Balance Hydrologics, Inc.

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February 13, 2004

Ms. Susan Schwartz
Friends of Five Creeks
1236 Oxford Street
Berkeley, California 94709

RE: Hydrologic Feasibility Study for Daylighting the Mouth of Schoolhouse Creek, City of Berkeley

Dear Ms. Schwartz:

We are pleased to submit the results of the hydrologic feasibility study for daylighting of Schoolhouse Creek in the City of Berkeley. This study considered several aspects related to the development of conceptual restoration plans for the site with the goal of generating a preferred conceptual grading plan to guide soil sampling and testing at the site.

This letter summarizes the hydrologic feasibility study, the preferred conceptual plan and an alternative “minimum excavation” plan.

Work Conducted

Balance staff reviewed background materials and carried out several site visits to collect pertinent data on the restoration site. Several previous maps and aerial photographs were of particular importance, including the excellent base topographic mapping provided by Northwest

Hydraulics (NWH) and historical plans for the Virginia Street storm drain system provided by Friends of Five Creeks. The topographic mapping information was augmented by additional survey data collected at the site by Balance staff.

The background information was compiled and reviewed in light of the restoration objectives conveyed by staff from Save The Bay. Alternative conceptual plans were developed, leading to a preferred plan for which hydraulic modeling was prepared.

Existing Hydrologic Setting

The restoration site is located between the frontage road west of I-80 and the Berkeley North Basin (an extension of San Francisco Bay) approximately 1800 feet north of University Avenue. The site is traversed by an existing 60-inch reinforced concrete pipe (RCP) storm drain line that is the outfall pipe for the Virginia Street trunk line of the City of Berkeley storm drain system. The distance from the west edge of the frontage road to the end of the existing pipe is roughly 500 feet. Elevations at the site range from somewhat below mean sea level along the shore of the Bay to roughly 11.5 feet on some of the higher rubble piles.[1] The average elevation is on the order of 9 feet and the elevation of the invert at the end of the 60-inch RCP is approximately -3.6 feet.

The existing site is characterized by fill material that was placed in the Bay in the first half of the twentieth century. The existing storm drain outfall is located well to the west of the historical creek mouth, which emptied into the southernmost end of the large tidal marsh that was formerly located behind Fleming Point. This would place the historical creek mouth in the vicinity of the intersection of Virginia and 4th Streets, roughly 2500 feet east of the existing outfall.

[1] All elevations are given in feet, referencing the National Geodetic Vertical Datum of 1929 (NGVD 29) unless otherwise noted.

The Schoolhouse Creek watershed has been highly altered through development of the City of Berkeley. The present drainage area of the Virginia Street storm drain is approximately 640 acres (one square mile). Previous analyses by NWH calculated the expected stormwater discharge for various design storms in the watershed, summarized in Table 1. It is important to note that the NWH calculations show that the storm drain capacity upstream of I-80 may only be sufficient to convey storms somewhat larger than the two-year event or approximately 130 cubic feet per second (cfs). The existing pipe west of I-80 was estimated to have a capacity of approximately 300 cfs, still well below the 100-year peak discharge of 700 cfs estimated by NWH.

Restoration Goals

Many different approaches to restoration could potentially be implemented at the mouth of Schoolhouse Creek. Thus, it is necessary to define clear objectives to guide the development of a conceptual restoration plan. Several goals were particularly important for the feasibility study, including the following:

1. *Compatibility with other uses*. The project site is located within the boundaries of the newly-formed East Shore State Park. Therefore the scope of any restoration will need to conform to and support other planned land uses in the immediate vicinity and should advance the overall goals of the park plan.

2. *Limiting excavation*. Restoration of creek and/or marsh habitat will generally require excavation to lower elevations to reestablish hydraulic connectivity with San Francisco Bay. Excavation will produce significant amounts of fill that must be moved from the site at a significant cost. Additionally, there are concerns that some of the fill may be contaminated. Therefore, less excavation reduces the possibility of contact with, and need to dispose of, contaminated fill.

3. *Habitat types*. Save The Bay staff were instrumental in identifying the preferred habitat objectives. The overall goal is to create as large an area of high salt marsh as practical given the existing constraints.

Tidal Characteristics

The restoration goals require an understanding of the tidal characteristics at the site. Tidal gaging was not carried out as part of the feasibility study. However, previous gaging work by Balance Hydrologics at the nearby Buchanan Marsh site in the City of Albany established relationships with respect to the National Oceanic and Atmospheric Administration tide gage at Richmond (Station 9414863). These relationships can reasonably be applied to the mouth of Schoolhouse Creek and are illustrated in Figure 1. The predicted mean higher high water (MHHW) elevation is 3.25 feet. The observed high water mark at the site in December 2003 was at an elevation of 4.2 feet, consistent with the tidal record in Figure 1.

Conceptual Grading Plan

The information above was used to develop the preferred conceptual grading plan shown in Figure 2. Key characteristics of this grading configuration include:

1. *Grading limits*. The extent of the grading activities would be confined to the roughly triangular area between the abandoned roadway to the south and the bulk of the rubble piles and informal trails to the north. The eastern extent of grading would be set back from the frontage road to allow space for other uses. The grading limit would include approximately 1.58 acres.

2. *Disposition of existing infrastructure*. There are several overhead utility lines at the site. Several poles appear to serve temporary hook-ups for the nearby seasonal vending locations, and the plan assumes that these poles and lines can be removed and/or relocated at minimal cost. However, the larger utility poles that carry lines out to the City of Berkeley Marina should be protected and left undisturbed by grading activities. There is no clear evidence of buried utilities, but confirmation will be needed during preparation of construction documents. A minimum of 60 feet of the existing 500 feet of 60-inch storm drain (measured from the end of pipe) will need to be removed. It may be possible to leave much of the remaining pipe in place, if it is capped.

3. *New infrastructure*. The conceptual plan can be implemented with a minimum of new infrastructure. However, the preferred plan envisions constructing a new outfall for the Virginia Street storm drain at the head of the restoration area. This would require approximately 117 feet of new RCP, a new manhole and a new headwall at the outfall point. The relatively new existing manhole at the edge of the frontage road may also need to be replaced when the new pipe is connected.

   The relatively sheltered location of the restoration site will minimize the need to protect the upper bank areas from wave action. However, some slope protection will be needed on the more exposed south bank, especially within 100 feet of the basin where a utility pole needs to be protected. The slope protection could be of several types, including loose rock rip rap of an appropriate size, and will need to extend above the anticipated highest tide elevation to account for wave run-up.

4. *Marsh characteristics.* The grading plan generally utilizes 3:1 bank slopes to transition from existing grades down to a high tidal marsh elevation of about 3.25 feet. This elevation would lead to tidal inundation of the entire marsh during the higher high tide on roughly half the days of a typical month. The created marsh would have an area of approximately 1.12 acres. Depending on the desired habitat mix within the marsh, a low berm may be beneficial near the western edge of the restoration site along the North Basin shore to reduce wave action. This wave action is likely responsible for creating the existing point, which extends southwards from the north end of the site. This point feature would not be disturbed during restoration of the site.

5. *Channel characteristics.* A channel would be excavated to connect the new outfall location to the Basin. This channel should be viewed as a pilot channel that would adjust in depth and shape with time. The geometry of the channel is strictly conceptual at this time, pending the findings of the soil sampling and substrate characterization. The conceptual channel as depicted has relatively steep banks (roughly 1:1.5) and a bottom width of 4 feet at the outfall, transitioning to 8 feet at the Basin. The average depth of the channel would be on the order of 6 feet, giving an average channel width of 24 feet. The channel planform is based on hydraulic geometry relationships for streams in the Bay Area with a similar 2-year discharge. The meander amplitude is roughly 70 feet, with a wavelength of approximately 225 feet. The channel width and amplitude increase somewhat near the mouth of the creek where tidal influences will be more pronounced.

6. *Excavation quantities.* Detailed cut and fill analyses were not carried out for this preliminary study. However, a simple calculation based on the conceptual grading plan suggests that the total excavation would be on the order of 15,000 cubic yards (see Table 2).

Hydraulic Analyses

Hydraulic modeling was carried out to verify that the conceptual restoration design would not impair the performance of the Virginia Street storm drain line. This modeling included two components: one for the open channel flow in the created marsh, and another for the flow in the closed-conduit pipe system downstream from the frontage road. The open channel modeling used the U.S. Army Corps of Engineers' HEC-RAS software package. A preliminary assessment model of the storm drain hydraulics was completed using the Hydraflow software package. The modeling results are presented in Tables 3 and 4.

The capacity of the storm drain is significantly affected by the water surface elevation at the outfall point. This water surface elevation is typically referred to as the tailwater elevation. Since the outfall will discharge into a tidal basin, the tailwater is actually constantly changing. However, it is common practice to assess the storm drain capacity using a fixed tailwater elevation as long as it is clearly identified. The mean higher high water elevation (MHHW) is a common reference elevation for this purpose and is generally considered to be appropriately conservative. This elevation is assumed to be on the order of 3.30 feet as shown in the Hydrology and Hydraulics Criteria Summary prepared by the Alameda County Flood Control and Water Conservation District.

Replacement of the existing 60-inch storm drain pipe will have the effect of moving the storm drain outfall roughly 390 feet east of the present location (or 538 feet, accounting for the sinuousity of the created channel). Therefore, the effective tailwater elevation at the outfall may be different from the MHHW value at the Basin shoreline. The expected change in the tailwater elevation at the end of pipe was assessed with the HEC-RAS model of the restoration site for the peak storm discharge values derived by NWH. The results of this modeling are shown in Table 3. The projected tailwater elevations are indeed higher than the MHHW value, and the higher tailwater values are associated with the larger design storms, as expected.

Although the tailwater elevations are expected to be higher for the proposed new outfall location, the conveyance capacity of the channel and marsh will be higher than that of the existing pipe, as verified by the hydraulic modeling. The net effect is that the hydraulic gradeline will be reduced at the manhole at the West Frontage Road for all storm events assuming that the new pipe segment is constructed using 60-inch diameter RCP (see Table 4). For example, the proposed daylighting coupled with a new outfall pipe would increase the capacity of the storm drain line west of I-80 from approximately 255 cfs (roughly the 4-year event) to 425 cfs (approximately the 10-year event). This improvement could be very important if the City of Berkeley should decide to increase the storm drain capacity upstream of I-80, since it would lower tailwater elevations and increase conveyance for any such improvements.

Because the storm drain pipes must be protected beneath a sufficient depth of soil, it is important to note that there is ample cover depth to markedly increase the size of the pipe leading from the frontage road to the new outfall point. A larger diameter pipe would provide even greater capacity in the storm drain west of the frontage road. Hydraulic modeling runs were used to assess the potential benefits of several larger pipe sizes, with results shown in Table 4. For example, if a 72-inch RCP is used from the West Frontage Road to the outfall, the maximum capacity of this section of pipe would increase to roughly 630 cfs, approximately the 40-year event. If an 84-inch RCP is utilized, the pipe capacity would increase to above that of the estimated 100-year storm.

Using larger pipes would have at least two drawbacks: 1) somewhat higher costs for all of the replacement storm drain infrastructure, and 2) larger pipe diameters would reduce exit velocities for a given discharge, thereby reducing the flushing action that would help to keep the outfall clear of sediment. However, given the trade-offs between benefits and drawbacks our initial recommendation would be to install an 84-inch pipe, which would be compatible with any upstream storm drain improvements, and able to provide full conveyance of the 100-year storm.

Minimum grading alternative design

A second schematic design (Option 2) was developed with the goal of presenting a workable configuration that involves less grading and excavation than Option 1. This design is depicted in Figure 7. Construction of this design would involve grading of approximately 0.97 acres to create roughly 0.59 acres of wetlands. This is roughly 38 percent less total grading area and 48 percent less wetland acreage than for Option 1. The total quantity of material to be removed is estimated to be on the order of 8,000 cubic yards as shown in Table 5.

It is important to note that the channel in this alternative is markedly more confined. Therefore, additional consideration would need to be given to bank protection if this alternative were selected for final design. The channel banks are shown at a very steep slope of 1:1 in Figure 7, and this may not be practical from a soil stability perspective. Nonetheless, the hydraulic characteristics of this design would be roughly comparable to Option 1.

Other alternative restoration designs

Clearly, there are many potential alternative designs depending on how the site constraints discussed above are addressed. However, the essential features of the alternative designs would likely be generally the same, resulting in creation of more or less marsh area than the design presented herein.

One alternative approach does merit discussion since it could be considerably less costly to implement. As discussed above, the preferred conceptual design includes a new outfall, pipe and manholes to direct the Virginia Street storm drain to the head of the marsh, features that will increase the construction cost of the project. We chose this approach in lieu of working with the existing 60-inch line because the existing line is encroached upon by the paved area immediately to the south. Therefore, simply cutting the existing pipe would make it difficult to achieve a hydraulically efficient outfall and would forego the opportunity to make large increases in the pipe capacity west of the frontage road. If the grading limit could be moved approximately 40 to 50 feet to the south, then the existing pipe could be left in place and used for the outfall. This would save the cost of the new storm drain infrastructure, but the opportunity to increase pipe capacity above roughly the 10-year event would be lost.

Closing

We appreciate the opportunity to have worked on this feasibility study for the daylighting of the mouth of Schoolhouse Creek. Pending the results of the soils investigations, the conceptual plan would be relatively easy to implement, providing habitat diversity that is presently absent from this section of the Basin shoreline while offering the opportunity to significantly improve the functioning of the City of Berkeley storm drain system upstream from the site.

Once further assessment of the benefits and constraints of this approach has been made, we would certainly be happy to generate alternative conceptual or detailed grading plans. We welcome any comments or suggestions from you or other reviewers, since feedback will be an important element of refining the conceptual plan.

Sincerely,

Balance Hydrologics, Inc

Edward D. Ballman, P.E.
Civil Engineer / Hydrologist

Gustavo Porras
Hydrologist / Geological Engineer

cc: Briggs Nesbitt, Save The Bay
Marilyn Latta, Save The Bay

Attachments: Tables 1 - 5
Figures 1- 11

TABLES

Table 1. Estimated peak flow and elevation data for the mouth of Schoolhouse Creek, City of Berkeley

From Northwest Hydraulic Consultants (Martin Fisher):
Using HEC-1:

2-year storm	Q_2 =	130	cfs
25-year storm	Q_{25} =	560	cfs
100-year storm	Q_{100} =	700	cfs
Pipe capacity between I-80 and outfall =		~300	cfs
Berkeley upstream capacity =		~170	cfs

Length of existing pipe from manhole to outfall	153.0	meters
Length of existing pipe from manhole to outfall	502.1	feet
current pipe outfall invert elevation	-3.60	feet NGVD
elevation of manhole invert	-2.82	feet NGVD
elevation difference	0.78	feet NGVD
slope	0.16	%

Length of pipe from existing manhole to proposed outfall	35.7	meters
Length of pipe from existing manhole to proposed outfall	117.0	feet
slope	0.14	%
elevation of manhole invert	-2.82	feet NGVD
elevation difference	0.16	feet NGVD
elevation of proposed outfall invert	**-2.98**	**feet NGVD**
	-0.91	**m NGVD**

Table 2. Estimated surface area values and excavation quantities for the daylighting of the mouth of Schoolhouse Creek, City of Berkeley

Rough calculation only, assume average existing grade is at elevation 2.75 meters

Elevation	Area	Volume	
m	*m2*	*m^3*	*yd^3*
-1.00	143	0	0
-0.75	368	64	83
-0.50	491	171	224
-0.25	613	309	404
0.00	758	480	628
0.25	919	690	903
0.50	1120	945	1236
0.75	1378	1257	1644
1.00	4550	1998	2614
1.25	4874	3176	4154
1.50	5099	4423	5785
1.75	5320	5725	7488
2.00	5543	7083	9264
2.25	5767	8497	11113
2.50	5918	9957	13024
2.75	6030	11451	14977

Grading Limit	6379		
	=	1.58	acres
Created marsh	4550		
(area <=1.0 meter)	=	1.12	acres
Channel	1378		
	=	0.34	acres

Table 3. HEC-RAS results

HEC-RAS Plan: Plan 07 River: Schoolhouse Cree Reach: Mouth - **Downstream Boundary Condition: MHHW 3.30 ft**

OPTION 1 channel **Manning's n values: LOB=0.10 ; Channel=0.035 ; ROB=0.10**

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Mouth	375.262	PF 1	130	-2.98	3.35		3.4	0.000332	1.71	76.05	16.94	0.14
Mouth	375.262	PF 2	170	-2.98	3.39		3.46	0.000557	2.22	76.66	17.03	0.18
Mouth	375.262	PF 3	300	-2.98	3.55		3.77	0.001585	3.78	79.46	17.44	0.31
Mouth	375.262	PF 4	560	-2.98	3.96		4.6	0.004432	6.46	86.73	18.47	0.53
Mouth	375.262	PF 5	700	-2.98	4.14		5.08	0.006215	7.76	90.27	19.13	0.62
Mouth	303.178	PF 1	130	-3.2	3.35		3.36	0.000135	0.99	173.97	142.58	0.1
Mouth	303.178	PF 2	170	-3.2	3.38		3.4	0.000221	1.28	178.6	142.8	0.13
Mouth	303.178	PF 3	300	-3.2	3.54		3.6	0.000559	2.1	201.53	143.89	0.21
Mouth	303.178	PF 4	560	-3.2	4.04		4.19	0.001065	3.2	275.17	147.34	0.29
Mouth	303.178	PF 5	700	-3.2	4.36		4.53	0.001186	3.57	322.21	149.5	0.31
Mouth	95.297	PF 1	130	-3.42	3.31		3.34	0.000189	1.38	145.44	142.8	0.12
Mouth	95.297	PF 2	170	-3.42	3.32		3.37	0.000321	1.8	146.5	142.85	0.15
Mouth	95.297	PF 3	300	-3.42	3.36		3.5	0.000955	3.13	152.13	143.12	0.27
Mouth	95.297	PF 4	560	-3.42	3.52		3.94	0.002773	5.46	175.43	144.2	0.46
Mouth	95.297	PF 5	700	-3.42	3.66		4.24	0.003698	6.44	196.07	145.16	0.53
Mouth	0	PF 1	130	-3.78	3.3	-1.61	3.31	0.000069	0.71	205.99	122.09	0.07
Mouth	0	PF 2	170	-3.78	3.3	-1.28	3.31	0.000118	0.93	205.99	122.09	0.09
Mouth	0	PF 3	300	-3.78	3.3	-0.41	3.34	0.000366	1.65	205.99	122.09	0.17
Mouth	0	PF 4	560	-3.78	3.3	0.94	3.44	0.001275	3.07	205.99	122.09	0.31
Mouth	0	PF 5	700	-3.78	3.3	1.45	3.53	0.001993	3.84	205.99	122.09	0.39

From Northwest Hydraulic Consultants (Martin Fisher):
Using HEC-1:

Q_2 =	130	cfs
Berkeley upstream capacity =	~170	cfs
Pipe capacity between I-80 and existing outfall =	~300	cfs
Q_{25} =	560	cfs
Q_{100} =	700	cfs

Table 4 . Summary of hydraulic modeling for the existing and proposed storm drain pipes at the mouth of Schoolhouse Creek, City of Berkeley

Pipe Diameter (inches)	Model Run	Discharge (cfs)	Tailwater (feet, NGVD)	Predicted Hydraulic Grade Line 1st Manhole (feet, NGVD)	Frontage Manhole (feet, NGVD)	Exit Velocity (feet/sec)
Existing Conditions						
60-inch	Maximum Capacity	255	3.30	9.7	10.8	13.2
	Low Discharge	50	3.30	---	---	2.6
Proposed Conditions						
60-inch	At Existing Maximum Q	255	3.50	4.5	6.6	13.0
	New Maximum Capacity	425	3.71	6.6	12.2	21.6
	Low Discharge	50	3.32	---	---	2.6
72-inch	At Existing Maximum Q	255	3.50	3.9	4.8	9.0
	New Maximum Capacity	630	4.04	6.7	12.1	22.3
	Low Discharge	50	3.32	---	---	1.8
84-inch	At Existing Maximum Q	255	3.50	3.7	4.2	6.8
	New Maximum Capacity	870	4.52	7.0	12.2	22.6
	Low Discharge	50	3.32	---	---	1.4

Notes:

The limiting ground elevation for the existing storm drain line is 9.8 feet at the existing catch basins just off the frontage road.
The limiting ground elevation for the proposed storm drain line is the manhole on the frontage road with a rim elevation of 12.5 feet.
The tailwater elevations for the proposed conditions are taken from the HEC-RAS modeling of the restoration area routing the respective discharge against a mean higher high water elevation of 3.30 feet NGVD. The

Table 5. Estimated surface area values and excavation quantities for the daylighting of the mouth of Schoolhouse Creek, Option 2, City of Berkeley

Rough calculation only, assume average existing grade is at elevation 2.50 meters

Elevation	Area		Volume	
m	*m2*		*m^3*	*yd^3*
-1.00	142.7		0	0
-0.75	279.4		53	69
-0.50	343.2		131	171
-0.25	407.5		224	294
0.00	471.7		334	437
0.25	536.1		460	602
0.50	600.6		602	788
0.75	665.1		761	995
1.00	2389.1		1142	1494
1.25	2680.4		1776	2323
1.50	2892.9		2473	3234
1.75	3100.2		3222	4214
2.00	3308.4		4023	5262
2.25	3521.9		4877	6379
2.50	3750	est	5786	7567

Grading Limit	3917			
		=	0.97	acres
Created marsh	2389			
(area <=1.0 meter)		=	0.59	acres
Channel	665			
		=	0.16	acres

FIGURES

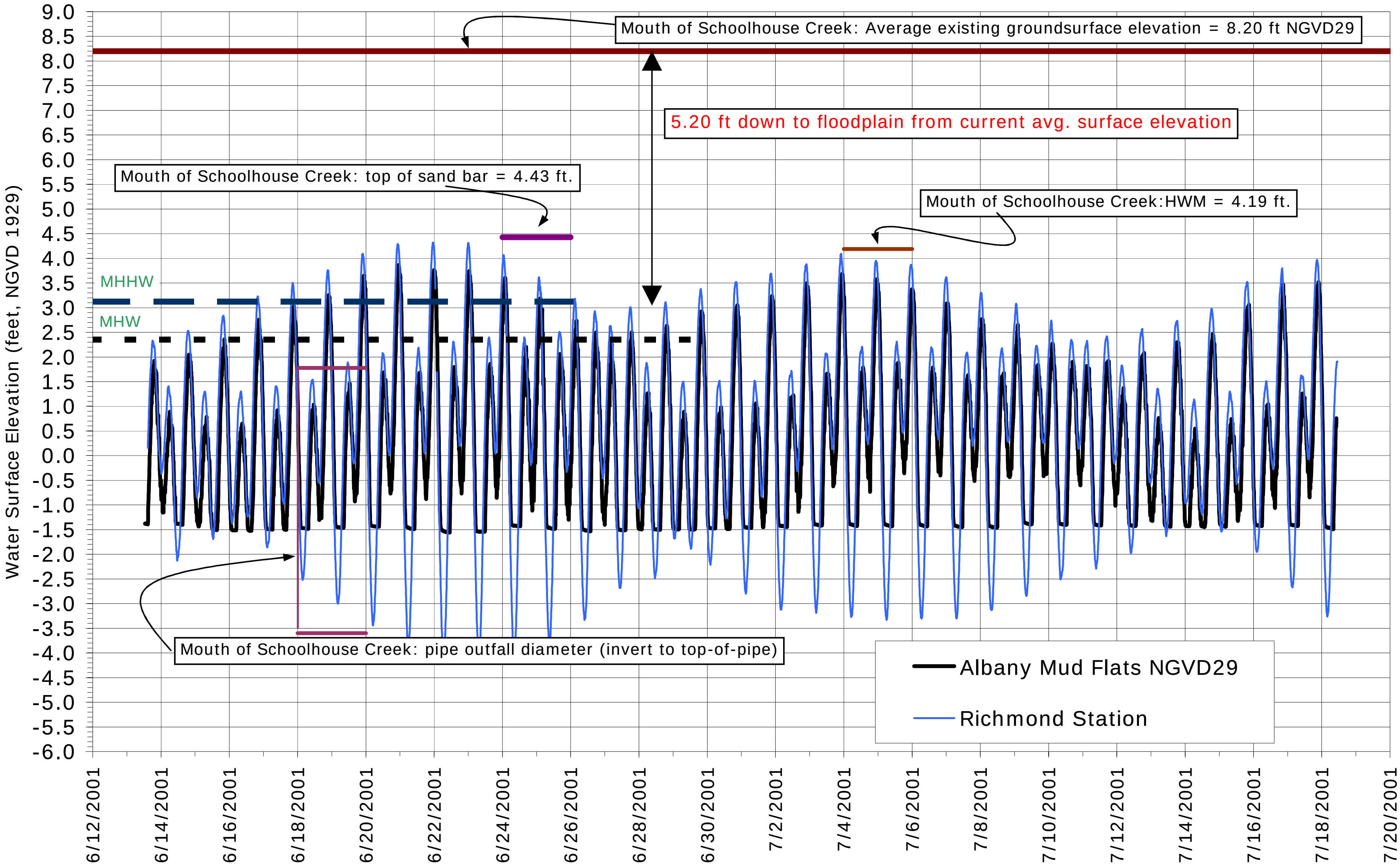

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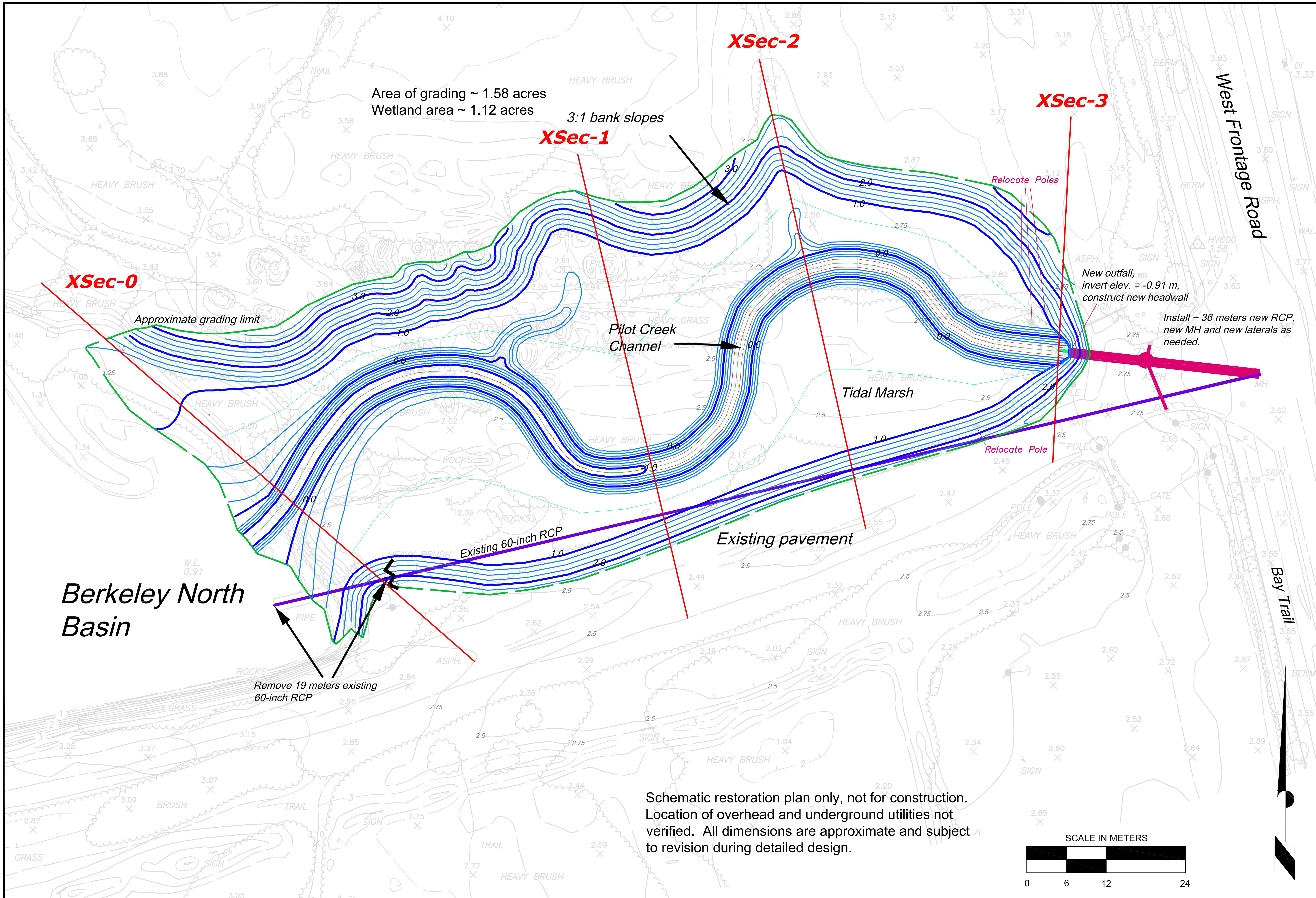
Figure 1. **Water surface elevation, NGVD 29 datum, Channel in Albany mud flats,Albany, Calilfornia**



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REVISIONS	BY	DATE

DATE 02-12-2004

DRAWN BY GP

PROJ MGR GP

EXP. DATE 09-30-2006

Schoolhouse Creek Daylighting

OPTION 1

CITY OF BERKELEY, CALIFORNIA

JOB NUMBER 203098

FIGURE 2

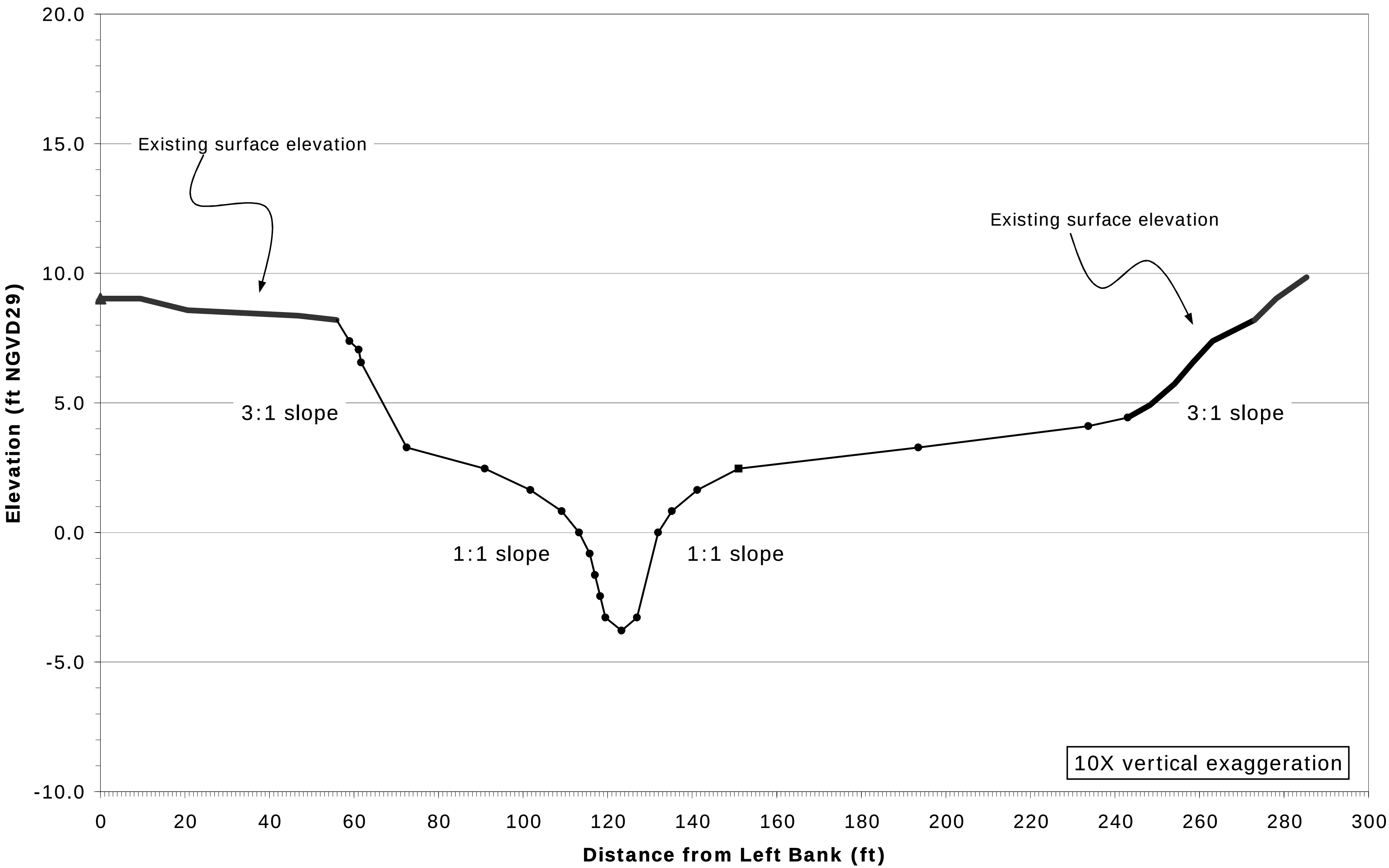

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Figure 3. **Cross section 0 surface elevations, NGVD 29 datum, Schoolhouse Creek, Berkeley, Calilfornia**

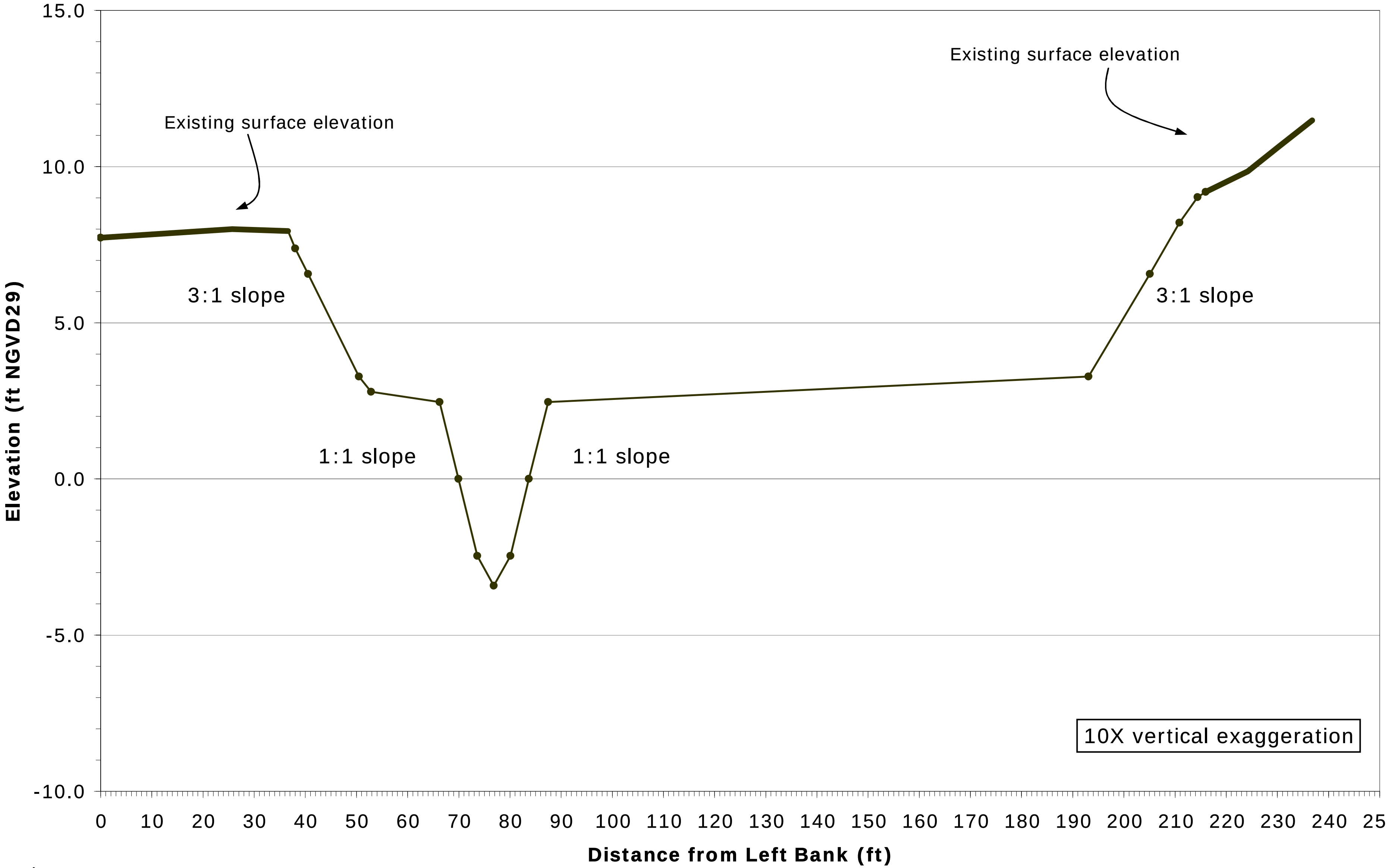

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Figure 4. Cross section 1 surface elevations, NGVD 29 datum, Schoolhouse Creek, Berkeley, Calilfornia

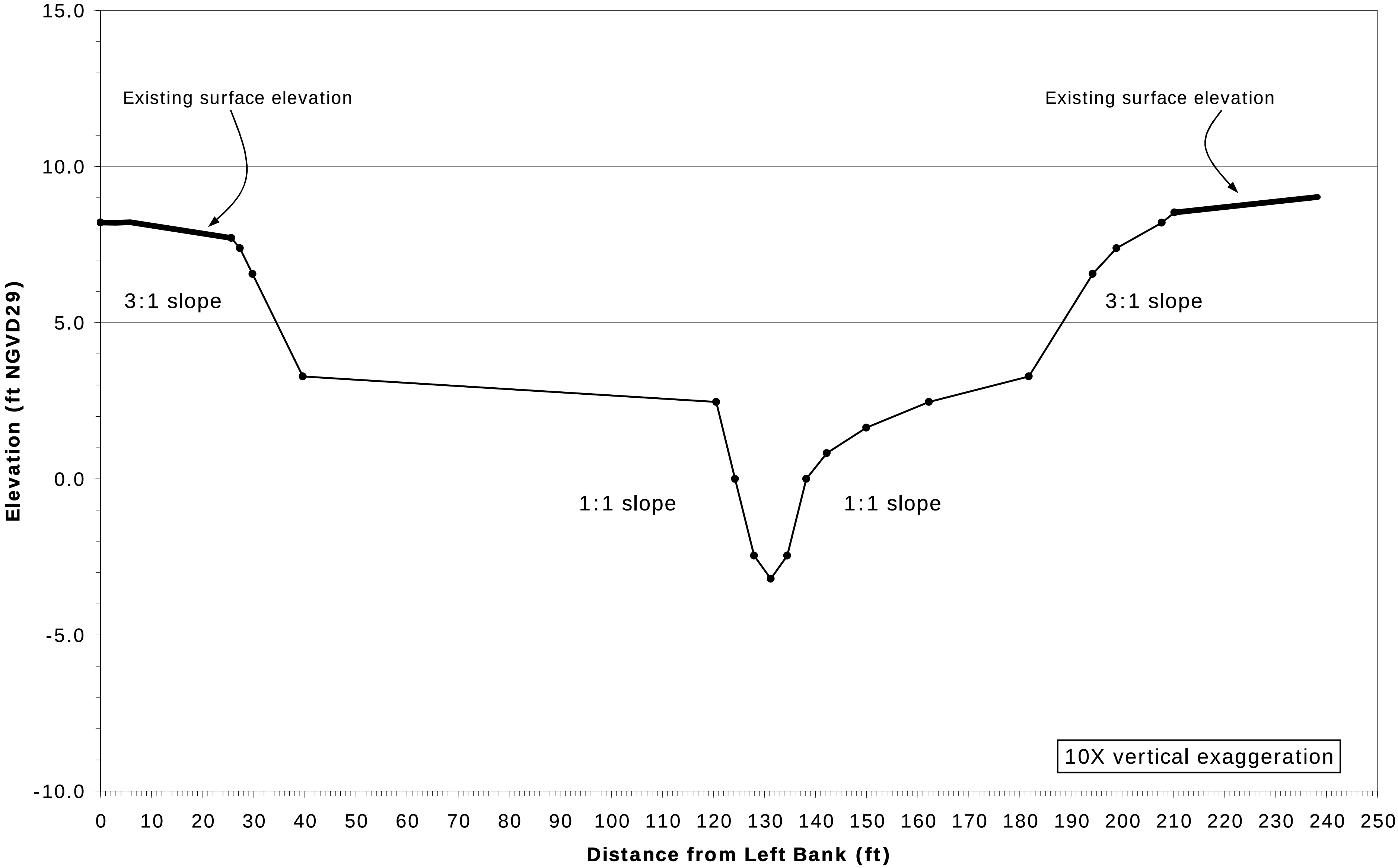

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Figure 5. Cross section 2 surface elevations, NGVD 29 datum, Schoolhouse Creek, Berkeley, Calilfornia

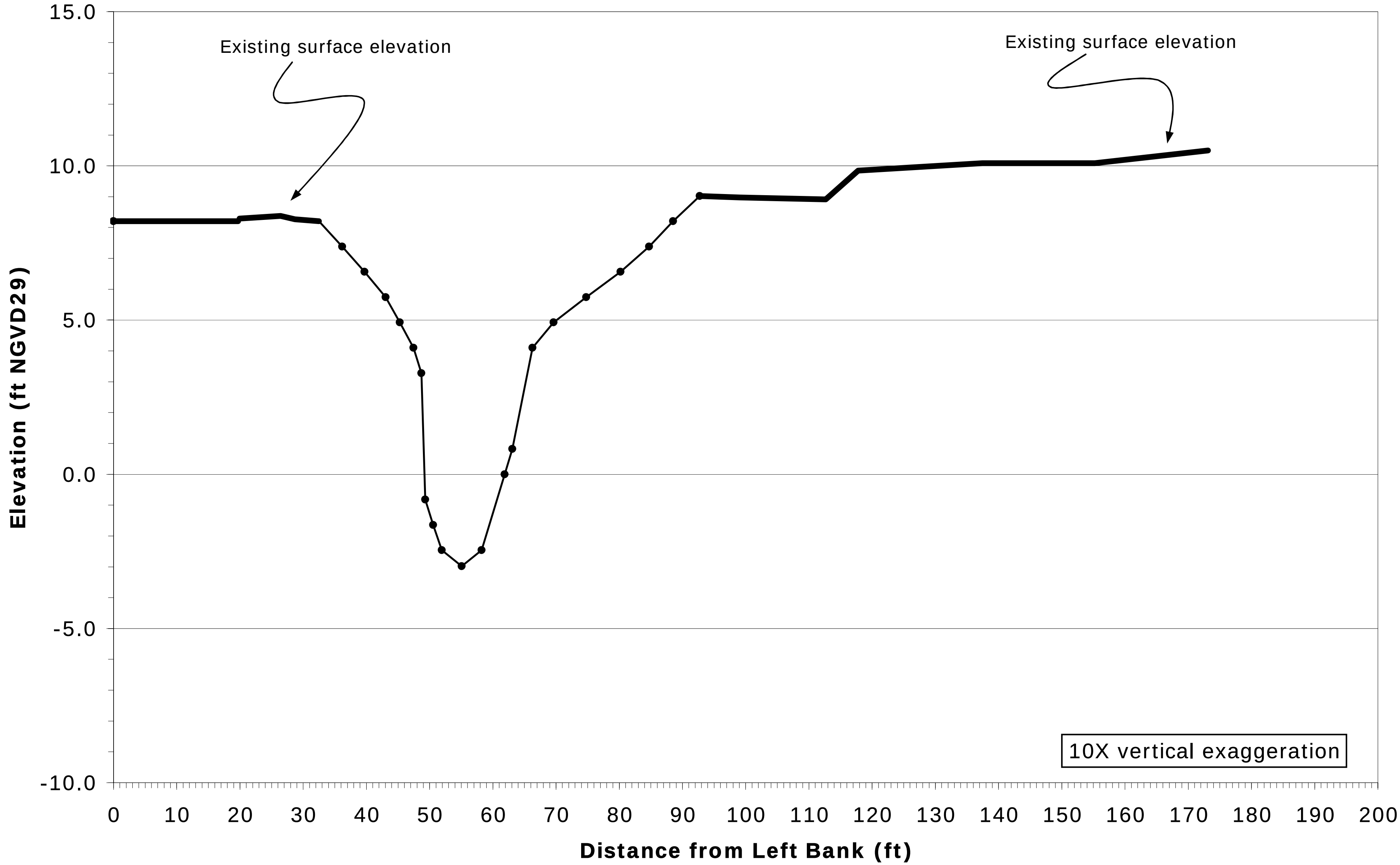

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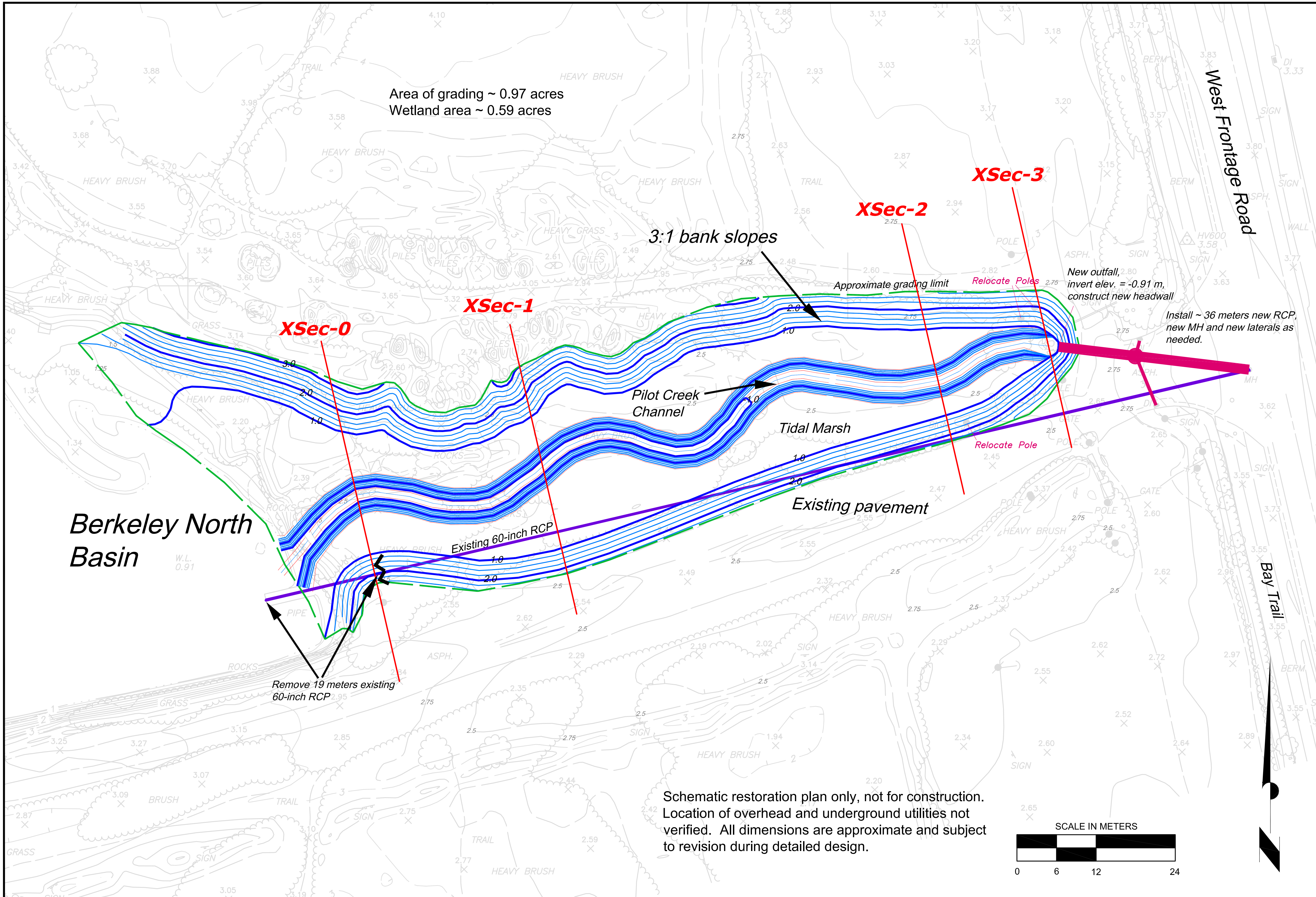
Figure 6. **Cross section 3 surface elevations, NGVD 29 datum, Schoolhouse Creek, Berkeley, Calilfornia**



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DATE 02-12-2004
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EXP. DATE 09-30-2006

Schoolhouse Creek Daylighting
OPTION 2
CITY OF BERKELEY, CALIFORNIA

JOB NUMBER
203098

FIGURE
7

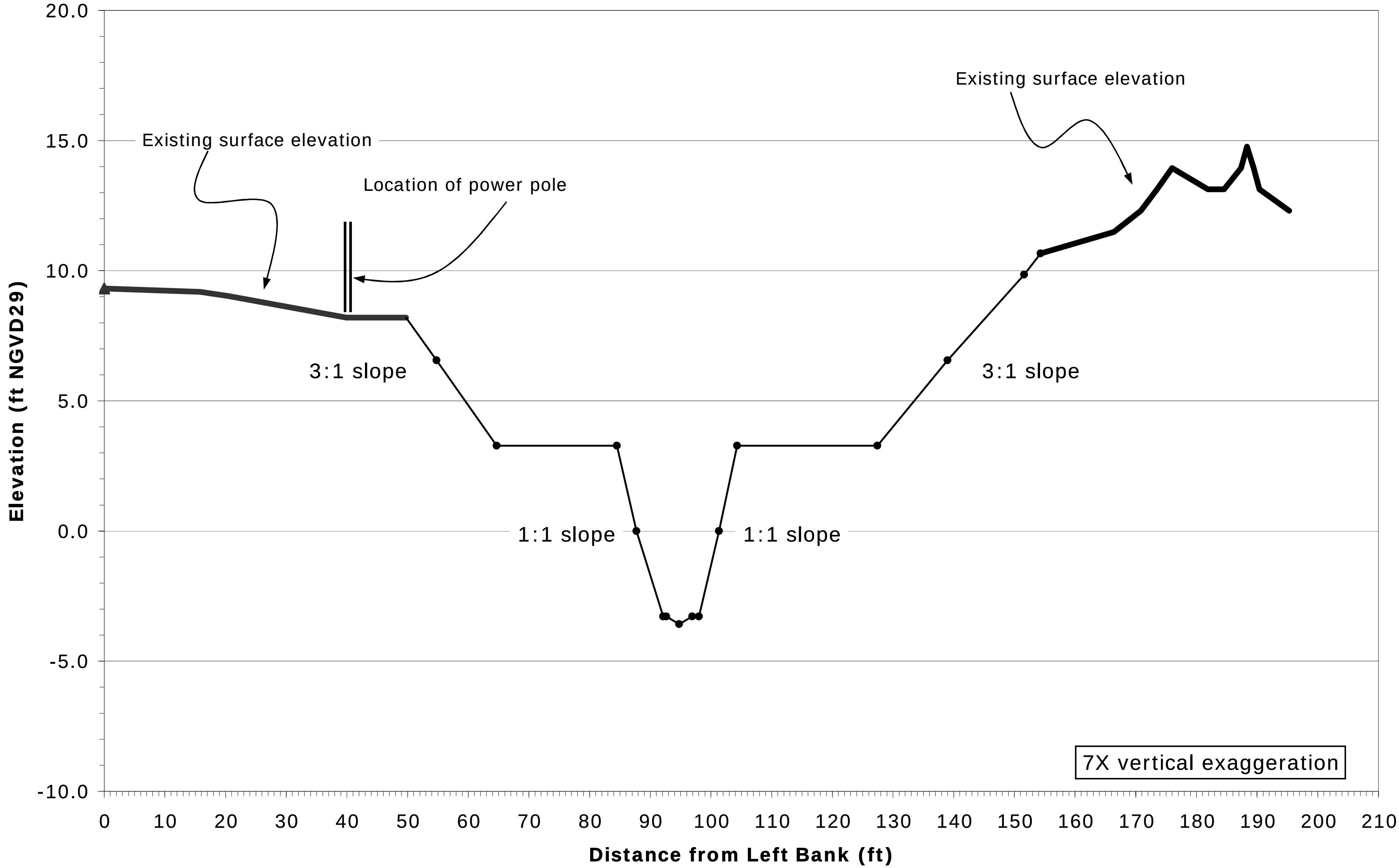

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Figure 8. **Cross section 0 surface elevations, NGVD 29 datum, Schoolhouse Creek, Berkeley, Calilfornia**

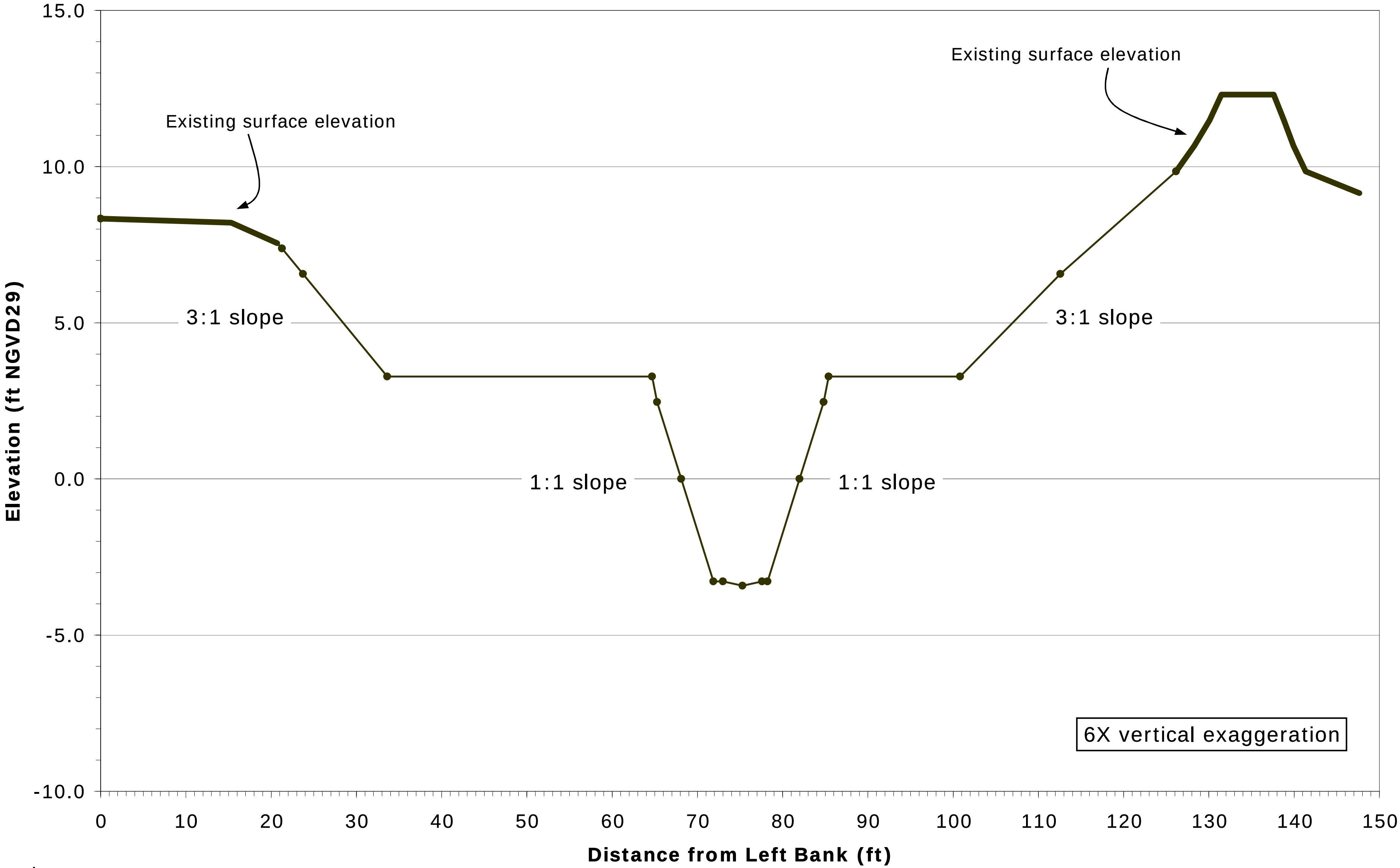

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Figure 9. **Cross section 1 surface elevations, NGVD 29 datum, Schoolhouse Creek, Berkeley, Calilfornia**

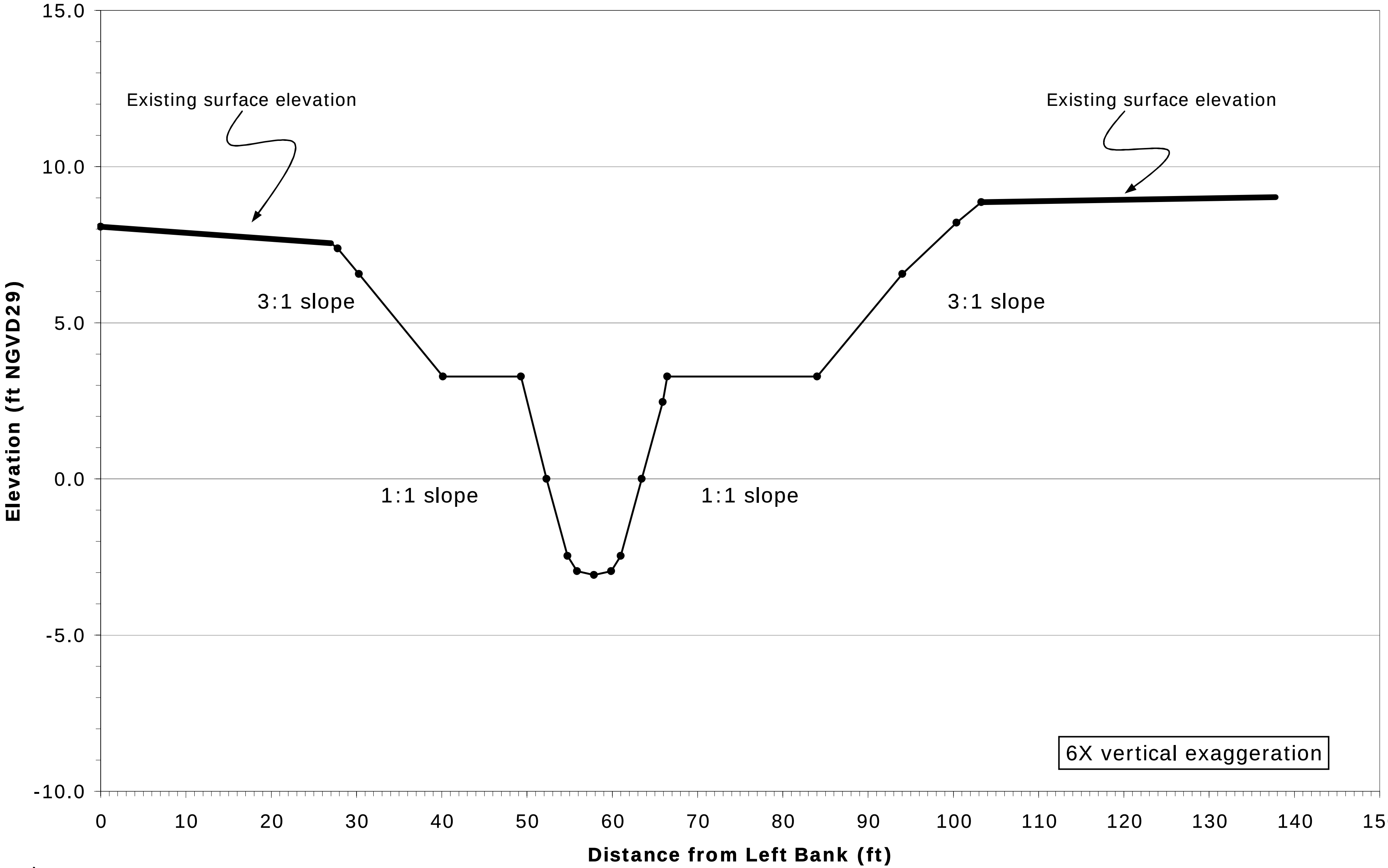

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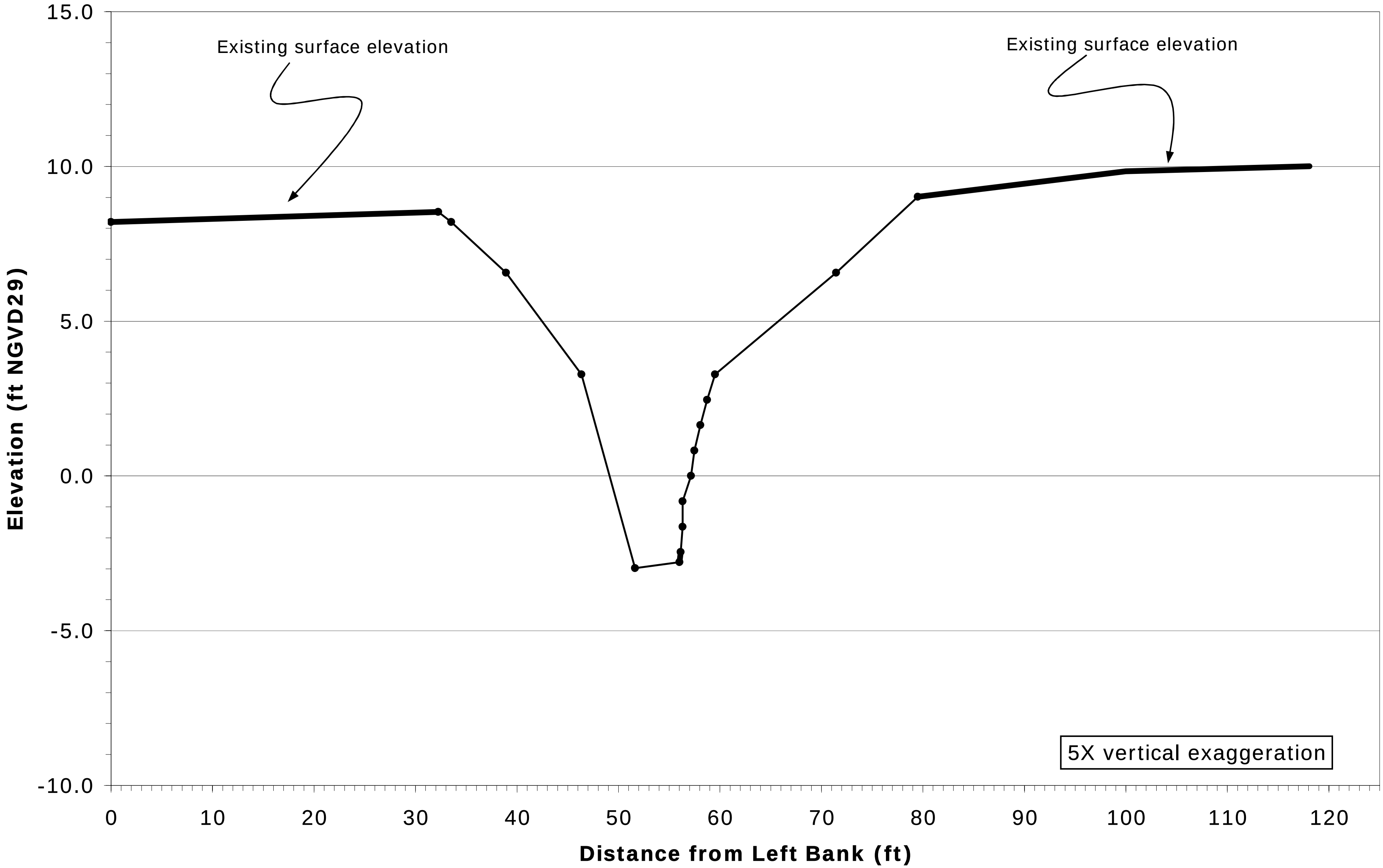
Figure 10. **Cross section 2 surface elevations, NGVD 29 datum, Schoolhouse Creek, Berkeley, Calilfornia**

203098 calcs rev.xls, Fig. 10 Cross Section 2



Balance Hydrologics, Inc.

Figure 11. **Cross section 3 surface elevations, NGVD 29 datum, Schoolhouse Creek, Berkeley, Calilfornia**