention.

Paulsell (2005) also commented on the differences between the percentages of natives and non-natives in the count and coverage data. She noted that growth was greater in the wetter, riparian area, the coverage data accounted for plants growing outside of the quadrant, and the fast-growing willows and dogwoods accounted for a greater coverage area that was misrepresented in the plant counts.

Overall, the revegetation efforts of FoSC were successful and native vegetation is thriving according to the 2003 vegetation monitoring. “The understory has gone ‘from 0 to 50’ percent cover in the 18 months from the initial planting to the date the survey was performed”

(Pausell, 2005, p. 11). Before the restoration project, the percent cover of native vegetation was 12 percent compared to 75 percent in the riparian area (Figure 29). Also, the Simpson's Diversity Index Values indicated that plant diversity drastically increased after the project.

Aquatic Insects

Aquatic insects are an indicator of the overall health of a stream (Brown, 2002). Benthic macroinvertebrates are most commonly used in biological assessments because they are ubiquitous in stream environments, have long life histories, and can tolerate perturbations in the stream (Rosenberg et al., 1993). In Sausal Creek, FoSC hopes to find macroinvertebrates from the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). Within the orders, families are ranked based on their ability to tolerate pollutants (Brown, 2002). FoSC looks for a variety and an abundance of insects to indicate a healthy level of trophic groups and habitat (Emma Brown, personal communication, November 8, 2005).

Brown (2005) reported an increase in sample totals from 514 in 1999 to 804 in 2000. This is probably due to the increased streamflow after the new sewage pipe was installed. In 2001, the counts dropped to 280 probably because of the construction at the site. Immediately after the restoration was completed, sample totals increased to 1002, but they have decreased by 1/3 annually since then. The decrease may be due to a lack of food sources and light vegetative cover (Emma Brown, personal communication, November 8, 2005).

The proportion of EPT has fluctuated over the years. In 1998, the proportion was 48% and then it dropped to 21% after the sewage pipe replacement. It dropped again to 10% after the channel restoration, and now the proportion is back up to 91%. The rise in the proportion of EPT is mainly due to an increase in the Baetid (Mayfly) population, which is the most pollutant-tolerant member of the EPT orders. However, the beneficial Mayfly has replaced the Chironomid

(True Fly) and the Nematophora (Horsehair worm) as the most dominant taxon (Brown, 2005).

The Family Taxa Richness was 12 in 1998, 14 after the pipe replacement, 13 in 2002, and only three in 2004. The control site, Palo Seco Creek, had a Family Taxa Richness of 14 in 2004 (Emma Brown, personal communication, November 8, 2005). The decrease in the Family Taxa Richness reflects the overall decrease in macroinvertebrate diversity.

Purcell (2004) performed a similar study of macroinvertebrates at Baxter Creek in El Cerrito, California, which is about 12 miles from the Sausal Creek restoration site. She performed a biological assessment in 2004, compared her data to data collected in 1997 (two years after the restoration project), and concluded that there was no improvement in macroinvertebrates. She cited flow variations, interannual variability of biotic assemblages (Vogel, 1998), urban pollution, and water quality as possibilities for no observed improvement. She stated that the "1999 biological assessment may represent the ecological 'plateau' of the community within the constraints of a highly disturbed and impacted system" (Purcell, 2004, p.11).

Sausal Creek may be experiencing similar urban disturbances and natural variability. Even though the creek restoration provided more vegetative cover and channel complexity for insect habitat, other factors may be affecting the populations, such as water quality, which could explain the increase in the pollutant-tolerant Baetid population. In addition, natural variations in flow and yearly assemblages could be affecting the insect sample totals and Family Taxa Richness. From 1999 to 2004, there was no improvement in the biological assessment of aquatic insects at Palo Seco Creek or Baxter Creek, so the Sausal Creek trends could be mimicking regional trends.

In conclusion, the aquatic insect sample total and Family Taxa Richness have decreased since the restoration, but the beneficial insects are outnumbering the fly larvae. There are many factors that could be influencing the aquatic insect habitat, and future monitoring should provide a better indication of aquatic insect health.

Community Survey

The informal community survey is a skewed sample since we only surveyed the people currently using the site. From our conversations with park visitors, we discovered that use has increased since the restoration site because of the newly developed multi-purpose trail.

Water Quality

In general, the temporal trend analyses of water quality parameters did not yield any conclusive evidence indicating the restoration project had an affect on water quality. The temporal trends indicate water quality within the project reach mimics the seasonal trends of water quality at the upstream and downstream sampling location. No significant difference was noticed between the project reach, upstream, and downstream sampling locations (Figures 4-7). The water quality within the project reach is probably a function of upstream conditions as the restoration reach is relatively small compared to the large watershed. Additionally, the variability of the small post-project monitoring data set inhibits our ability to establish meaningful trends.

The baseflow analysis provides a view of conditions within Sausal Creek without significant stormwater input, although a thorough assessment of precipitation data would provide a more complete analysis. The comparison of baseflow data indicates that there may have been a small short-term negative effect as a result of the restoration project. The short-term effect is reflected in dissolved oxygen, water temperature, and conductivity. The pH remained constant at all three locations throughout the monitoring period.

The baseflow analysis indicates that water temperature gradually increased from 2002 to 2004 at all three locations. The restoration site water temperature was consistently higher than the upstream water temperature (Table 6). However, the water temperature dropped in 2005 to equilibrate with the upstream data. We can speculate that as the riparian vegetation matured, more shading was provided and the water temperature decreased. The upstream conditions are fairly shaded; therefore, we would expect the water temperature within the project reach to equilibrate with the upstream sampling location.

Dissolved oxygen gradually decreased within the restoration site from 2002 to 2004. In 2002 and 2003, the dissolved oxygen concentration was higher than the upstream or downstream locations. It appears that the restoration project may have had some short-term effect on increasing dissolved oxygen levels within the project reach. However, the dissolved oxygen has equilibrated with the upstream sampling location over the past two years (Table 6). Overall, the dissolved oxygen concentrations throughout Sausal Creek are at relatively healthy levels (USEPA 1997).

Conductivity increased annually at the restoration site and the downstream site from 2002 to 2004, while remaining relatively constant at the upstream site. Conductivity is a sign of salt and sediment loading and can reveal changes in pollutant loadings. An increase can be caused by increases in groundwater flow, wastewater, sediment loads, or turbidity (USEPA 1997). The restoration site may be a source of the increased conductivity. However, 2005 data indicate that the restoration site is in equilibrium with the upstream site (Table 6).

Overall, we were unable to elucidate the effects of the restoration project on water quality. The baseflow analysis indicates that a short-term negative effect on conductivity, dissolved oxygen, and water temperature was experienced within the project reach. However, the limited data set of post-project monitoring does not allow for a complete and definitive analysis. More time and continued efforts from FoSC will provide a larger data set from which stronger conclusions can be made in the future.

Channel Morphology

Because the starting point of the as-built longitudinal profile survey was not indicated, it was difficult to compare our data to the as-built data. However, by performing a best-fit line analysis to both sets of data, we found that the slope of the restoration reach has increased by 0.20 percent, which indicates that the channel is stable. The channel slope in the restoration plans was 2.6 percent, but may have been modified during construction. In addition, minor differences in the surveys could be attributed to the number of data collection points or varying horizontal thalweg distances.

We prepared detailed longitudinal profile plots at the rock weir locations to determine the effect the weirs have had on upstream and downstream channel depths. From 2001 to 2005, the pool depth increased by 0.43, 2.06, and 0.92 feet at rock weirs one, two, and four, respectively. There is a noticeable scouring effect immediately downstream of these rock weirs and the pools are generally deeper and longer than the as-built dimensions. The pool downstream of rock weir six has remained constant and the pool downstream of rock weir seven has aggraded 0.54 feet. The channel appears to have incised just upstream of the weirs, but this may be an artifact of more survey points in the post-project survey rather than actual incision.

Rock weirs three and five appeared on the pre-project and as-built plans, but we could not find them. However, two of the rock weirs were redesigned at the last minute and out of concern for pool scour, one may not have been installed at all, and no toe rocks were used for either of them (Drew Goetting, personal communication, 2005). We observed large boulders in the channel just downstream of the location of one of the planned weirs suggesting this one washed out.

In addition, we were unable to determine the location of the as-built cross sections, which may explain the differences between the as-built and current conditions (Figures 18-27). We did not have as-built data for cross-section A, but we were able to compare current data to the pre-project information (Figure 18). Our survey provides baseline data for future channel assessments.

Just upstream of cross-section B, the failing check dam was removed during construction and the channel modification is demonstrated in Figure 19. Since the restoration, the channel has slightly incised and widened. Also, there is deposition along the edge of the trail from erosion possibly caused by dogs.

Cross-section C (Figure 20) is located at a rock weir, so we were able to determine its location, but it was difficult to determine where along the rock weir the as-built survey data was collected. Also, the as-built survey includes more survey points. However, it does appear that there is slight channel incision and erosion along the left bank, which could be caused by people and dogs accessing or crossing the creek at the weir.

The pre-project channel geometry is evident in cross-section D (Figure 21) where concrete walls were removed to construct the current channel conditions. Again, the as-built survey data includes more data points, and it is difficult to compare the current conditions to the as-built conditions because we are not confident with the location of our survey. It does appear that the channel is stable and the banks may be slightly eroding in some areas and depositing in others.

Even though cross-section E (Figure 22) is located at a rock weir, we are not certain the current and as-built surveys were performed in the same location, so this survey provides baseline data for future channel surveys.

We did not survey cross-section F because there was no pre-project or as-built data and we did not survey cross-sections G and H (Figures 23-24) because of time constraints.

The as-built and current channel morphology at cross-section I (Figure 25) match up well except for the elevations at the trail, which probably have not changed. Other than this anomaly, the channel has remained stable and the thalweg has shifted slightly to the left.

Cross-section J (Figure 26) indicates that the channel and banks are stable. There was no as-built data for cross-section K (Figure 27), so our survey provides baseline data for future surveys.

Overall, we noticed slight channel incision and some bank movement, but the channel appears to be stable and we have outlined these results in Table 8. The results from the longitudinal profile survey also indicate that the channel is stable. In addition, the rock weirs are successfully creating pools.

Conclusions

The first objective of the Sausal Creek restoration project was to remove one concrete and two steel structures from the channel, which was successfully completed. The second objective was to restore hydrologic function (for storm water conveyance), obtain sediment dynamic equilibrium, and improve water quality. Restoring hydrologic function is not a clear and quantifiable objective and we cannot determine how the project will fare until after it experiences a flood. Sediment transport is largely controlled by flow and sediment input and it is difficult to predict how the restoration project will affect sediment transport, but this information could be very valuable in predicting the long-term success of the project. Developing a sediment budget and evaluating sediment size throughout the restored reach could provide more information about channel morphology. Improving water quality is a difficult goal for an urban restoration project to achieve especially for a relatively small project within a large urban watershed. Therefore, it was difficult to isolate the effects the project had on water quality although we observed some short-term effects.

The third objective of the project was to “restore a stable channel profile and meander sequence which transitions smoothly and safely between the reaches up and downstream of the restoration site” (WMA, 2000, p.3). The forth objective was to re-establish the channel and the banks by removing WPA-era walls. Our survey data demonstrates both of these objectives were successfully completed.

The fifth objective of restoring native plants was successfully completed, which aids in the future success of the sixth objective, which is to restore habitat for terrestrial and aquatic species. This is a difficult goal for a small reach within a large urban watershed, but by improving the diversity of plants and restoring the channel to a more natural state, the environment will become more favorable for aquatic and terrestrial species. The populations of aquatic insects may be affected by water quality and natural variations, and long-term data collection will help demonstrate this more clearly.

The seventh objective was to provide long-term erosion control, and again time will demonstrate this. No major landslides have occurred since the construction, so the project has been successful thus far. However, we are concerned about the erosion on the banks, which is caused by informal trails. Erosion at the toe of the bank can cause channel and hillslope instability.

The last objective was to provide a multi-use trail, interpretive signage, footbridges, and overlooks. Our informal community survey demonstrated that the project has greatly improved access to the canyon and the trail is functioning well. There is interpretive signage at the beginning of the trail and there are various informal overlooks.

Overall, the restoration of Sausal Creek at Dimond Canyon is successful. However, we feel that there are some additional efforts that will help to insure long-term success. There are still many invasive plants that could be removed. Bank erosion could be mitigated by implementing a dog management plan, installing a sensitive habitat sign and a “stay on designated trail” sign, installing dog fencing, planting thick vegetation along the trail, and constructing a foot bridge across the creek. A more complete community survey could be conducted to make a complete assessment of community awareness and involvement. The as-built cross sections should be clearly marked along the bank in an area that is not susceptible to erosion and marked on the longitudinal profile. In addition, a metal detector could be used to locate the cross-section pins. Future longitudinal profiles should start at the debris rack upstream of the site to minimize confusion and ensure accuracy. Water quality monitoring should occur immediately upstream and immediately downstream of the restored reach. If these improvements are made and monitoring continues, this project could become a model for urban creek restoration and post restoration monitoring.

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Table 1: Understory Percent Cover Vegetation Including Bare Ground (Paulsell, 2005)

	Native (% cover)	Non-native (% cover)	Bare Ground (% cover)
Riparian	41	14	44
Upland	24	33	43
Control	11	80	9

Table 2: Understroy Percent Cover Vegetation Excluding Bare Ground (Paulsell, 2005)

	Native (% cover)	Non-native (% cover)	Unknown (% cover)
Riparian	74	25	1.2
Upland	42	58	0.35
Control	12	88	0

Table 3: Percent Native and Non-native Plants (Paulsell, 2005)

	Native (% cover)	Non-native (% cover)	Unknown (% cover)
Riparian	52	47	1
Upland	39	61	0
Combined	44	56	1

Table 4: Simpson's Diversity Index
(Paulsell, 2005)

	All Plants			Native Plants Only		
Area	Diversity Index	# of species	# of plants	Diversity Index	# of species	# of plants
Riparian	0.095	60	806	0.234	24	419
Upland	0.108	66	1688	0.17	27	548
Combined	0.074	91	2394	0.131	39	967
Control (pre-project)	0.413	11	113	0.625	2	6

Table 5. Aquatic Insect Study (Brown, 2005)

DATE	Location	Sample Total	Total EPT	% EPT	Family Taxa Richness	Dominant Taxon	% of Dominant Taxon
5/16/98	Dimond Park	597	288	48%	12	Nematophora (Horsehair worm)	34%
5/24/99	Dimond Park	514	182	35%	13	Nematophora (Horsehair worm)	39%
4/30/00	Dimond Park	804	165	21%	14	Chironomid (True Fly)	75%
4/22/01	Dimond Park	280	103	37%	11	Chironomid (True Fly)	40%
4/21/02	Dimond Park	1002	104	10%	13	Chironomid (True Fly)	84%
4/20/03	Dimond Park	397	284	72%	7	Baetid (Mayfly)	71%
3/21/04	Dimond Park	112	102	91%	3	Baetid (Mayfly)	91%

Control Site:

6/13/98	Palo Seco	623	527	85%	21	Baetid (Mayfly)	52%
4/25/99	Palo Seco	617	493	80%	14	Baetid (Mayfly)	47%
5/21/00	Palo Seco	381	298	78%	17	casebuilders (Caddisfly)	36%
5/20/01	Palo Seco	299	233	78%	14	Baetid (Mayfly)	40%
6/16/02	Palo Seco	138	96	70%	18	Baetid (Mayfly)	36%
5/25/03	Palo Seco	86	56	65%	13	Chloroperlid (Stonefly)	23%
4/18/04	Palo Seco	94	78	83%	14	Mayfly (Baetid)	51%

Table 6: Baseflow Water Quality Conditions

Site	Parameter	Dry 1998	Dry 2001	Dry 2002	Dry 2003	Dry 2004	Dry 2005
		May-Oct.	Aug.-Oct.	May-Oct.	May-Oct.	June-Aug.	May-Oct.
Palo Seco	Water Temp C	13.4	14.4	13.2	14.0	15.0	14.3
	DO mg/L	9.4	8.3	8.6	8.3	7.6	8.4
	pH	7.8	7.8	8.2	8.2	8.1	8.5
	Conductivity (uS)	725	790.5	689.3	679.7	702.3	684.0
		May-Oct.	Aug.-Oct.	May-Oct.	May-Oct.	June-Aug.	May-Oct.
El Centro	Water Temp C	15.8	15.1	14.6	15.8	17.6	14.1
	DO mg/L	8.9	9.8	8.2	7.8	8.5	7.8
	pH	7.9	7.8	8.1	8.1	7.9	8.3
	Conductivity (uS)	632	781	716.8	768.5	893.0	738.3
				June-Oct.	May-Oct.	June-Aug.	May-Oct.
Restoration	Water Temp C	No Data Available		15.2	15.5	18.4	14.0
	DO mg/L			10.1	8.6	7.2	8.5
	pH			8.3	8.3	8	8.4
	Conductivity (uS)			614	732.3	888.7	707.5

Table 7: Change in Scour Pool Depth Downstream from Rock Weir

Weir ID:	Weir 1	Weir 2	Weir 3	Weir 4	Weir 5	Weir 6	Weir 7
2001 Pool Depth (ft)	1.31	0.82	??	1.33	??	0.97	2.07
2005 Pool Depth (ft)	1.74	2.88	??	2.25	??	0.94	1.53
Change in Pool Depth (ft)	-0.43	-2.06	??	-0.92	??	+0.03	+0.54
Weir Location on 2005 LP (ft)	651’	583’	515?	437’	398?	339’	238’

Table 8: Cross Section Observations

Cross Section ID:	Location on 2005 LP	Observed Changes
A	683’	No as-built cross section
B	652’	Slightly incised channel, channel widened, deposition along edge of trail (from eroding hillside, dog trail),
C	584’	Slight channel incision, erosion along left bank, general same width.
D	514’	Channel stable, minor bank erosion and deposition
E	437’	Cross sections do not match up, inconclusive.
F	N.S.	Not surveyed
G	N.S.	Not surveyed
H	N.S.	Not surveyed
I	283’	Stable, slight shift to left of thalweg
J	234’	Stable
K	198’	No as-built cross section

Figure 1. Map of Dimond Park (Mapquest website, 2005)

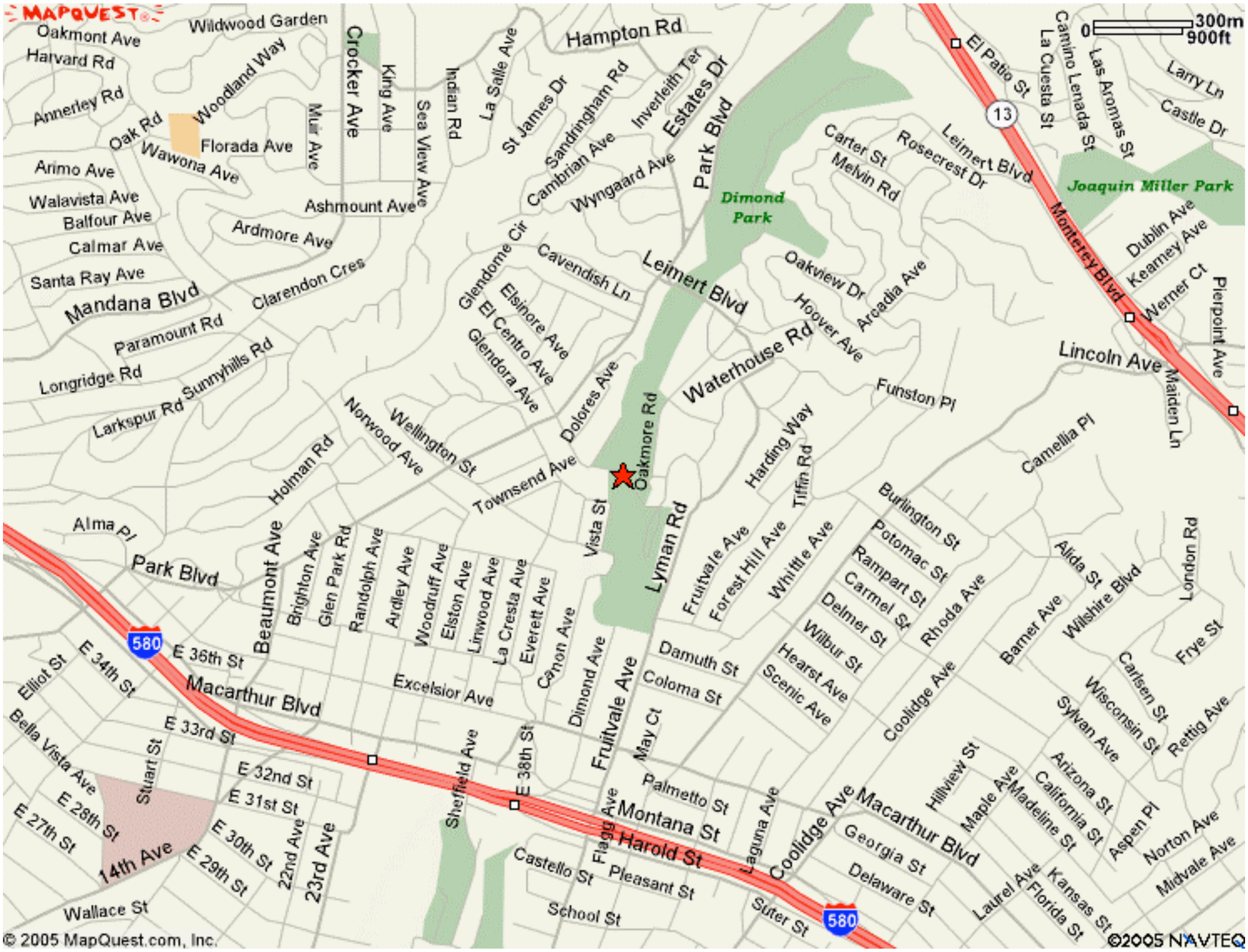


Figure 2. Sausal Creek Watershed Map
(Oakland Museum of California website, 2005)

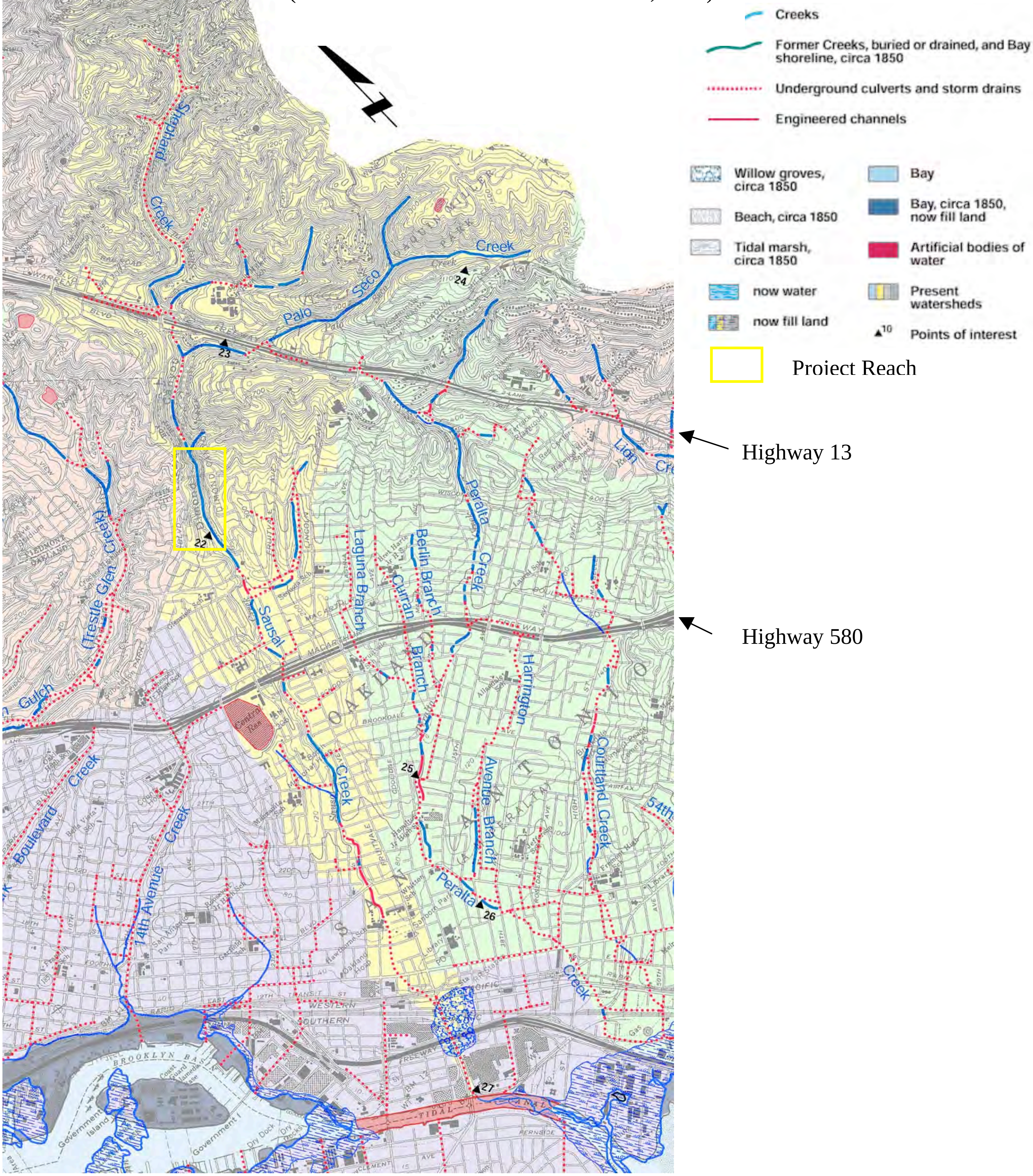
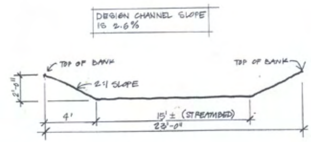


Figure 3. Sausal Creek Watershed (FoSC website, 2005)

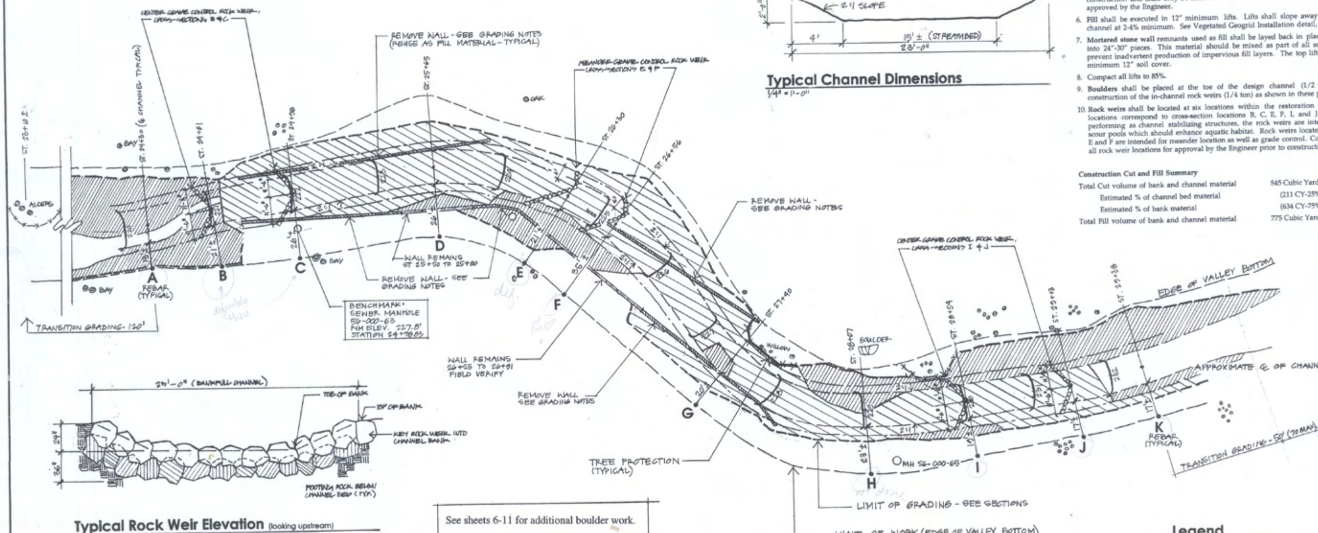
Fish Habitat

1. In two weir/pool locations within the restoration reach, the contractor shall grade pools, install toe of bank boulders and/or cut log material, and install stream channel aggregates per the immediate on site direction of the Engineer and the Fisheries Biologist.
2. Selection of the two pool locations will be per the Engineer and Fisheries Biologist after the tree removal operations are complete.
3. All work shall be inclusive of the related base bid items. Habitat enhancement of the fish pools requires only that certain on site and imported boulder material be placed in varying configurations to create hiding/spawning places for the fish.



Typical Channel Dimensions

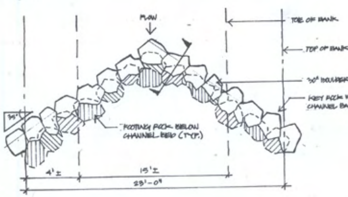
1/4" = 1'-0"



Typical Rock Weir Elevation (looking upstream)

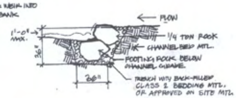
1/4" = 1'-0"

See sheets 6-11 for additional boulder work.



Typical Rock Weir Plan

1/4" = 1'-0"



Typical Rock Weir Section

1/4" = 1'-0"

Grading Notes

1. Limit disturbance to reduce potential for erosion throughout the area of work except in areas where the removal of structures, earthwork, grading, and tree removal are proposed and necessary. Contractor shall be responsible for all dust abatement and control throughout restoration project construction.
2. Base bid for grading operations shall be based upon the construction cut and fill summary (below). The intent is to balance cut and fill on-site. Adjustments to the quantities, if necessary, shall be shall be estimated and paid for as described in the specifications.
3. Cut channel bed and bank material shall be separated for use in different fill situations as described below. Channel bed material is not limited to the three areas noted on sheet 4. All channel bed material shall be reused in the new channel as indicated on the plan or directed by the Engineer.
4. **Channel bed material** (gravel) is unsuitable for bank construction and shall only be used for channel construction and as specified in the bank stabilization details and notes. Contractor shall separate and stockpile channel and bank material separately at appropriate and approved on-site staging areas.
5. **Bank material** (soil and removed and broken up stone walls) is unsuitable for channel construction and shall only be used for bank construction and soil bio-engineering as approved by the Engineer.
6. **Fill** shall be executed in 12" minimum lifts. Lifts shall slope away from the stream channel at 2-4% minimum. See Vegetated Geogrid Installation detail, Sheet 7.
7. **Mortared stone wall** remnants used as fill shall be layed back in place and broken up into 24"-30" pieces. This material should be mixed as part of all soil layers so as to prevent inadvertent production of impervious fill layers. The top lift shall always be a minimum 12" soil cover.
8. Compact all lifts to 85%.
9. **Boulders** shall be placed at the toe of the design channel (1/2 ton) and in the construction of the in-channel rock weirs (1/4 ton) as shown in these plans and details.
10. **Rock weirs** shall be located at six locations within the restoration reach. These six locations correspond to cross-section locations B, C, E, F, I, and J. In addition to performing as channel stabilizing structures, the rock weirs are intended to produce scour pools which should enhance aquatic habitat. Rock weirs located at cross-sections E and F are intended for meander location as well as grade control. Contractor shall flag all rock weir locations for approval by the Engineer prior to construction.

Construction Cut and Fill Summary

Total Cut volume of bank and channel material	845 Cubic Yards Cut
Estimated % of channel bed material	(211 CY-25%)
Estimated % of bank material	(634 CY-75%)
Total Fill volume of bank and channel material	775 Cubic Yards Fill

Rock Weir Installation

1. Refer to Sheet L-4, Layout Plan for general layout and location of rock weir structures. Prior to installation, Contractor shall flag layouts and extents of rock weirs in order to coordinate and verify final structure locations with Engineer.
2. Excavate trench two to three feet below streambed elevation and three to four feet wide running across entire channel and keyed into both banks.
3. Place four to six inches class 2 bed material in the trench.
4. Place first course of large (1/4 ton) boulders on bedding material in trench. Use stockpiled channel bed material to fill interstitial spaces between boulders. Place second rock course above footing rock layer. Final elevation of rock weirs at thalweg (low-flow channel) shall be a maximum of 12".
5. Backfill excavated channel area above rock weir structure with channel bed material as shown in the details.

Legend

- APPROXIMATE AREA OF CUT
- APPROXIMATE AREA OF FILL
- 2:1 BANK / PROPOSED GRADE CONTOUR OF DESIGN CHANNEL BOTTOM / 2:1 BANK
- LIMIT OF GRADING (APPROXIMATE)
- LIMIT OF WORK (EDGE OF VALLEY BOTTOM)
- EXISTING TREES TO REMAIN

REVISIONS	BY

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Sausal Creek Restoration in Dimond Park

City of Oakland, Alameda County Public Works
Collaborative Creek Improvement Project

Grading and Demolition Plan

Date April 2, 2001
Scale 1"=20'-0"
Drawn CK
Job
Sheet 5 Of 13

3@ lower

Figure 5: Temporal Water Temperature Variability

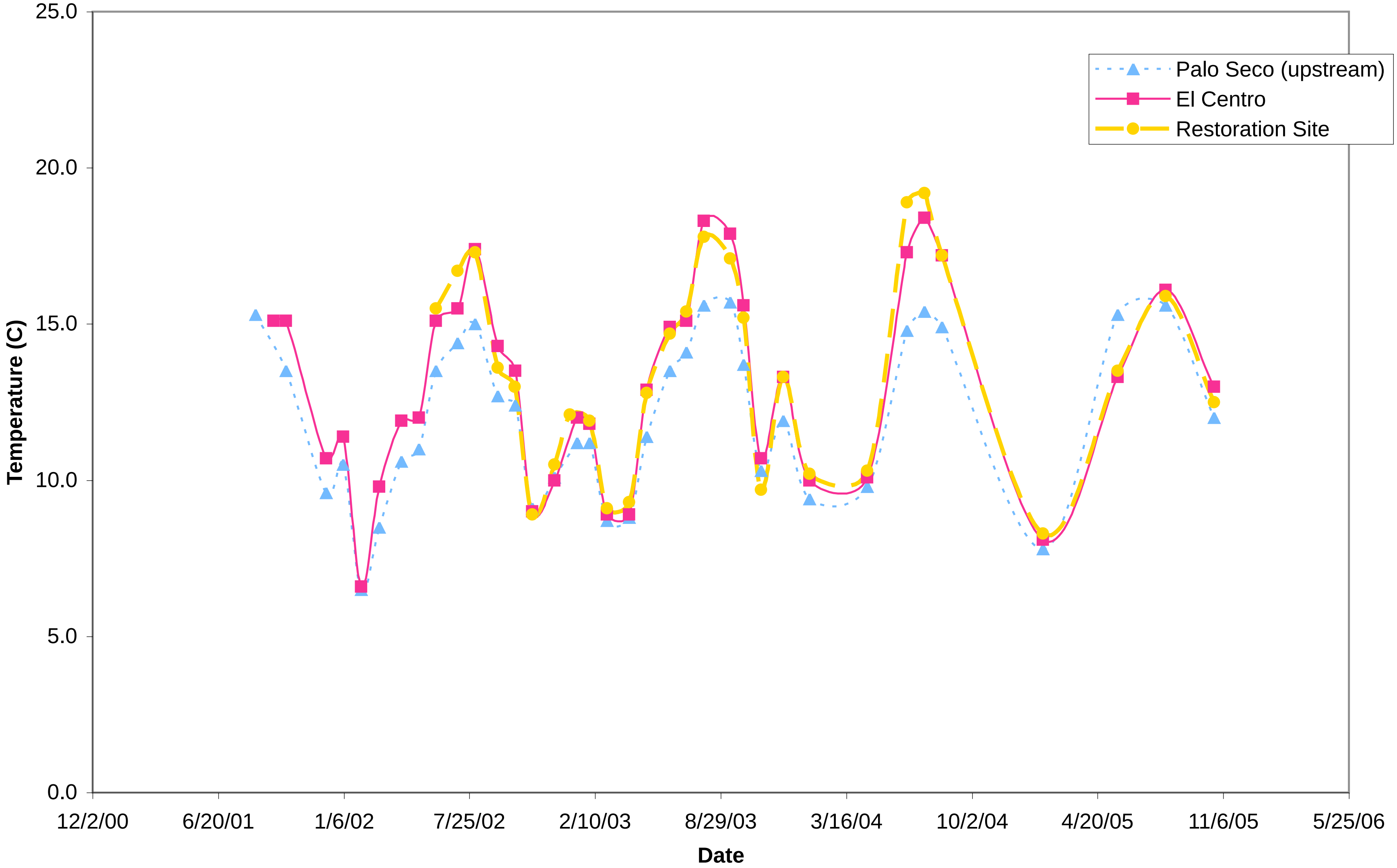


Figure 6: Temporal DO Variability

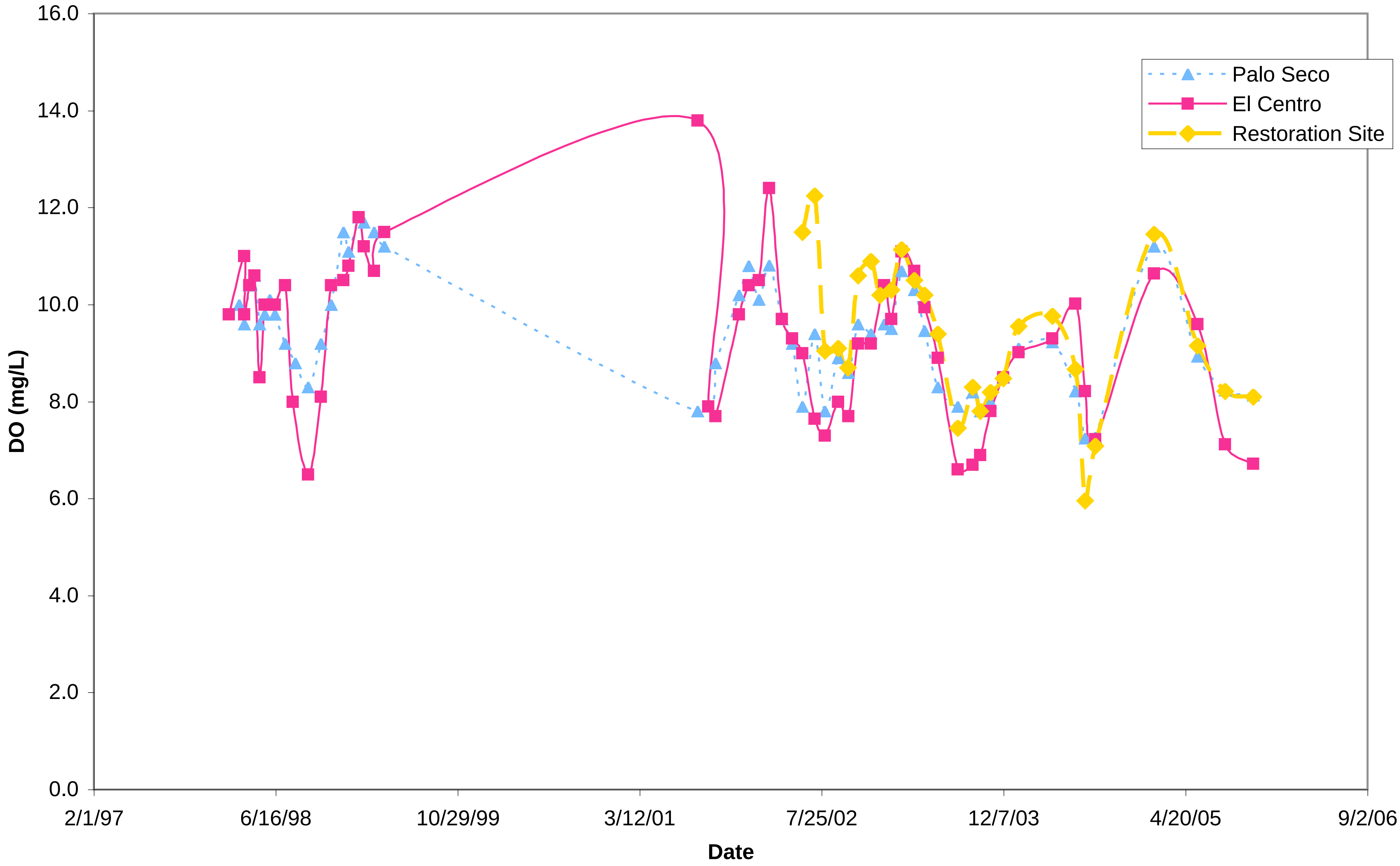


Figure 7: Upstream and Downstream Temporal pH Variability

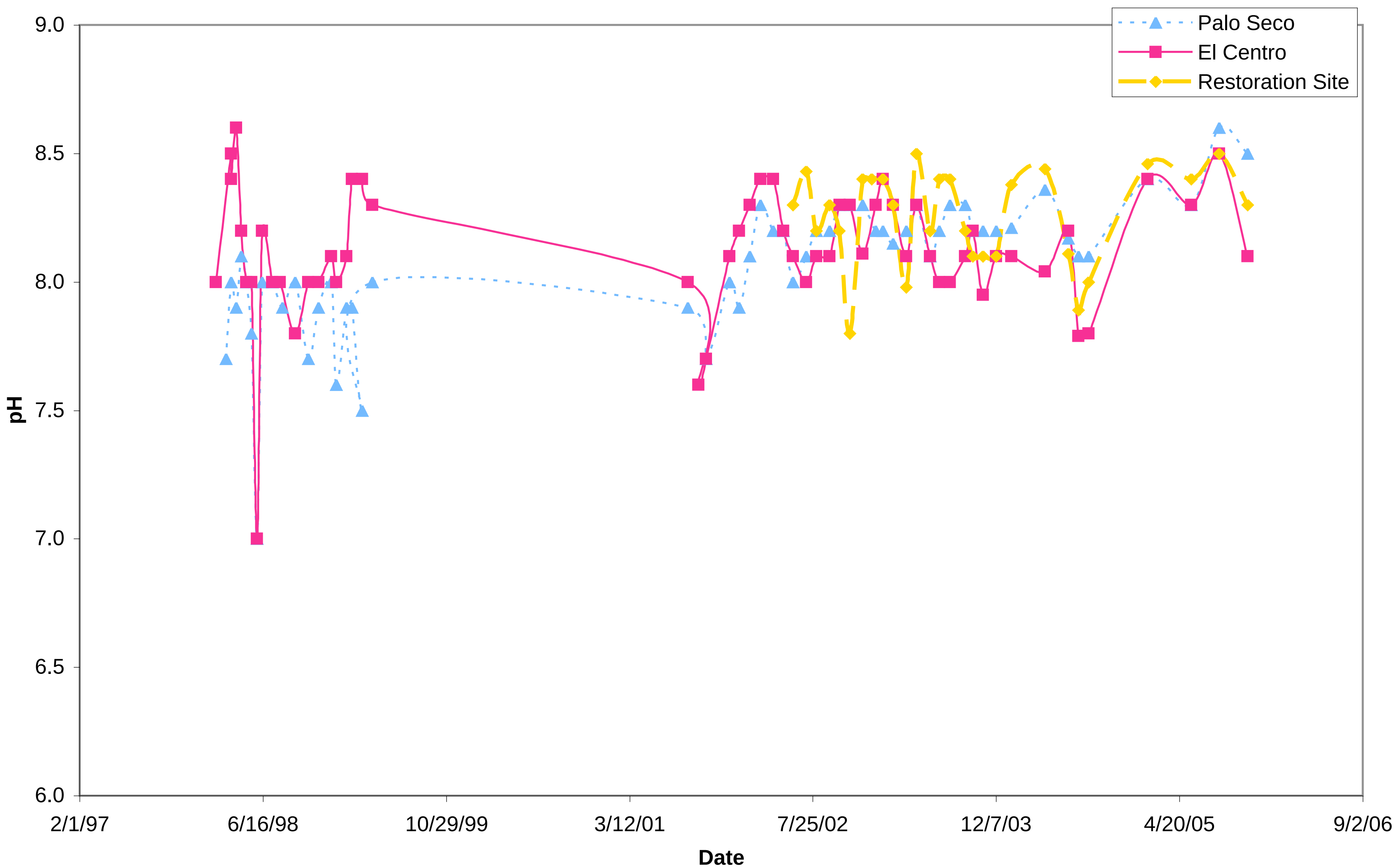


Figure 8: Upstream and Downstream Temporal Conductivity Variability

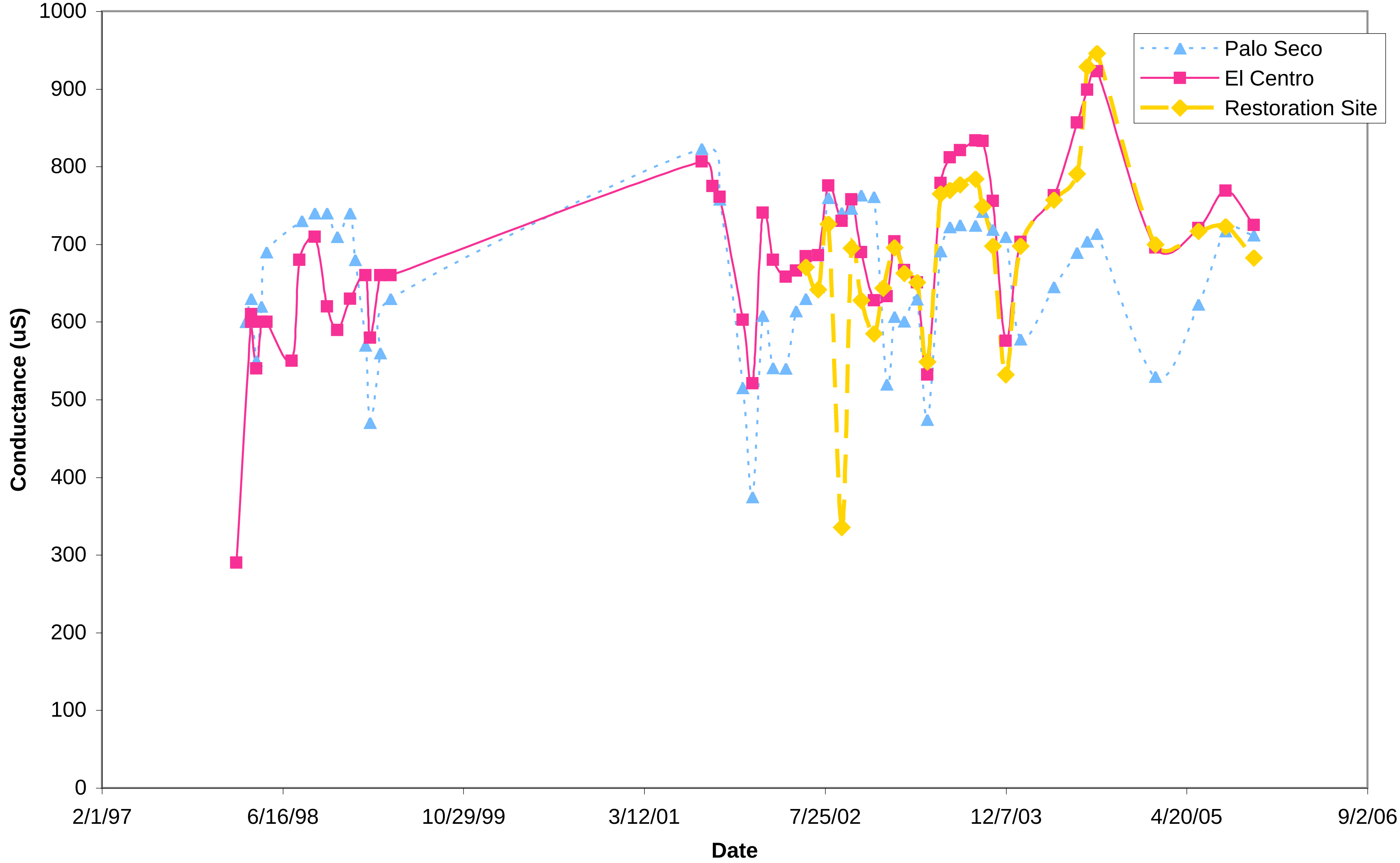
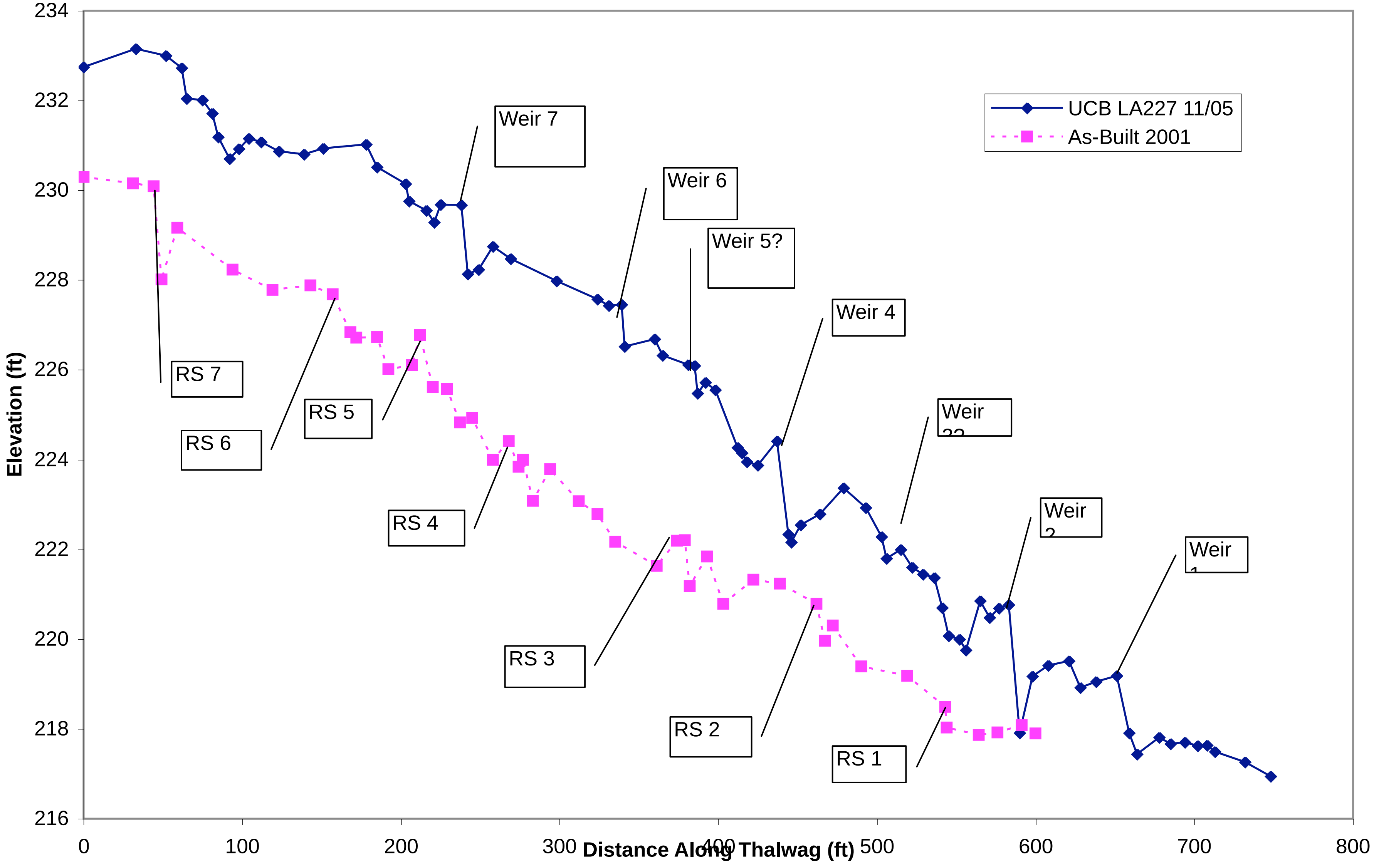


Figure 9: Longitudinal Profile of Sausal Creek Restoration Site at Dimond Park



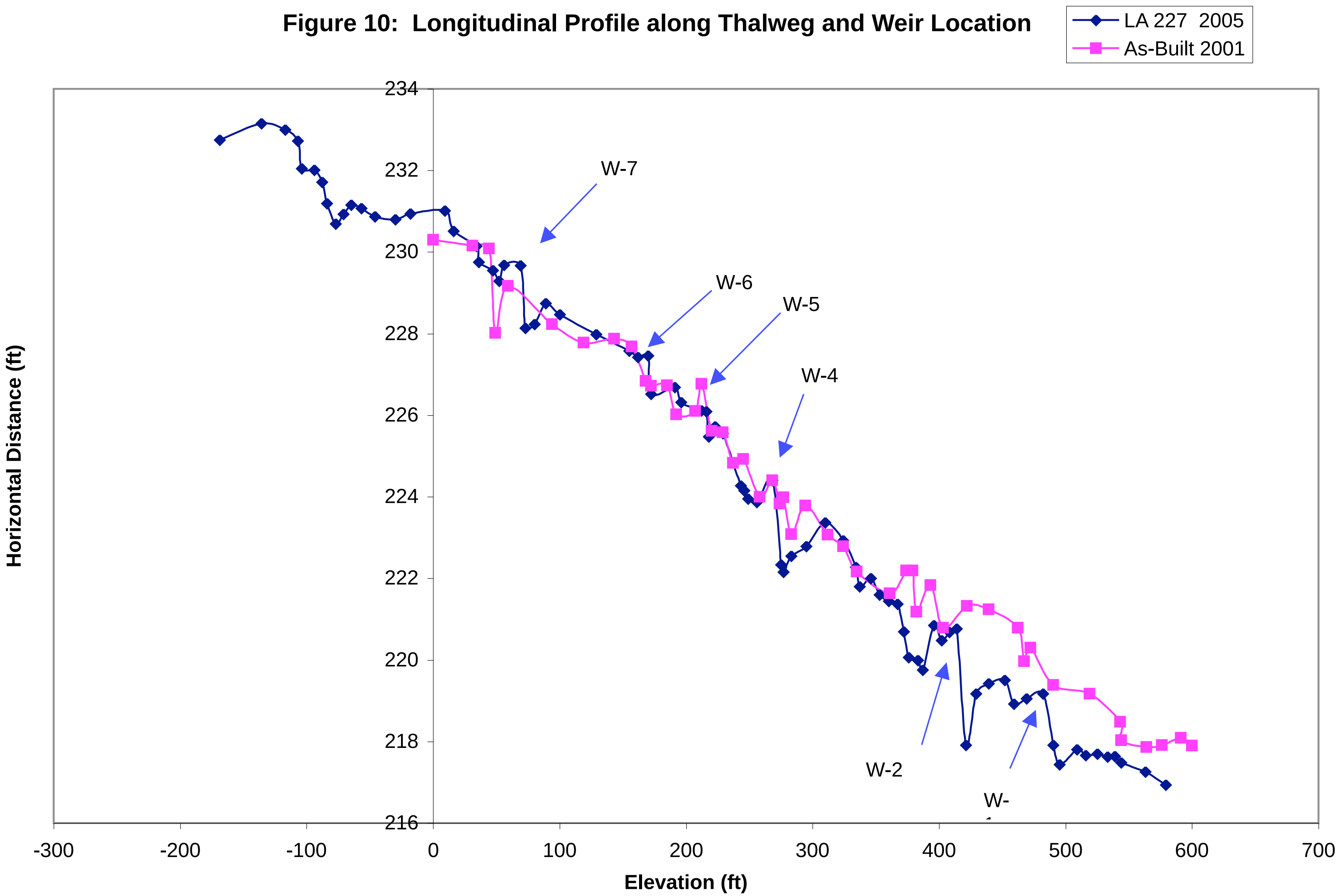
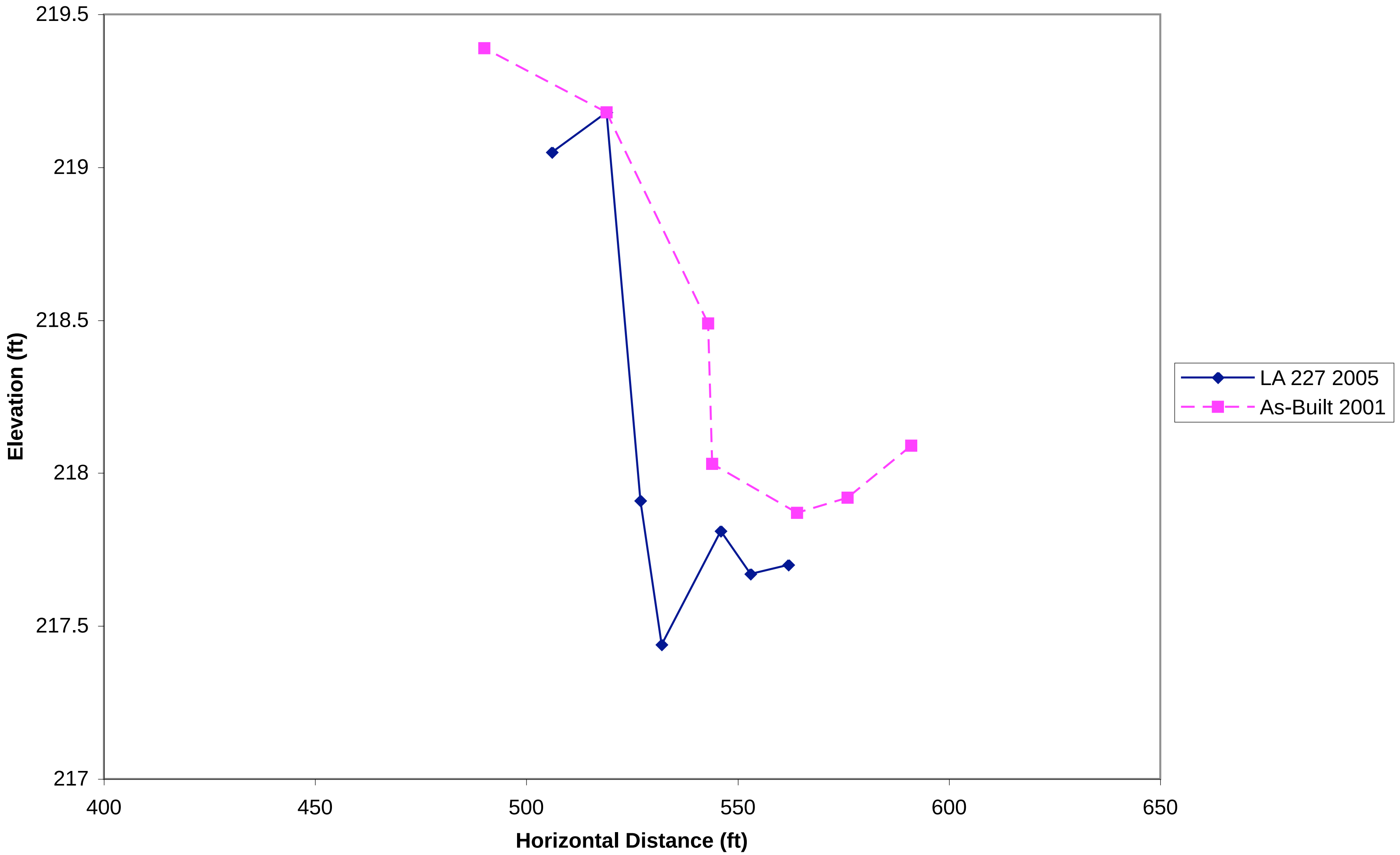


Figure 10: Longitudinal Profile along Thalweg and Weir Location
LA 227 2005
As-Built 2001
W-7
W-6
W-5
W-4
W-2
W-
Horizontal Distance (ft)
Elevation (ft)
234
232
230
228
226
224
222
220
218
216
-300
-200
-100
0
100
200
300
400
500
600
700

Figure 11: Weir 1/ RS 1



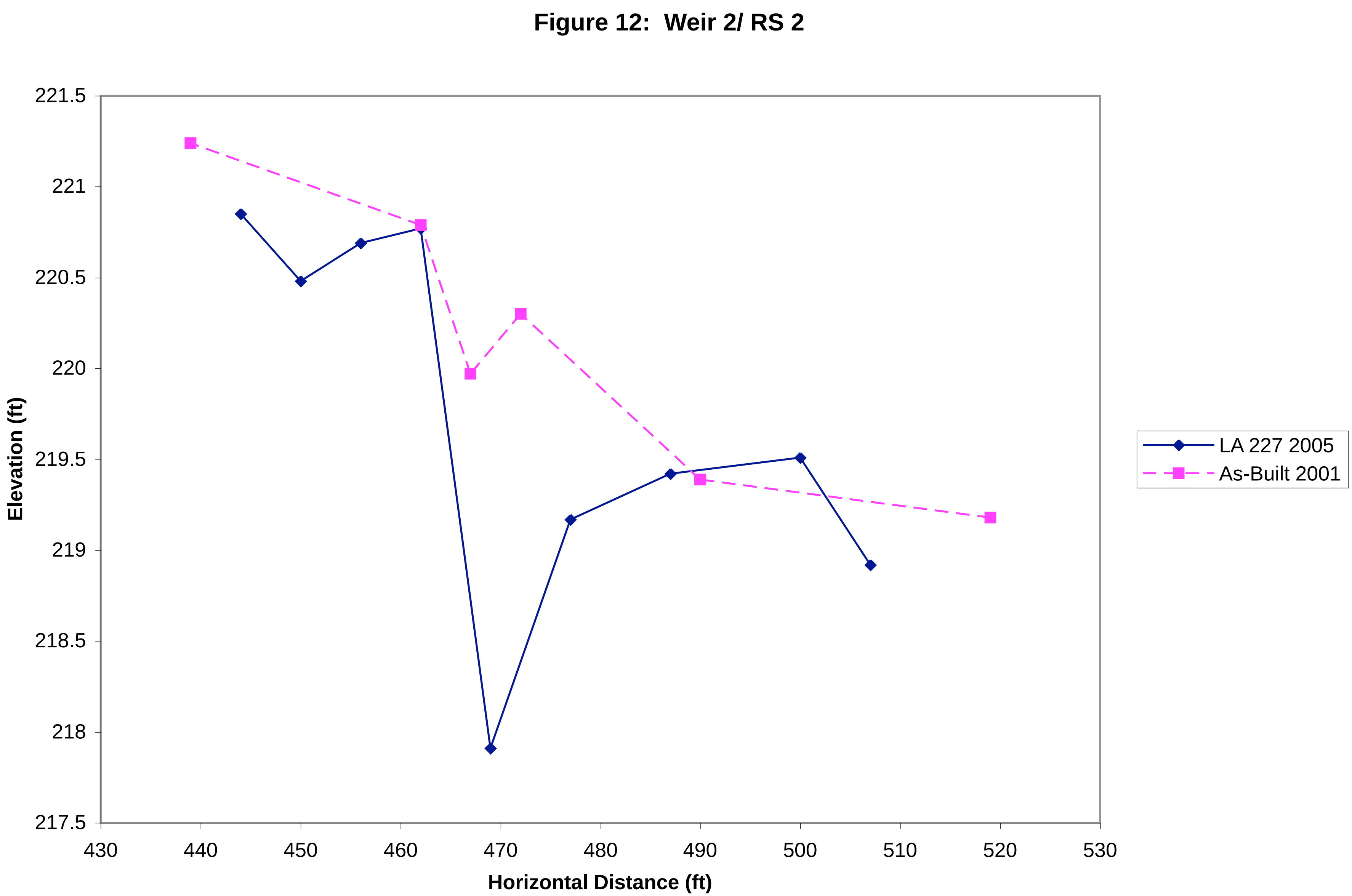


Figure 12: Weir 2/ RS 2
221.5
221
220.5
220
219.5
219
218.5
218
217.5
Elevation (ft)
430
440
450
460
470
480
490
500
510
520
530
Horizontal Distance (ft)
LA 227 2005
As-Built 2001

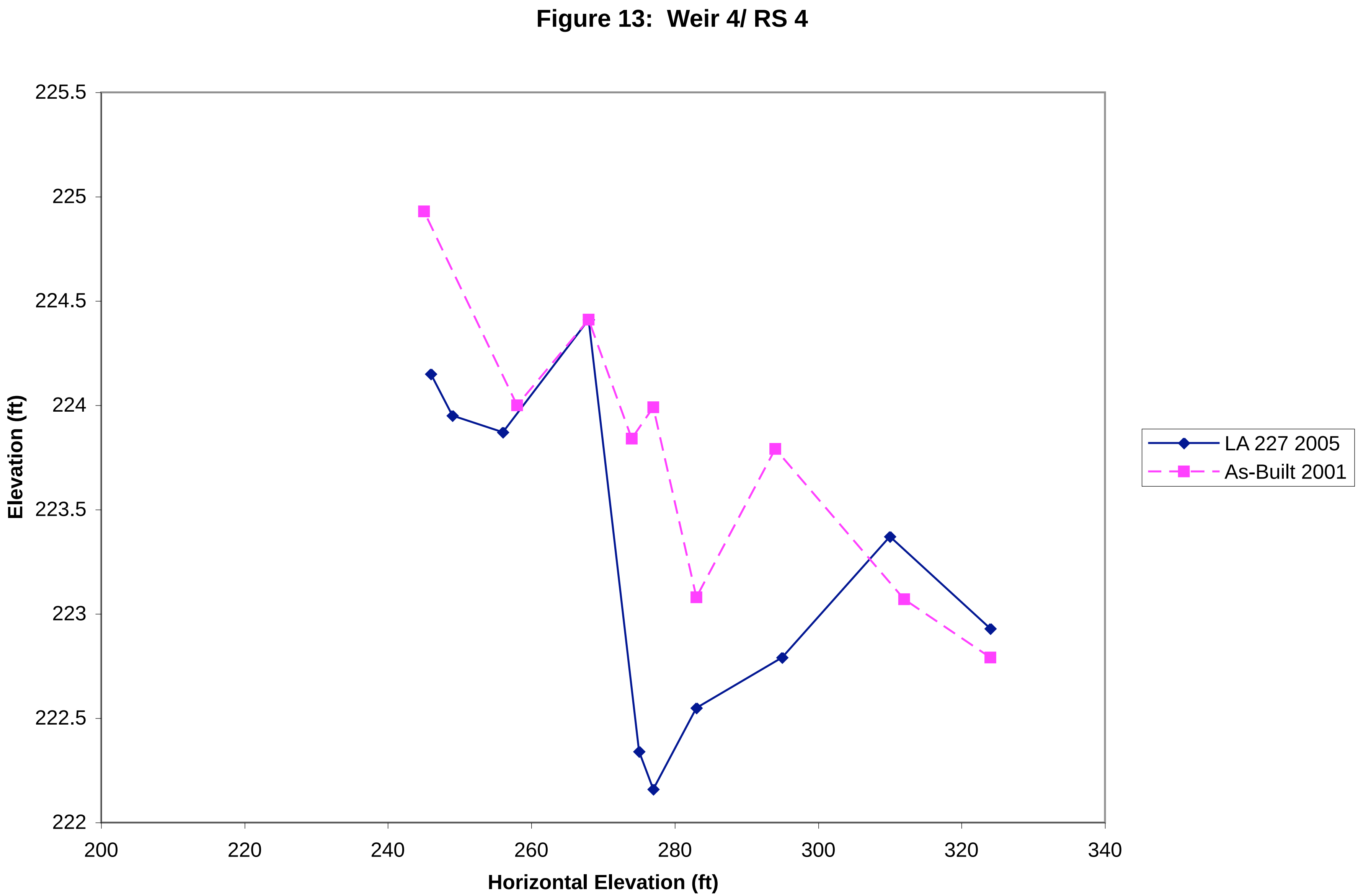


Figure 13: Weir 4/ RS 4
225.5
225
224.5
224
223.5
223
222.5
222
Elevation (ft)
200
220
240
260
280
300
320
340
Horizontal Elevation (ft)
LA 227 2005
As-Built 2001

Figure 14: Weir 5/RS 5

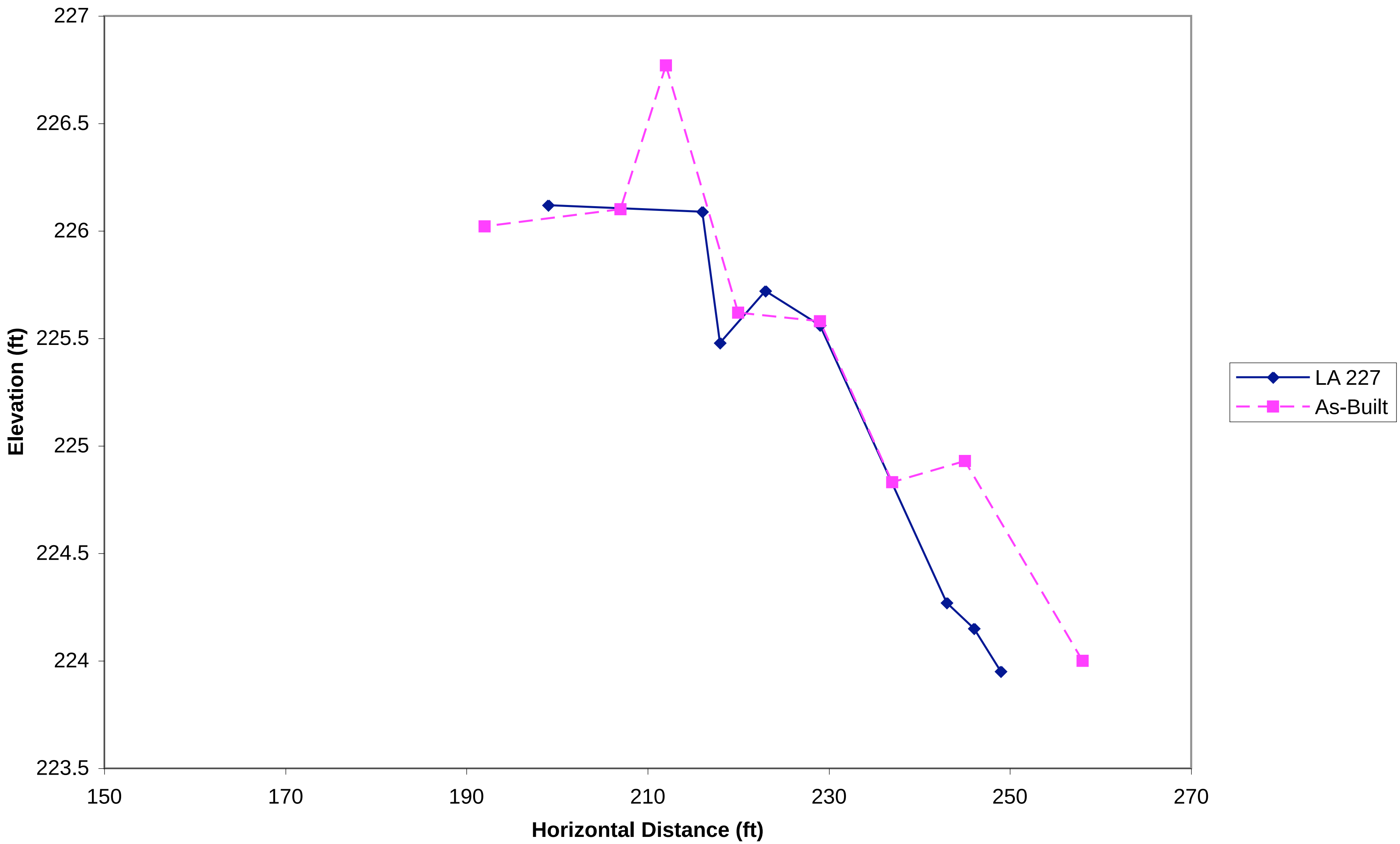


Figure 15: Weir 6/ RS 6

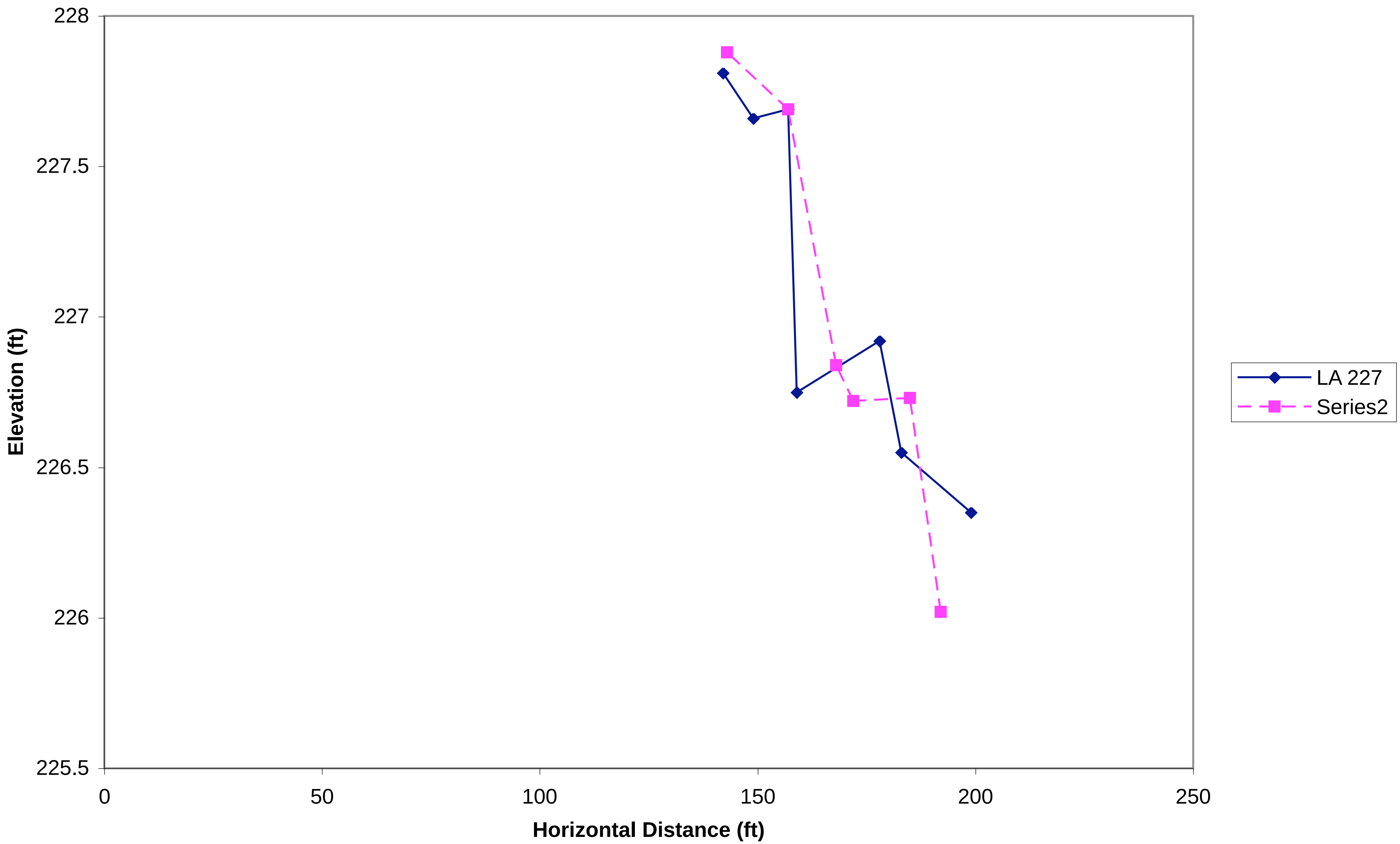


Figure 16: Weir 7/ RS 7

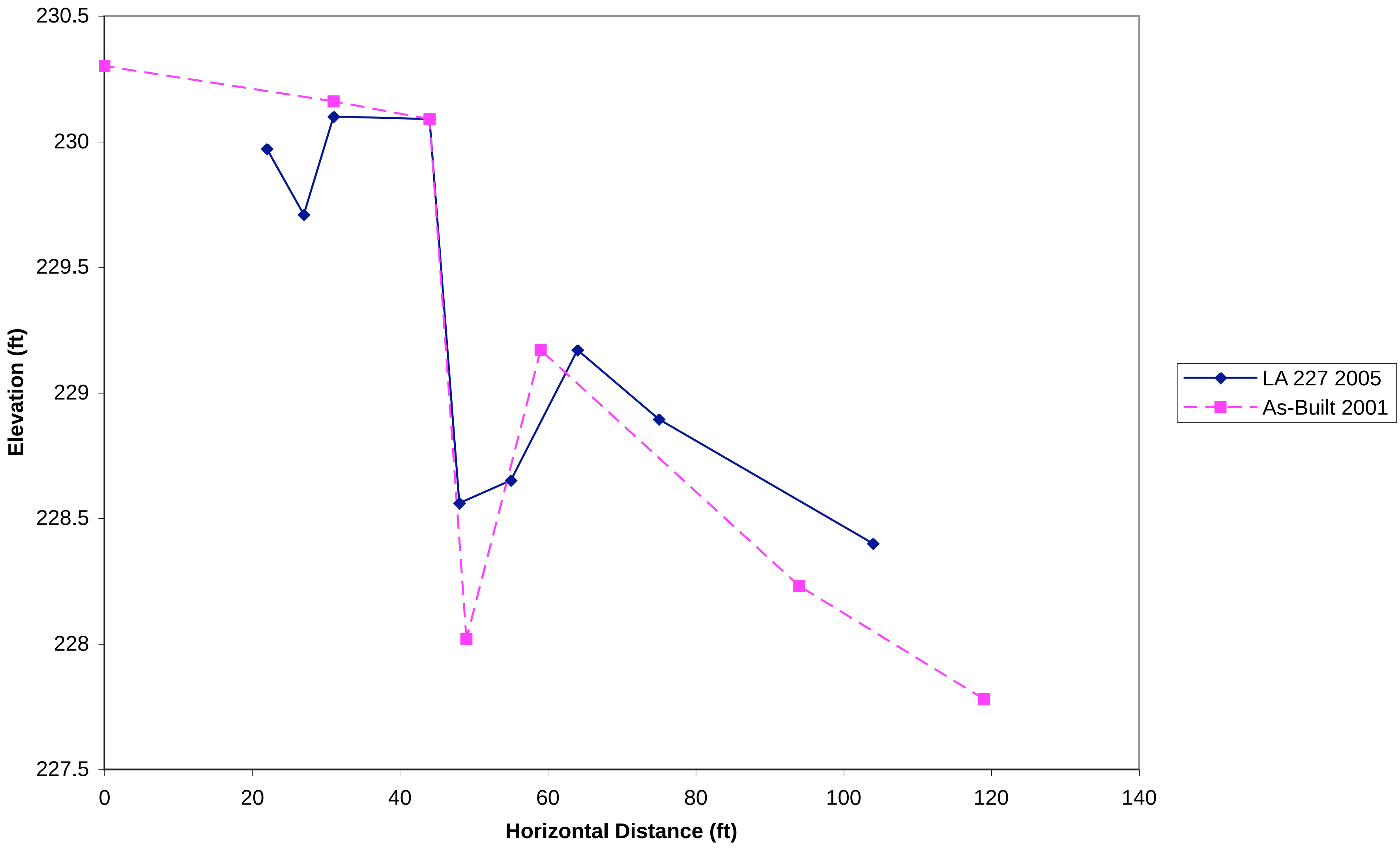


Figure 17: Location of 2005 Cross Sections on Thalweg Profile

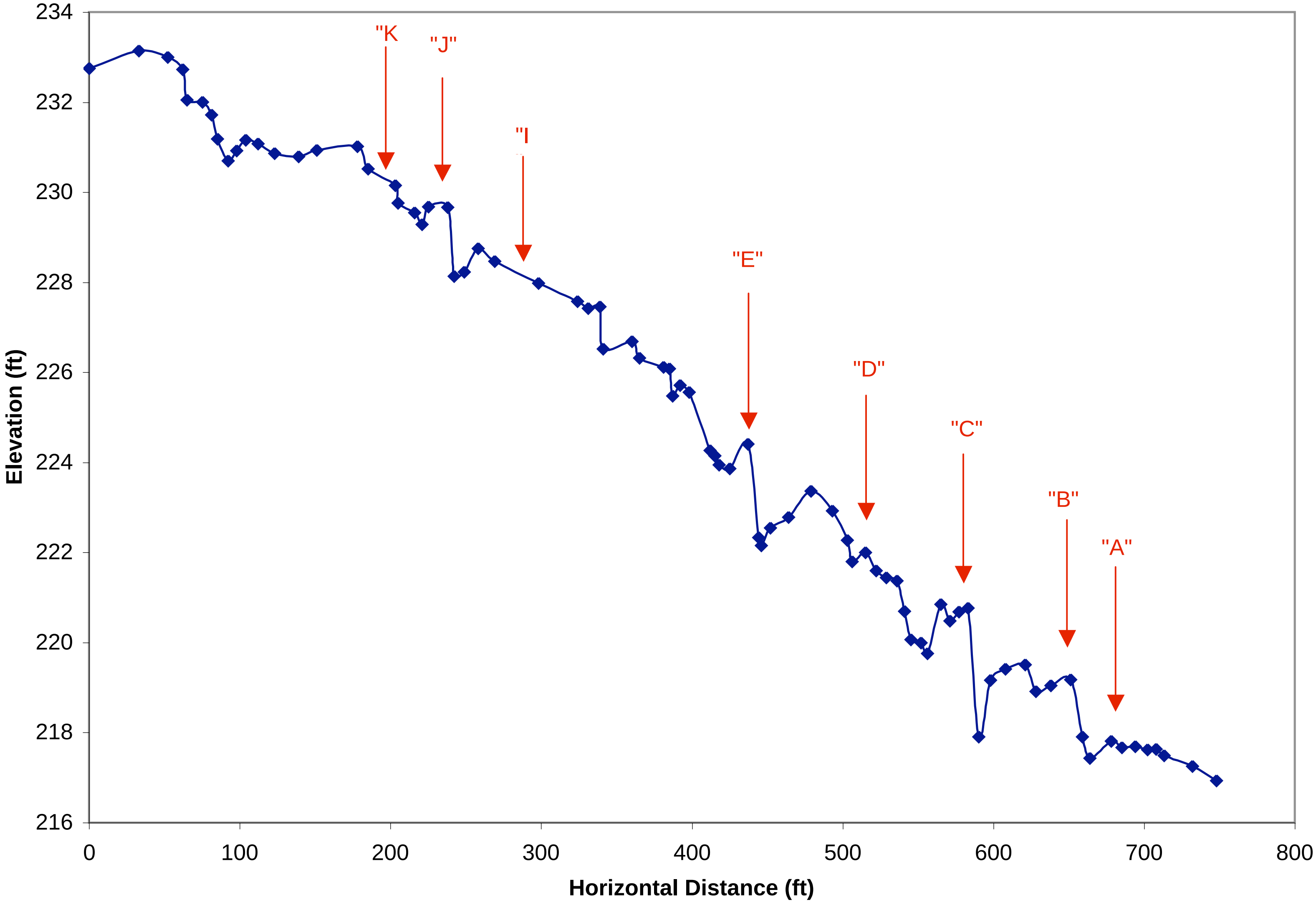


Figure 18: XS "A"

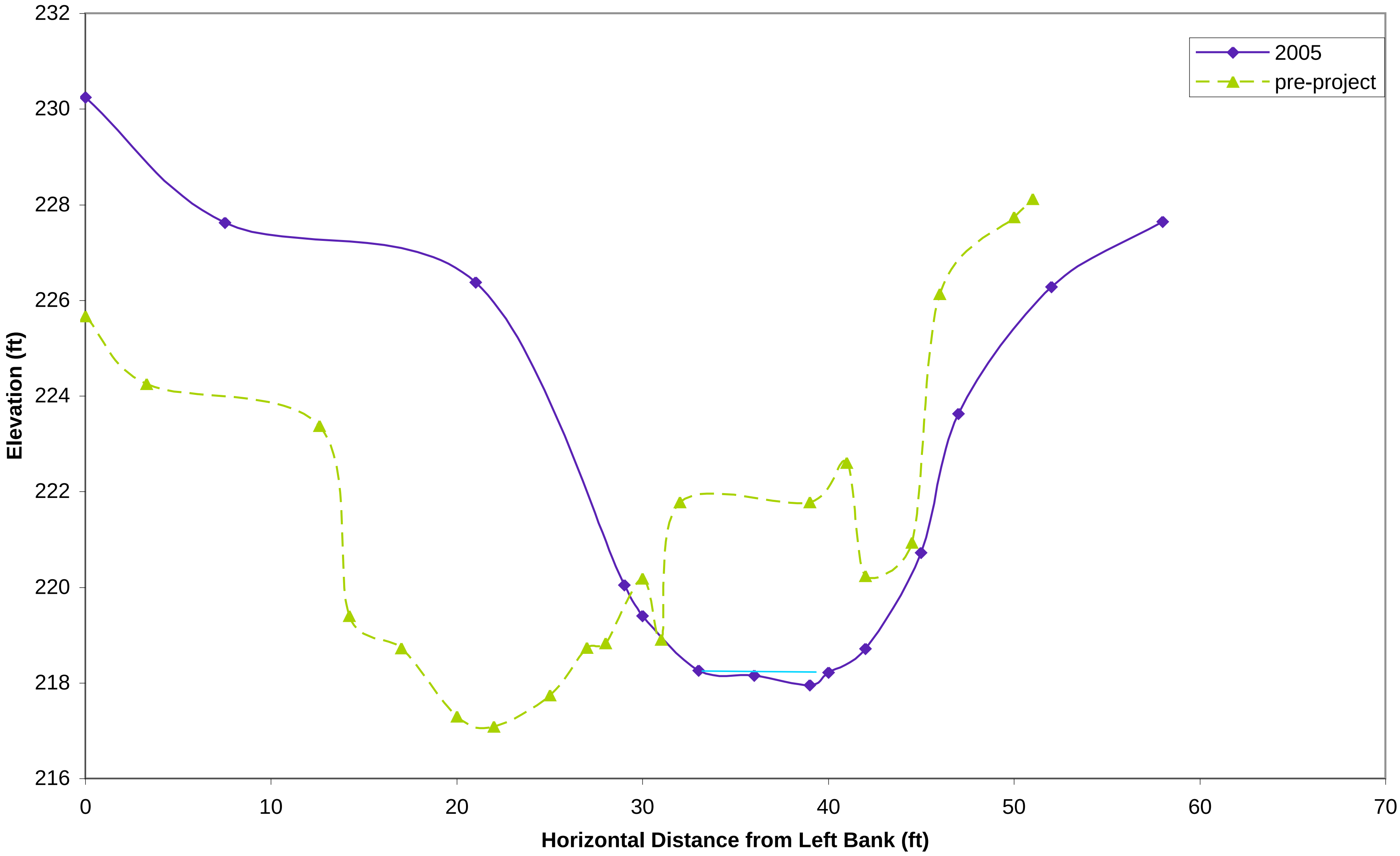


Figure 19: XS "B"

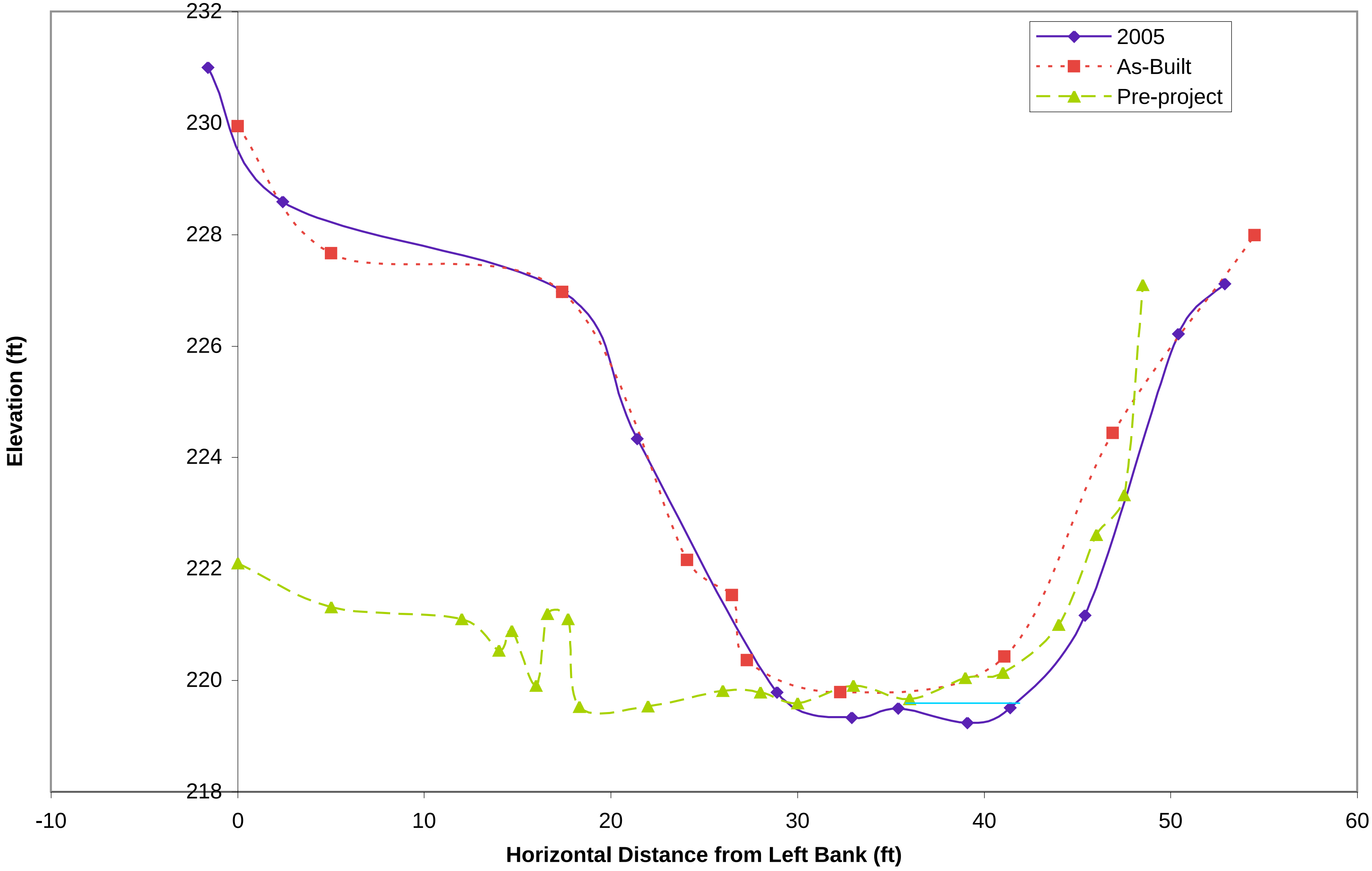
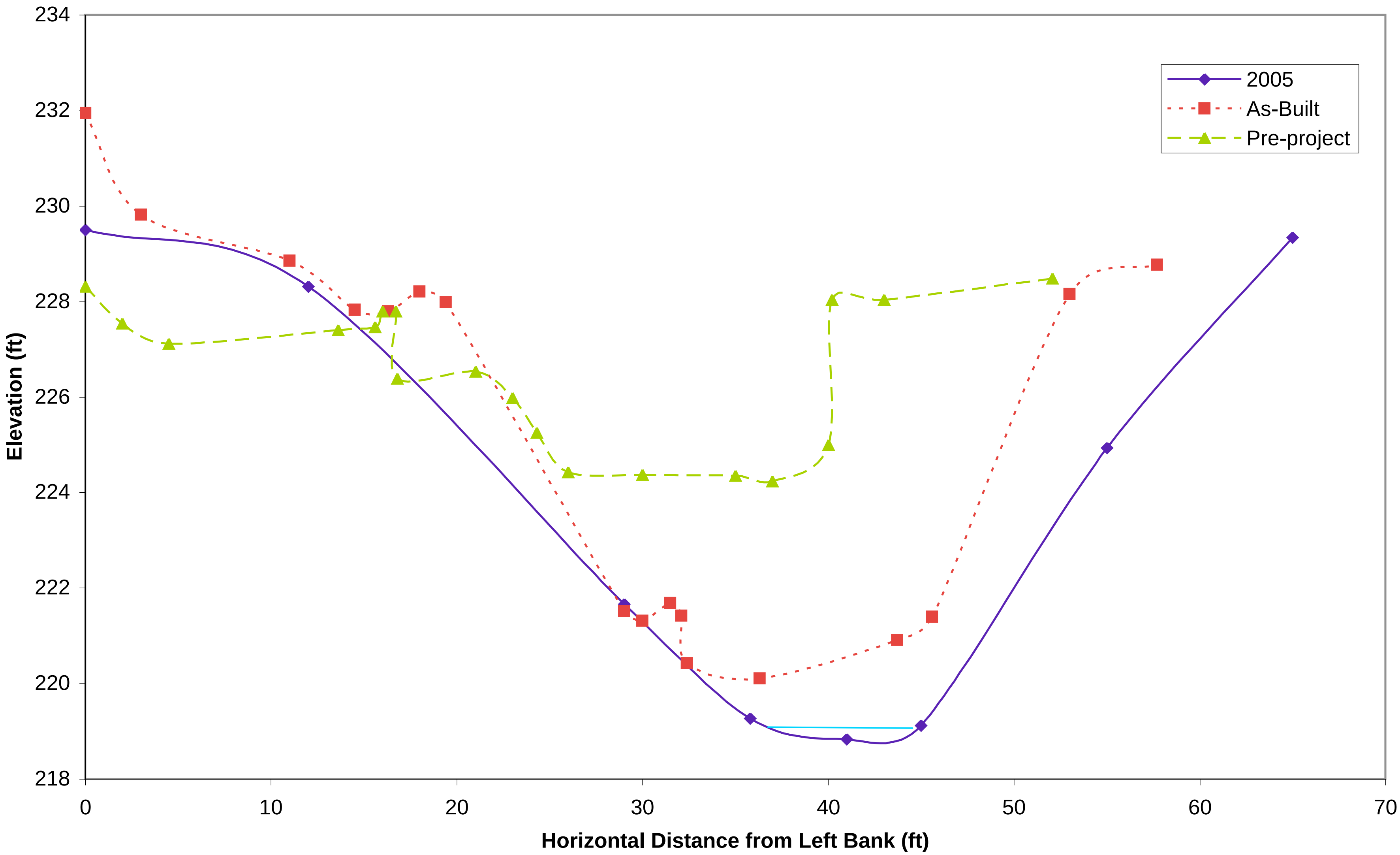


Figure 20: XS "C"



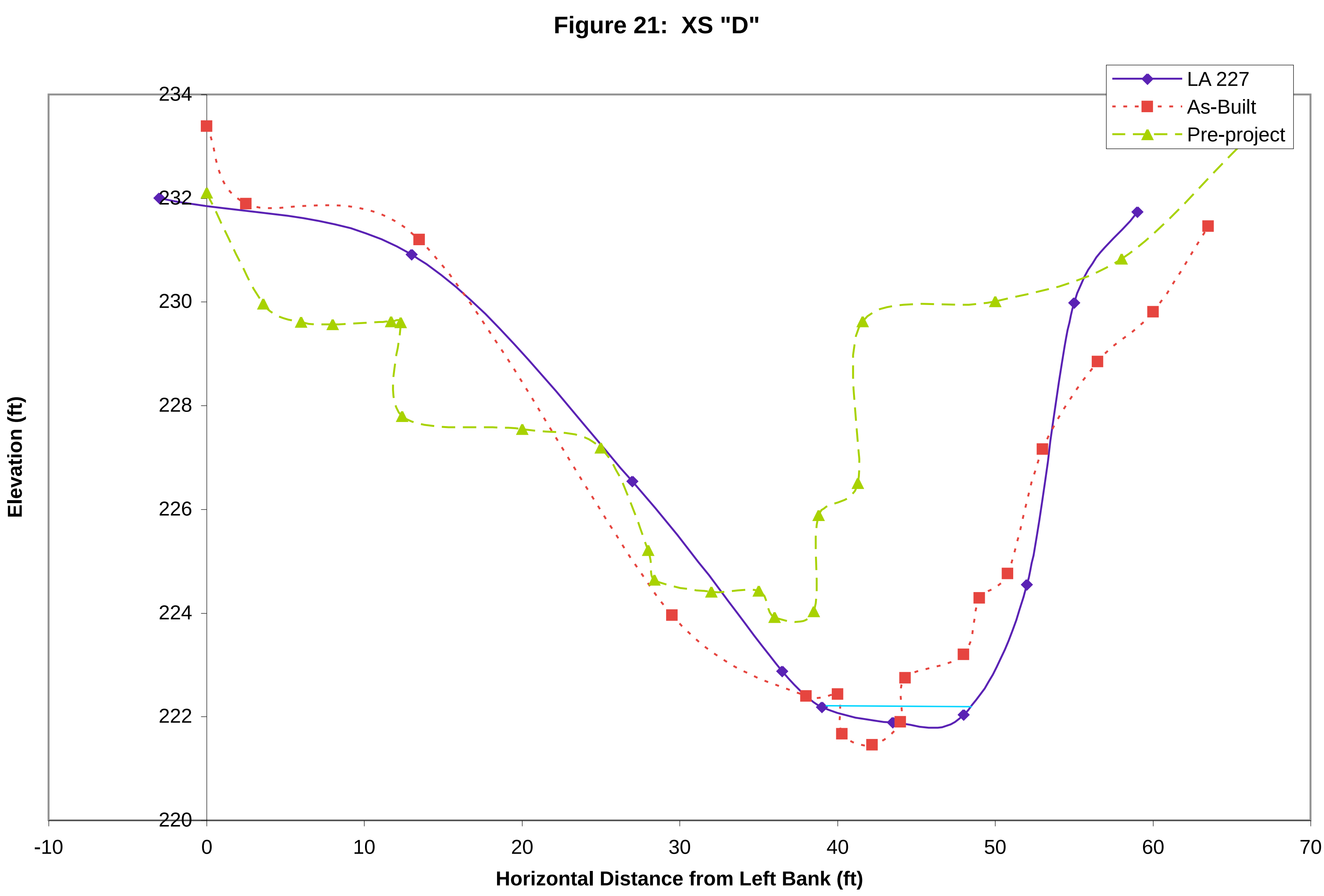


Figure 21: XS "D"
LA 227
As-Built
Pre-project
Elevation (ft)
234
232
230
228
226
224
222
220
-10
0
10
20
30
40
50
60
70
Horizontal Distance from Left Bank (ft)

Figure 22: XS "E"

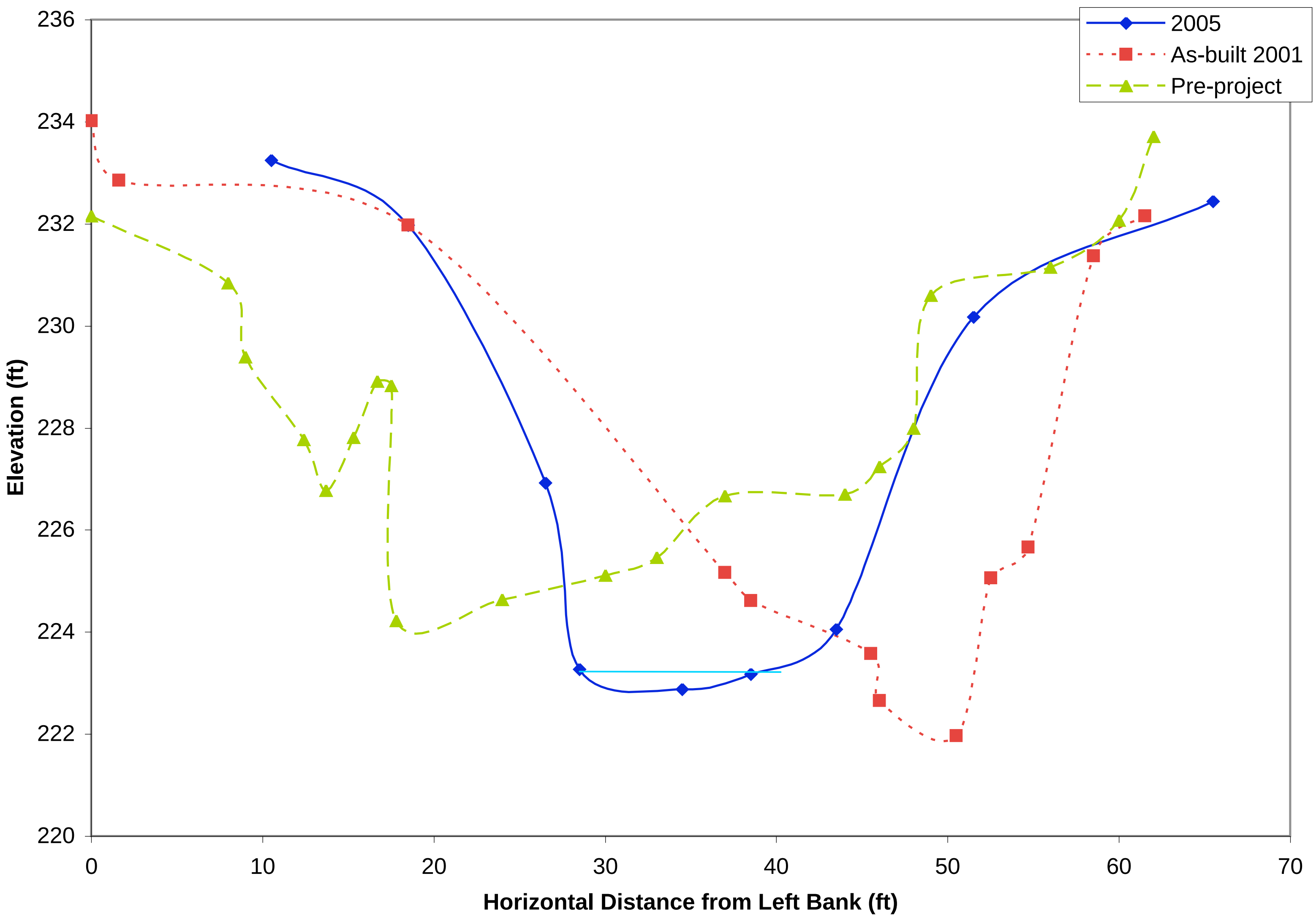


Figure 23: XS G

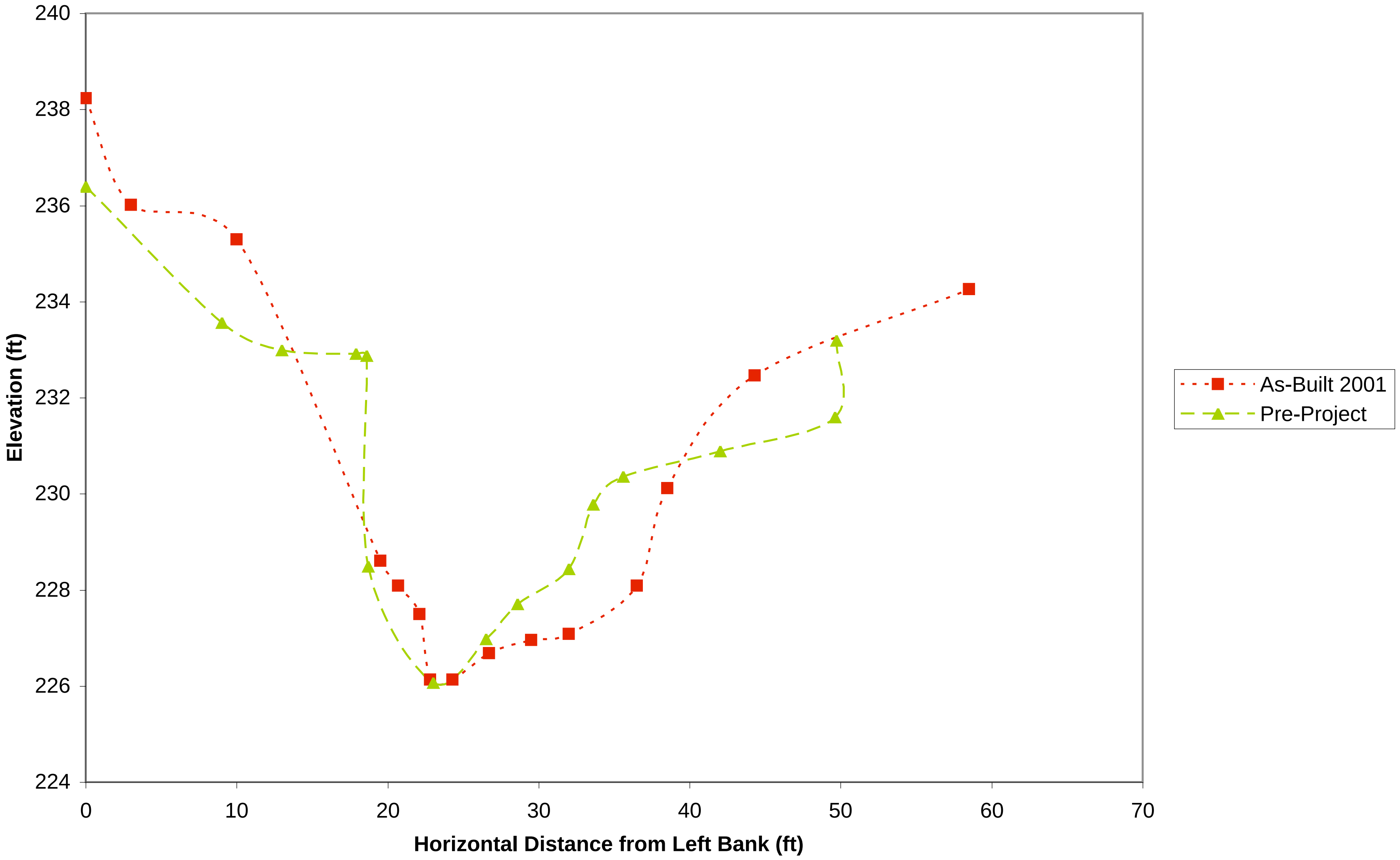


Figure 24: XS "H"

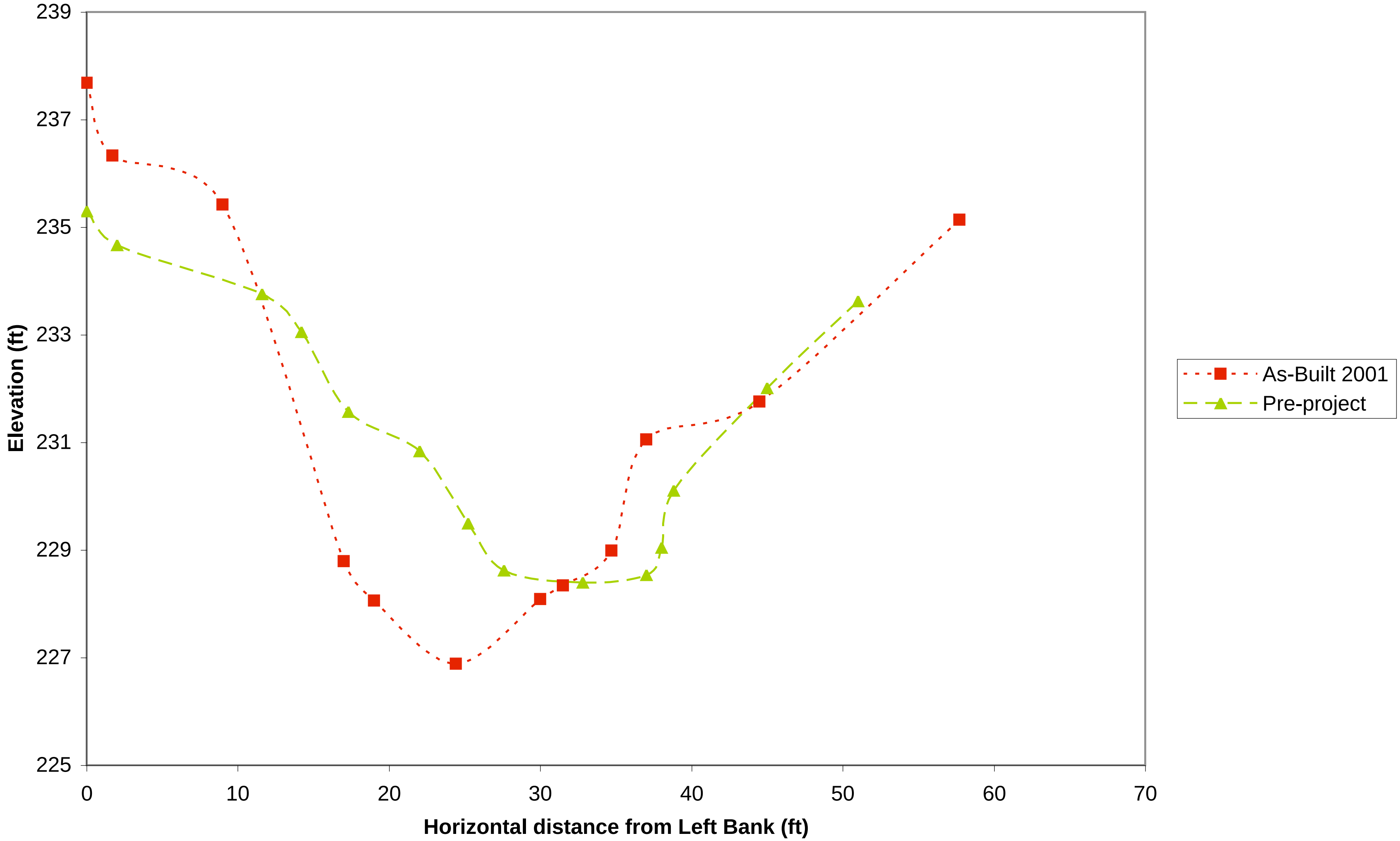


Figure 25: XS "I"

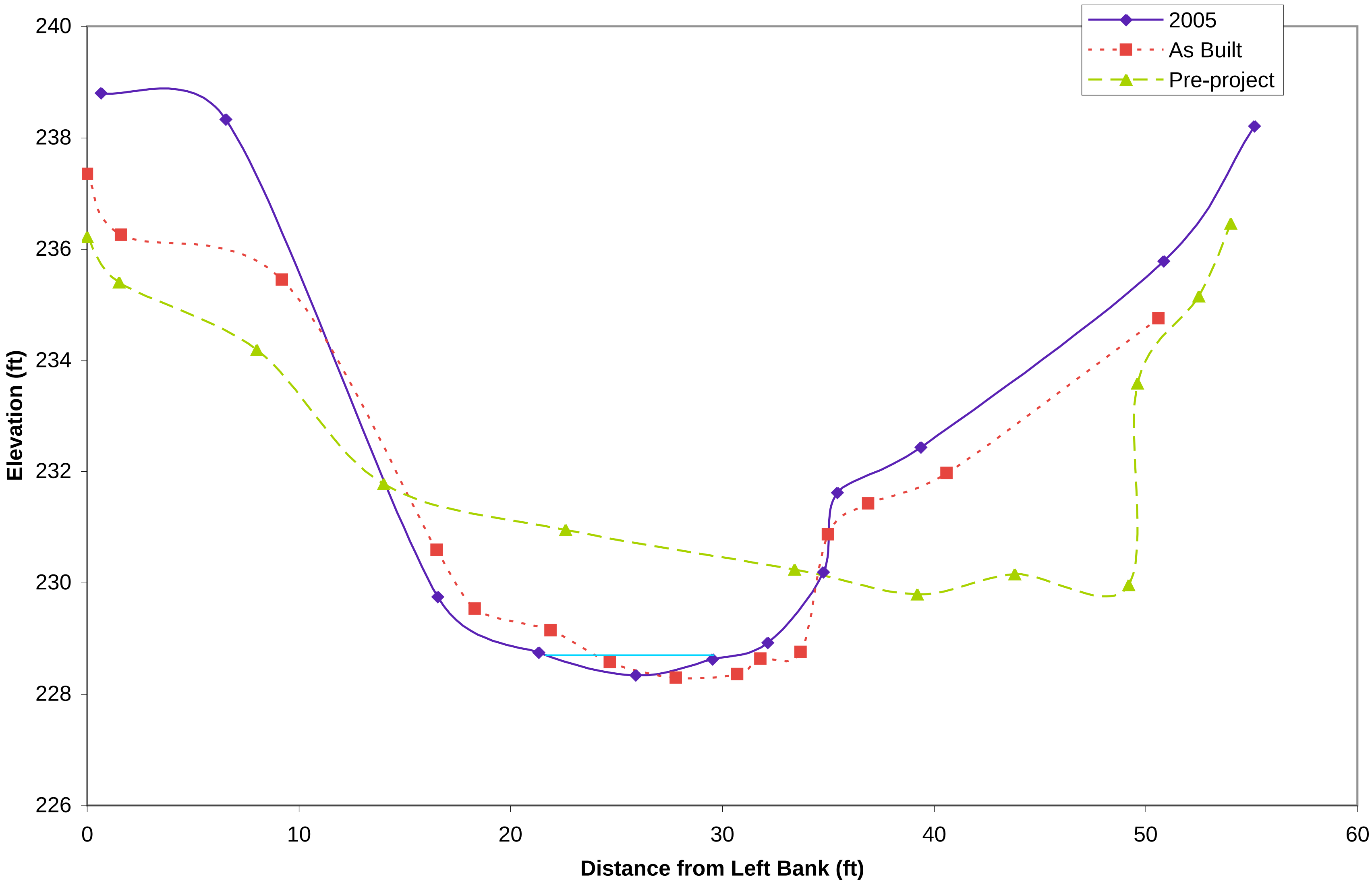


Figure 26: XS "J"

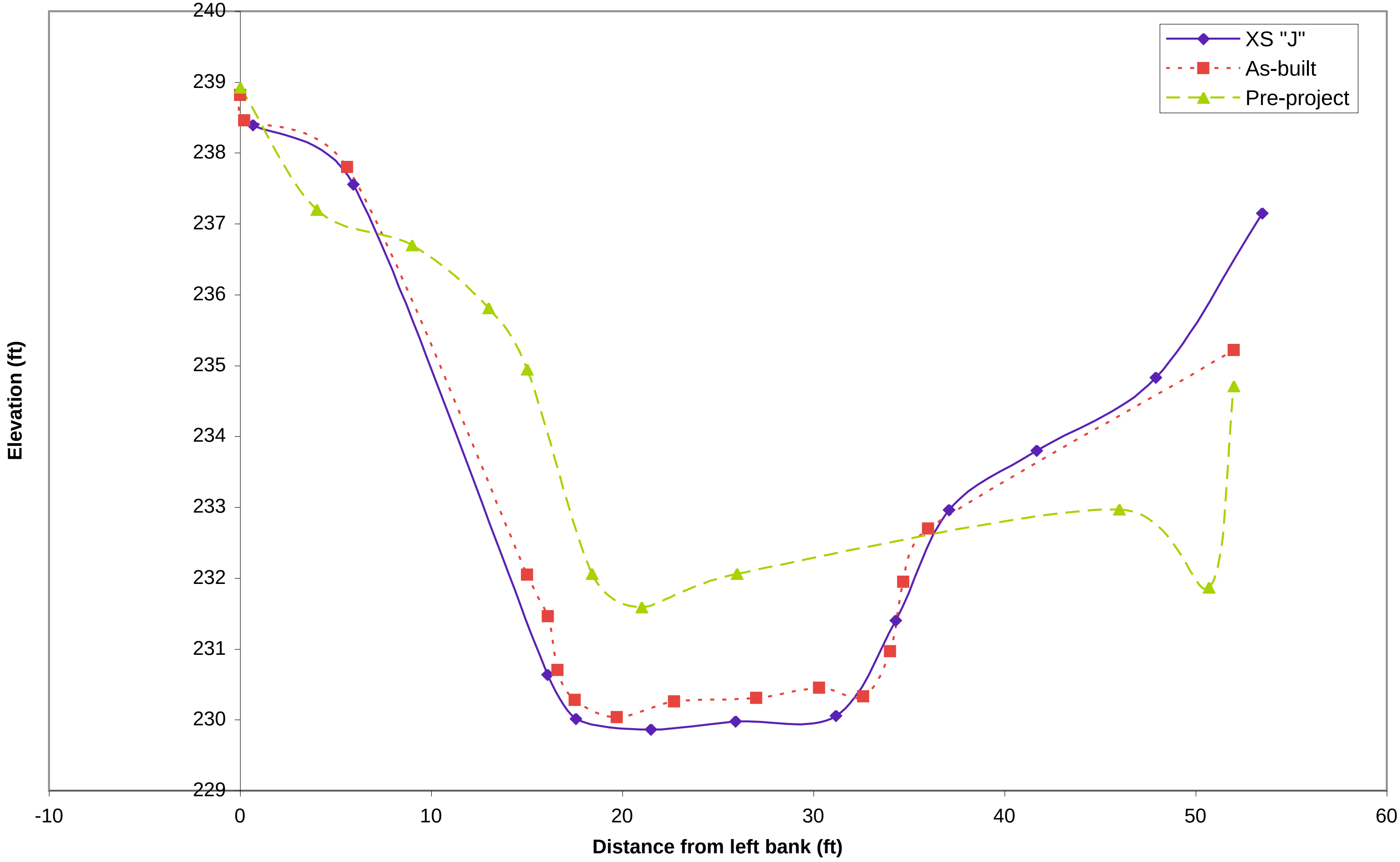


Figure 27: LA XS "K"

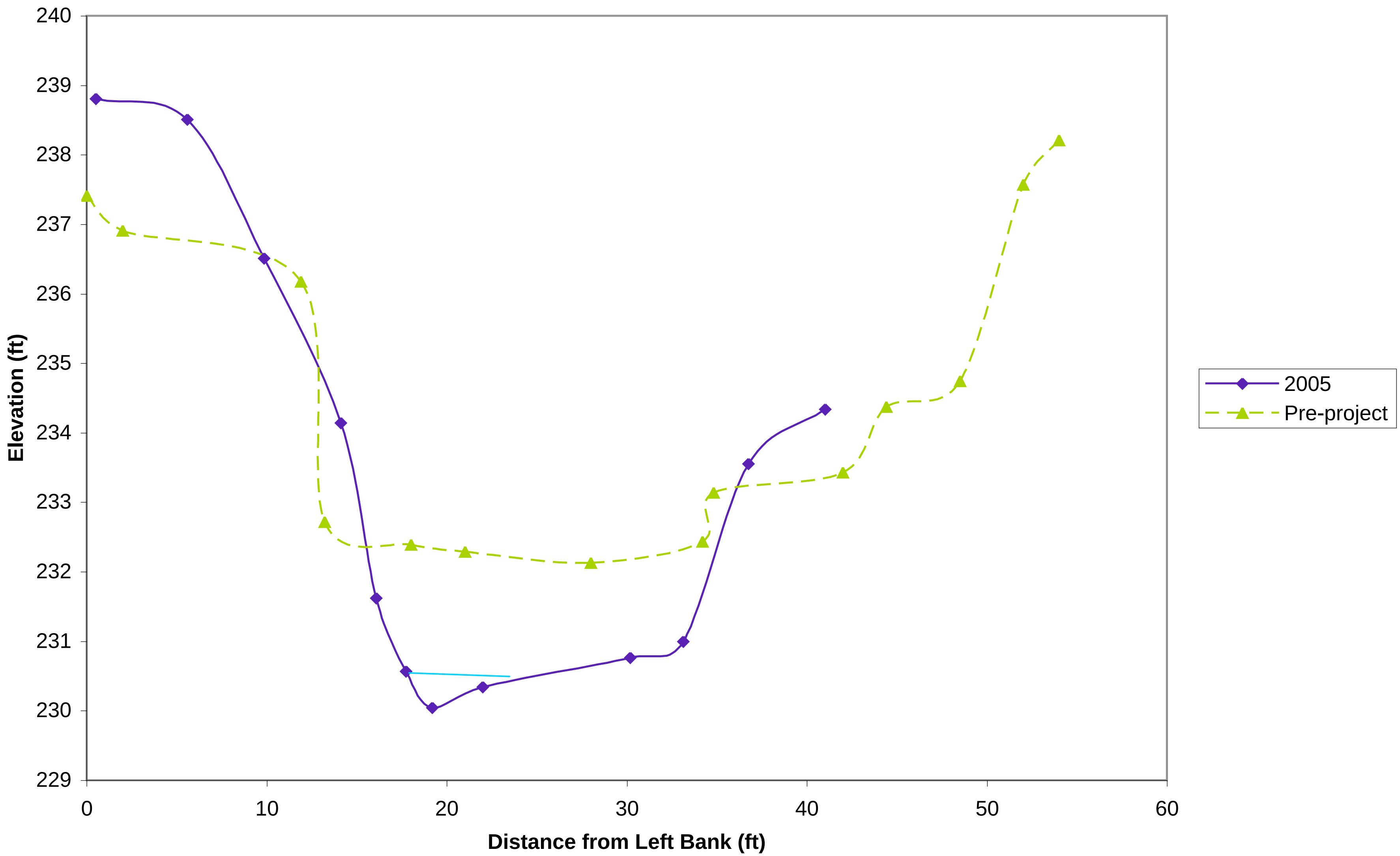
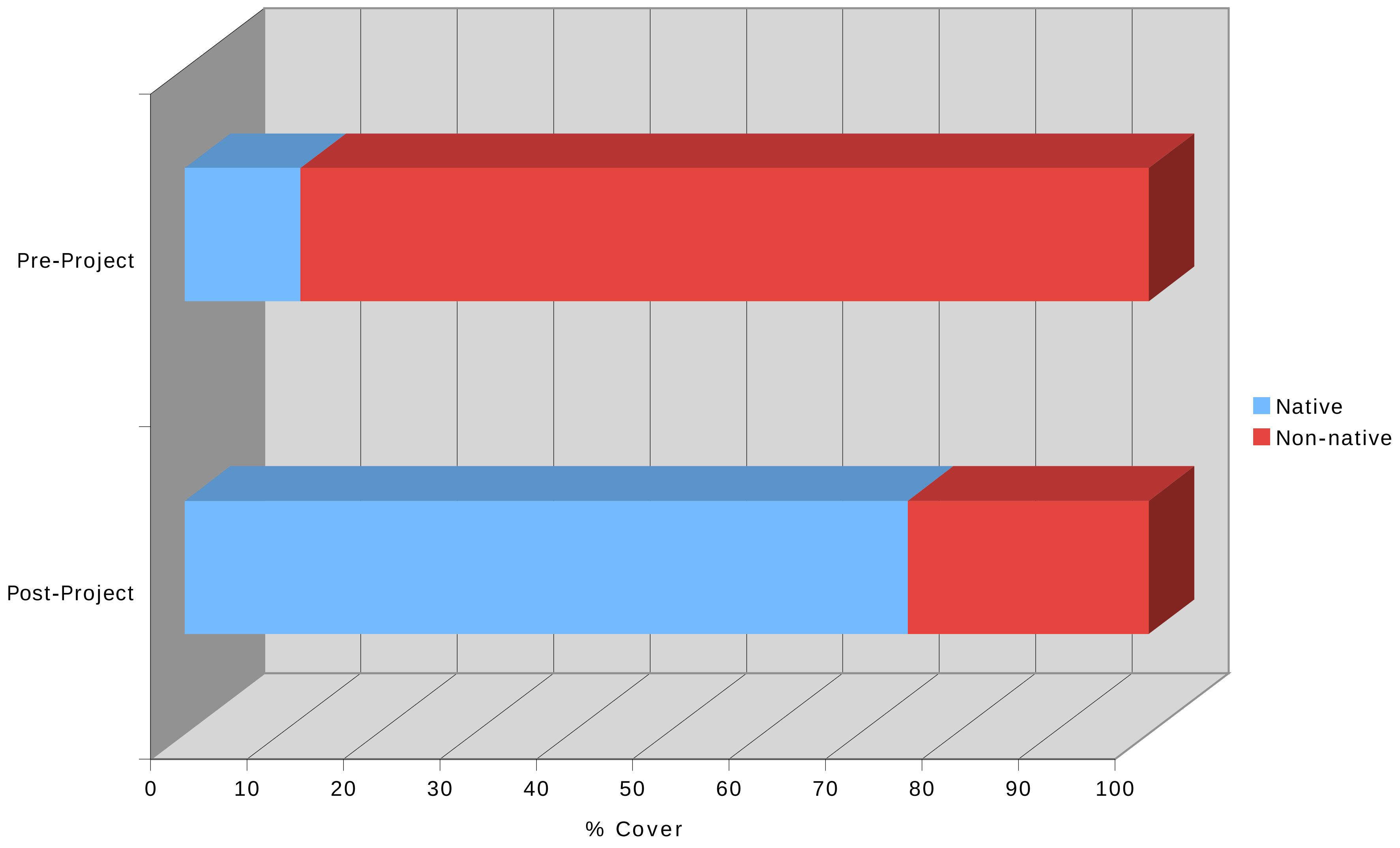


Figure 29. % Cover of Native and Non-Native Vegetation



Appendix A: FoSC Water Quality Data

Palo Seco Site

Date	Water Temp (C)	DO (ppm)	pH	Conductivity
3/7/98	10.0	10.0	7.7	600
3/21/98	14.0	9.6	8.0	630
4/4/98	10.5	10.4	7.9	550
4/18/98	10.5	10.6	8.1	620
5/2/98	14.0	9.6	8.0	690
5/16/98	11.5	9.8	7.8	NS
5/30/98	11.5	10.1	7.0	NS
6/13/98	14.0	9.8	8.0	NS
7/11/98	14.0	9.2	8.0	NS
8/8/98	15.0	8.8	7.9	730
9/12/98	15.0	8.3	8.0	740
10/17/98	12.0	9.2	7.7	740
11/14/98	10.5	10.0	7.9	710
12/19/98	8.5	11.5	8.0	740
1/2/99	10.0	11.1	7.6	680
1/30/99	9.0	11.8	7.9	570
2/13/99	9.5	11.7	7.9	470
3/13/99	10.5	11.5	7.5	560
4/10/99	9.5	11.2	8.0	630
8/18/01	15.3	7.8	7.9	823
10/6/01	13.5	8.8	7.7	758
12/9/01	9.6	10.2	8.0	515
1/5/02	10.5	10.8	7.9	375
2/2/02	6.5	10.1	8.1	608
3/3/02	8.5	10.8	8.3	541
4/7/02	10.6	9.7	8.2	540
5/5/02	11.0	9.2	8.2	614

6/1/02	13.5	7.9	8.0	630		
7/6/02	14.4	9.4	8.1	645		
8/3/02	15.0	7.8	8.2	760		
9/8/02	12.7	8.9	8.2	741		
10/6/02	12.4	8.6	8.3	746		
11/2/02	9.1	9.6	8.3	763		
12/7/02	10.1	9.4	8.3	761		
1/12/03	11.2	9.6	8.2	520		
2/1/03	11.2	9.5	8.2	607		
3/1/03	8.7	10.7	8.2	601		
4/5/03	8.8	10.3	8.2	629		
5/3/03	11.4	9.5	8.3	474		
6/9/03	13.5	8.3	8.1	691		
7/5/03	14.1	Not Sampled	8.2	722		
8/2/03	15.6	7.9	8.3	725		
9/13/03	15.7	8.2	8.3	724		
10/4/03	13.7	7.8	8.2	742		
11/1/03	10.3	8.0	8.2	719		
12/6/03	11.9	8.5	8.2	710		
1/17/04	9.4	9.1	8.21	578		
4/18/04	9.8	9.23	8.36	645		
6/20/04	14.8	8.22	8.17	689		
7/18/04	15.4	7.25	8.1	704		
8/15/04	14.9	7.27	8.1	714		
1/23/05	7.8	11.2	8.4	530		
5/22/05	15.3	8.93	8.3	623		
8/6/05	15.6	8.24	8.6	717		
10/22/05	12	8.13	8.5	712		
El Centro Site						
2/7/98	14.0	9.8	8.0	290		
3/21/98	14.0	11.0	8.5	610		
3/21/98	14.0	9.8	8.4	600		
4/4/98	12.0	10.4	8.6	540		
4/18/98	11.5	10.6	8.2	600		

5/2/98	20.0	8.5	8.0	600		
5/16/98	14.0	10.0	8.0	NS		
5/30/98	13.5	10.0	7.0	NS		
6/13/98	15.0	10.0	8.2	NS		
7/11/98	17.0	10.4	8.0	550		
8/1/98	16.0	8.0	8.0	680		
9/12/98	17.5	6.5	7.8	710		
10/17/98	13.0	8.1	8.0	620		
11/14/98	11.0	10.4	8.0	590		
12/19/98	9.0	10.5	8.1	630		
1/2/99	9.0	10.8	8.0	NS		
1/30/99	9.0	11.8	8.1	660		
2/13/99	10.0	11.2	8.4	580		
3/13/99	11.5	10.7	8.4	660		
4/10/99	10.0	11.5	8.3	660		
8/18/01	NS	13.8	8.0	807		
9/16/01	15.1	7.9	7.6	775		
10/6/01	15.1	7.7	7.7	761		
12/9/01	10.7	9.8	8.1	603		
1/5/02	11.4	10.4	8.2	521		
2/2/02	6.6	10.5	8.3	741		
3/3/02	9.8	12.4	8.4	680		
4/7/02	11.9	9.7	8.4	658		
5/5/02	12.0	9.3	8.2	666		
6/1/02	15.1	9.0	8.1	685		
7/6/02	15.5	7.7	8.0	686		
8/3/02	17.4	7.3	8.1	776		
9/8/02	14.3	8.0	8.1	730		
10/6/02	13.5	7.7	8.3	758		
11/2/02	9.0	9.2	8.3	690		
12/7/02	10.0	9.2	8.1	628		
1/12/03	12.0	10.4	8.3	633		
2/1/03	11.8	9.7	8.4	704		
3/1/03	8.9	11.1	8.3	667		
4/5/03	8.9	10.7	8.1	651		
5/3/03	12.9	10.0	8.3	532		

6/9/03	14.9	8.9	8.1	779
7/5/03	15.1	NS	8.0	812
8/2/03	18.3	6.6	8.0	821
9/13/03	17.9	6.7	8.1	834
10/4/03	15.6	6.9	8.2	833
11/1/03	10.7	7.8	8.0	756
12/6/03	13.3	8.5	8.1	576
1/17/04	10	9.02	8.1	703
4/18/04	10.1	9.3	8.04	763
6/20/04	17.3	10.02	8.2	857
7/18/04	18.4	8.22	7.79	899
8/15/04	17.2	7.22	7.8	923
1/23/05	8.1	10.64	8.4	696
5/22/05	13.3	9.6	8.3	721
8/6/05	16.1	7.12	8.5	769
10/22/05	13	6.72	8.1	725

RestorationSite	Air Temp	Water Temp	DO	pH	Conductivity
6/1/02	17.8	15.5	11.5	8.3	671
7/6/02	18.5	16.7	12.2	8.4	642
8/3/02	18.8	17.3	9.1	8.2	726
9/8/02	17.7	13.6	9.1	8.3	336
10/5/02	14.1	13.0	8.7	8.2	695
11/2/02	11.0	8.9	10.6	7.8	628
12/7/02	11.5	10.5	10.9	8.4	585
1/1/03	15.3	12.1	10.2	8.4	644
2/1/03	15.4	11.9	10.3	8.4	696
3/1/03	12.1	9.1	11.1	8.3	663
4/5/03	11.5	9.3	10.5	8.0	651
5/3/03	15.4	12.8	10.2	8.5	549
6/9/03	16.4	14.7	9.4	8.2	765
7/5/03	17.8	15.4	N.M	8.4	770
8/2/03	20.1	17.8	7.5	8.4	777
9/13/03	18.4	17.1	8.3	8.2	784

10/4/03	15.7	15.2	7.8	8.1	749	
11/1/03	12.8	9.7	8.2	8.1	698	
12/6/03	16.0	13.3	8.5	8.1	532	
1/17/04	13.6	10.2	9.56	8.38	698	
4/18/04	15.5	10.3	9.77	8.44	757	
6/20/04	18.6	18.9	8.7	8.11	791	
7/18/04	19.9	19.2	5.96	7.89	929	
8/15/04	17	17.2	7.085	8	946	
1/23/05	6.9	8.3	11.45	8.46	700	
5/22/05	19.5	13.5	9.16	8.4	717	
8/6/05	19.8	15.9	8.22	8.5	723	
10/22/05	12	12.5	8.1	8.3	682.5	

APPENDIX B: Survey Data

Longitudinal Thalweg Profile Data

Distance (ft)	Elevation (ft)	Distance (ft)	Elevation (ft)
0	232.75	479	223.44
33	233.15	493	223
52	233	503	222.28
62	232.73	506	-541
65	232.05	515	-545
75	232.01	522	-552
81	231.72	529	-556
85	231.19	536	-565
92	230.7	541	-571
98	230.93	545	-577
104	231.16	552	-583
112	231.08	556	-590
123	230.87	565	-598
139	230.8	571	-608
151	230.94	577	-621
178	231.02	583	-628
185	230.52	590	-638
203	230.15	598	-659
204	229.76	608	-664
216	229.55	621	-678
221	229.29	628	-685
225	229.68	638	-694
238	229.67	651	-702
242	228.14	659	-708
249	228.23	664	-713
258	228.75	678	-732
269	228.475	685	-748
298	227.98	694	0
324	227.58	702	0
221	227.43	708	0
229	227.46	713	0
241	226.52	732	0
260	226.69	748	0
365	226.32		
381	226.12		
385	226.09		
387	225.48		
392	225.72		
298	225.56		
412	224.27		
415	224.22		
418	224.02		
425	223.94		
437	224.48		
444	222.41		
446	222.23		
452	222.62		
464	222.86		

APPENDIX B

LAEP 227 2005 Cross Section Data

Cross Section A:

Distance on Longitudinal Profile= 683'

Distance (ft)	Elevation (ft)
0	230.25
7.5	227.52
21	226.38
29	220.05
30	219.4
33	218.26
36	218.16
39	227.65
40	226.28
42	223.63
45	220.72
47	218.72
52	218.22
58	217.95

Cross Section B

Distance on Longitudinal Profile = 652'

Distance	Elevation
-2.5	230.995
1.5	228.59
16.5	226.98
20.5	224.34
28	219.79
32	219.33
4.5	219.5
38.2	219.24
40.5	219.51
44.5	221.17
49.5	226.22
52	227.12

Cross Section C

Distance on Longitudinal Profile=584'

Distance	Elevation
0	229.5
12	228.31
29	221.66
35.8	219.27
41	218.84
45	219.12
55	229.94
65	229.34

Cross Section D

Distance on LP = 514'

Distance f(ft)	Elevation
-2.5	231.74
13.5	229.99
27.5	224.55
37	222.04
39.5	221.89
44	222.19
48.5	222.88
52.5	226.54
55.5	230.92
59.5	232.01

Cross Section E

Distance on LP=437'

Distance (ft)	Elevation
10.5	232.44
18.5	230.18
26.5	224.06
28.5	223.18
34.5	222.88
38.5	223.27
43.5	226.93
51.5	231.98
65.5	233.25

Cross Section I

Distance on LP=283.25

Distance (ft)	Elevation
0.66	238.8
6.56	238.33
16.56	229.75
21.32	228.74
15.9	228.34
29.53	228.63
32.15	228.93
34.78	230.19
35.43	231.62
39.37	232.44
50.85	235.79
55.11	238.22

Cross Section J

Distance on LP =234.25'

Distance f(ft)	Elevation
0.66	238.4
5.9	237.56
16.08	230.63
17.55	230.01
21.49	229.86
25.92	229.98
31.17	230.06
34.28	231.41
27.07	232.97
41.67	233.8
47.9	234.84
53.48	237.15

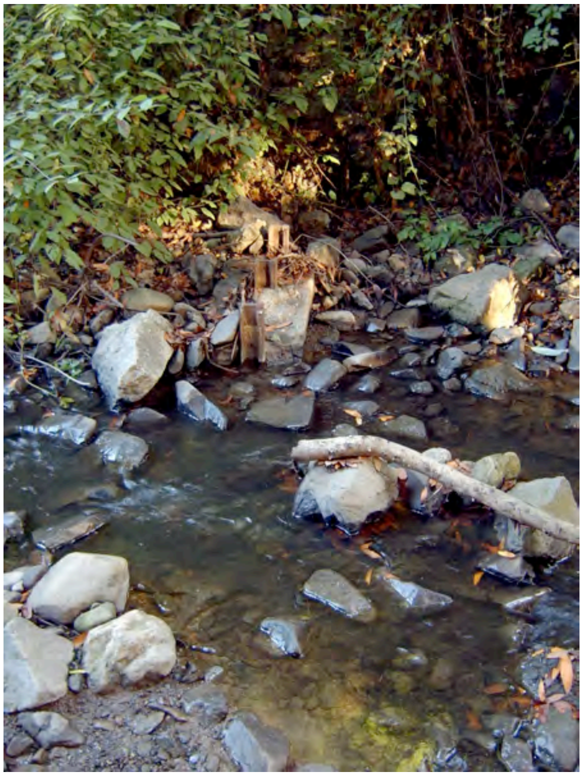
Cross Section K

Distance on LP =198.82"

Distance (ft)	Elevation
0.49	238.8
5.58	238.51
9.84	236.51
14.11	234.15
16.08	231.62
17.72	230.57
19.19	230.05
21.98	320.34
30.18	230.77
33.14	231
36.75	233.56
41.01	23.34

APPENDIX C: Photographs, 2005

Constructed Rock Weir

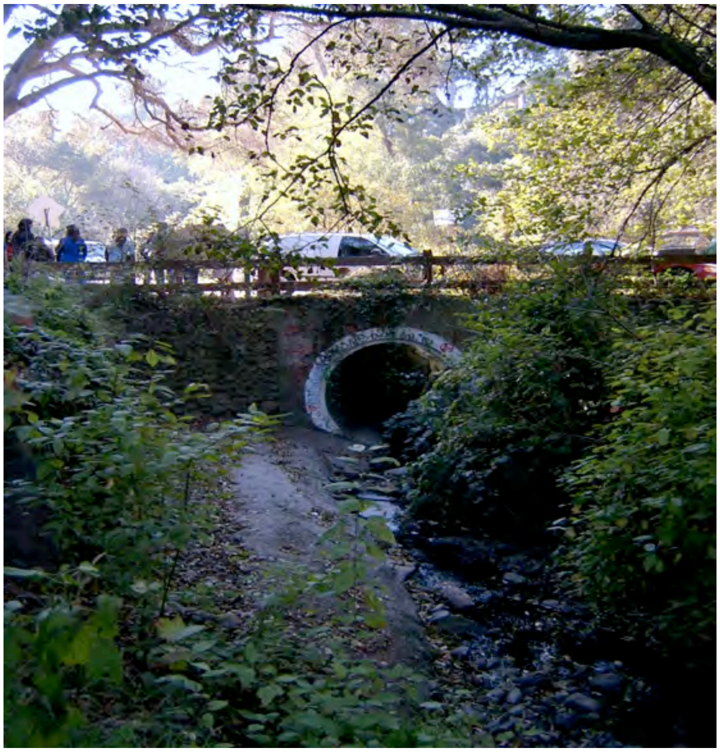


Remnants of removed debris rack

Large Woody Debris

Channel Incision and Upstream Check Dam

Sewer Line in Bottom of Channel



Culvert at El Centro

Friends of Sausal Creek mobilizing for macro-invertebrate survey

Figure 28: Erosion due to informal creek crossing at rock weir