WEST CREEK DRAINAGE IMPROVEMENT ASSESSMENT
TIBURON, CALIFORNIA

Prepared For:

County of Marin, Department of Public Works,
Flood Control and Water Conservation District

Prepared by:

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1.0 INTRODUCTION

This report summarizes the results of a hydrologic and hydraulic study completed by Kamman Hydrology & Engineering, Inc. (KHE) of San Rafael, California, to identify opportunities to alleviate flooding of properties bordering West Creek on a reach lying between Rancho Drive and Blackfield Drive in Tiburon, California (see Figure 1). This work was completed on behalf of the County of Marin Department of Public Works (DPW), Flood Control and Water Conservation District (Flood Control) under Contract Number 06-287. The DPW performs maintenance and installs temporary flood protection measures along this project reach on an annual basis. In addition to identifying opportunities to alleviate future flooding along the project reach, a goal of this study is to develop a conceptual design for a more permanent solution.

2.0 APPROACH AND METHODS

The study presented herein focuses on 1) characterizing existing flood conditions and 2) developing and evaluating flood reduction measures. This work was completed through the implementation of hydrologic and hydraulic feasibility and design assessments. The development and analysis of potential flood reduction strategies (alternatives) was completed through the development of a computer-based hydraulic model that simulates historic, existing and proposed project conditions. It is intended that the conceptual design developed under this scope of work will be of sufficient detail and quality to initiate project permitting and the environmental compliance process and documentation. Opportunities for riparian corridor and aquatic habitat enhancement were also considered and integrated into the conceptual design.

To address the study objectives KHE developed a hydraulic model of West Creek that predicts water surface elevations and flow velocities in the creek between Via Los Altos Road and Richardson Bay, with focus on the flood-prone reach upstream of Cecilia Way (see Figure 1). Two baseline models were developed for comparison to proposed project alternatives: 1) the “Existing Conditions (EC)” model, reflecting channel conditions during the winter of 2005/06 when sandbags and water bags were temporarily placed along the eastern bank to protect adjacent homes from flooding; and 2) the "Historic Conditions" model, reflecting channel conditions without any of the County's seasonal flood protection measures. KHE also developed and assessed potential flood hazard reduction measures in the form of 6 project alternatives (Alternatives A through F). The hydraulic model results for each alternative were compared against baseline conditions in order to evaluate their ability to alleviate flood hazards.

3.0 ANALYSIS OF EXISTING AND HISTORIC CONDITIONS

3.1 Field Investigations

In order to develop accurate hydraulic models for this study, a project topographic survey was completed along the study reach consisting of regularly spaced cross-sectional profiles. In addition, detailed surveys of the Cecilia Way and Tiburon Boulevard road crossings were completed. This survey, completed by KHE staff, augmented existing survey information provided by the County. All surveying by KHE was tied into the County horizontal and vertical datums and was completed using a Leica GeoSystems-brand total station and prism reflector target. The location of surveyed cross-sectional profiles are indicated on Figure 1. To aid in model calibration, KHE also surveyed in high water marks (HWM) from the December 31, 2005 storm (New Year's Eve Flood), which, based on review of local peak flow estimates from various stream gauging sources, is believed by KHE to represent a flood having between a 30- and 50-year recurrence interval.

KHE also completed synoptic water level measurements in the tidally influenced reach immediately upstream of Tiburon Boulevard in order to quantify the magnitude of tidal attenuation associated with downstream channel geometry/grades and energy loss through the Tiburon Boulevard culverts. The extreme winter spring tide water levels through the project reach were also observed on December 31, 2005. This spring tide event occurred during the waning peak flows of the New Year's Eve Flood, but neither tidal waters or backwater effects were observed in the main study reach at or upstream of the Cecilia Way crossing.

A pair of high flows were also measured within the project reach during the receding flows of the New Year's Eve Flood. These flow measurements and corresponding water surface heights were used to back-calculate an accurate channel roughness coefficient (i.e., Manning's n-value) as well as calibrate the hydraulic model. Flow measurements were completed using a pygmy-standard flow velocity meter and standard discharge measurement methods.

3.2 Hydraulic Model Configuration

KHE prepared a HEC-RAS, one-dimensional, depth integrated steady flow model of West Creek. The model encompasses approximately 2860-feet of West Creek from the upstream Via Los Altos road culvert outfall to Richardson Bay, the downstream model boundary (Figure 1). Two culverted road crossings (at Cecilia Way and Tiburon Boulevard) are within the model domain, the remainder of the reach is open earthen or concrete lined channel.

The main focus of the project study is the flood-prone reach between Via Los Altos and Cecilia Way (see Figure 2). As such, the frequency of model cross-sections increases through this reach, with channel cross sections extending laterally onto adjoining parcels. The cross-section numbers presented on Figure 2 are creek stations in feet measured upstream of Richardson Bay with an arbitrary starting station number of 2141-feet. The County easement along the project reach, access road alignment, top of creek bank, and adjacent parcel boundaries are also indicated on Figure 2. In addition, the location and alignment of sand bags and water bags placed by the County along the eastern creek bank during the 2005/06 rainy season are also indicated on Figure 2.

Required inputs for the HEC-RAS model include: channel cross-sections; Manning’s roughness coefficients; bridge geometry including top of deck elevations; and inflow rates or design flows along the project reach. The channel cross-section and bridge geometry data input came from the site surveys. The Manning’s roughness values used for the active channel were back-calculated using the discharge measurements and associated surveyed water surface levels. The active channel roughness coefficient used was 0.035. An overbank roughness coefficient of 0.09 was used for densely vegetated and overbank areas. This value was estimated based on field observations at the site and methods outlined by Arcement and Schneider (1989). Estimated coefficients were also confirmed by comparison to published values in a variety of reports/texts (Barnes, 1967; Chow, 1959; Limerinos , 1970; and Coon, 1998).

3.3 Design Flow Estimates

There are no long-term flow records for West Creek. The FEMA Flood Insurance Study (FIS) for Tiburon (FEMA, 1976) and associated Flood Insurance Rate Maps (FIRM) do not include coverage of the project area. Therefore, KHE utilized a Windows-based version of the Technical Release 55 (WinTR-55) Urban Hydrology for Small Watersheds model to estimate peak flow rates for a suite of floods between and including the 2- to 100-year recurrence intervals (NRCS, 2003). WinTR-55 is a single-event rainfall-runoff small watershed hydrologic model. The model generates hydrographs from urban areas at selected points along the stream system. Hydrographs are routed downstream through channels using the Muskingum-Cunge routing method. Many of the WinTR-55 modeling assumptions and variables used for this analysis are consistent with those used in the hydrologic analyses and flood flow estimates presented in a draft EIR completed in 2005 on behalf of the City of Tiburon for the proposed Congregation Kol Shofar facility expansion. This facility is located immediately upstream of the project site. It was determined through discussions with County staff that the design flows estimated for the West Creek project should be consistent with the Kol Shofar facility studies. The flood flow estimates for inflow to the upstream end of the West Creek project were in very close agreement with those derived for the Kol Shofar facility (see Table 1). A summary of WinTR-55 model assumptions and variables follows. Peak flow estimates for design flows are presented in Table 1.

- Watershed area draining to project site = 184.3-acres;
- Time of concentration = 0.45-hours;
- Weighted Curve Number (CN) = 77 (using the same percentage landuse types as presented in Kol Shofar EIR);
- 24-hour rainfall amounts for the 2-, 5-, 10-, 25-, 50-, and 100-year storms came from Rantz, 1971 (assuming mean annual precipitation total of 30-inches for project site);
- A Type 1A rainfall distribution was utilized; and
- A standard dimensionless unit hydrograph was used (peak rate factor 484).

TABLE 1: PROJECT DESIGN FLOW ESTIMATES

Design Flood Recurrence Interval	Estimated Peak Flows West Creek Flood Study (cfs)	Estimated Peak Flows Kol Shofar EIR (cfs)
2-year	40	45
5-year	73	N/A
10-year	98	N/A
25-year	131	134
50-year	156	N/A
100-year	179	185

3.4 Tidal Boundary Conditions

Tidal datums for Richardson Bay at the downstream boundary of the project reach were derived from NOAA's San Francisco tide gauge (see Table 2). The mean higher high water (MHHW) tidal datum is 3.21-feet. Results of water level measurements and HWM surveys indicate that the extreme winter spring tide water level reached 5.35-feet in elevation on December 31, 2005 at 10:00 AM. Based on review of flow hydrographs of the New Year's Eve flood on Corte Madera and Arroyo Corte Madera Creeks, this spring tide event occurred during the receding limb of the flood hydrograph, approximately 3-hours after the peak flow. For reference, the channel bed elevation on the downstream side of the Cecilia Way culvert is at 4.75- with the top of culvert elevation at 7.80-feet. During the peak spring tide event, water was observed flowing through the culvert without noticeable backwater effects.

TABLE 2: PROJECT TIDAL DATUMS

(Tidal Epoch: 1983-2001)

Tidal Datum	Water Surface Elevation (feet NGVD29)
High Water – 12/31/05 10:00	5.35
MHHW	3.21
MHW	2.60
MTL	0.55
NGVD29	0.00
MLW	-1.49
MLLW	-2.63

3.5 Model Calibration and Baseline Simulation Results

The HEC-RAS model was calibrated to the high flow measurements from the morning of December 31, 2005 and associated surveyed water levels. Model calibration was completed by adjusting the channel roughness coefficients so that simulated water surface elevations for measured flows best matched the associated surveyed water surface elevations. In addition, the simulated 25- and 50-year flood water surface elevations were used to bracket the likely flood levels of the 2005 New Year's Eve storm. Surveyed HWMs for this event fell on or between the simulated 25- and 5-year flood water surface levels indicating the model was reasonably predicting higher flood flow levels.

Results for the Existing Conditions simulation are presented on Figures 3 and 4. Figure 3 is a profile of the flood-prone reach between Via Los Altos and Cecilia Way. The river cross-section stations are indicated along the bottom of Figure 3. Figure 4 provides cross-sectional profiles between and including stations 4578 through 4099. Simulated water surface elevations plotted on Figures 3 and 4 indicate that the sand/water bag treatments along the east (left[1]) bank provide flood protection through the 100-year flood event. Simulated water surface elevations for the 100-year event fall about 1-foot below the top of the temporary flood wall (indicated by the red "Left Levee" line on Figure 3) at all locations except stations 4497 and 4578 - locations where the 100-year water surface approach the top of the temporary flood wall. Along the opposite bank (indicated by green "Right Levee" line on Figure 3), the 10- through 100-year floods approach or overtop the bank at stations 4178 and 4269. These simulation results agree with anecdotal accounts of flood from the 2005 New Year's Eve storm in which local residents indicated that no flooding occurred along the left (east) bank, but that overbank flooding did occurred along the right (west) bank in the immediate vicinity of stations 4178 and 4269 (Jack Curley, Marin DPW, personal communication, June 2006).

Under Historic Conditions, none of the County's flood control treatments (sand/water bags) are present along the left bank, which, on Figure 5, represents the ground or "Left

[1] The "left" creek bank is that bank lying to an observers left-hand side when facing downstream. The right bank is on the observer's right-hand side when facing down-stream.

Levee" surface at the top of the bank. Simulation results of historic conditions indicate that overbank flooding along the left bank occurs at and between stations 4497 and 4129 (see Figures 5 and 6). Similar to the Existing Conditions, flooding along the right bank occurs for a length of 350-feet between river stations 4178 and 4269. In summary, the location of overbank flooding under Existing and Historic Conditions is displayed graphically on Figure 7. No attempt is made to indicate the lateral (east-west) extent of flooding into the adjoining parcels on Figure 7, only the reach of creek prone to overbank flooding.

4.0 CONCEPTUAL PROJECT ALTERNATIVES AND ANALYSIS

4.1 Alternative Design Elements

During evaluation of existing and historic conditions, special attention was paid to identify potential opportunities and constraints for drainage improvements that would reduce the flooding hazard through the flood-prone project reach. KHE focused this analysis on the ability to establish self-sustaining and ecologically friendly elements that minimize long-term operation and maintenance requirements and costs. Based on this analysis, five (5) design elements were identified as potential project components, including:

1. Remove the sediment plug that has deposited within and immediately downstream of the Cecilia Way culvert in order to improve flow conveyance and reduce potential backwater effects.

2. Lower the channel bed through the majority of the flood-prone reach to increase flow conveyance and reduce design flood water levels.

3. Widen the channel where space permits in order to increase flow conveyance and reduce peak flood water surface elevations.

4. Build a permanent berm or levee along the left (east) top of bank that replaces the seasonal sand/water bag treatments and provides, at a minimum, the same level of protection.

5. Raise the access road (or create a levee on the creek side of the road) along selected portions of the right (west) top of bank to preclude flooding.

Using both individual and a mixture of associated design elements, KHE developed a total of six (6) project alternatives to assess the ability and feasibility for achieving project goals. Table 3 presents a matrix of the design elements included under each of the project Alternatives. A more detailed discussion of each alternative is provided in the following section.

TABLE 3: SUMMARY OF PROJECT ALTERNATIVES

Alternative	**Design Elements**				
	Remove Sediment Plug	***Lower Channel Bed***	***Increase Channel Width***	***Build Left Bank Levee***	***Raise Access Road***
Alternative A	X				
Alternative B		X			
Alternative C			X		
Alternative D				X	
Alternative E			X	X	
Alternative F				X	X

4.2 Alternative A: Removal of Sediment Plug

<u>Alternative A: Design Concept</u>: Alternative A includes removing the sediment accumulation within and immediately downstream of the Cecilia Way culvert. The extent of sediment removal is indicated on Figure 8 and extends for a linear distance of approximately 225-feet downstream of the culvert inlet. This excavation includes removing approximately 88-cubic yards of material and lowering the creek bed up to 2-feet at the point of thickest accumulation. According to County DPW staff, this is a recurring site of sediment deposition and is frequently excavated (Jack Curley, Maring DPW, personal communication, June 2006). Cecilia Way marks a notable shallowing in channel gradient resulting in reduced stream power and sediment transport capacity.

<u>Alternative A: Feasibility Assessment</u>

The hydraulic modeling results of Alternative A are summarized in Figure 9, which presents a comparison of the 5- and 100-year flood surface elevations under Alternative A and Existing Conditions. This plot indicates that removal of the sediment plug results in a lowering of simulated water surface elevations within the immediate sediment removal area. However, no significant conveyance or water surface lowering benefits extend upstream of the culvert. In summary, this Alternative does not reduce the frequency or magnitude of flooding within the existing or historic zones of overbank flooding (see Figure 7). Because of the sharp reduction in slope at this location, it will continue to be a site of sediment deposition and accumulation. As a consequence, it is believed that the flood reduction benefits afforded this design element will be relatively short-lived without near-annual maintenance.

4.3 Alternative B: Lower Channel Bed Elevation

Alternative B: Design Concept: Alternative B builds on the Alternative A excavation, extending channel lowering activities upstream through the flood-prone reach to river station 4732 (see Figure 10). The depth of channel bed lowering is depicted on Figure 11 and averages about 0.5-feet. A total of 170-cubic yards of material will be removed by this action. The existing channel bed is armored upstream of the Cecilia Way crossing, suggesting the project reach is supply limited - sediment transport capacity far exceeds sediment supply. This condition is not anticipated to change and the lowered bed will likely persist over the long term with the exception of the depositional zone at and downstream of Cecilia Way as discussed above.

Alternative B: Feasibility Assessment: Simulated water surface profiles for the 10- and 100-year floods under Alternative B and Historic Conditions are presented on Figure 11. These results indicate a notable but small decrease in flood water surface elevations in response to the channel lowering actions. Thus, the lowering of flood levels does not translate into any significant reduction in the frequency and distribution of flooding – the left and right banks still overtop during a greater-than 10-year flood event.

4.4 Alternative C: Increase Channel Width

Alternative C: Design Concept: Alternative C focuses on increasing the channel width through the flood-prone reach by excavating and removing material from the right bank along much of the project reach (see Figure 12). The extent of excavation at river stations 4578 through 4049 is depicted in the cross-sectional profiles provide in Figure

13. On each profile in Figure 13, the excavated areas are defined by extending a 2:1 slope down to the channel bed elevation from the edge of the existing access road. This excavation results in the removal of 794-cubic yards of material. All proposed excavation work would be completed within the existing County easement boundaries.

Alternative C: Feasibility Assessment: Simulated water surface profiles for the 10-, 25- and 100-year floods under Alternative C and Historic Conditions are presented on each of the cross-sections provided on Figure 13. Simulation results indicate a substantial reduction in the location and extent of overbank flows under Alternative C, eliminating all overbank flooding except for the 100-year flood along the left bank at cross-section 4497. Figure 14 is a longitudinal profile of simulated flood levels, indicating channel full conditions along the left bank at stations 4379, 4178, and 4049, Bankfull conditions also exist along the right bank during the 100-year flow at stations 4269 and 4178. Although flowing full at these stations, Alternative C eliminates overbank flooding along the right bank.

One potential adverse effect of expanding the channel under Alternative C is a reduction in channel flow velocities and stream power through the flood-prone reach. Comparison of the 2-year flood flow velocities for Alternative C versus Existing Conditions indicates that channel velocities are reduced by up to 50-percent at some cross-sectional locations under Alternative C. This reduction in channel flow velocity results in a reduction in sediment transport capacity, possibly allowing some modified reaches to become areas of sediment deposition if there is sufficient supply. The long-term effects of this modification should be further evaluated if this project element is incorporated into a final design.

4.5 Alternative D: Construct Permanent Levee

Alternative D: Design Concept: Alternative D includes constructing a permanent earthen levee or structural floodwall along the top of the left (east) bank where the County constructs the seasonal sand/water bag flood wall (see Figure 15). A wide variety of designs and materials could be used to build this feature. For purposes of this study, we assumed an earthen levee built with a 1-foot top width and 3:1 side slopes. The height of this structure would range form 0.5- to 1.5-feet, averaging about 1.0-foot. Examples of the levee profile are provided in the Alternative D cross-sections plotted on Figure 16. An estimated 74-cubic yards of material would be required to construct this feature. A concrete flood wall would require a much narrower foot-print.

Alternative D: Feasibility Assessment: Simulated water surface profiles for the 10-, 25- and 100-year floods under Alternative D and Historic Conditions are presented on each of the cross-sections provided on Figure 16. These simulation results indicate, that similar to Existing Conditions, the levee/floodwall is effective at eliminating overbank flooding along the left (east) bank through the project reach. However, also consistent with Existing Conditions, this feature does not provide any relief to flooding along the opposite (right) bank ast stations 4269 and 4178. Figure 17 presents a longitudinal water surface and top-of-bank profiles for Alternative D. This plot clearly shows that floods approaching a 25-year event overtop the right bank at stations 4269 and 4178 under this Alternative.

4.6 Alternative E: Widen Channel and Construct Levee

Alternative E: Design Concept: Alternative E combines the design elements of Alternatives C and D - widening the channel along the right bank and constructing a permanent earthen levee or structural floodwall along the top of the left (east) bank. A plan view of this alternative is presented on Figure 18 while cross-sectional profiles are provided in Figure 19. For purposes of this study, it is assumed that the full channel widening excavation would be completed, excavating 794-cubic yards of material. As a result of the flood benefits provided by the channel widening design element, the left bank flood levee/wall does not need to be constructed as long or as high as described under Alternative D. This results in two shorter and separate left top-of-bank levees centered on river stations 4578 and 4129 (see Figure 18). A total of only 13-cubic yards of material is necessary to build this levee with the similar dimensions as described above, but to an average height of 0.5-feet (see Figure 19).

<u>Alternative E: Feasibility Assessment:</u> Hydraulic modeling results indicate that the combination of these design elements eliminates overbank flooding along both the left and right banks (see Figures 19 and 20). The longitudinal profiles of selected simulated water surface levels (Figure 20) indicate that the 100-year water surface is well below both banks with the exception of where it just falls short of the top of the right bank at river stations 4269 and 4178.

4.7 Alternative F: Construct Levee and Raise Access Road

<u>Alternative F: Design Concept:</u> Based on the positive results provided by Alternative D, Alternative F incorporates full levee construction along the left bank with construction activities that raise the access roadway bed along the flood prone right bank reach. The linear extent of these activities are displayed on Figure 21 while cross-sectional profiles are presented in Figure 22. Alternative F will require importing a total of 200-cubic yards of material; 74-cubic yards to construct an earthen levee along the top of the left bank and 126-cubic yards to raise the access road. An alternative design could consist of a concrete floodwall or earthen levee along the right bank in lieu of raising the road, actions that would probably require significantly less material. However, raising the access road bed along the alignment depicted in Figure 21 may alleviate seasonal saturated conditions that limit utility company access to the roadway. Again, for purposes of this study, we assume an earthen levee built with a 1-foot top width and 3:1 side slopes. The height of this structure would range form 0.5- to 1.5-feet, averaging about 1.0-foot. Examples of the levee profile are provided in the Alternative F cross-sections plotted on Figure 22.

<u>Alternative F: Feasibility Assessment:</u> Simulated water surface profiles for the 2-, 25- and 100-year floods under Alternative F and Existing Conditions are presented on each of the cross-sections provided on Figure 22. All simulation results (presented on Figure 22 and 23) indicate, that the combined benefits of both of these design elements provide full flood protection from all design floods. In fact, the longitudinal profile of simulated water surfaces in Figure 23 indicate there is approximately 0.5-feet of freeboard along the entire length of both banks under this alternative.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The ability of project alternatives in satisfying project goals are summarized in Table 4. This matrix indicates which Alternatives were successful in alleviating overbank flooding along both the left and right banks with a "Y" indicating full relief from flooding through the 100-year design flow and "N" indicating flooding at some location under the 2- through 100-year design flows.

TABLE 4: PROJECT ALTERNATIVES PERFORMANCE

Alternative	*Alleviates Overbank Flooding Left Bank?*	*Alleviates Overbank Flooding Right Bank?*	**Design Elements**				
			Remove Sediment Plug	*Lower Channel Bed*	*Increase Channel Width*	*Build Left Bank Levee*	*Raise Access Road*
Alternative A	N	N	X				
Alternative B	N	N		X			
Alternative C	N	Y			X		
Alternative D	Y	N				X	
Alternative E	Y	Y			X	X	
Alternative F	Y	Y				X	X

No single design element was successful in alleviating overbank flooding on both the left and right banks of the flood-prone reach. Alternatives A and B did not provide significant flood reduction benefits and would require on-going maintenance through sediment removal at the Cecilia Way culvert. Alternatives C and D provide complete relief from overbank flooding to only one side of the Creek. Both Alternatives E and F provide relief from overbank flooding along both banks. However, Alternative E does not provide any margin of error in the form of available freeboard along a stretch of right bank during a 100-year flood (river stations 4269 to 4178 on Figure 20) whereas Alternative F does provide 0.5-feet of freeboard along both banks under 100-year flood conditions. In addition, Alternative E requires considerable more earthwork (794-cubic yards of excavation and 74-cubic yards of fill) versus Alternative F, which necessitates a total of 200-cubic yards of fill placement and no excavation. Finally, there is the possibility for long-term sediment deposition through the project reach under Alternative E due to reduced flow velocity and stream power associated with the channel widening design element. There will be less change in hydraulic and geomorphic conditions associated with the changes proposed under Alternative F. Therefore, based on these findings and design considerations, it appears that Alternative F best satisfies project goals for the least amount work and potential long-term maintenance.

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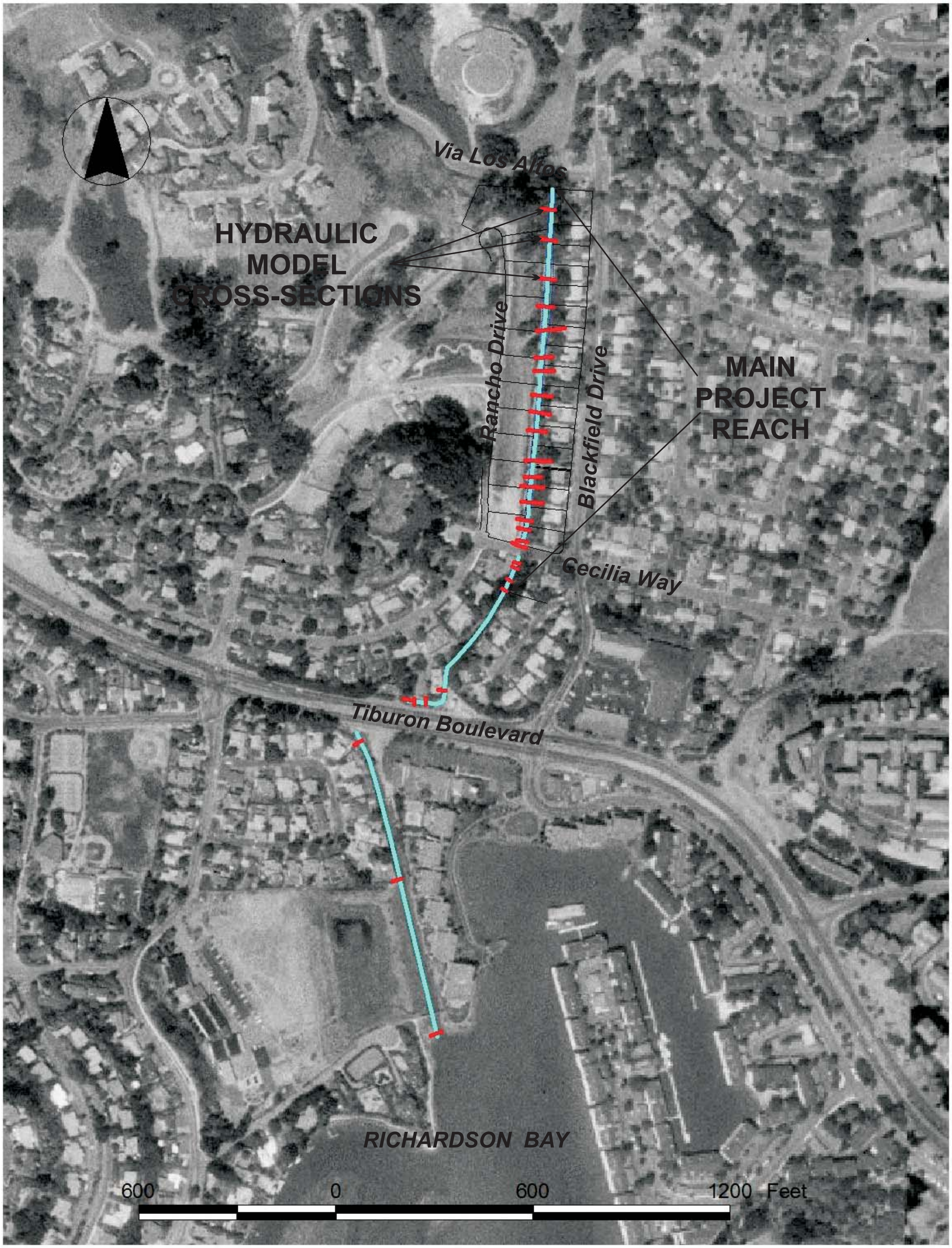

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Site Map

West Creek Drainage Improvement Assessment
Tiburon, California

FIGURE

1

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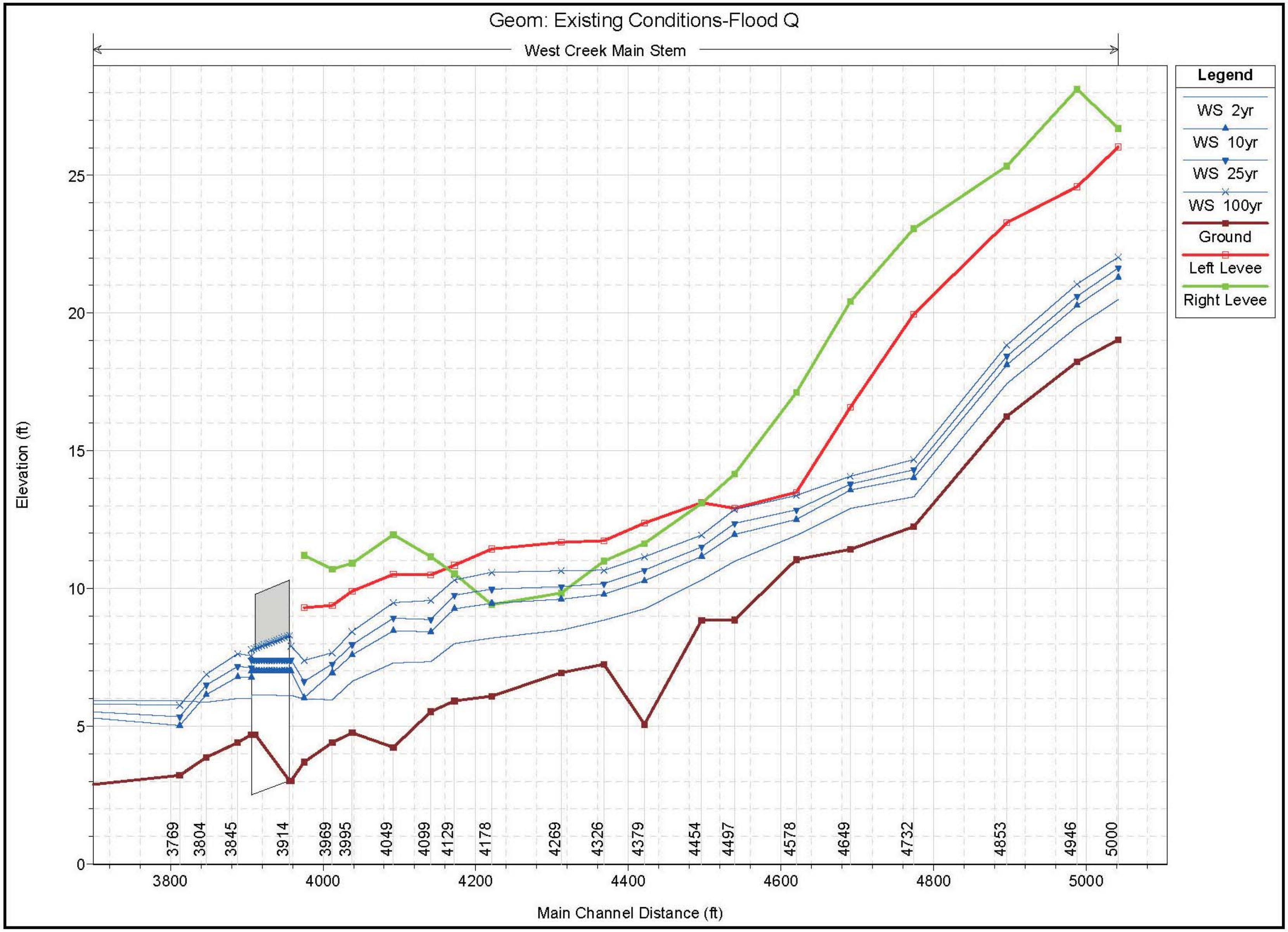
Model Cross-Section Locations

West Creek Drainage Improvement Assessment
Tiburon, California

FIGURE
2



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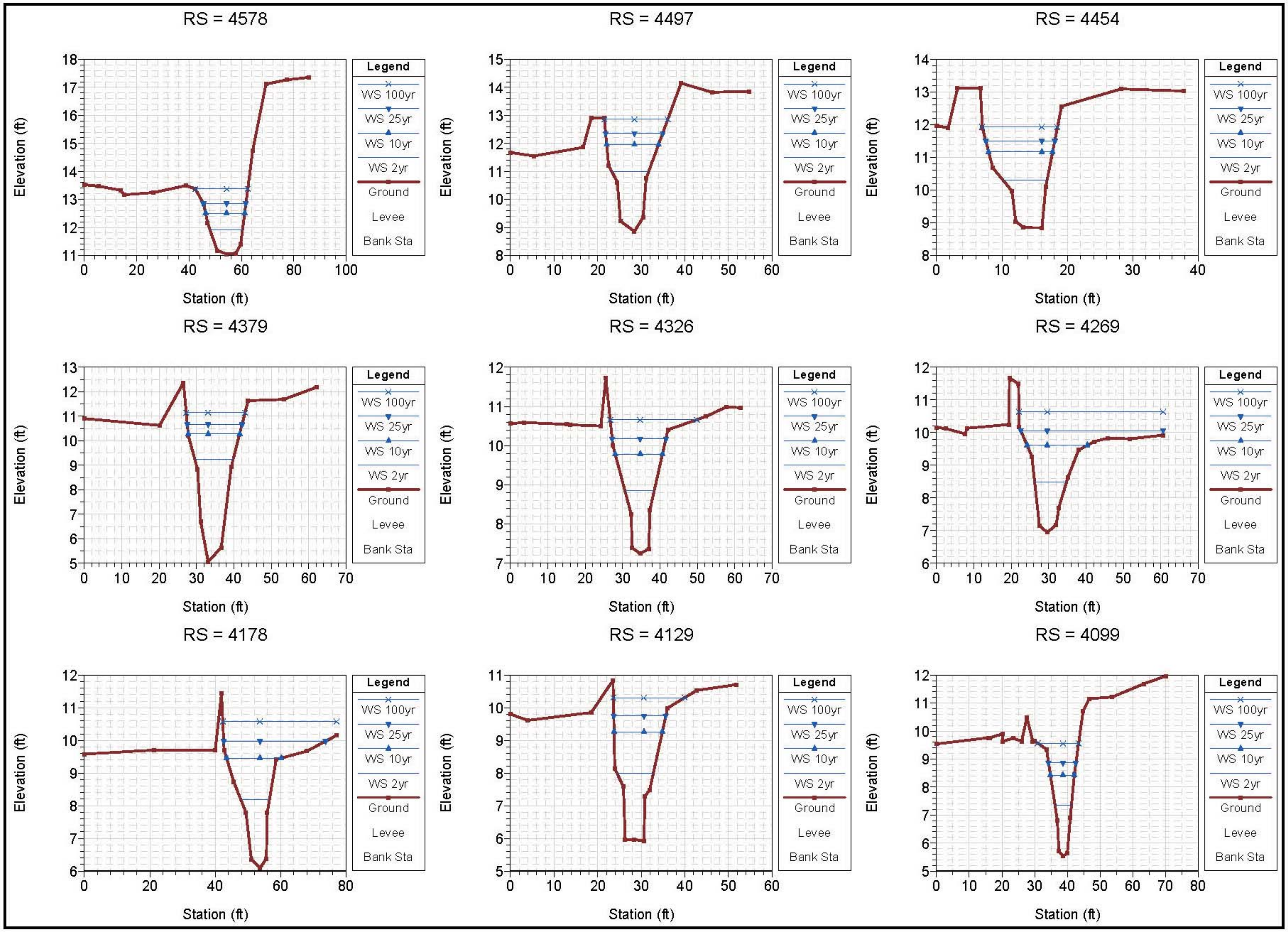
Water Surface Profiles - Existing Conditions (Circa 2005/06)

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

3



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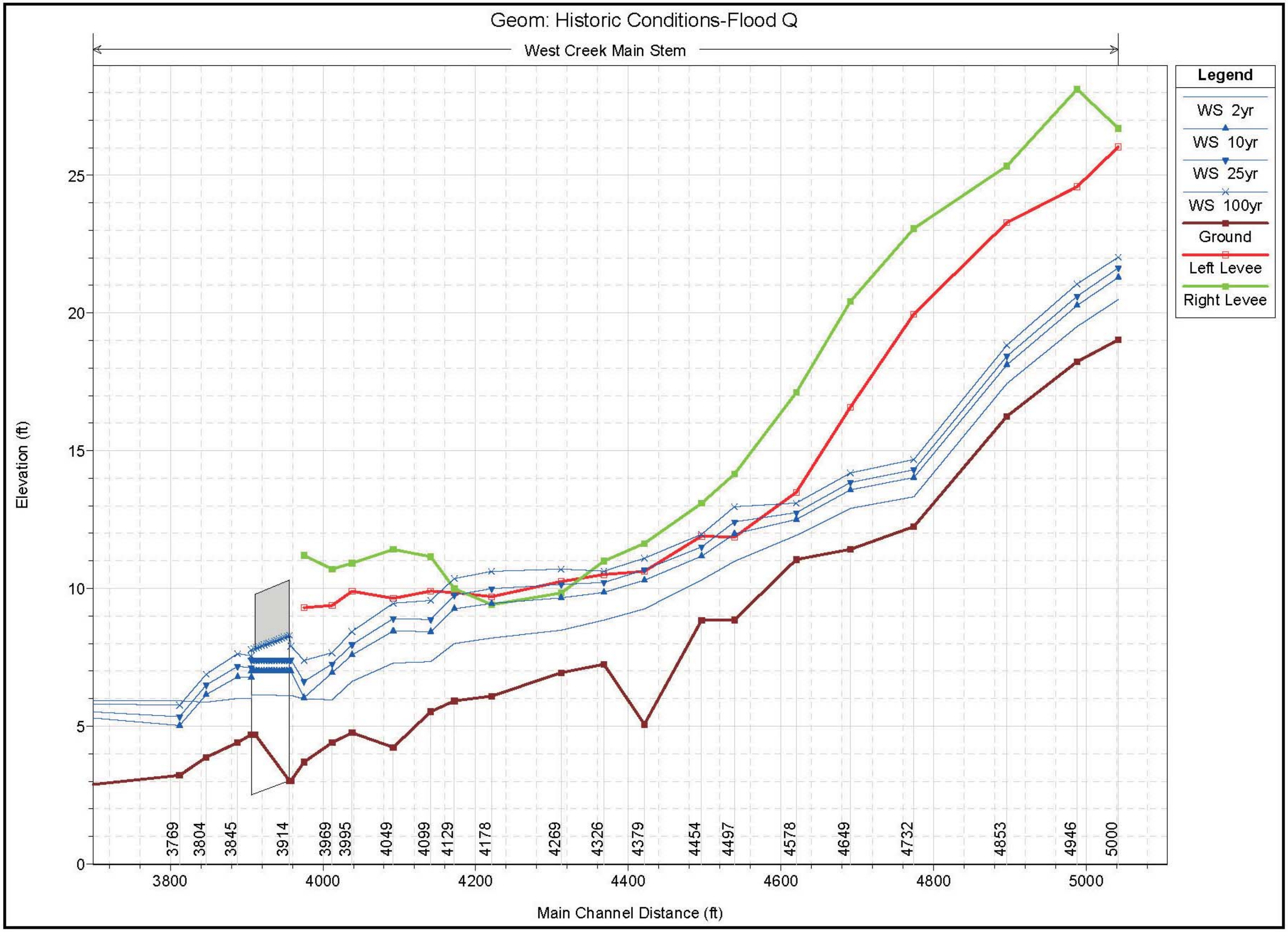
Cross Sectional Profiles - Existing Conditions (circa 2005/06)

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

4



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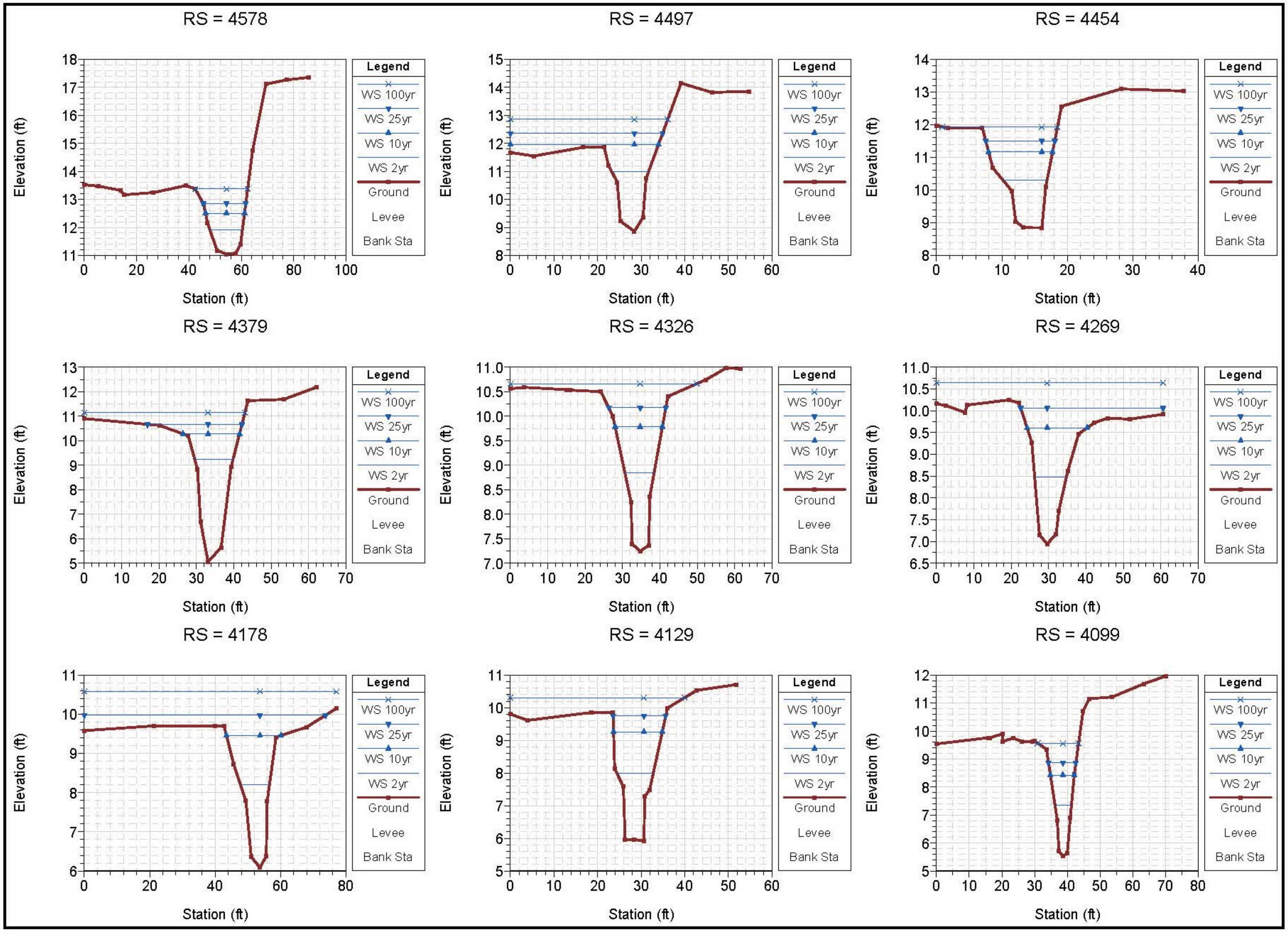
Water Surface Profiles - Historic Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

5



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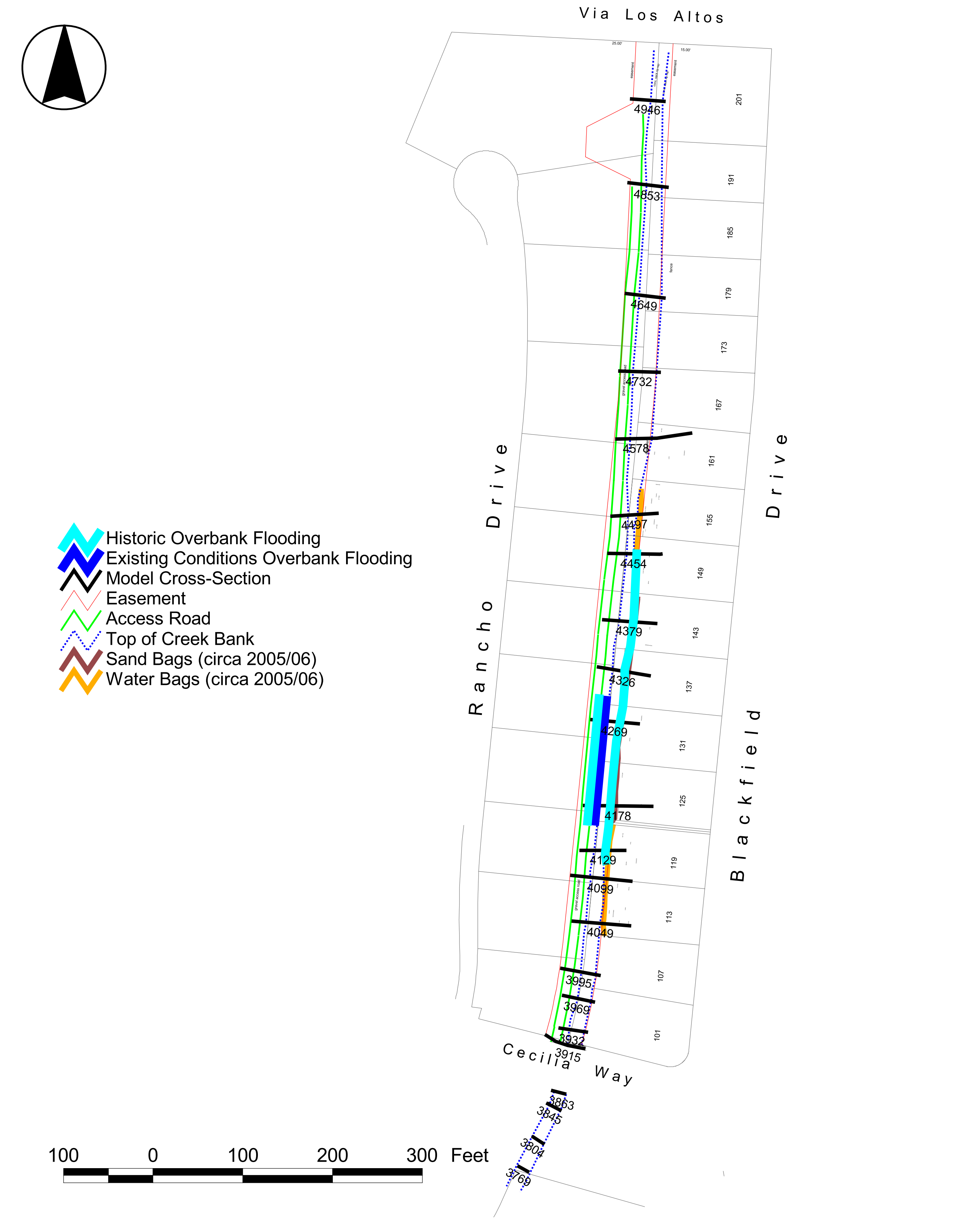
Cross Sectional Profiles - Historic Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE
6



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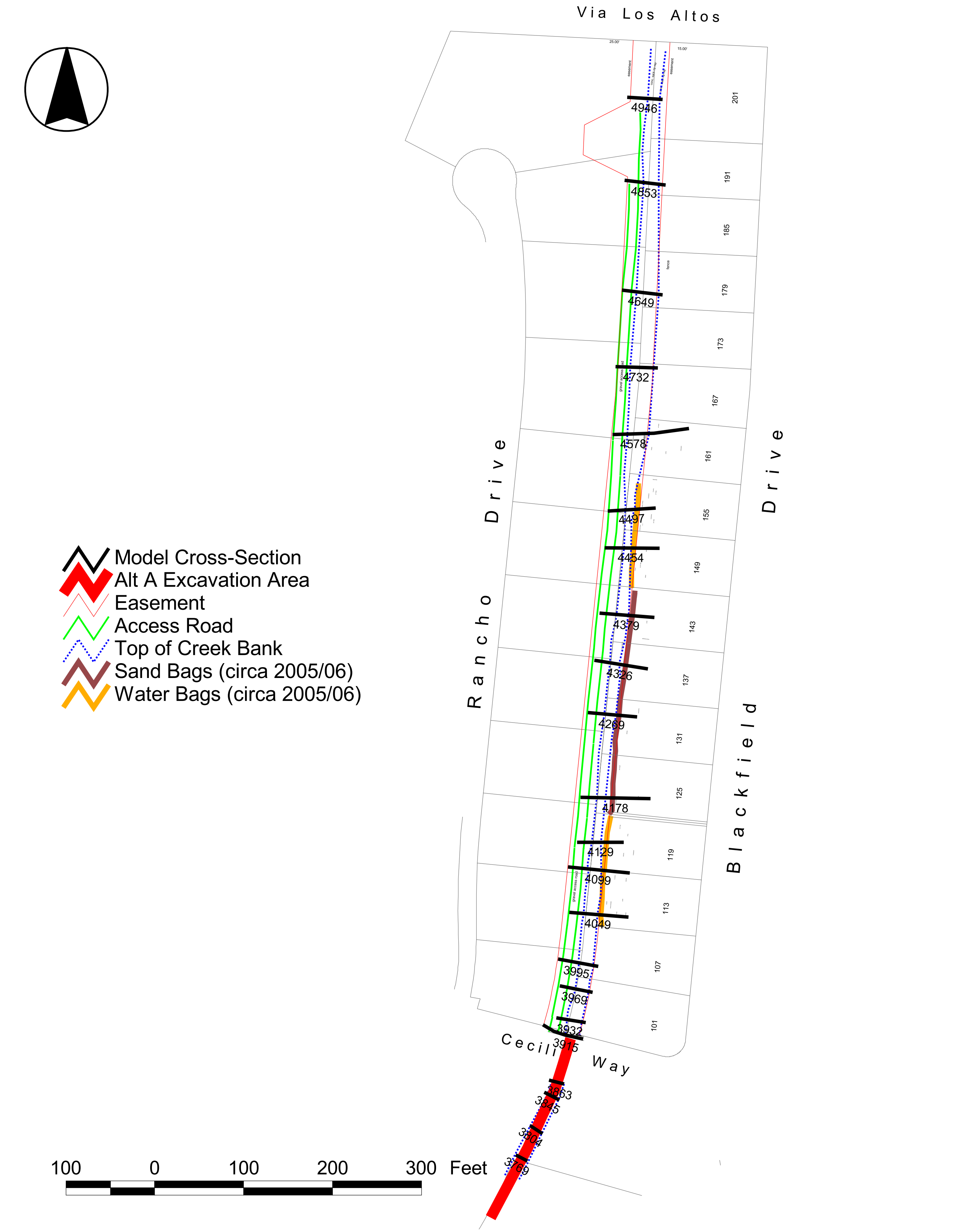
Predicted Areas of Overbank Flooding
Existing and Historic Conditions

West Creek Drainage Improvement Assessment
Tiburon, California

FIGURE
7



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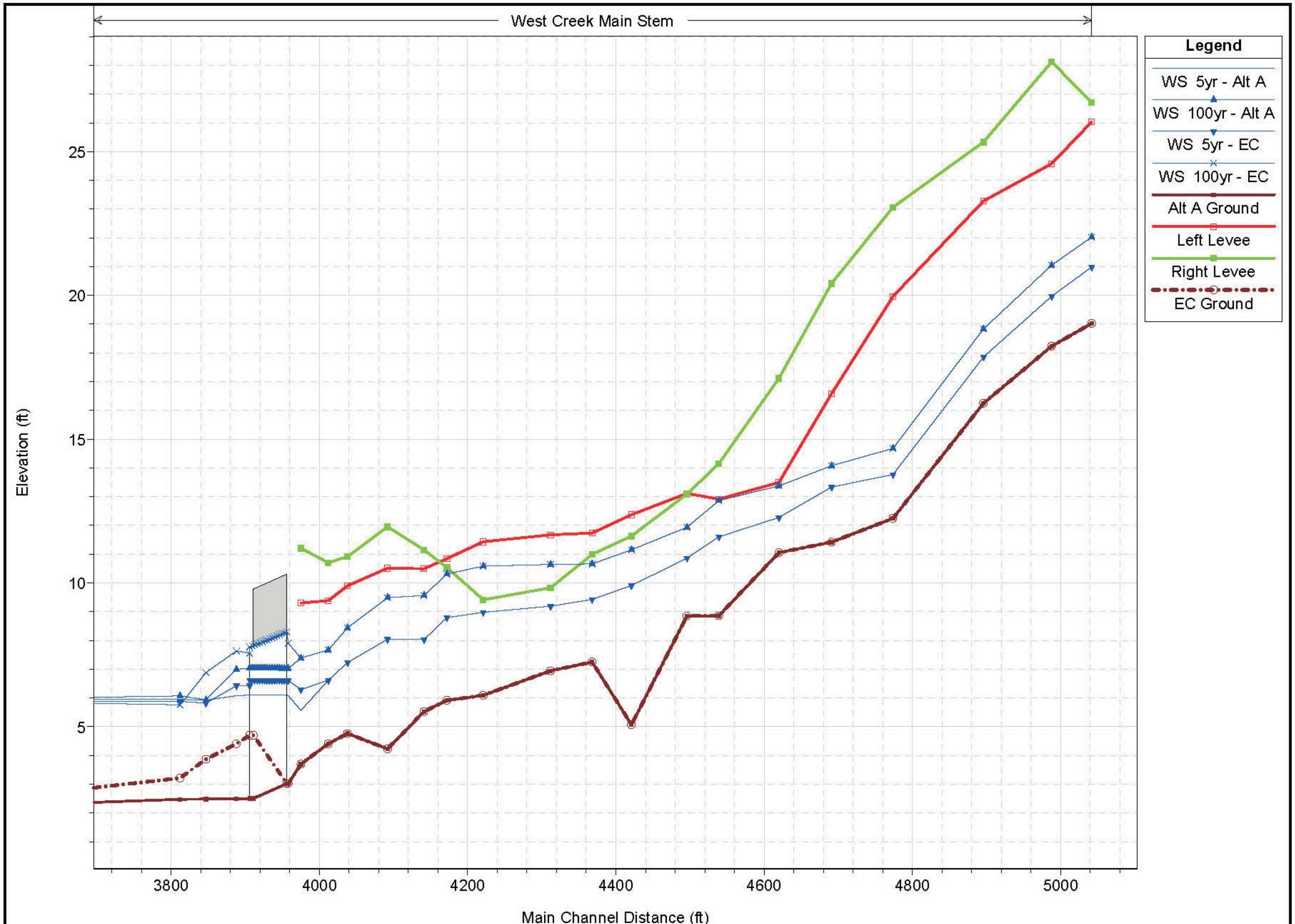
Alternative A Excavation Area

West Creek Drainage Improvement Assessment
Tiburon, California

FIGURE 8



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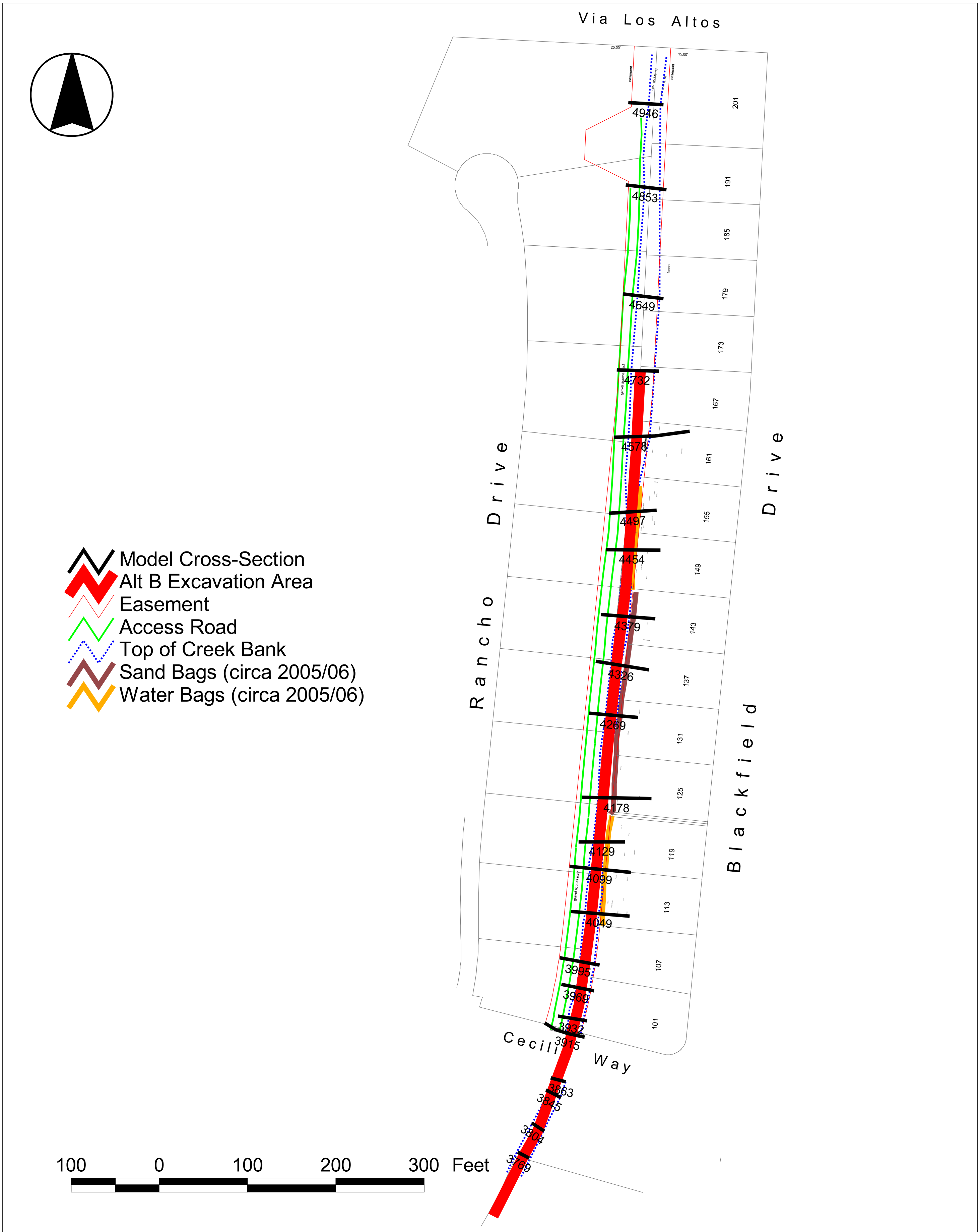
Water Surface Profiles - Alternative A vs. Existing Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

9



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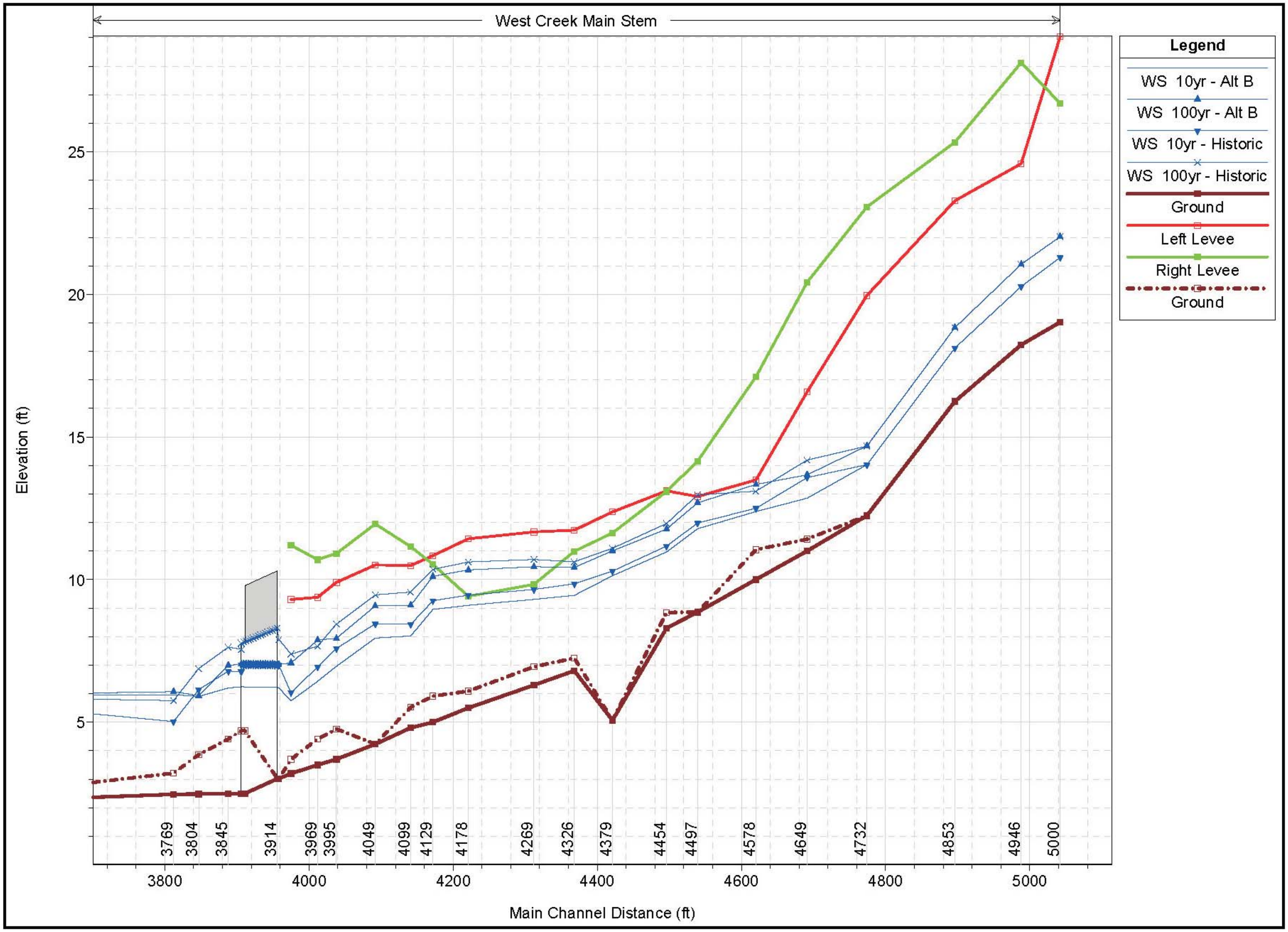
Alternative B Excavation Area

West Creek Drainage Improvement Assessment
Tiburon, California

FIGURE
10



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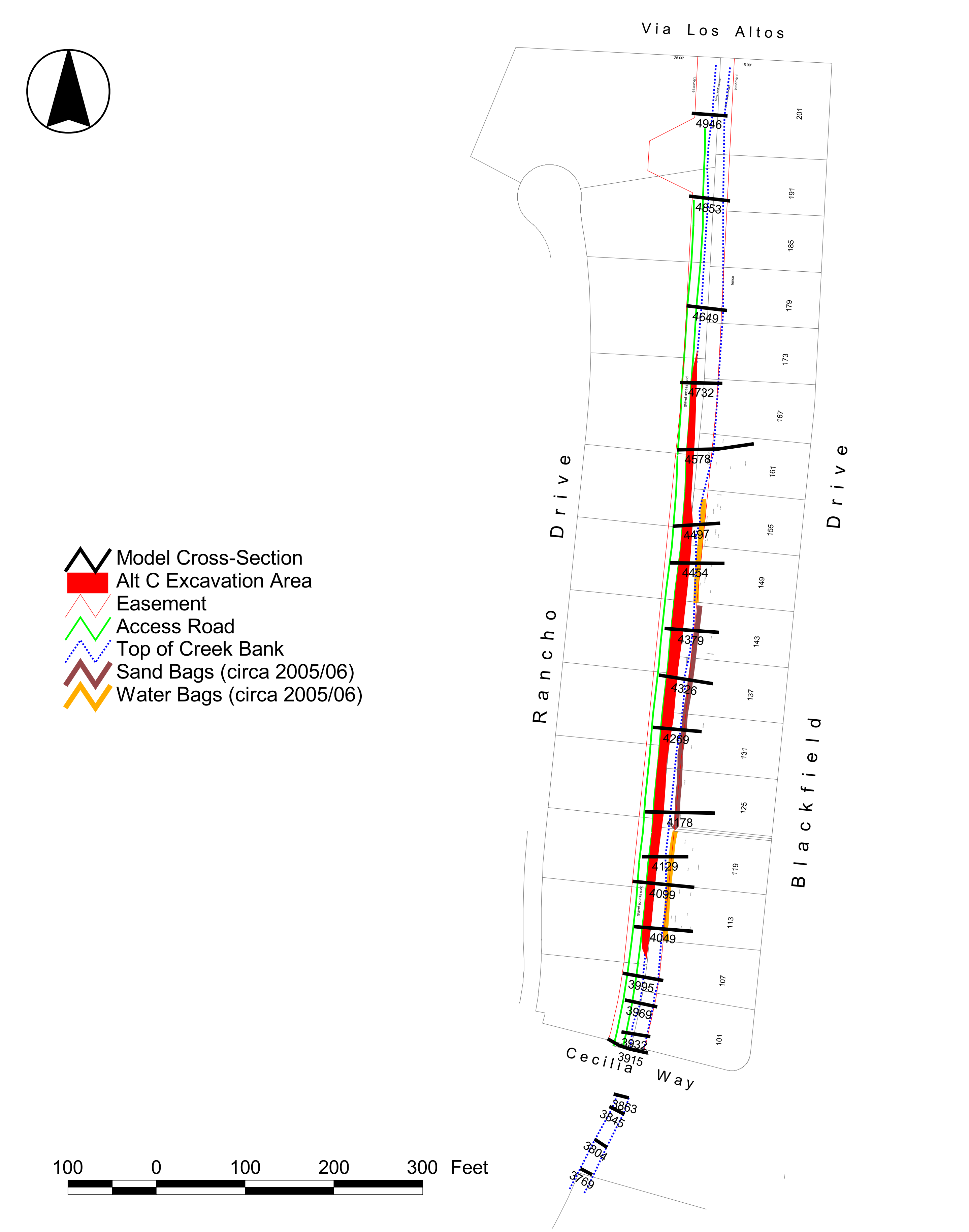
Water Surface Profiles - Alternative B vs. Historic Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

11



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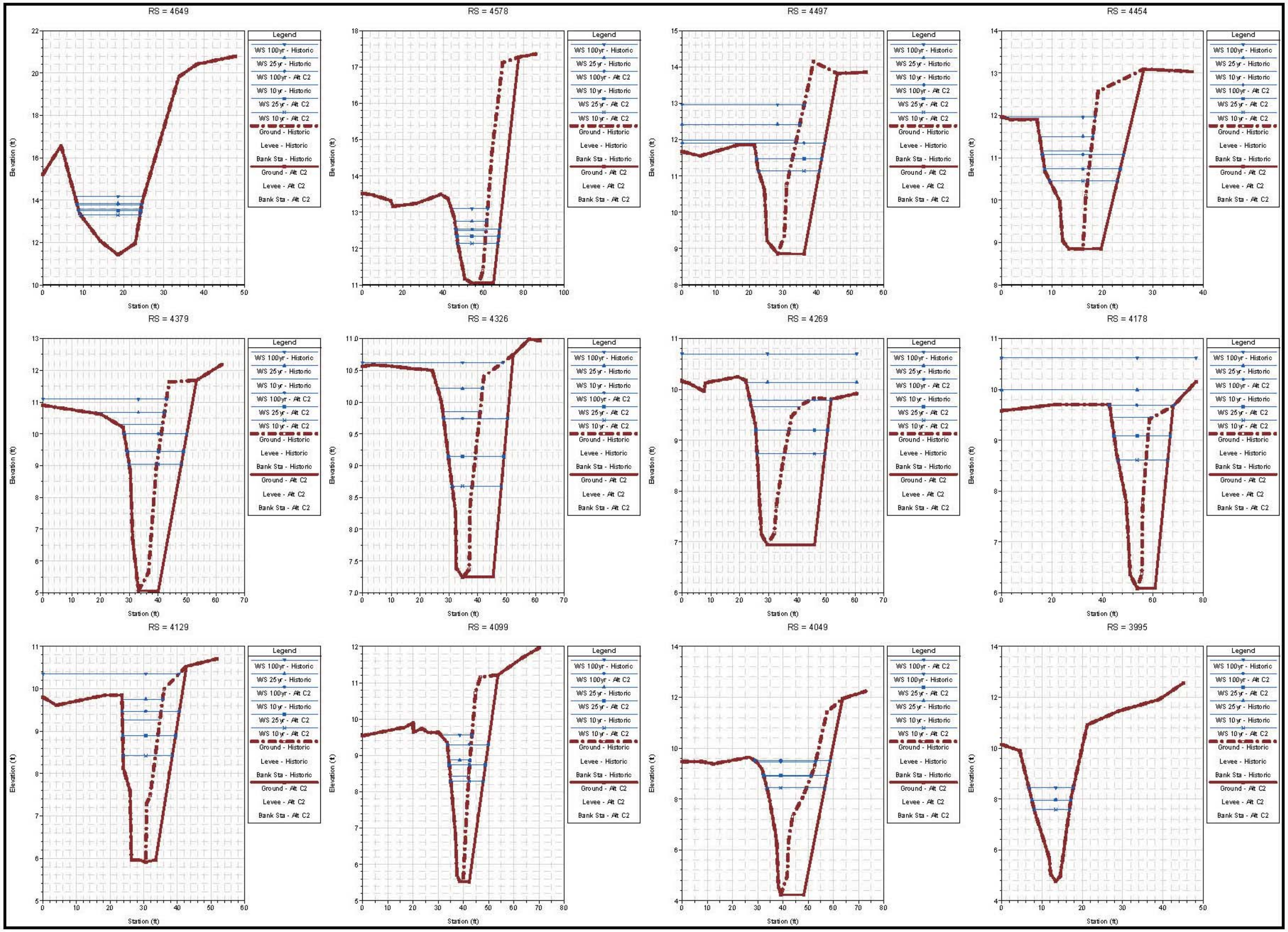
Alternative C Excavation Area

West Creek Drainage Improvement Assessment
Tiburon, California

FIGURE
12



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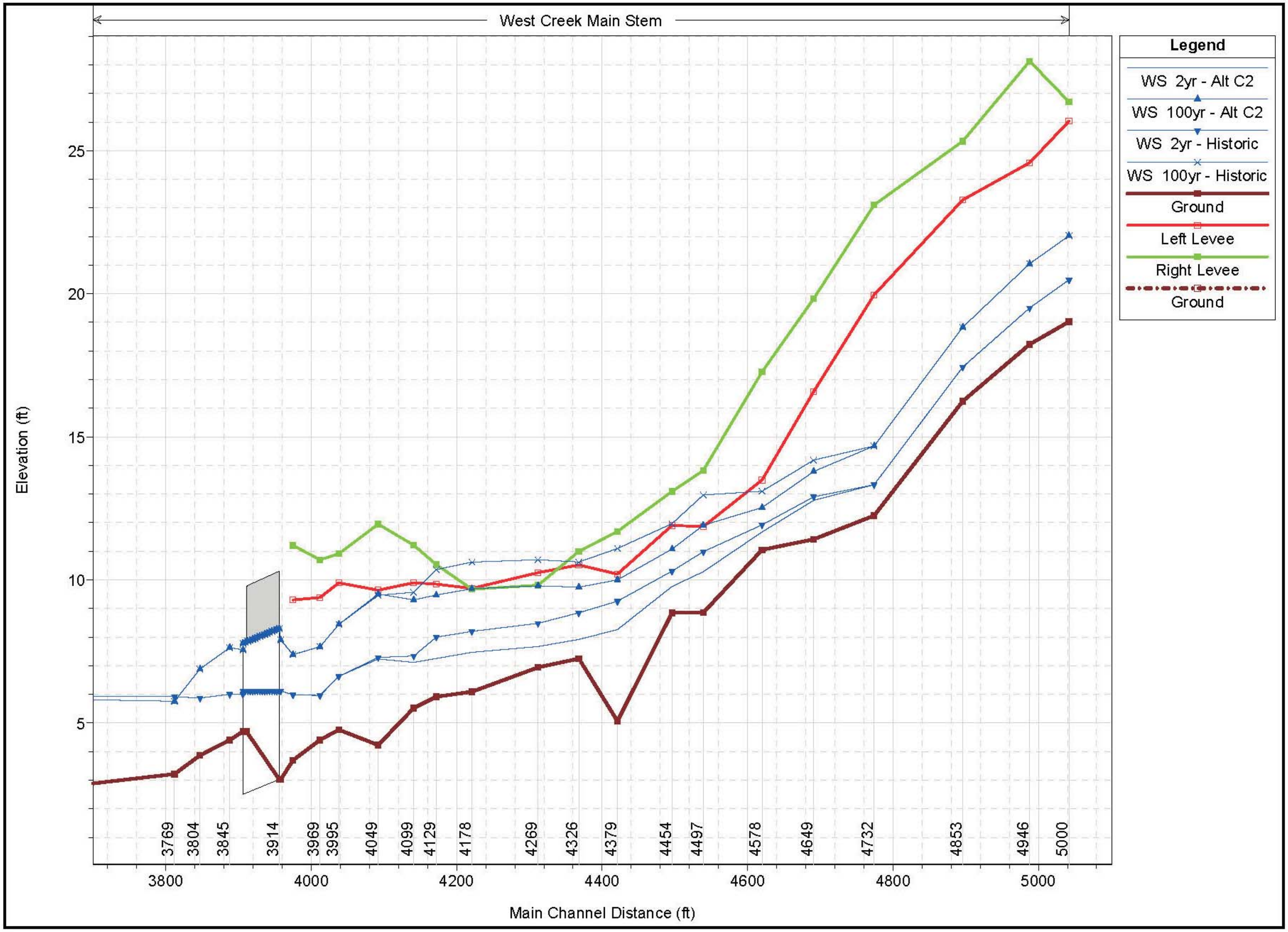
Cross Sectional Profiles - Alternative C

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

13



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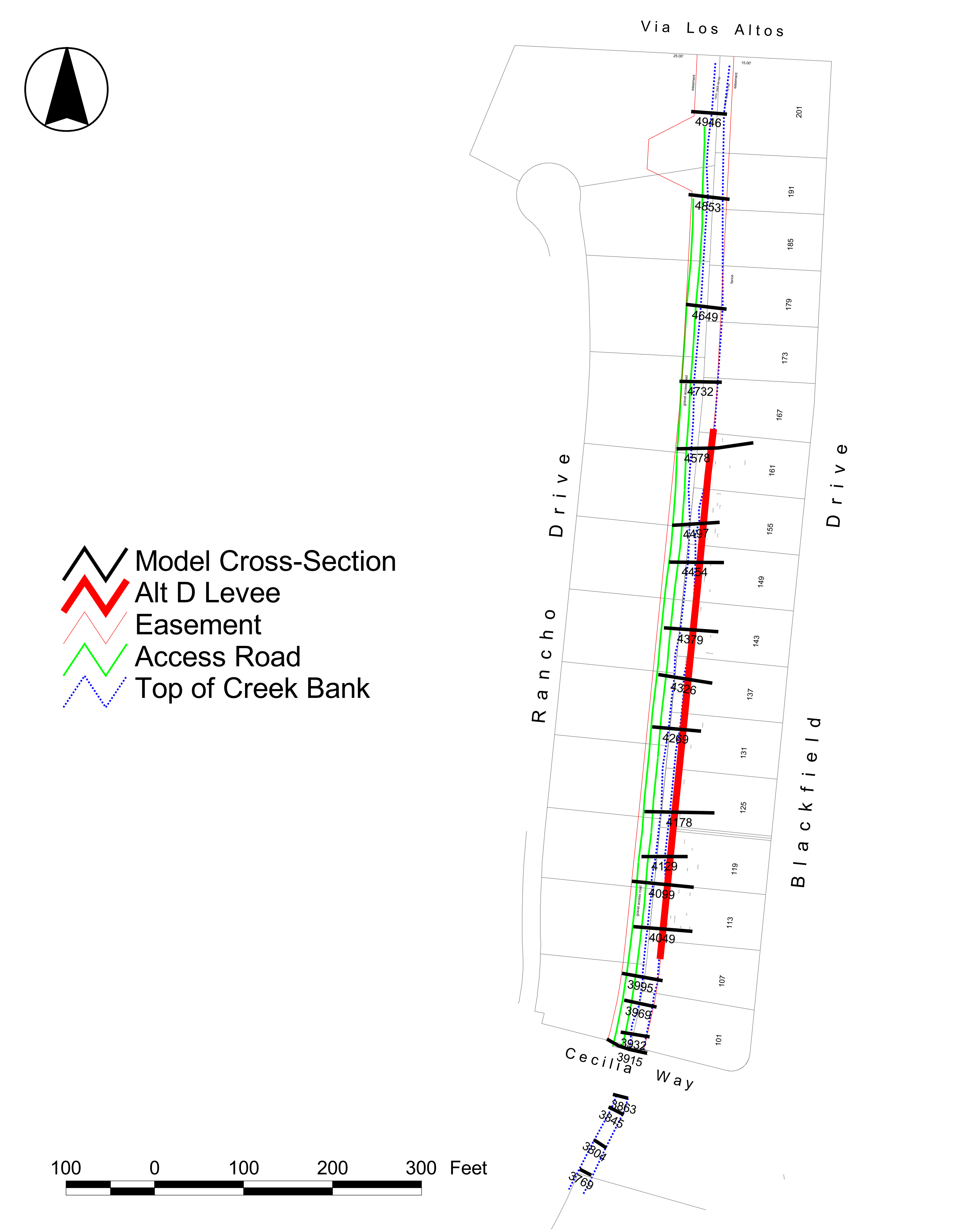
Water Surface Profiles - Alternative C vs. Historic Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

14



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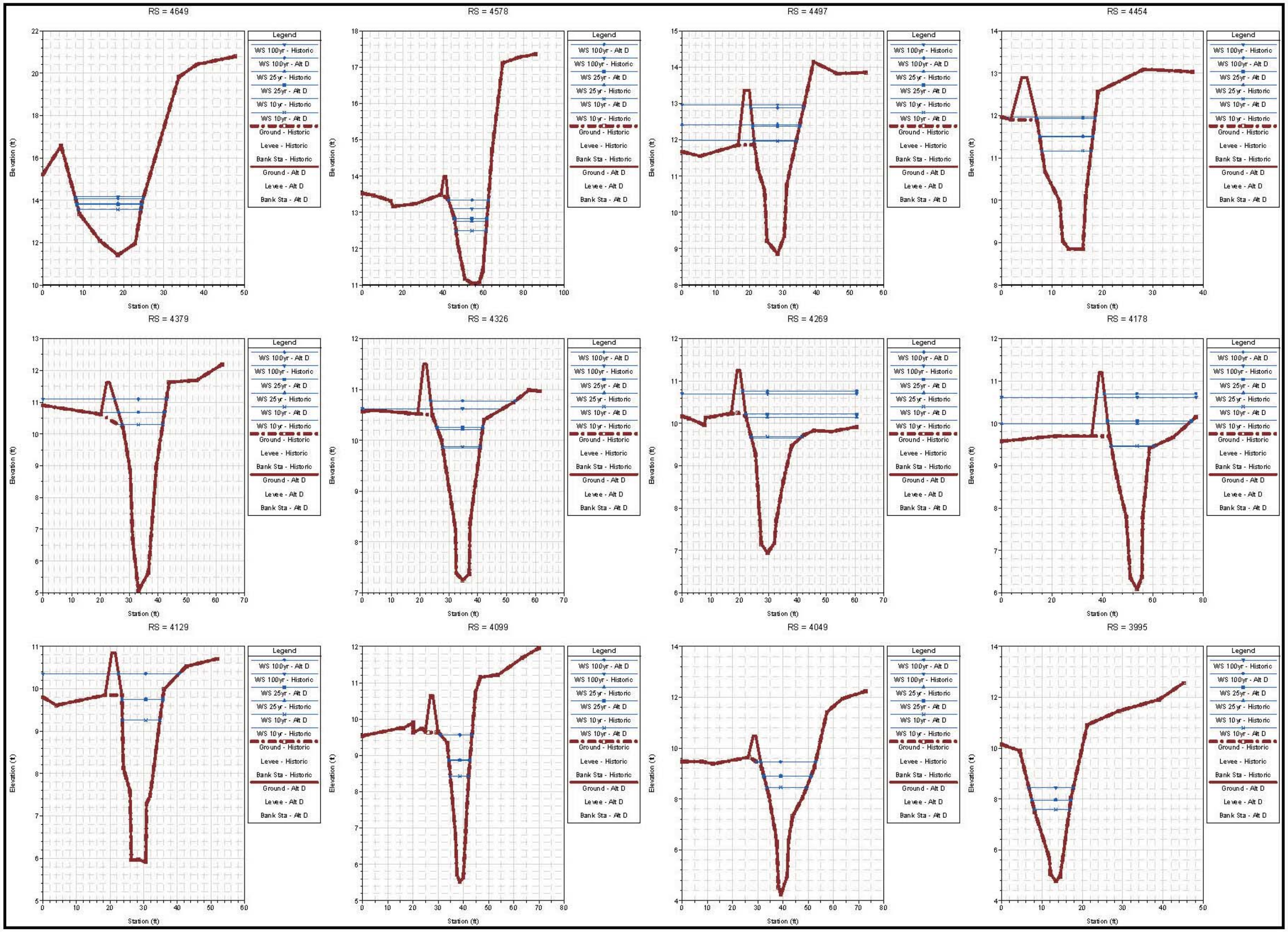
Alternative D Earthen Berm

West Creek Drainage Improvement Assessment
Tiburon, California

FIGURE
15



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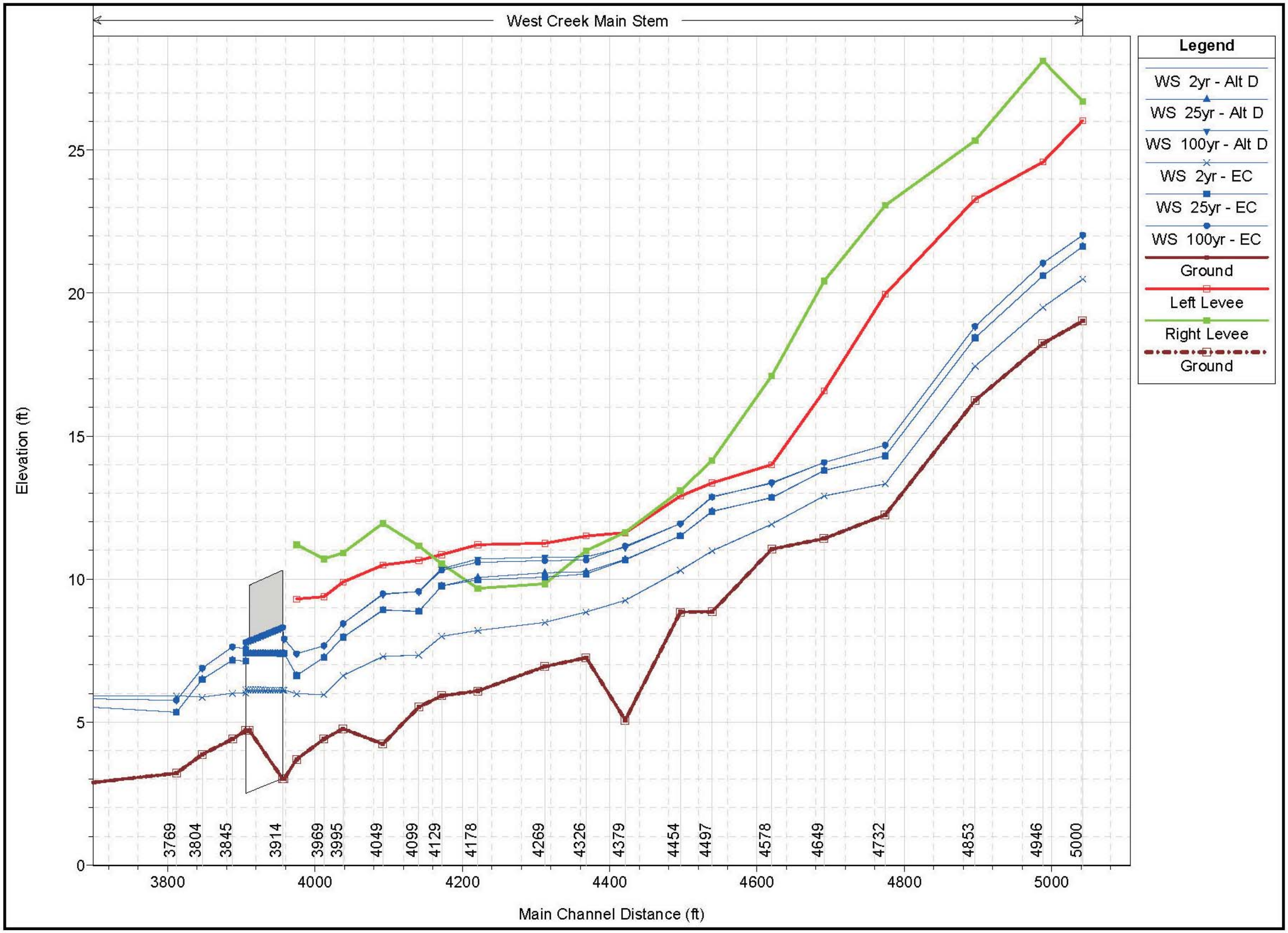
Cross Sectional Profiles - Alternative D vs. Historic Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

16



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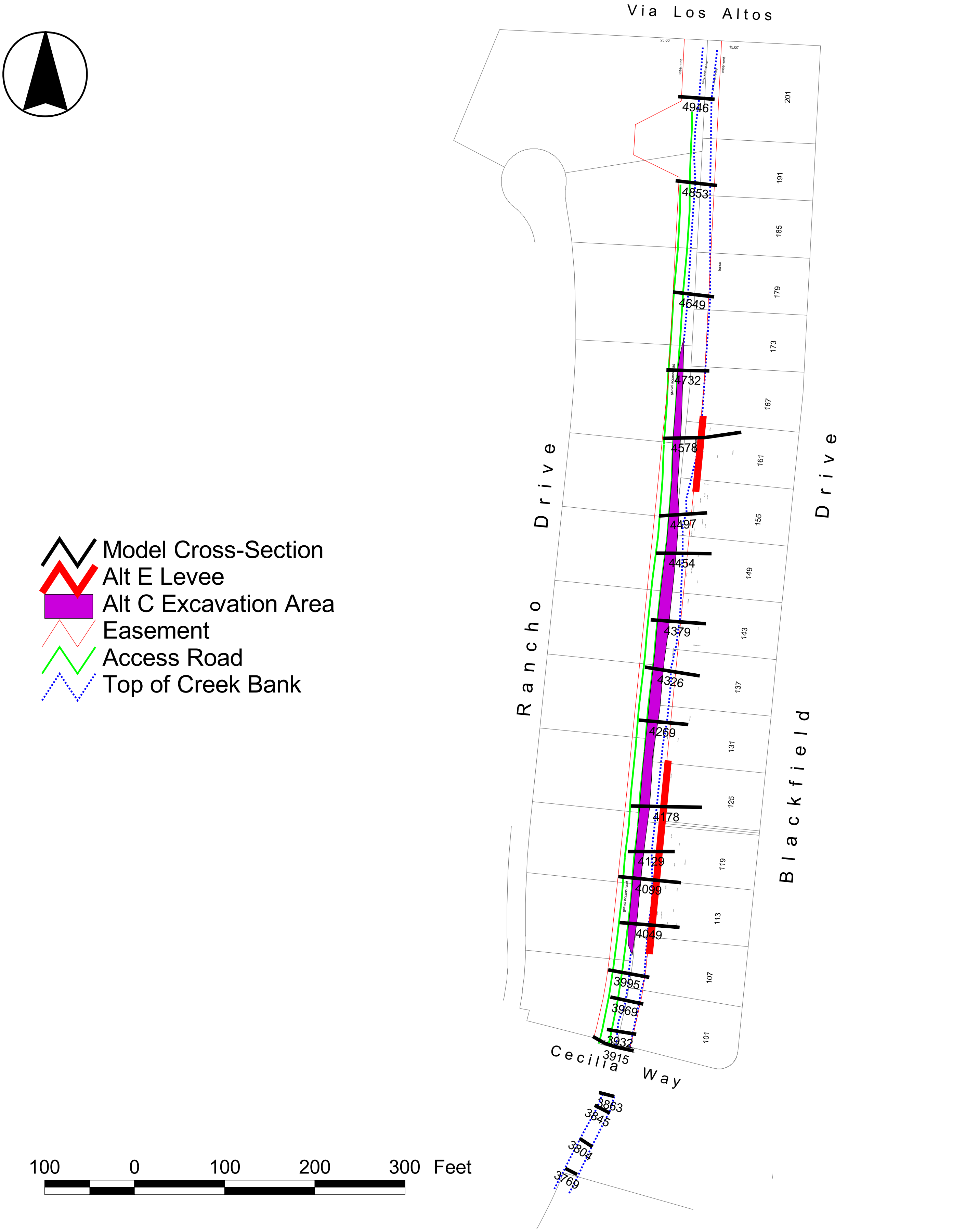
Water Surface Profiles - Alternative D vs. Existing Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

17



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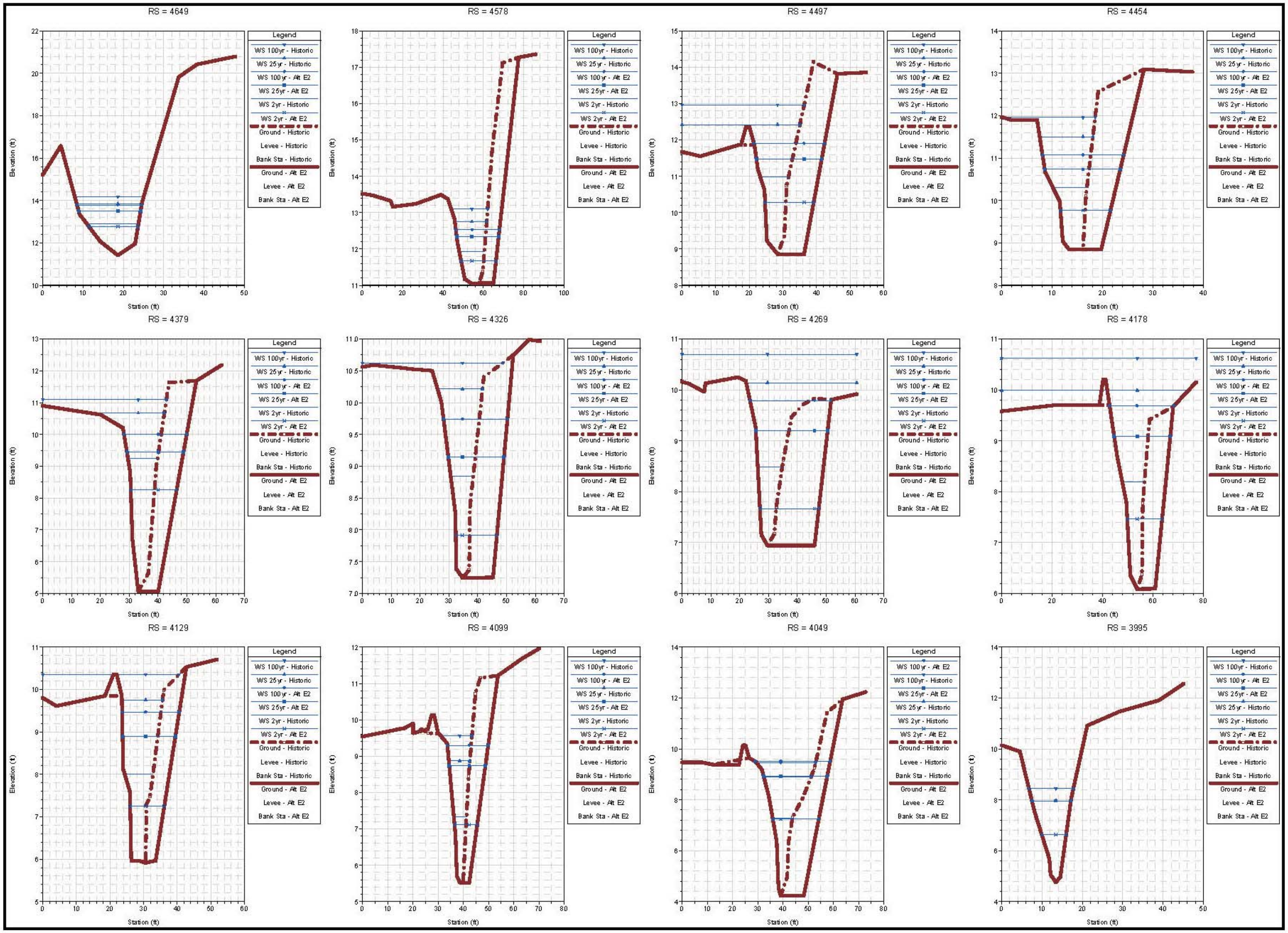
Alternative E: Floodplain Expansion on Right Bank and Earthen Berm on Left Bank

West Creek Drainage Improvement Assessment
Tiburon, California

FIGURE
18



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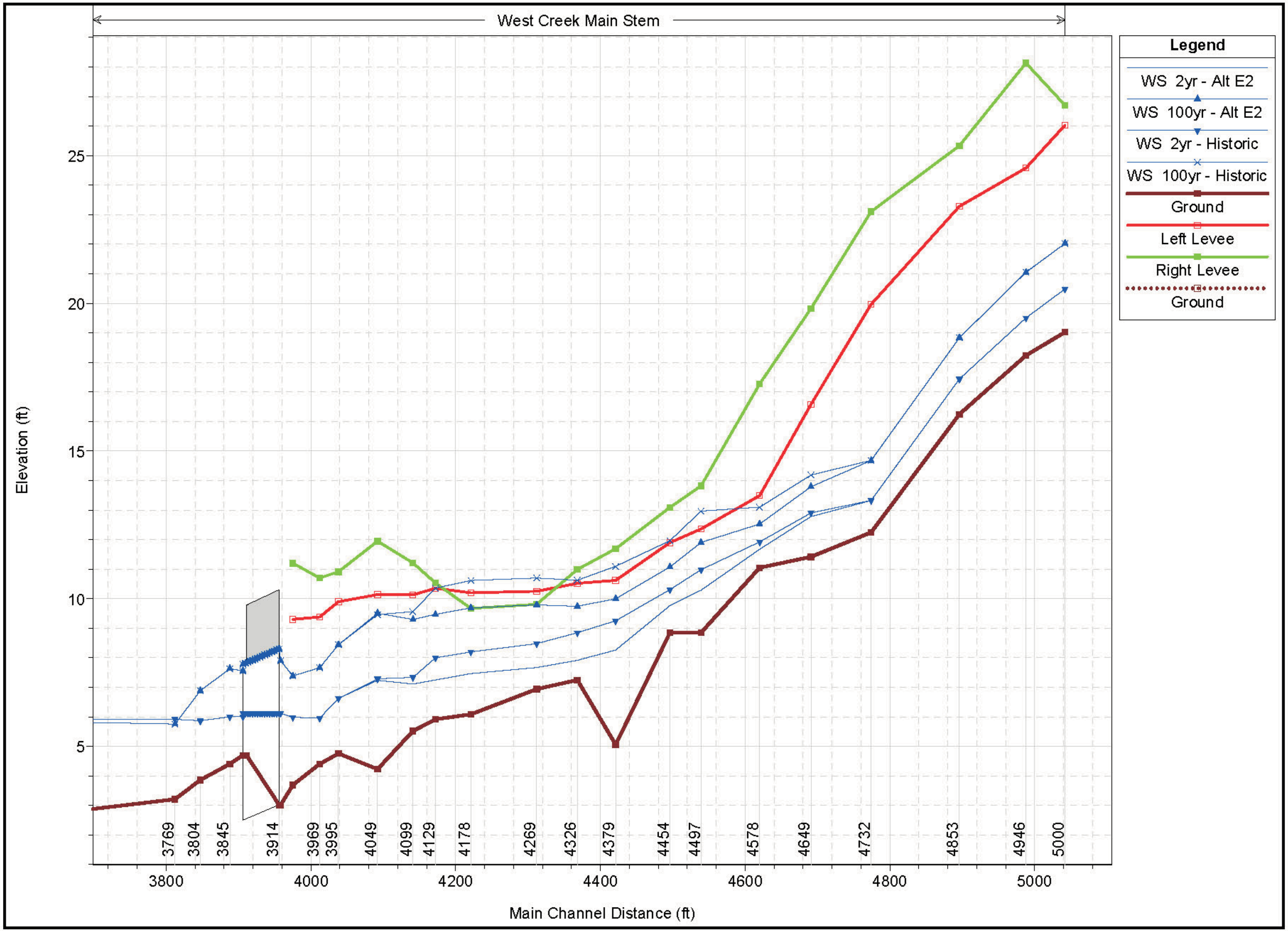
Cross Sectional Profiles - Alternative E vs. Existing Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

19



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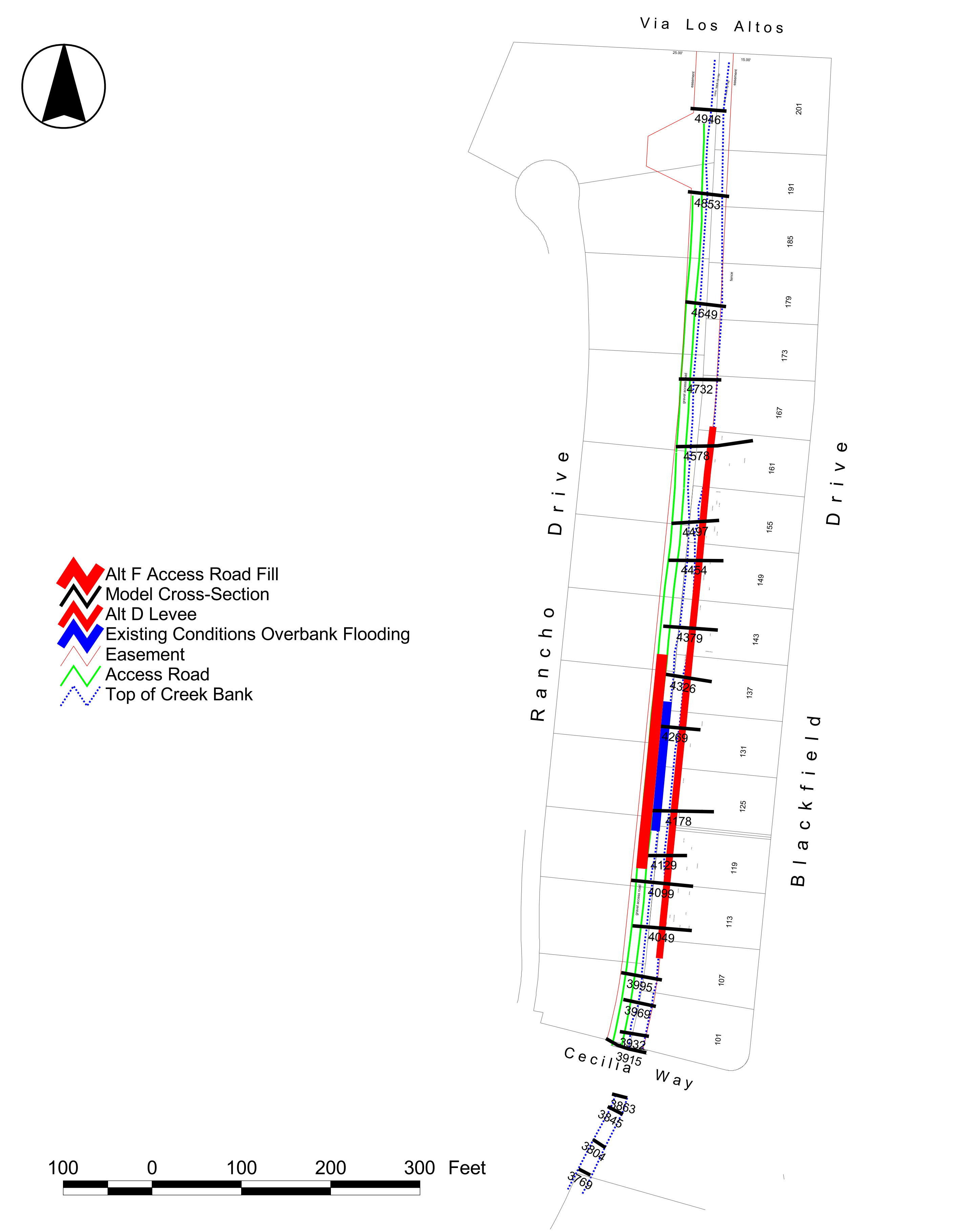
Water Surface Profiles - Alternative E vs. Historic Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

20



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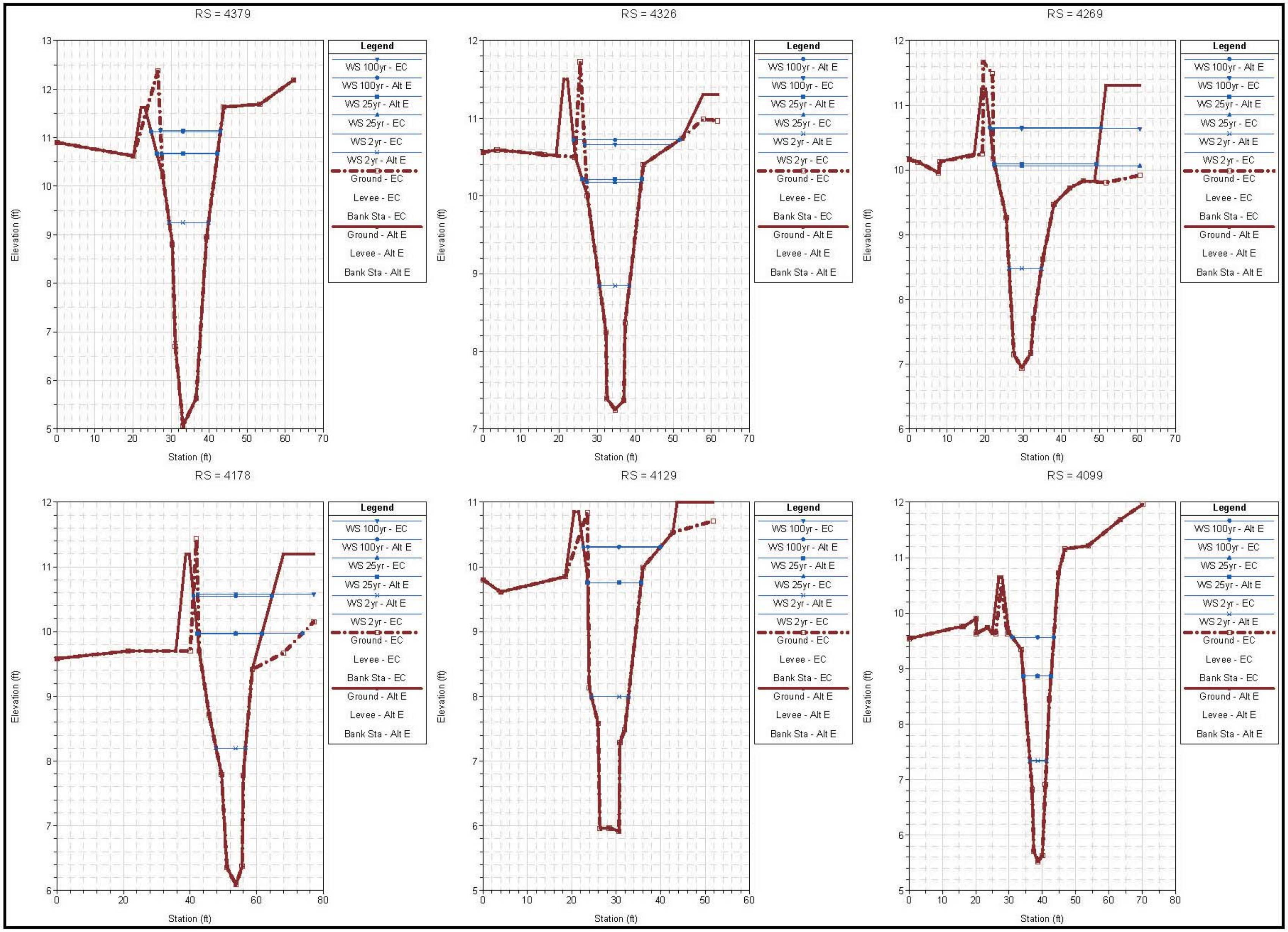
Alternative F: Earthen Berm and Raise Access Road

West Creek Drainage Improvement Assessment
Tiburon, California

FIGURE
21



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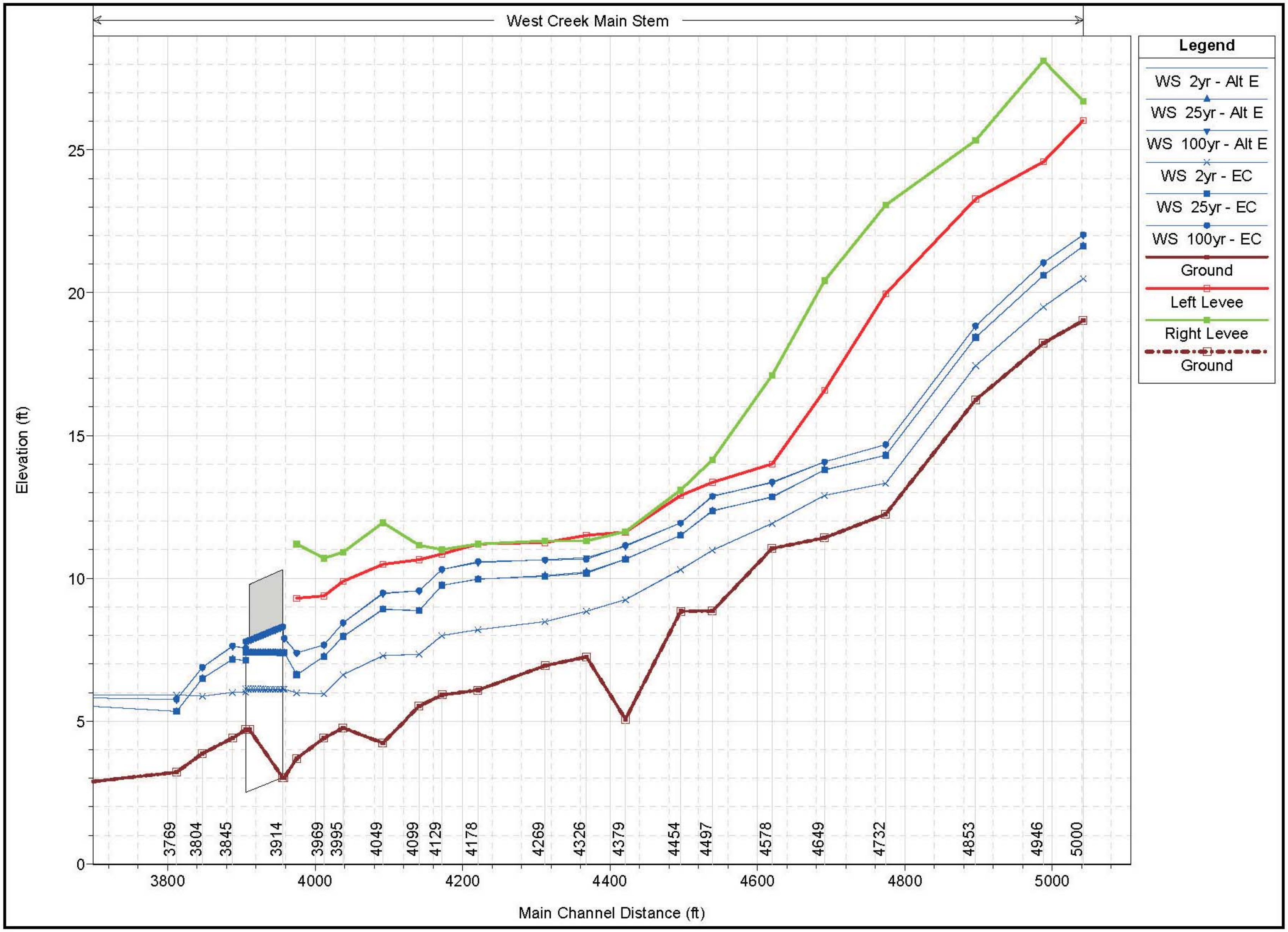
Cross Sectional Profiles - Alternative F vs. Existing Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

22



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Water Surface Profiles - Alternative F vs. Existing Conditions

West Creek Drainage Improvement Assessment, Tiburon, California

FIGURE

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