Hydraulic Analysis
Tennessee River

Prepared for:

First Marine Properties, LLC
Port of Calvert City Project
Marshall County, Kentucky

Submitted to:

Kentucky Division of Water

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submitted by

ICA Engineering

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A CD containing the HEC-RAS models used to perform the hydraulic analyses is attached to inside rear cover.

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INTRODUCTION

First Marine Properties, LLC proposes to construct a port near Calvert City, KY along the Tennessee River. The proposed port is located on the left bank of the Tennessee River at Mile Point 10.9. The project area encompasses approximately 19 acres that will require fill placed within the floodplain. An adjacent 17 acre site will be the source of the borrow material.

ICA Engineering Inc. has performed a hydraulic analysis to study the effects of proposed construction with respect to the Tennessee River. This report presents the findings of the hydraulic analysis for permitting purposes.

HYDRAULIC ANALYSIS

Current Effective Model

The Tennessee River was included in a Flood Insurance Study for Marshall County, Kentucky and Incorporated Areas, community number 210164, dated June 2, 2011. The limits of the Flood Insurance Study extended upstream to the KY Dam and downstream to the confluence with the Ohio River.

The Current Effective model utilized in the development of results published in the Flood Insurance Study could not be obtained for use in this analysis. In the absence of this data, the Ohio River Community HEC-RAS model (ORCHR) was obtained from the National Weather Service. The ORCHR model was a cooperative effort involving the US National Weather Service, Ohio River Forecasting Center, and the US Army Corps of Engineers. The model contains the reach of the Tennessee River having the same up and downstream limits as those published Flood Insurance Study. A report which discusses the development of the OHCHR and its intended purposes is presented in Appendix I.

The Flood Insurance Study utilized seven (7) cross sections spanning just over 18 river miles to determine the base flood elevations for the Tennessee River. The OHCHR model utilized nine (9) cross sections for the same 18 mile reach. This analysis utilizes these nine cross sections to create a Duplicate Effective Model in absence of the Current Effective Model. The cross sections used in the OHCHR model are in different locations than those published in the Flood Insurance Study. In order to compare the results from the Duplicate Effective Model to those published in the Flood Insurance Study; base flood elevations for both with and without floodways were interpolated at each of the eight (8) the cross sections included in the OHCHR model. The following table presents these elevations.

FIS Published - Current Effective Data				
Cross Section	Distance		Base Flood WSE (NAVD 88)	
	Miles	Feet	Without Floodway	With Floodway
$AA_{1\ (OHCHR)}$	8.52	44985.6	340.42*	341.32*
A	9.4	49632	340.6	341.5
$AA_{2\ (OHCHR)}$	10.38	54806.4	340.90*	341.80*
$A_{1\ (OHCHR)}$	11.3	59664	340.98*	341.88*
B	11.9	62832	341.1	342
$B_{1\ (OHCHR)}$	12.37	65313.6	341.22*	342.12*

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Cross Section	Distance		Base Flood WSE (NAVD 88)	
	Miles	Feet	Without Floodway	With Floodway
$B_{2\ (OHCHR)}$	13.38	70646.4	341.49*	342.39*
C	13.8	72864	341.6	342.5
$C_{1\ (OHCHR)}$	14.41	76084.8	341.88*	342.78*
$C_{2\ (OHCHR)}$	15.63	82526.4	341.63*	342.53*
D	15.8	83424	342	342.9
$D_{1\ (OHCHR)}$	17.03	89918.4	342.17*	343.07*
E	17.5	92400	342.6	343.5
F	19.7	104016	342.9	343.8
G	21.6	114048	343.3	344.3

*interpolated water surface elevations based on published Floodway Data.

The National Weather Service ORCHR model utilized real time unsteady flow data for use in flood predictions, which is not applicable in determining the base flood elevations. To perform a steady flow analysis required base flood boundary conditions. The Duplicate Effective Model uses known water surfaces as boundary conditions for each return interval, which were obtain from the flood profiles presented in the Flood Insurance Study. The Duplicate Effective Model also utilizes the same discharges as presented in the Flood Insurance Study. These boundary conditions are presented in the following table.

Peak Discharges (cfs)

10-Year	50-Year	100-Year	500-Year
388,000	480,000	517,000	600,000

Boundary Conditions

(Know Downstream Water Surface Elevations – NAVD 88)

330.82	337.82	340.42	341.82

Utilizing the data obtained from ORCHR model, a Duplicate Effective Model was developed and compared against the water surface elevations published in the Flood Insurance Study. The Duplicate Effective Model used the same cross section data as the ORCHR model and the same, manning's values and floodway widths as published in the Flood Insurance Study. The results indicate the Duplicate Effective Model closely reproduced the results published in the Study. The results are particularly close within the limits of the proposed site between Mile 10.38 and Mile 11.3. The following table summarizes the results. Detailed output from the Duplicate Effective Model is provided in Appendix II.

Comparison of Current Effective Data to the Duplicate Effective Model

FIS Published - Current Effective Data						Duplicate Effective Model				
Cross Section	Distance		100 Yr. Base Flood WSE*			100 Yr. Base Flood WSE*				
	Miles	Feet	Without Floodway	With Floodway	Δ	Without Floodway	Δ_A	With Floodway	Δ_B	Δ_C
$AA_{1\ (OHCHR)}$	8.52	44985.6	340.4	341.3	0.9	340.4	0.0	341.3	0.0	0.9
$AA_{2\ (OHCHR)}$	10.38	54806.4	340.9	341.8	0.9	340.8	-0.2	341.6	-0.2	0.9
$A_{1\ (OHCHR)}$	11.3	59664	341.0	341.9	0.9	341.0	0.0	342.0	0.1	0.9
$B_{1\ (OHCHR)}$	12.37	65313.6	341.2	342.1	0.9	341.3	0.1	342.3	0.2	1.0
$B_{2\ (OHCHR)}$	13.38	70646.4	341.5	342.4	0.9	341.5	0.0	342.6	0.2	1.1

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Cross Section	Distance		100 Yr. Base Flood WSE*			100 Yr. Base Flood WSE*				
	Miles	Feet	Without Floodway	With Floodway	Δ	Without Floodway	Δ_A	With Floodway	Δ_B	Δ_C
$C_{1\ (OHCHR)}$	14.41	76084.8	341.9	342.8	0.9	341.6	-0.3	342.8	0.0	1.2
$C_{2\ (OHCHR)}$	15.63	82526.4	341.6	342.5	0.9	341.8	0.2	343.0	0.4	1.2
$D_{1\ (OHCHR)}$	17.03	89918.4	342.2	343.1	0.9	342.2	0.0	343.3	0.2	1.1

Δ_A = Duplicate Effective (Without Floodway) - Current Effective (Without Floodway)

Δ_B = Duplicate Effective (With Floodway) - Current Effective (With Floodway)

Δ_C = Duplicate Effective (With Floodway) - Duplicate Effective (Without Floodway)

* All elevation data utilizes the NAVD 88 vertical datum.

Existing Conditions Model

The Duplicate Effective model was then used to create an Existing Conditions Model. Four cross sections were inserted by interpolating between the sections up and downstream of the proposed site and substituting survey data representing the existing ground at the specific locations of the proposed construction. A plan view and cross sections depicting the inserted sections along with an excerpt from the Flood Hazard Boundary Map are presented in Appendix III. No vertical adjustments were required to the survey data since the ORCHR model and the Flood Insurance Study both utilized the NAVD 88 vertical datum. The Existing Conditions Model used the same boundary conditions, Manning's values, and floodway widths as the Duplicate Effective Model. The following table summarizes the results of the Existing Conditions Model compared to the Duplicate Effective Model. Detailed output from the Existing Conditions Model is provided in Appendix IV.

Comparison of Duplicate Effective and Existing Conditions Models

Cross Section	Distance		Duplicate Effective Model		Existing Conditions Model				
			100 Yr. Base Flood WSE*		100 Yr. Base Flood WSE*				
	Miles	Feet	Without Floodway	With Floodway	Without Floodway	Δ_A	With Floodway	Δ_B	Δ_C
$AA_{1\ (OHCHR)}$	8.52	44985.6	340.4	341.3	340.4	0.0	341.3	0.0	0.9
$AA_{2\ (OHCHR)}$	10.38	54806.4	340.8	341.6	340.8	0.0	341.6	0.0	0.9
A_{1A}	10.71	56548.8			340.7		341.7		1.0
A_{1B}	10.9	57552			340.8		341.8		1.0
A_{1C}	10.95	57816			340.9		341.8		1.0
A_{1D}	10.99	58027.2			340.9		341.8		1.0
$A_{1\ (OHCHR)}$	11.3	59664	341.0	342.0	341.1	0.1	342.0	0.1	0.9
$B_{1\ (OHCHR)}$	12.37	65313.6	341.3	342.3	341.4	0.1	342.4	0.1	1.0
$B_{2\ (OHCHR)}$	13.38	70646.4	341.5	342.6	341.6	0.1	342.7	0.1	1.1
$C_{1\ (OHCHR)}$	14.41	76084.8	341.6	342.8	341.7	0.1	342.9	0.1	1.1
$C_{2\ (OHCHR)}$	15.63	82526.4	341.8	343.0	342.0	0.1	343.1	0.1	1.1
$D_{1\ (OHCHR)}$	17.03	89918.4	342.2	343.3	342.3	0.1	343.4	0.1	1.0

Δ_A = Existing Conditions (Without Floodway) - Duplicate Effective (Without Floodway)

Δ_B = Existing Conditions (With Floodway) – Duplicate Effective (With Floodway)

Δ_C = Existing Conditions (With Floodway) – Existing Conditions (Without Floodway)

* All elevation data utilizes the NAVD 88 vertical datum.

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Proposed Conditions Model

The Existing Conditions Model was then utilized to create a Proposed Conditions Model. Each of the four (4) inserted sections were modified to reflect the proposed conditions. The Proposed Conditions Model uses the same boundary conditions, Manning's values, and floodway widths as the Existing Conditions Model. These four (4) cross sections represent the 19 acres of proposed fill that would be placed in the floodplain. No cross sections were inserted to represent the proposed 17 acre borrow site because the additional flow area would primarily be ineffective flow. The following table summarizes the results from the Proposed Conditions Model compared to the Existing Conditions model. Detailed output form the Proposed Conditions Model is provided in Appendix V.

Comparison of Existing Conditions and Proposed Conditions Models

			Existing Conditions Model		Proposed Conditions Model				
	Distance		100 Yr. Base Flood WSE*		100 Yr. Base Flood WSE*				
Cross Section	Miles	Feet	Without Floodway	With Floodway	Without Floodway	Δ_A	With Floodway	Δ_B	Δ_C
$AA_{1\ (OHCHR)}$	8.52	44985.6	340.4	341.3	340.4	0.0	341.3	0.0	0.9
$AA_{2\ (OHCHR)}$	10.38	54806.4	340.8	341.6	340.8	0.0	341.6	0.0	0.9
A_{1A}	10.71	56548.8	340.7	341.7	340.8	0.0	341.7	0.0	1.0
A_{1B}	10.9	57552	340.8	341.8	340.8	0.0	341.8	0.0	1.0
A_{1C}	10.95	57816	340.9	341.8	340.8	0.0	341.8	0.0	1.0
A_{1D}	10.99	58027.2	340.9	341.8	340.9	0.0	341.9	0.0	1.0
$A_{1\ (OHCHR)}$	11.3	59664	341.1	342.0	341.2	0.0	342.0	0.0	0.9
$B_{1\ (OHCHR)}$	12.37	65313.6	341.4	342.4	341.4	0.0	342.4	0.0	0.9
$B_{2\ (OHCHR)}$	13.38	70646.4	341.6	342.7	341.6	0.0	342.7	0.0	1.1
$C_{1\ (OHCHR)}$	14.41	76084.8	341.7	342.9	341.7	0.0	342.9	0.0	1.1
$C_{2\ (OHCHR)}$	15.63	82526.4	342.0	343.1	342.0	0.0	343.1	0.0	1.1
$D_{1\ (OHCHR)}$	17.03	89918.4	342.3	343.4	342.3	0.0	343.4	0.0	1.0

Δ_A = Proposed Conditions (Without Floodway) – Existing Conditions (Without Floodway)

Δ_B = Proposed Conditions (With Floodway) – Existing Conditions (With Floodway)

Δ_C = Proposed Conditions (With Floodway) – Proposed Conditions (Without Floodway)

* All elevation data utilizes the NAVD 88 vertical datum.

CONCULSIONS

The results from this analysis indicate the construction associated with the proposed Port of Calvert City by First Marine Properties, LLC in Marshall County, Kentucky will result in no increase to the 100 year floodplain or the 100 year floodway water surface elevations. An Engineering No-Impact Certification has been prepared and provided in Appendix VI.

Appendix I
Ohio River Community HEC-RAS model (ORCHR)

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The Ohio River Community HEC-RAS model

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Abstract

In this paper we describe the Ohio River Community HEC-RAS Model (Model) and include some preliminary results. The Model is a cooperative effort involving the U.S. National Weather Service (NWS), Ohio River Forecast Center (OHRFC) and the U.S. Army Corps of Engineers (USACE), Great Lakes and Ohio River Division (LRD), Water Management Division. Initial planning to develop a community unsteady flow model for the mainstem of the Ohio River using the USASE HEC-RAS model began in late 2006. The purpose of collaborating on the development of the joint model was that, when completed, both agencies could independently use the model for operational/forecast purposes, yet share in the development effort, which is substantial. While the Model is now complete, continued enhancements and extensions are anticipated, such as modeling reaches of major tributaries like the Cumberland and Kanawha Rivers. Subsequent changes by one agency will be passed back to the other agency in order to maintain consistency, so that future development can be easily shared.

The scope of the modeling effort includes 20 locks and dams on the Ohio River, with storage areas and lateral structures such as levees, as well as bridges. The Model is comprised of over 2800 cross-sections, spanning approximately 1300 miles of modeled reach. The downstream boundaries are Chester, IL for the upstream portion on the Mississippi River and Carruthersville, MO for the downstream portion on the Mississippi River. The upstream boundaries include Braddock Lock and Dam, WV on the Monongahela River and Natrona, PA on the Allegheny River. The Model requires lateral and tributary inflows and is run in real-time; for the OHRFC the lateral and tributary inflows result from runoff produced by both observed and forecasted precipitation. Laterally, Model cross-sections extend to the 500-year floodplain limits, except for Mississippi River reaches that only extend to the USACE levees.

Model development involved substantial geographic information system (GIS) data preparation to obtain consistent vertical and horizontal datums between the various data sets used. Digital elevation model (DEM) data sources included U.S. Geological Survey (USGS) 10 meter DEM, and Lidar data provided by the USACE, and local and state agencies. Bathymetric and in-channel cross- section data were provided by the USACE. Every effort was made to include the best available data, and. it is anticipated that substantial improvements will be made in the future by the use of higher resolution data sets.

Background

The National Oceanic and Atmospheric Administration (NOAA), U.S. National Weather Service (NWS), Ohio River Forecast Center (OHRFC) and the U.S. Army Corps of Engineers (USACE), Great Lakes and Ohio River Division (LRD), have public forecast responsibilities for the mainstem of the Ohio River with local NWS Weather Forecast Offices (WFOs) having the responsibility of disseminating the official public forecast. For the OHRFC, forecast responsibilities are focused on public safety and protection of personal property, whereas LRD’s

focus is management of flood control structures to prevent or mitigate flooding. These responsibilities will be elucidated below.
Due to limited staffing and financial resources, the OHRFC and LRD reached an agreement in late 2006 to co-develop, on an unfunded basis, an unsteady 1-dimensional hydraulic model of the Ohio River mainstem — the *Community Ohio River HEC-RAS Model* — using the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) model (USACE HEC, 1995). Development of the model has the following goals:

(1) that the model would serve both agencies' real-time operational needs to improve forecasts;
(2) to add hydraulic reaches from the major tributaries in Phase 2 development (such as the Wabash, Kentucky, Green, Muskingum, Kanawha Rivers, etc.) as channel bathymetric data becomes available and the mainstem model is complete and operational;
(3) to use the best available data at the time of development and to enhance the model as higher quality data becomes available;
(4) to share model enhancements between the USACE LRD & NWS OHRFC;
(5) to distribute the model freely to other agencies, individuals, and organizations (with the stipulation that the OHRFC & LRD be credited for model development);
(6) to make possible the generation of real-time flood inundation maps;
(7) greatly improve visualization capabilities of flow dynamics.

OHRFC forecast responsibility for the mainstem of the Ohio River ends at Smithland Dam, KY, some 63 miles (~101 km) from the confluence with the Mississippi River. However, LRD responsibility includes protection of Cairo, IL, management of the Birds Point - New Madrid floodway and Kentucky Lake reservoir on the Tennessee River and Barkley Lake reservoir on the Cumberland River, which provide significant flood control storage for the protection of New Orleans and intervening points. Figure 1 shows the scope of the model area, with principle upstream boundaries including Braddock Lock and Dam, WV on the Monongahela River, Natrona, PA on the Allegheny River, and downstream flow boundary at Chester, IL for the upstream portion on the Mississippi River and rating curve boundary at Carruthersville, MO for the downstream portion on the Mississippi River.

Figure 2 is a schematic of the Ohio River mainstem profile showing the USACE Locks and Dams. The Lock and Dam operations, particularly during low flows, significantly affect the propagation of waves on the Ohio River as described by Lee et al (2002). Duplication of the Lock and Dam operations at low flows in real-time is highly problematic, as results (below) will show. The unpredictable nature of the Lock and Dam operations are due to human (dam operators) control of gate settings to regulate pool levels.

NWS/Ohio River Forecast Center
By U.S. Congressional mandate, the mission statement of the NWS is to "…provide[s] weather, hydrologic, and climate forecasts and warnings for the United States, its territories, and adjacent waters and ocean areas for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and

infrastructure which can be used by other government agencies, the private sector, the public, and the global community." As such, the OHRFC currently has the responsibility of issuing flood forecast and river stage forecast guidance for 274 locations located in the Ohio River basin and U.S. drainage into Lake Erie, including the Maumee River basin (see Figure 1). The OHRFC area of responsibility does not include the Tennessee River basin. The OHRFC maintains 43 forecast locations on the Ohio River mainstem.

OHRFC real-time operations are 16 hours per day, 365 days per year, which is extended to 24-hour operations during periods of flooding or significant threat of flooding. Tributary and lateral inflows to the HEC-RAS model are computed in real-time using the Sacramento Soil Moisture Accounting (SAC-SMA) model (Anderson, 2002; Burnash, 1973; Burnash, 1995) and SNOW-17 model (Anderson, 1973) within the NWS River Forecast System (NWSRFS) (U.S. Department of Commerce, 1972). Inputs to the SAC-SMA and SNOW-17 models utilize observed NEXRAD radar derived precipitation estimates and temperature station data and locally estimated forecast precipitation, known as quantitative precipitation forecasts (QPF), and forecast temperatures from NWS weather forecast offices (WFOs) National Digital Forecast Database (NDFD). Due to the lumped hydrologic routing schemes currently used, such as layered coefficient and Tatum, the OHRFC is unable to make *ad hoc* forecasts at intermediate points between forecast locations on the Ohio River. The HEC-RAS model will make possible forecasts at intermediate locations where the existing methods could not due to dynamic conditions.

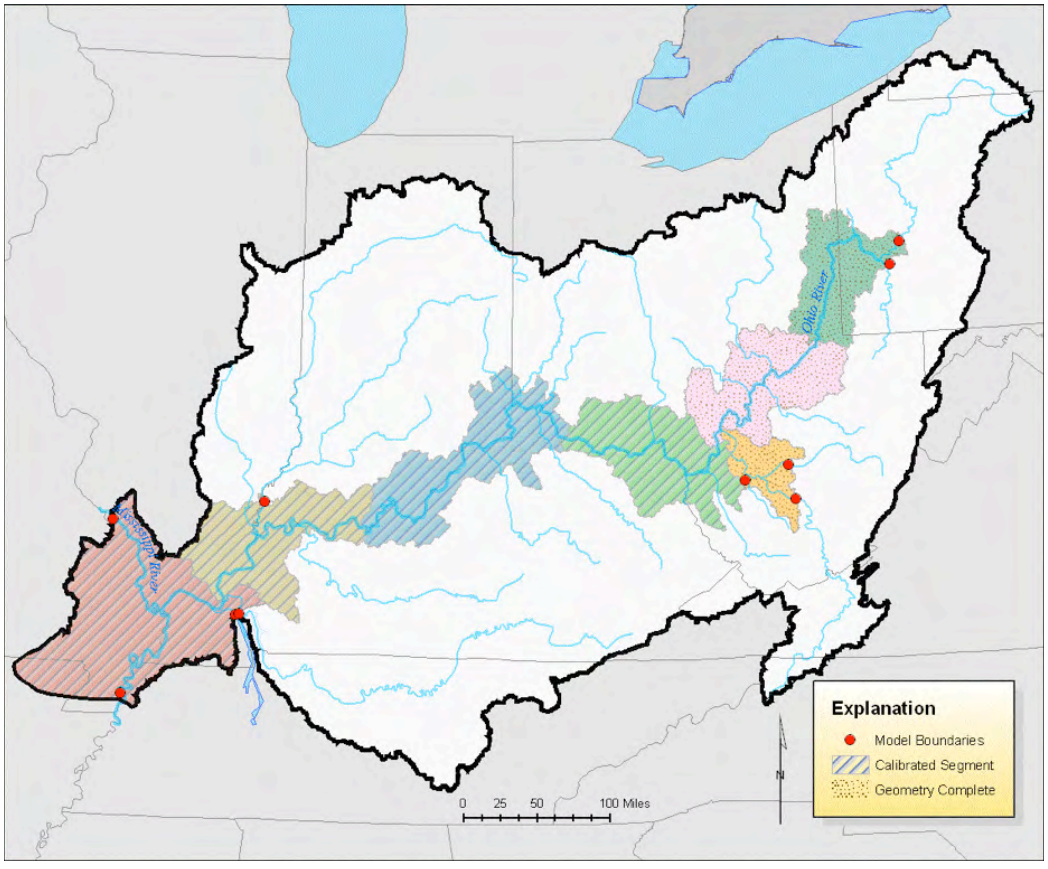

Figure 1. Scope of the Community Ohio River HEC-RAS model. Local runoff areas to the Ohio River mainstem are shown in color. Model boundaries are depicted as red dots. The OHRFC area of responsibility is shown by the black outline, with the exception of the area downstream of Smithland Dam near the confluence with the Mississippi River.

Figure 2 Location of the Ohio River Mainstem Locks and Dams (USACE), showing the Ohio River profile from Pittsburgh to Smithland Dam.

USACE/Great Lakes and Ohio River Division

The Great Lakes and Ohio River Division Water Management Team of the U.S. Army Corps of Engineers (USACE) is responsible for reducing water level stages along the lower Ohio and middle Mississippi Rivers during significant flood events. To accomplish this mission, LRD directs the flow releases from Barkley Lake on the Cumberland River and issues regulation instructions to the Tennessee Valley Authority for the operation of Kentucky Lake on the Tennessee River. LRD currently utilizes a dynamic, one-dimensional unsteady flow model

called “Cascade”, which has proven to be an effective management tool in coordinating the reservoir releases. Cascade routes Ohio River and upper Mississippi River flows to determine the impact of reservoir releases on flood levels. A complete description of LRD operations is described in Lee et al (2002).

Continued use of Cascade is problematic due to on-going code maintenance and difficulty of integrating the model into the USACE Corps Water Management System (CWMS) (Fritz et al, 2002). Consequently, LRD is emphasizing migration from Cascade to HEC-RAS for operations.

Description of the model

The best freely available data sources were used to construct channel cross-sections, using a combination of previously existing channel cross-section data, bathymetric data, lidar, and digital elevation model (DEM) data, as Table 2 indicates. The original data were produced using a differing vertical and horizontal datums and geographic projections. Consequently, the data had to be transformed to a common datum and projection in order to minimize distortions. One issue is that, due to the length of the greater than 1300 miles modeled on the curved surface of the Earth and with the desire to have geographically registered channel cross-sections for future real-time flood inundation mapping, some distortion of the channel length is unavoidable. One can only hope to minimize map distortions by choosing an appropriate map projection that preserves areas and minimizes horizontal distortions.

Table 1 indicates the steps taken to transform the various data sources to Albers Equal Area projection using NAD 83 and NAVD 88 within ESRI ArcGIS™ and with the National Geodetic Survey VERTCON software (http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html).

Model calibrations proceeded in a stepwise fashion, beginning with downstream reaches and progressively moving upstream. A reach would be calibrated and new cross-sections would be added upstream, followed by re-calibration of the entire model, including the new and old reaches. The calibration period spans September 25, 2004 to July 1, 2008.

Table 1. Data processing steps to transform data from all sources to the Albers Equal Area projection using NAD 83 and NAVD 88.

Step	DEM/Lidar	USACE cross-sections	Channel bathymetry	Gauge datum
1	Obtain DEM data — geographic projection (latitude-longitude), NAD 83, NAVD 88	Obtain USACE cross-section data	Obtain bathymetry data	Obtain gauge zero elevations for modeling ponts
2	Convert vertical units (meters to feet)	Project to NAD 83, Albers feet	Project cross-sections to NAD 83, Albers feet	Determine correction factor (ORD to NGVD 29)

Step	DEM/Lidar	USACE cross-sections	Channel bathymetry	Gauge datum
3	Mosaic DEM tiles	Determine correction factor (ORD to NGVD 29)	Define cross-sections by connecting bathymetry points	Determine correction factor (NGVD 29 to NAVD 88)
4	Project DEM from Geographic to Albers	Determine correction factor (NGVD 29 to NAVD 88)	Assign river mile locations to cross-sections	Apply gaude zero correction factors in HEC-RAS
5	•	Apply cross-section correction factors in HEC-RAS	Determine correction factor (ORD to NGVD 29)	•
6	•	•	Determine correction factor (NGVD 29 to NAVD 88)	•
7	•	•	Reduce the number of cross-sections	•
8	•	•	Apply correction factors to bathymetry cross-sections	•

Table 2. Data types and sources used to construct HEC-RAS cross-sections.

Data Type	Data Source
Surveyed Cross-section and Bathymetry Data	USACE Pittsburgh District USACE Huntington District USACE Louisville District USACE St. Louis District USACE Memphis District USGS
National Elevation Dataset (NED) (10 m and 3 m horizontal resolution)	USGS
Indiana DEM data (5 ft and 10 ft horizontal resolution)	USACE Louisville District
Lidar Data	USACE Memphis District PASDA: Pennsylvania OGRIP: Ohio
Elevation Datum Correction Factor Data (Ohio River Datum to NGVD29)	USACE Huntington District USACE Louisville District
Elevation Datum Correction Factor Data (VERTCON program to derive NVGD29 to NAVD88 correction factors)	NOAA National Geodetic Survey
USACE Levee Database Data	USACE Huntington District USACE Louisville District
Lock and Dam Geometry	USACE Navigation Charts USACE Pittsburgh District
National Hydrography Dataset (NHD)	USGS
Historic and Real-time Stage and Streamflow Data	USGS USACE LRD NWS OHRFC and LMRFC
Streamflow forecasts	NWS OHRFC and LMRFC

Data Type	Data Source
In-house Digitized Data (Levee line data and elevations) (Storage Area geometry)	NWS OHRFC
Ancillary/Miscellaneous Data	Internet Sources

Table 3. Model details, listing reach length modeled, numbers of bridges, storage areas, lateral structures, locks & dams, and cross-sections defined in the model.

River Name	River miles modeled	Bridges	Storage Areas	Lateral Structures	Locks & Dams	Cross Sections
Alleghaney R	24.30				2	263
Monongahela R	11.00					64
Ohio R	981.00	17	43	20	20	2194
Upper Mississippi R	110.00			16		246
Lower Mississippi R	107.00			18		119
Wabash R	45.00					22
Tennessee R	18.21					13
Cumberland R	29.36					21
Subtotal	1325.87	17	43	54	22	2942
Kanawah R	94.00	3			2	346
Elk R	25.67	5				151
Coal R	11.96	1				60
Subtotal	131.63	9			2	557
Total	**1457.50**	**26**	**43**	**54**	**24**	**3499**

Discussion

Initial results show very acceptable calibration statistics with R^2 values better than 0.98, except for the Pittsburgh location ($R^2 = 0.86$), where model calibrations are preliminary. Also, the Pittsburgh pool is controlled at low flows by Emsworth Dam, which has experienced operational difficulties over the calibration period. Figures 3 and 4 show the effect of downstream control of the Pittsburgh pool by Emsworth Dam, which has a target pool elevation of approximately 710.5 ft (MSL). Model results, in general, are expected to vary by location due to differences in the quality of the tributary flow and lateral inflow estimates. So, these selected results should not be considered universal; local conditions involving structural and natural controls can be problematic to duplicate in our HEC-RAS model implementation. However, model improvements will be an on-going process and will be implemented following a review and validation process.

Operational results are not expected to match calibration statistics due to errors with real-time lateral and tributary inflow estimation. Also, with the use of forecast precipitation (also known as quantitative precipitation forecast or, QPF) in real-time operations, HEC-RAS model errors will also reflect QPF error as well, which are often substantial. No comparison between existing lumped hydrologic routing methods at the OHRFC or CASCADE routing at LRD have yet been attempted. So, no conclusions can be drawn with respect to operational improvements.

Table 4. Verification statistics from model calibration, showing mean absolute error (MAE), mean error (ME), mean square error (MSE), and R^2 for selected locations.

Location	MAE	ME	MSE	R^2
Pittsburgh, PA (PTTP1)	0.2096	-0.0180	0.0847	0.8585
Evansville, IN (EVVI3)	0.7365	0.0587	0.9830	0.9842
Cairo, IL	0.8253	0.0277	1.0830	0.9935
Chester, IL	0.3677	0.1516	0.3269	0.9960
Cruthersville, MO	0.8634	0.2003	1.3260	0.9887

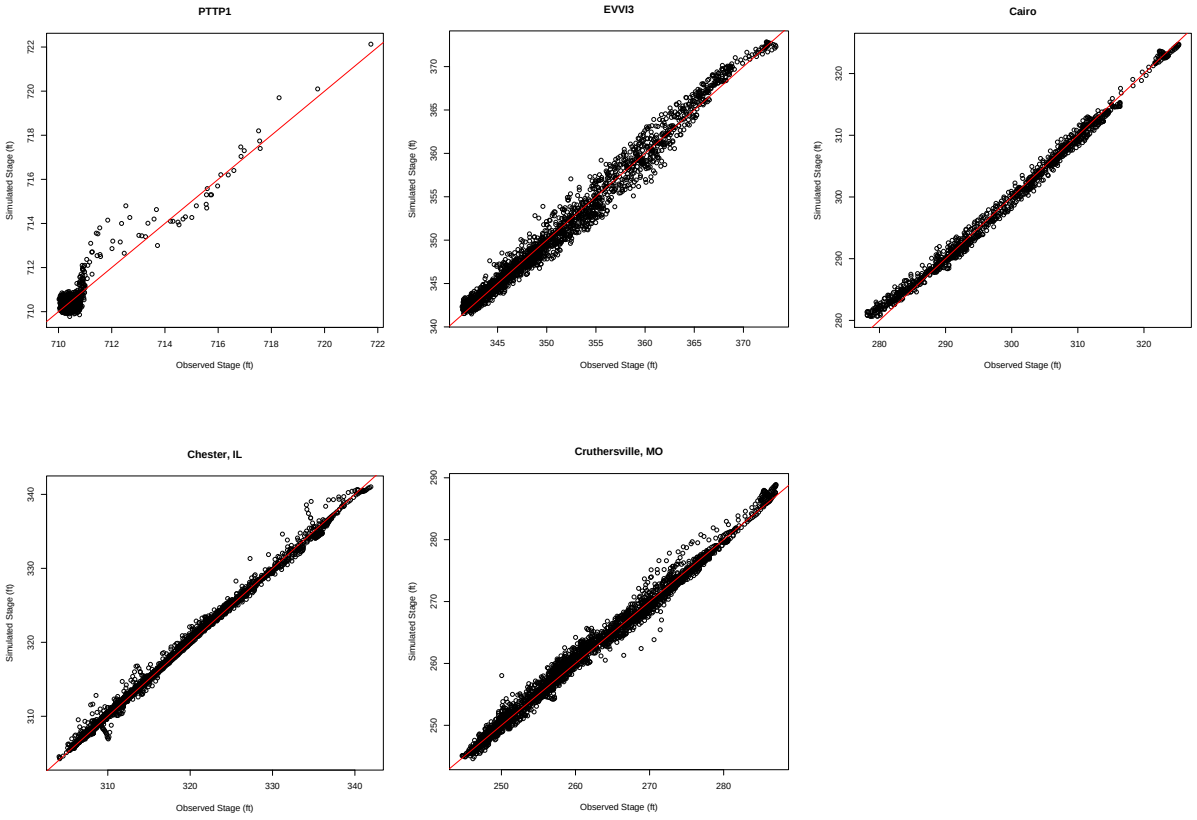

Figure 3. Scatterplots for selected modeling points for the calibration period. The *red* line indicates 1-to-1 agreement.

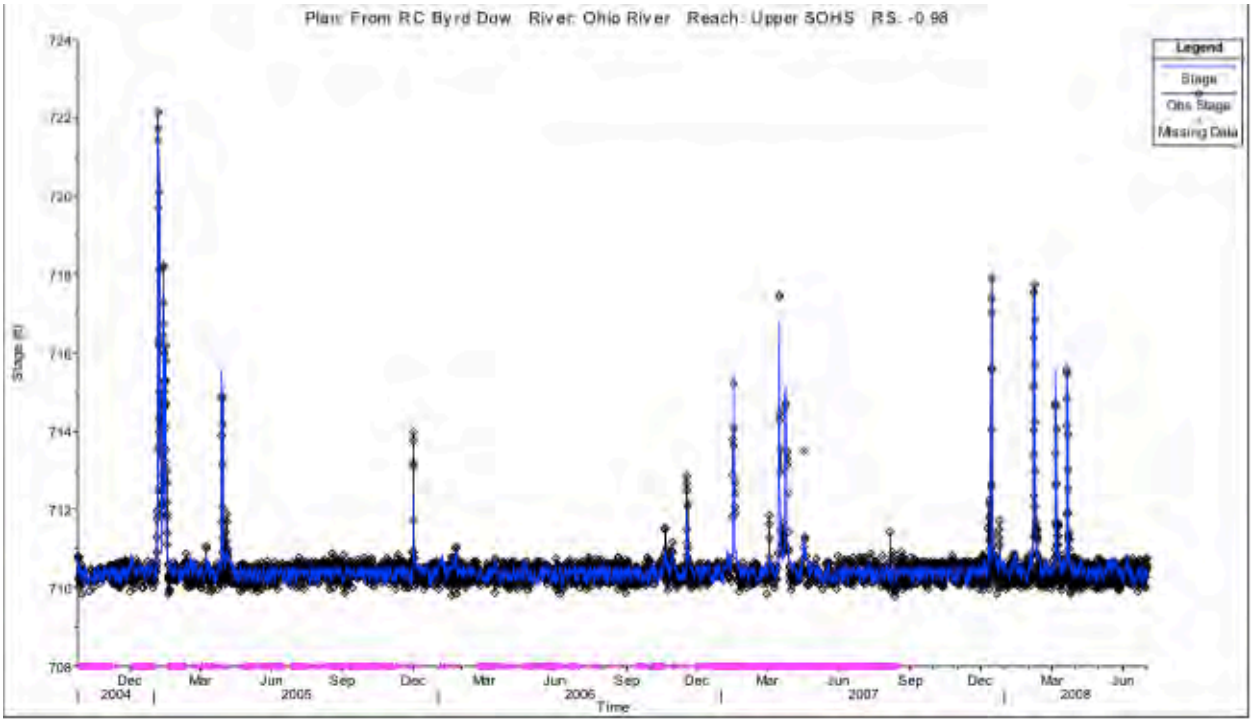

Figure 4. Stage hydrograph (ft, MSL) for Pittsburgh (PTTP1) for the calibration period, 01/01/2004 to 12/31/2008.

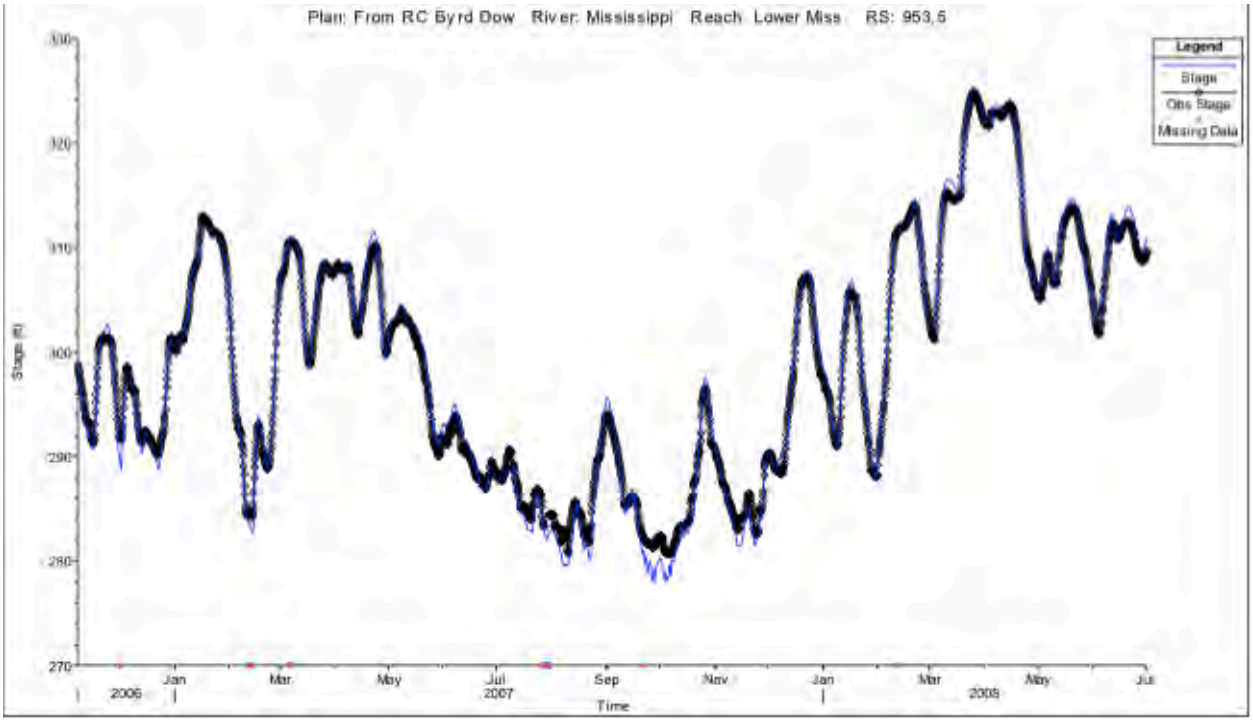

Figure 5. Stage hydrograph (ft, MSL) for Cairo, IL for the calibration period, 01/01/2004 to 12/31/2008.

Conclusion

The joint NWS-USACE cooperation in the co-development of the Ohio River Community HEC-RAS model has been successful. Real-time operations with the model will begin by mid-2010. While no model comparisons with existing routing models have been made, calibration statistics are very encouraging. Critically important to LRD operations is the ability to accurately model the confluence of the Ohio and Mississippi Rivers where Cairo, IL is located. Results presented in Table 4 and Figures 3 and 5 show promise for meeting LRD needs at Cairo, IL.

We also acknowledge Joe Heim (NOAA/NWS/OHRFC) for his significant efforts in data preparation for calibrations and preparing data pathways and procedures for operations at the OHRFC.

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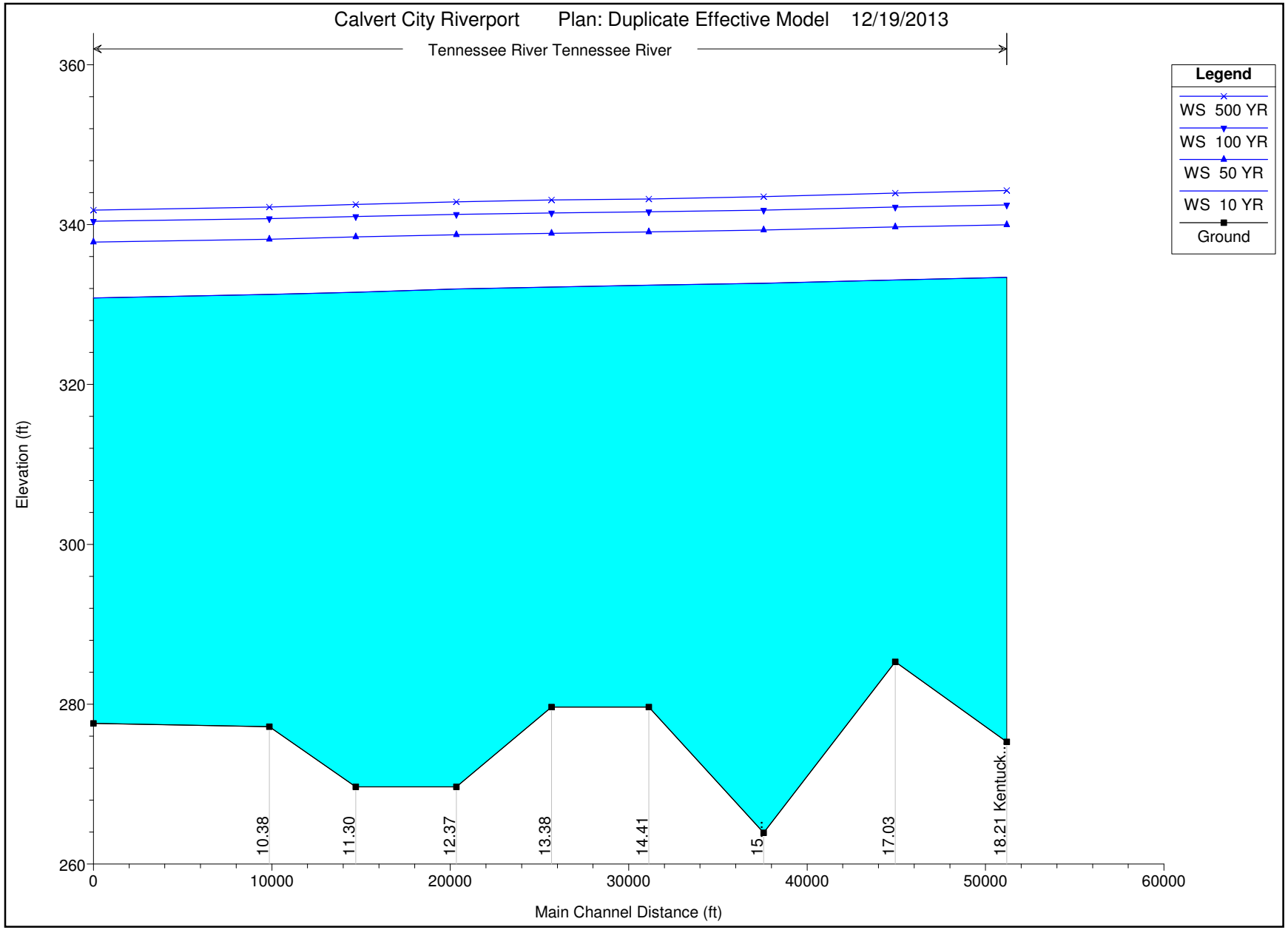
Appendix II
Duplicate Effective Model

ICA Engineering

HEC-RAS Plan: Dup Eff River: Tennessee River Reach: Tennessee River

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Tennessee River	8.52	10 YR	388000.00	277.59	330.82	293.53	331.18	0.000047	4.86	98258.48	6426.53	0.13
Tennessee River	8.52	50 YR	480000.00	277.59	337.82	295.74	338.15	0.000038	4.82	149719.10	7786.96	0.12
Tennessee River	8.52	100 YR	517000.00	277.59	340.42	296.54	340.74	0.000035	4.81	170779.90	8922.88	0.12
Tennessee River	8.52	500 YR	600000.00	277.59	341.82	298.29	342.21	0.000042	5.35	183498.00	9251.29	0.13
Tennessee River	10.38	10 YR	388000.00	277.17	331.28		331.72	0.000058	5.49	89904.79	5542.77	0.15
Tennessee River	10.38	50 YR	480000.00	277.17	338.18		338.60	0.000049	5.53	137885.50	8855.83	0.14
Tennessee River	10.38	100 YR	517000.00	277.17	340.75		341.16	0.000045	5.51	163252.10	10952.77	0.13
Tennessee River	10.38	500 YR	600000.00	277.17	342.21		342.72	0.000054	6.15	180397.40	12790.00	0.15
Tennessee River	11.30	10 YR	388000.00	269.66	331.54	289.14	332.00	0.000054	5.46	81215.20	3185.32	0.14
Tennessee River	11.30	50 YR	480000.00	269.66	338.46	291.64	338.82	0.000040	5.15	143323.40	5178.86	0.12
Tennessee River	11.30	100 YR	517000.00	269.66	341.01	292.59	341.37	0.000039	5.21	178676.60	12748.24	0.12
Tennessee River	11.30	500 YR	600000.00	269.66	342.54	294.67	342.96	0.000045	5.74	198664.70	13380.53	0.13
Tennessee River	12.37	10 YR	388000.00	269.66	331.94	289.14	332.28	0.000043	4.78	109734.40	7869.44	0.13
Tennessee River	12.37	50 YR	480000.00	269.66	338.73	291.64	339.04	0.000035	4.72	171348.40	10354.43	0.12
Tennessee River	12.37	100 YR	517000.00	269.66	341.28	292.61	341.57	0.000032	4.69	201190.10	13611.63	0.11
Tennessee River	12.37	500 YR	600000.00	269.66	342.86	294.68	343.21	0.000038	5.17	223646.60	14803.00	0.12
Tennessee River	13.38	10 YR	388000.00	279.64	332.19	296.04	332.52	0.000046	4.60	84358.50	2105.99	0.13
Tennessee River	13.38	50 YR	480000.00	279.64	338.92	298.00	339.23	0.000038	4.59	128955.20	4318.88	0.12
Tennessee River	13.38	100 YR	517000.00	279.64	341.47	298.73	341.75	0.000034	4.48	175405.90	9729.05	0.11
Tennessee River	13.38	500 YR	600000.00	279.64	343.07	300.34	343.41	0.000040	4.95	191586.20	10497.13	0.12
Tennessee River	14.41	10 YR	388000.00	279.64	332.42	296.04	332.75	0.000041	4.65	91445.33	3675.27	0.12
Tennessee River	14.41	50 YR	480000.00	279.64	339.09	298.00	339.45	0.000037	4.88	116770.30	3896.20	0.12
Tennessee River	14.41	100 YR	517000.00	279.64	341.60	298.75	341.97	0.000036	4.97	126612.90	3953.97	0.12
Tennessee River	14.41	500 YR	600000.00	279.64	343.22	300.46	343.68	0.000044	5.56	133038.00	3994.27	0.13
Tennessee River	15.63	10 YR	388000.00	263.92	332.67	289.08	333.03	0.000045	4.88	91867.79	3527.27	0.13
Tennessee River	15.63	50 YR	480000.00	263.92	339.33	291.66	339.71	0.000041	5.11	116237.90	3848.19	0.13
Tennessee River	15.63	100 YR	517000.00	263.92	341.83	292.68	342.22	0.000039	5.19	126065.00	3984.04	0.12
Tennessee River	15.63	500 YR	600000.00	263.92	343.49	294.81	343.98	0.000047	5.80	132739.60	4040.63	0.14
Tennessee River	17.03	10 YR	388000.00	285.31	333.06	302.07	333.43	0.000064	5.00	98502.28	4968.03	0.15
Tennessee River	17.03	50 YR	480000.00	285.31	339.70	304.26	340.05	0.000050	4.97	132282.80	5207.46	0.14
Tennessee River	17.03	100 YR	517000.00	285.31	342.20	305.07	342.54	0.000046	4.98	145383.40	5291.18	0.13
Tennessee River	17.03	500 YR	600000.00	285.31	343.95	306.80	344.36	0.000054	5.50	154713.50	5426.39	0.14
Tennessee River	18.21	10 YR	388000.00	275.29	333.41	294.79	333.75	0.000041	4.83	114439.20	5822.12	0.12
Tennessee River	18.21	50 YR	480000.00	275.29	339.99	297.00	340.31	0.000036	4.91	155346.70	7281.12	0.12
Tennessee River	18.21	100 YR	517000.00	275.29	342.47	297.87	342.79	0.000034	4.92	176624.30	9106.00	0.12
Tennessee River	18.21	500 YR	600000.00	275.29	344.27	299.74	344.65	0.000039	5.42	193676.30	9929.64	0.13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Tennessee River Tennessee River
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WS 100 YR
WS 50 YR
WS 10 YR
Ground
Elevation (ft)
360
340
320
300
280
260
0
10000
20000
30000
40000
50000
60000
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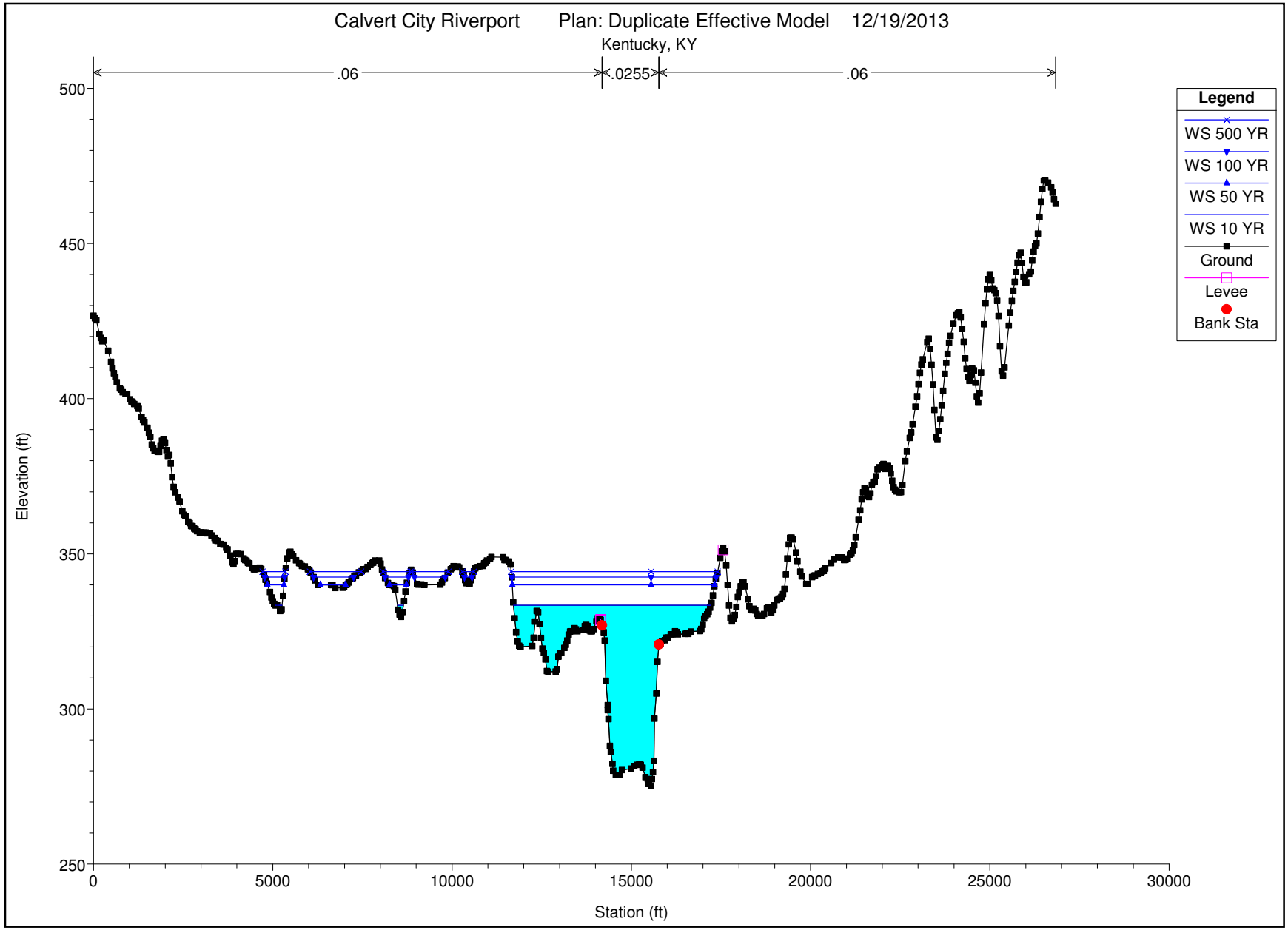
11.30
12.37
13.38
14.41
15...
17.03
18.21 Kentuck...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12/19/2013
Kentucky, KY
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WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
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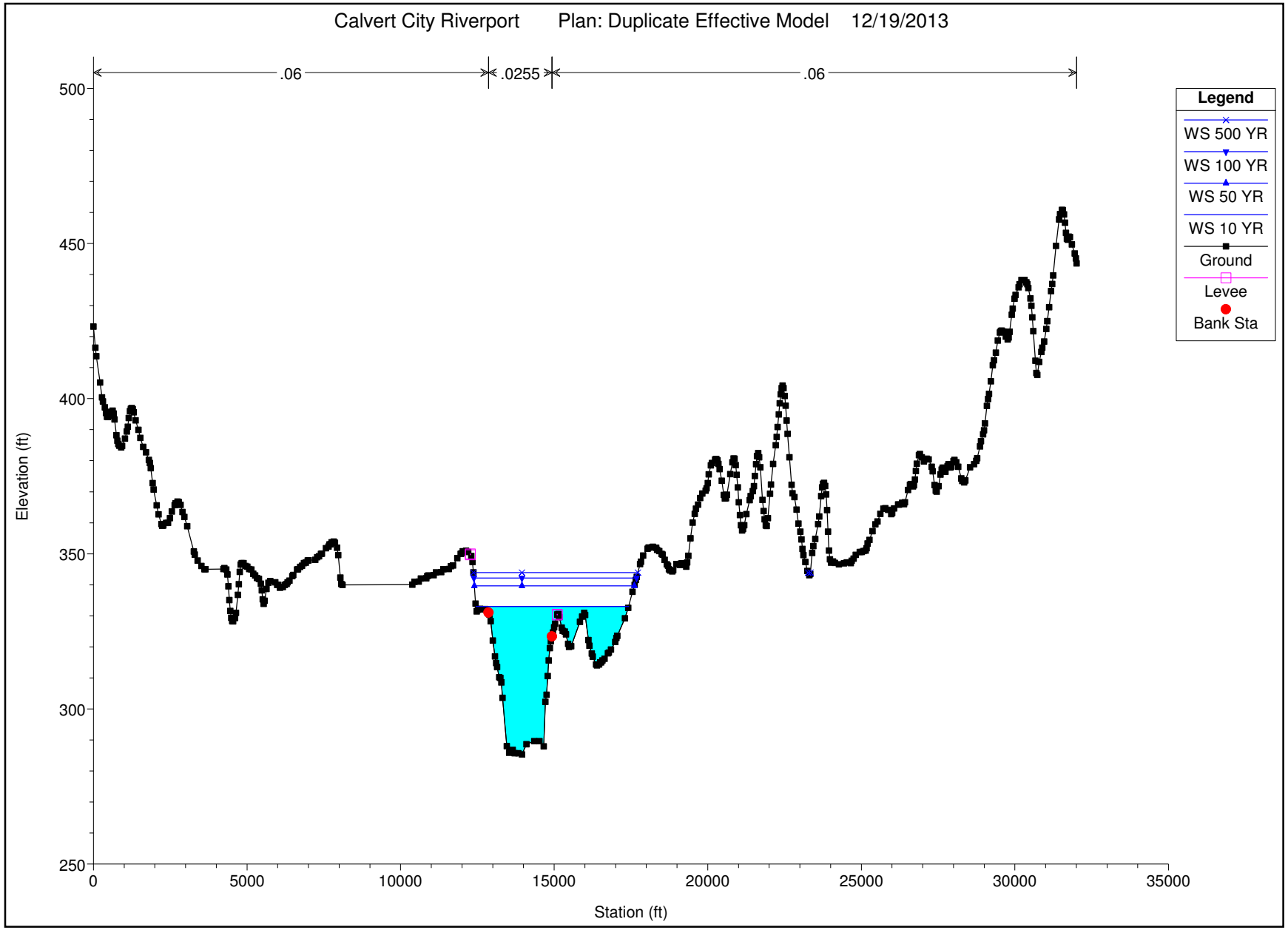
Station (ft)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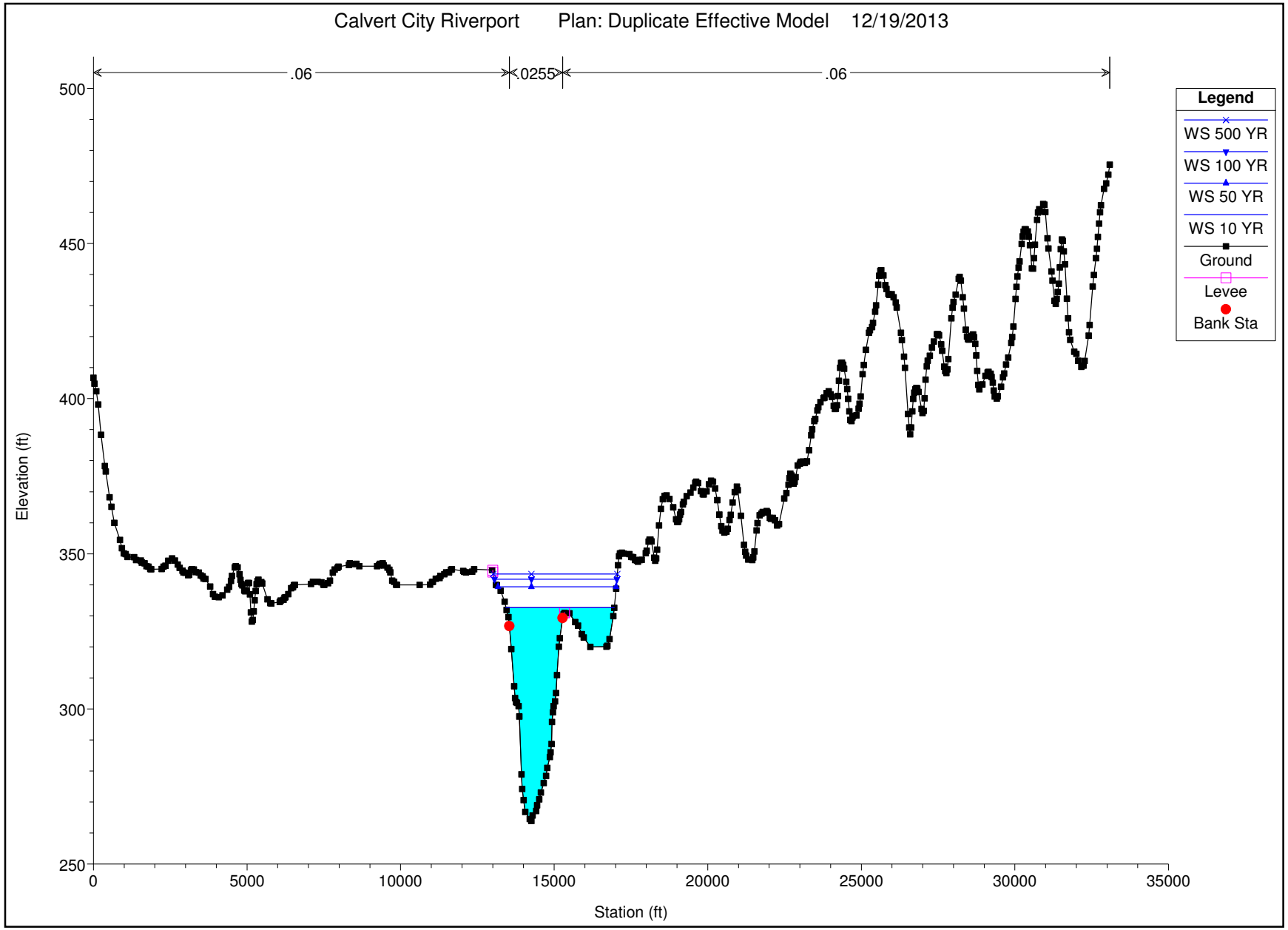
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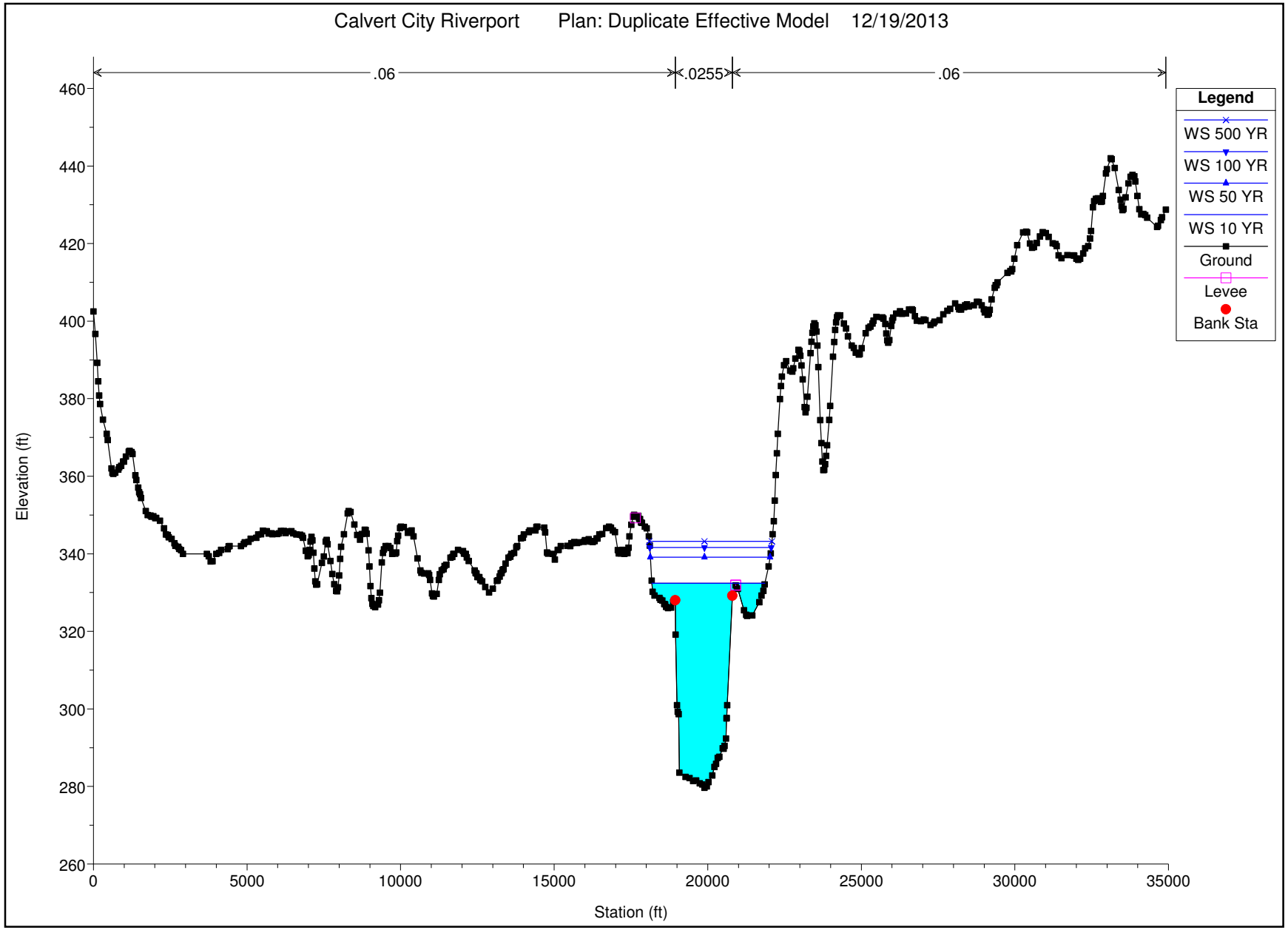
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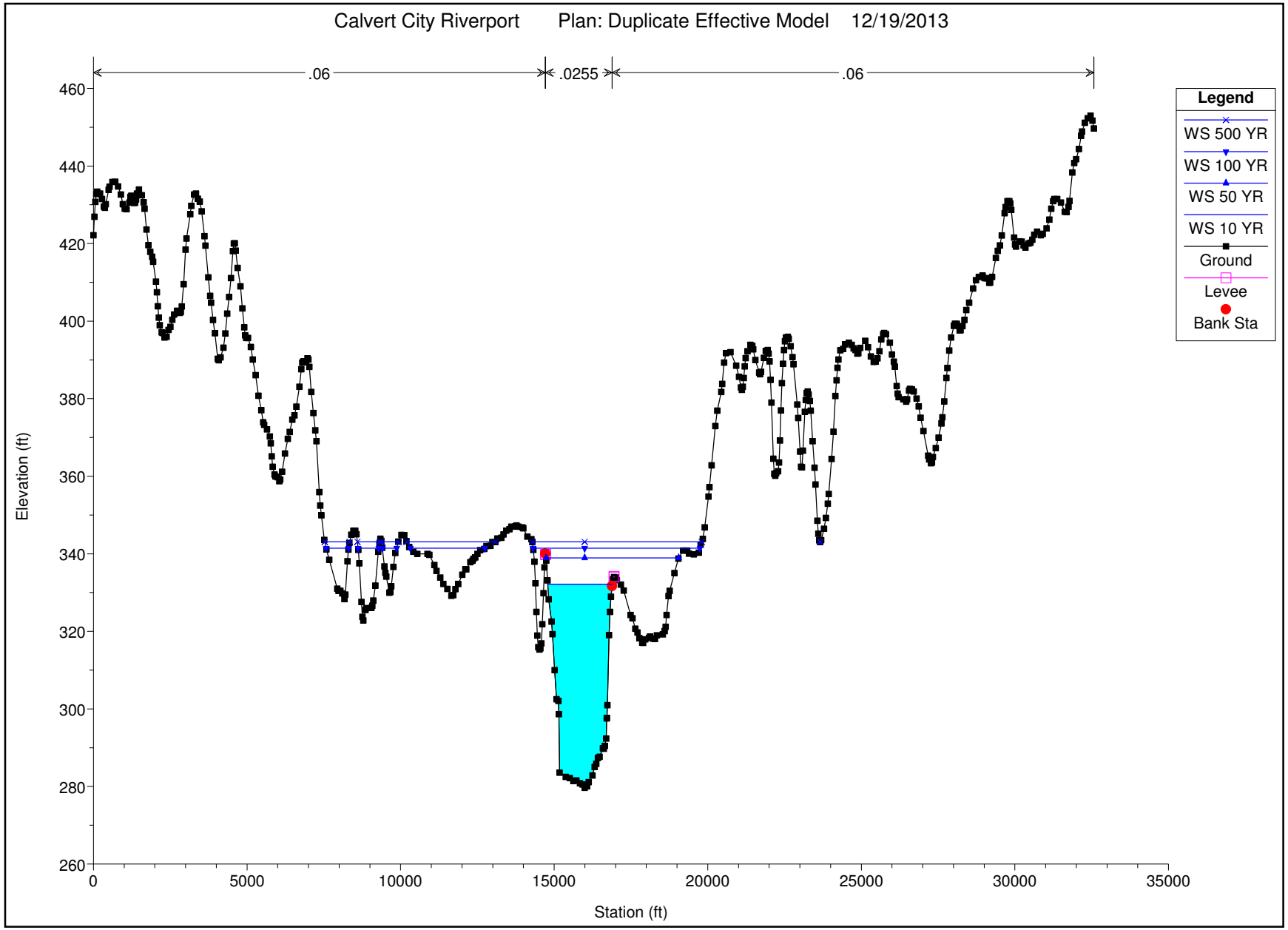
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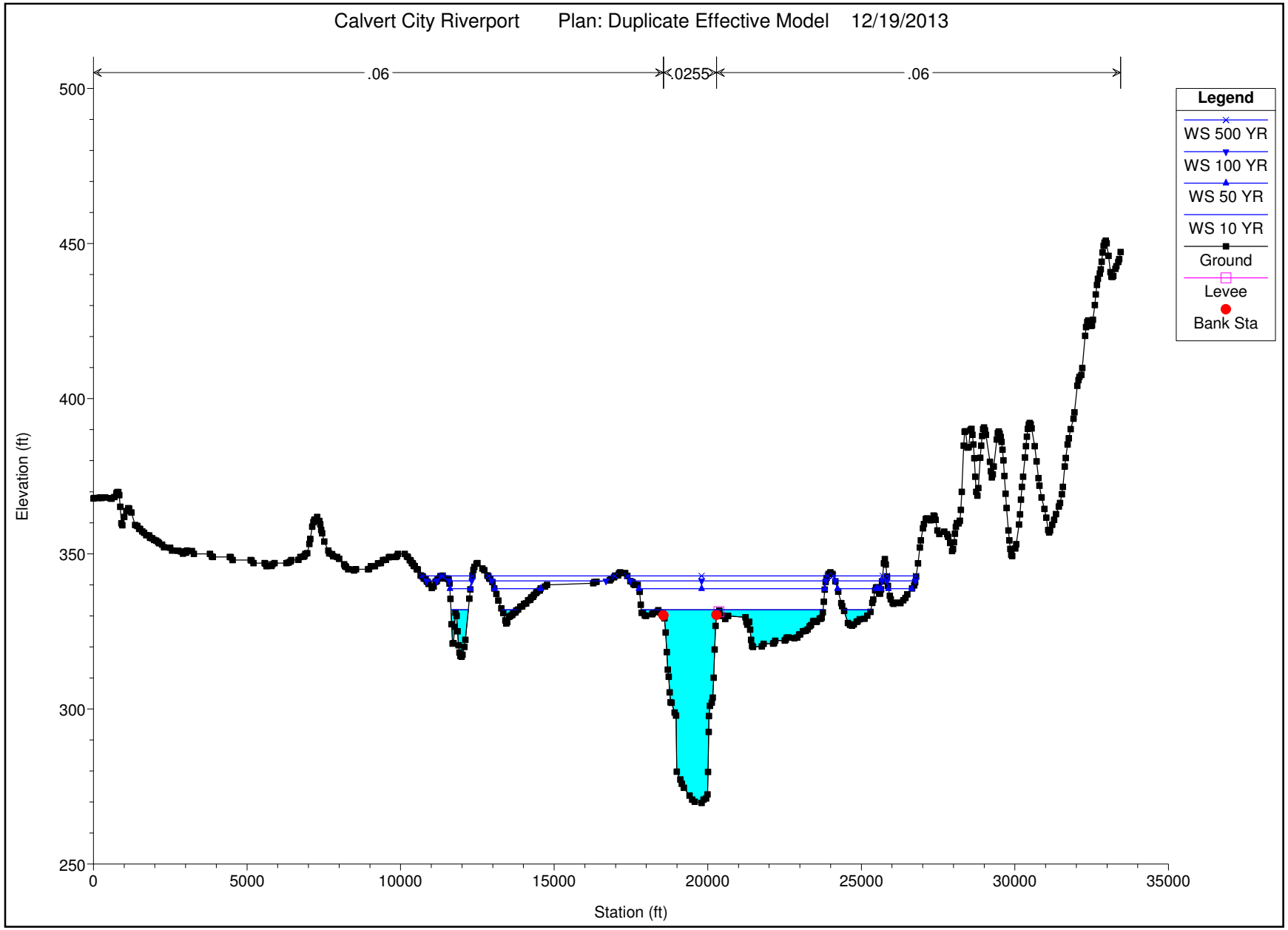
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WS 100 YR
WS 50 YR
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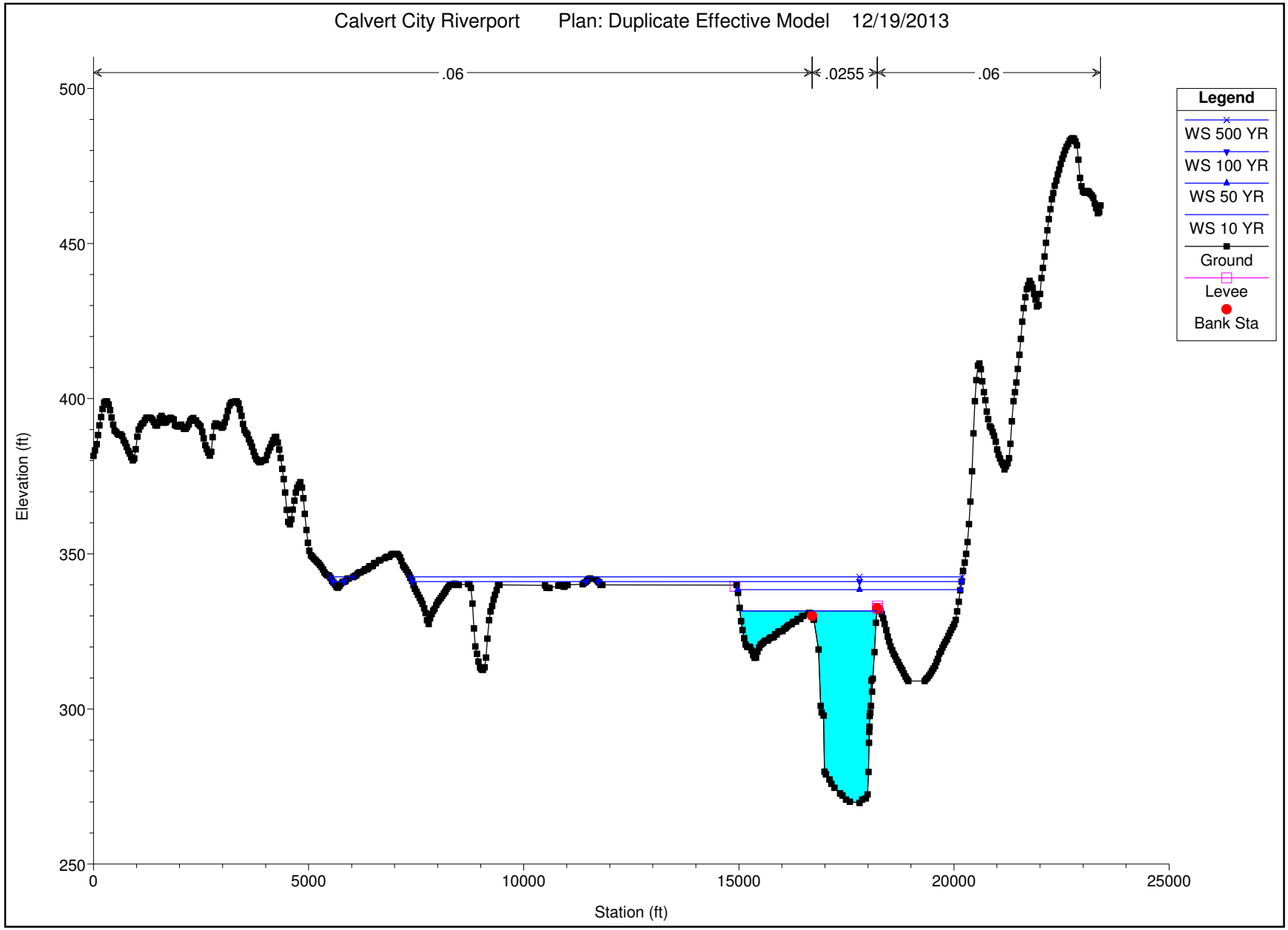
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WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
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Elevation (ft)
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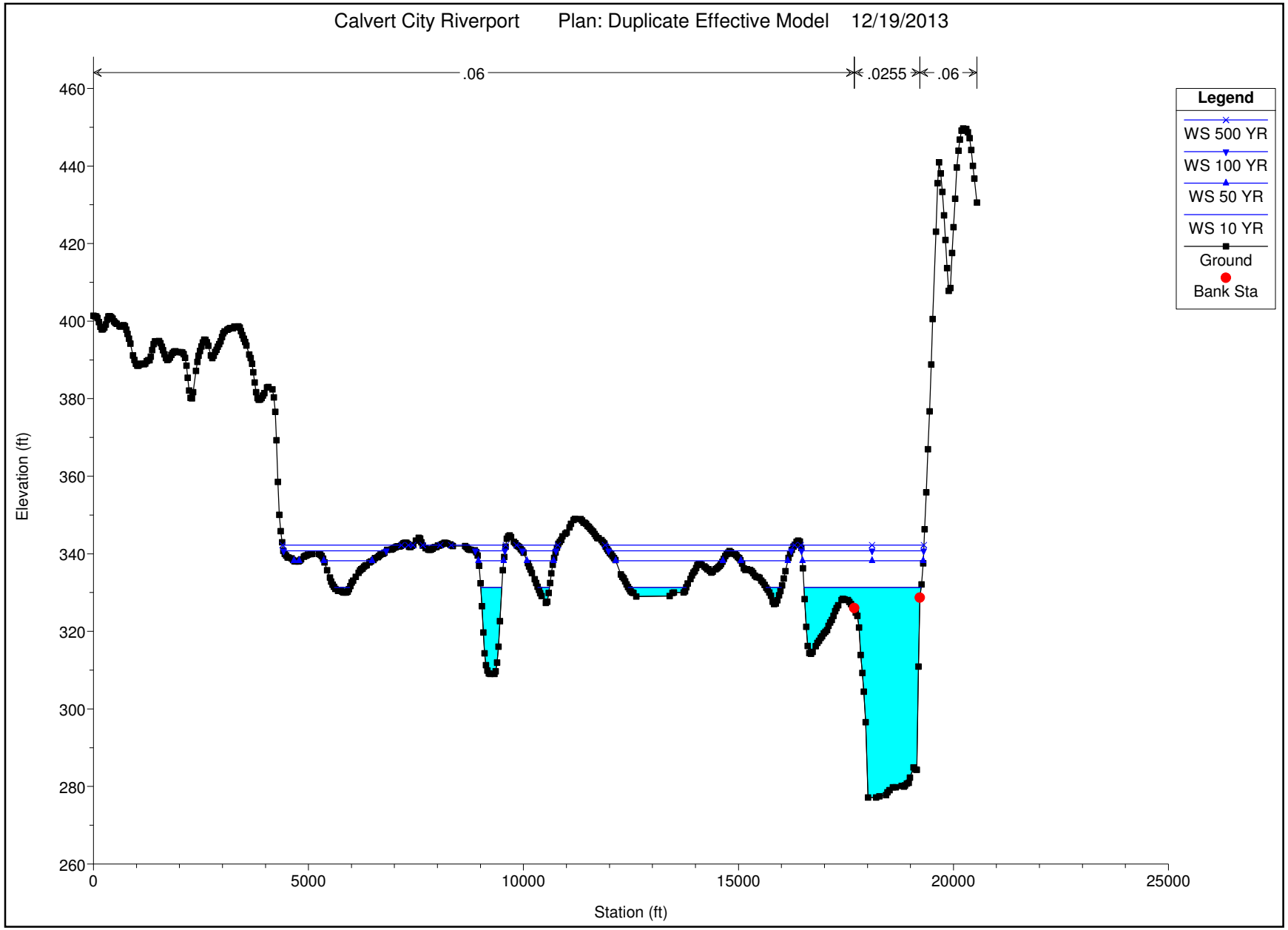
Station (ft)


Calvert City Riverport Plan: Duplicate Effective Model 12/19/2013
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Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
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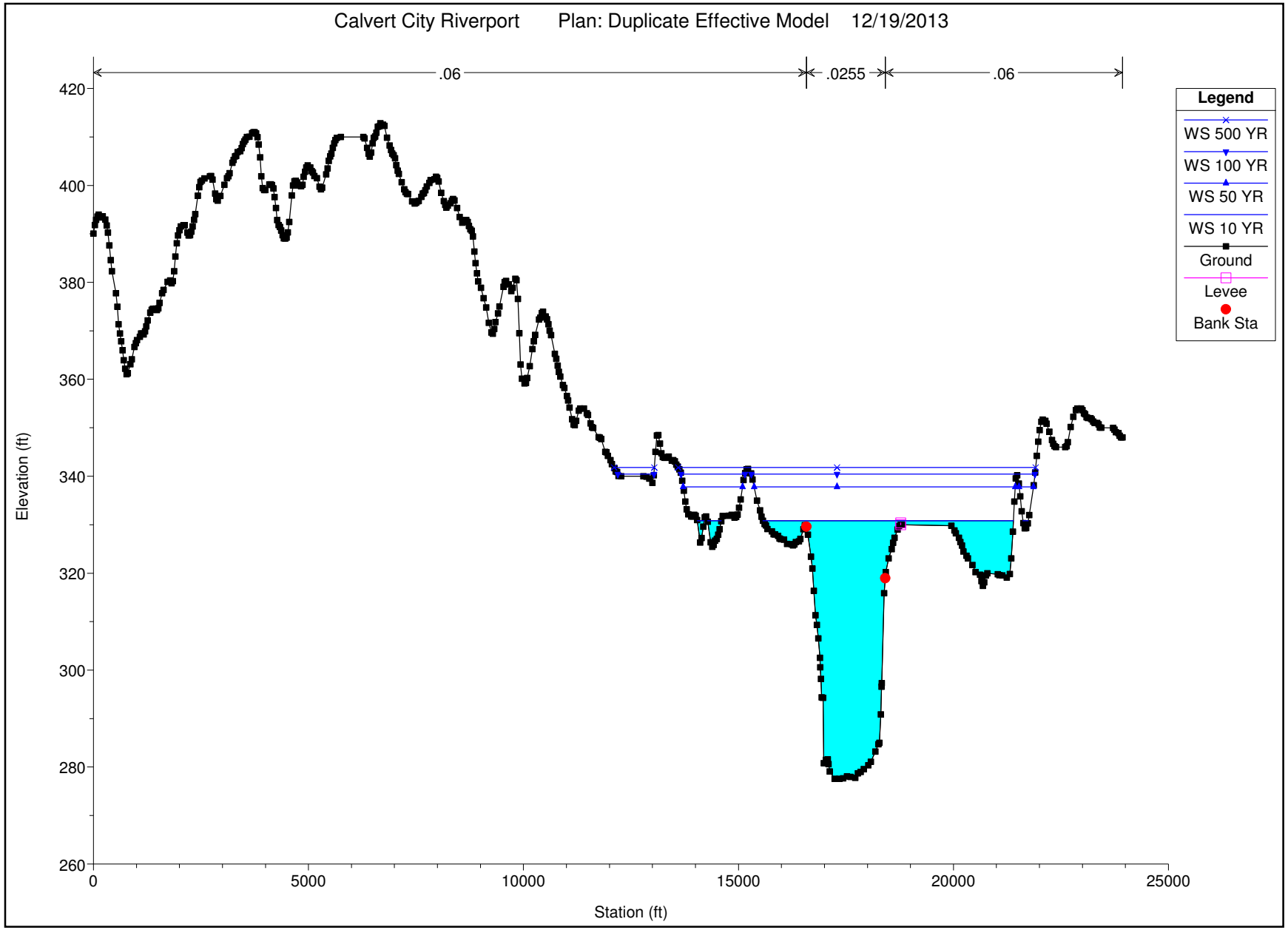
Station (ft)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.0255
.06
Legend
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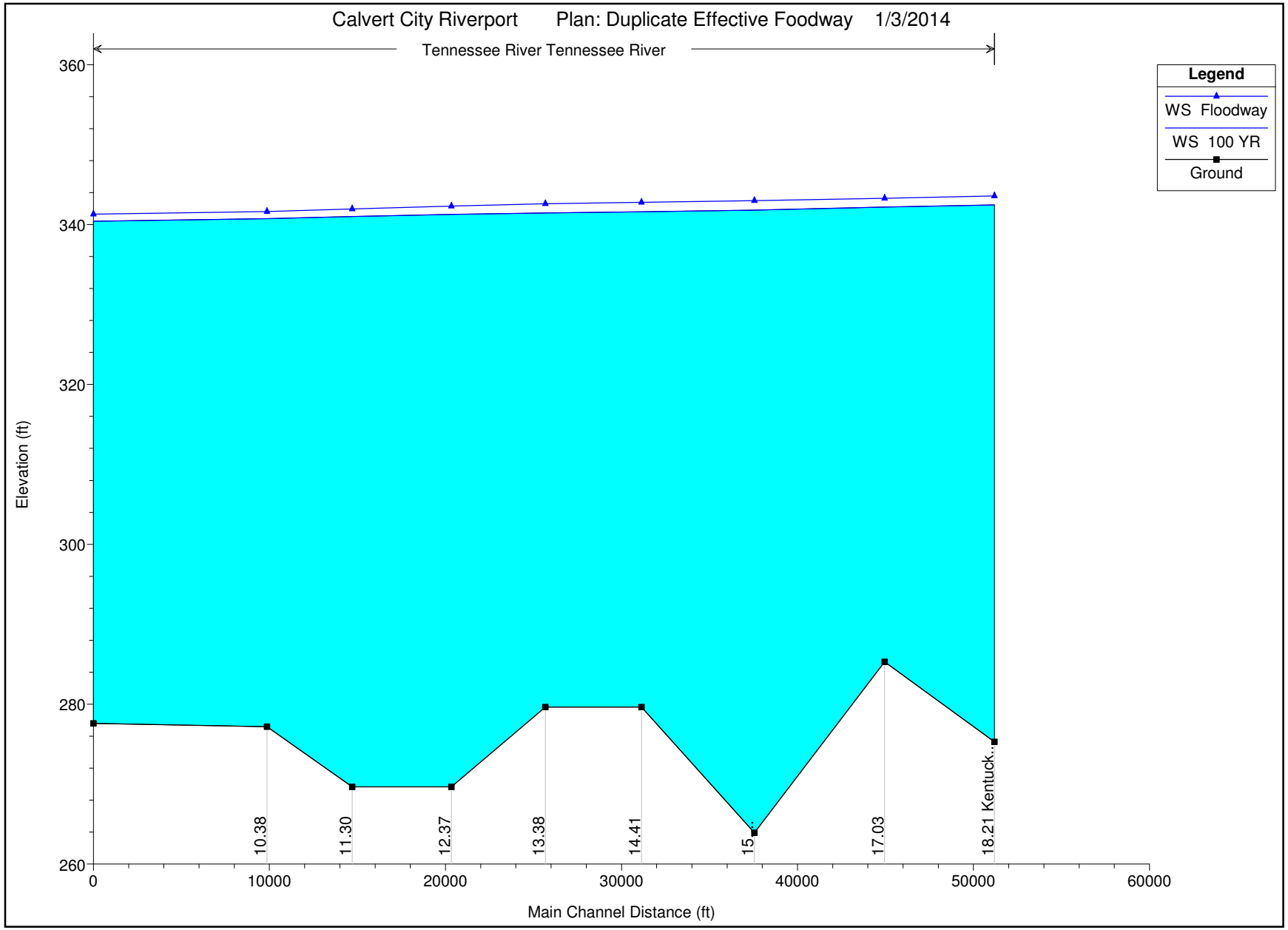
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
Station (ft)

HEC-RAS Plan: Dup Eff Flood River: Tennessee River Reach: Tennessee River

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Tennessee River	8.52	100 YR	340.42		340.74	8922.88	19025.66	458334.70	39639.68		16580.49	18413.81	
Tennessee River	8.52	Floodway	341.32	0.90	341.71	3592.00	10733.19	496240.20	10026.67	15727.00	16580.49	18413.81	19319.00
Tennessee River	10.38	100 YR	340.75		341.16	10952.77	67300.30	449315.90	383.79		17692.81	19220.38	
Tennessee River	10.38	Floodway	341.64	0.89	342.22	2092.30	7282.30	509214.80	502.84	17220.00	17692.81	19220.38	19464.00
Tennessee River	11.30	100 YR	341.01		341.37	12748.24	24229.85	437385.50	55384.70		16705.15	18217.82	
Tennessee River	11.30	Floodway	341.95	0.95	342.47	2466.00	4926.06	501250.80	10823.13	16259.00	16705.15	18217.82	18725.00
Tennessee River	12.37	100 YR	341.28		341.57	13611.63	18536.31	439279.50	59184.22		18556.83	20288.50	
Tennessee River	12.37	Floodway	342.31	1.03	342.73	3215.50	6703.09	504011.10	6285.76	17702.50	18556.83	20288.50	20918.00
Tennessee River	13.38	100 YR	341.47		341.75	9729.05	21157.71	466734.10	29108.23		14714.13	16884.17	
Tennessee River	13.38	Floodway	342.62	1.15	342.94	3662.83	6213.75	493768.20	17018.03	14290.00	14714.13	16884.17	17960.00
Tennessee River	14.41	100 YR	341.60		341.97	3953.97	8956.77	494901.00	13142.22		18941.33	20800.00	
Tennessee River	14.41	Floodway	342.78	1.18	343.14	3388.38	9937.27	497425.50	9637.28	17978.50	18941.33	20800.00	21490.00
Tennessee River	15.63	100 YR	341.83		342.22	3984.04	1397.15	485170.70	30432.16		13539.42	15277.83	
Tennessee River	15.63	Floodway	342.98	1.16	343.39	3313.21	1811.62	496522.40	18665.99	12979.00	13539.42	15277.83	16341.00
Tennessee River	17.03	100 YR	342.20		342.54	5291.18	3389.68	457239.40	56370.96		12863.34	14926.95	
Tennessee River	17.03	Floodway	343.29	1.09	343.73	2867.50	4293.61	507394.50	5311.91	12344.00	12863.34	14926.95	15246.00
Tennessee River	18.21	100 YR	342.47		342.79	9106.00	57741.96	435401.30	23856.69		14187.33	15772.74	
Tennessee River	18.21	Floodway	343.59	1.12	344.02	3057.00	13749.56	487451.60	15798.86	13404.00	14187.33	15772.74	16461.00


Calvert City Riverport Plan: Duplicate Effective Foodway 1/3/2014
Tennessee River Tennessee River
Legend
WS Floodway
WS 100 YR
Ground
Elevation (ft)
360
340
320
300
280
260
0
10000
20000
30000
40000
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Main Channel Distance (ft)
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11.30
12.37
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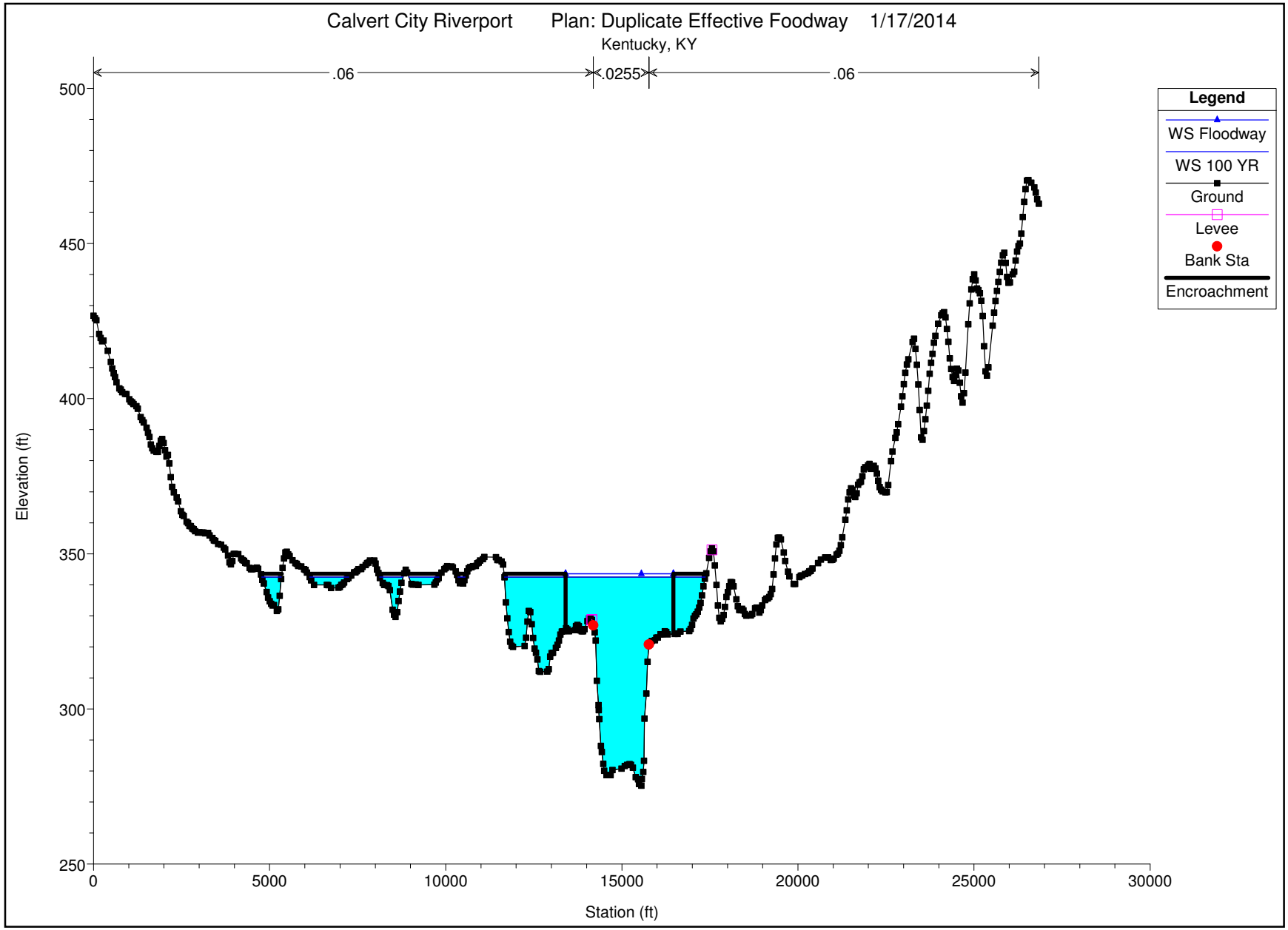
15...
17.03
18.21 Kentuck...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Kentucky, KY
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
500
450
400
350
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5000
10000
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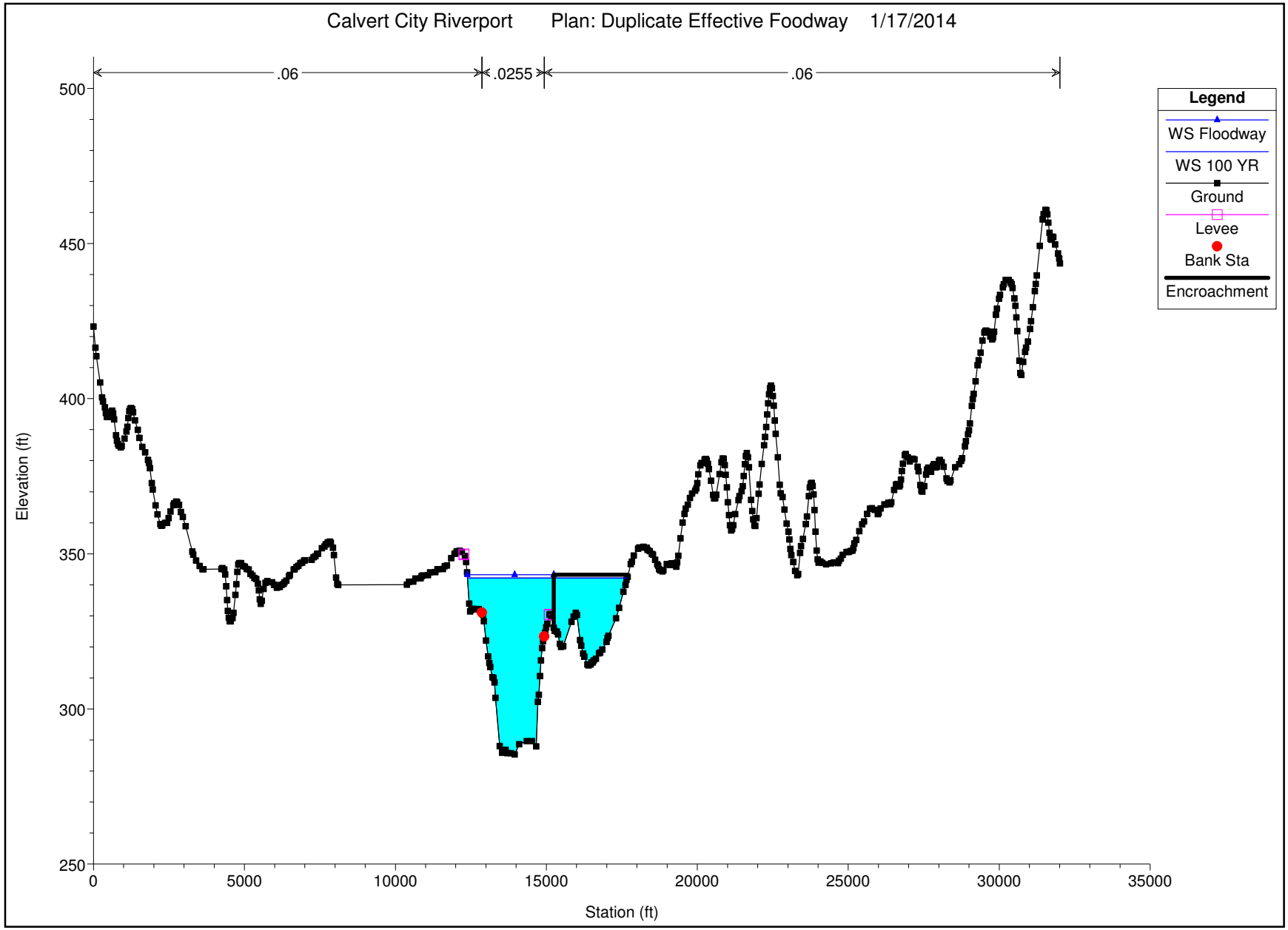
20000
25000
30000
Station (ft)


Calvert City Riverport Plan: Duplicate Effective Foodway 1/17/2014
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.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
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400
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250
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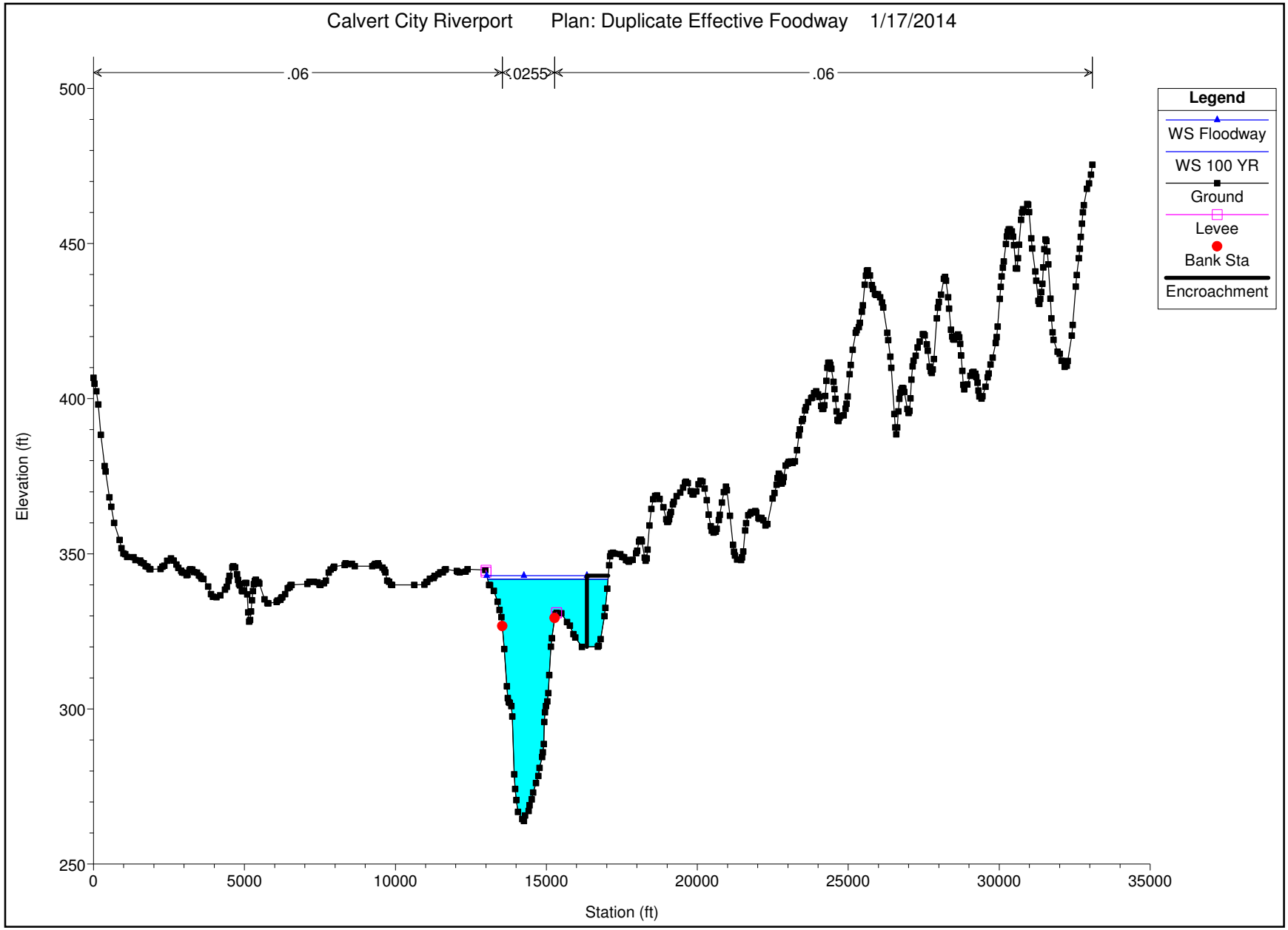
Station (ft)


Calvert City Riverport Plan: Duplicate Effective Foodway 1/17/2014
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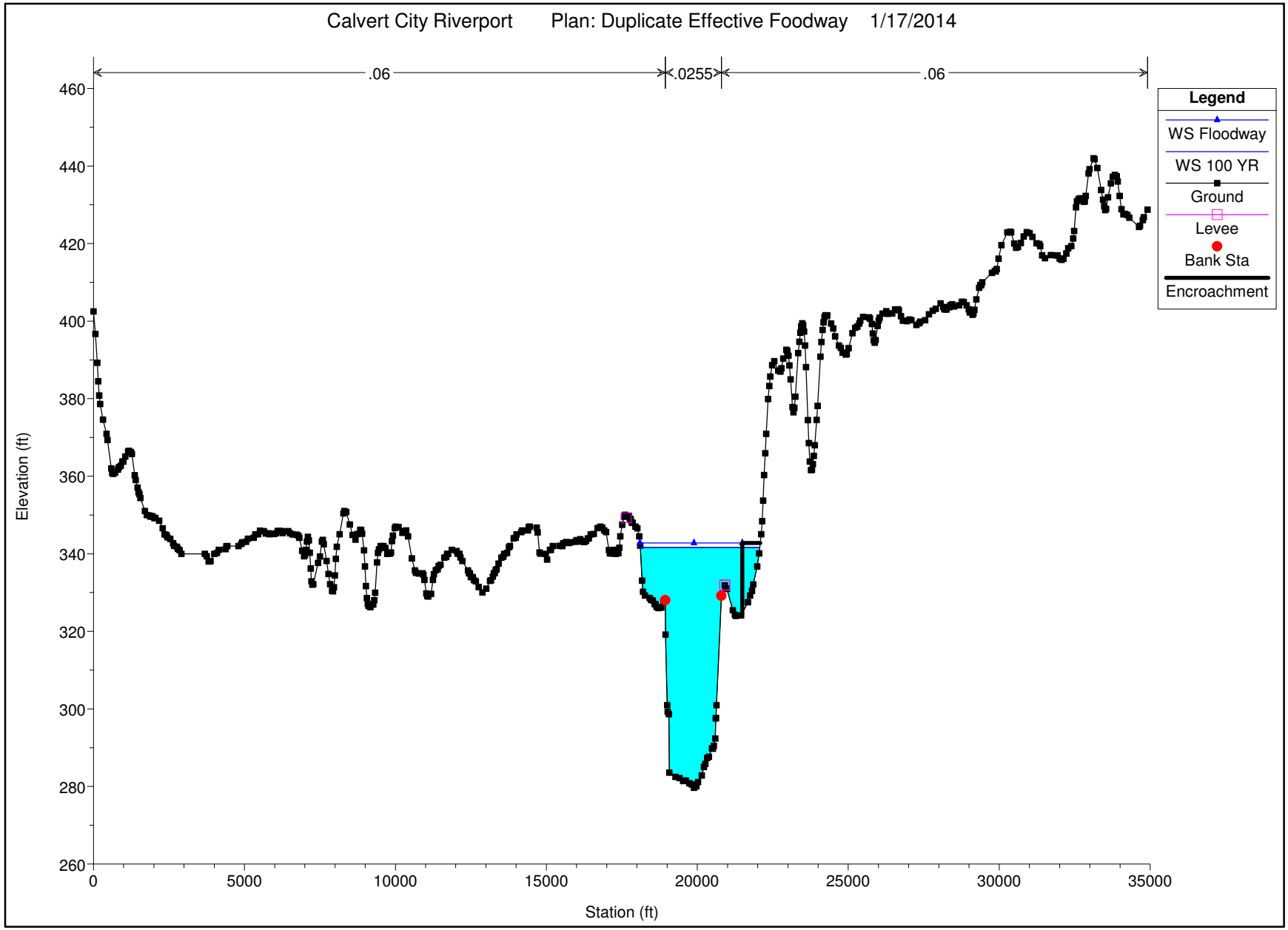
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Duplicate Effective Foodway 1/17/2014
.06
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Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
460
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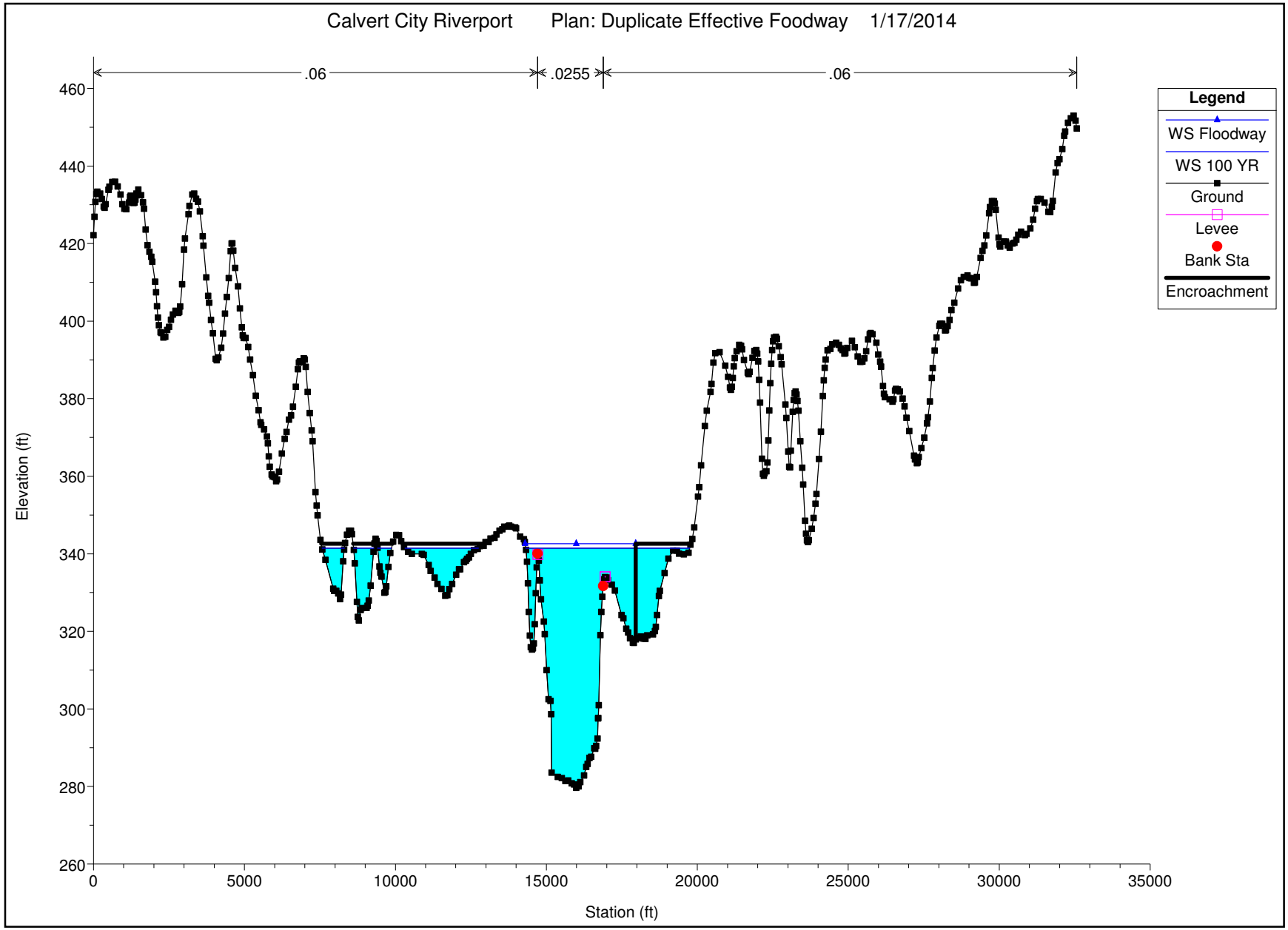
Station (ft)


Calvert City Riverport Plan: Duplicate Effective Foodway 1/17/2014
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Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
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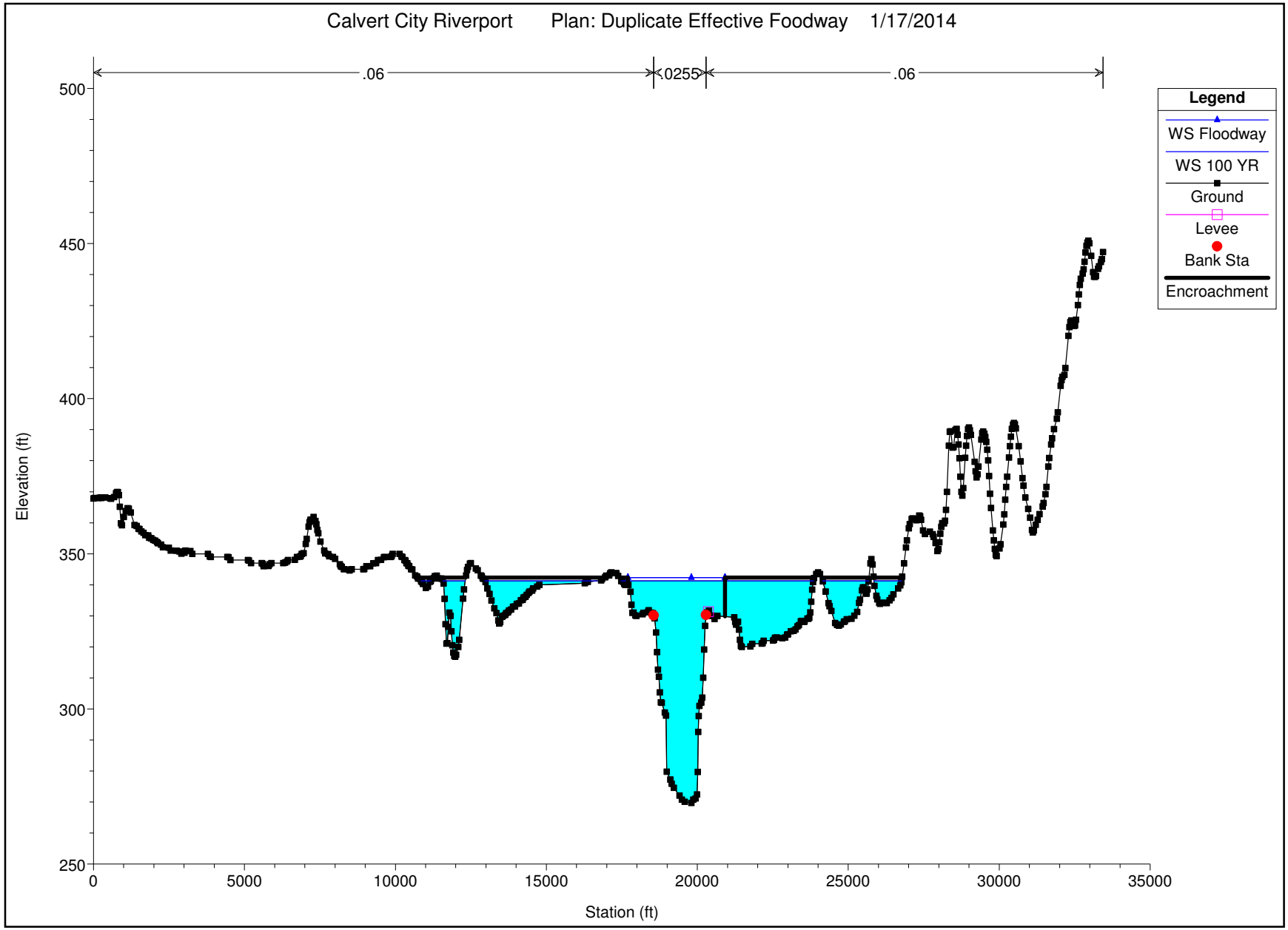
Station (ft)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Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
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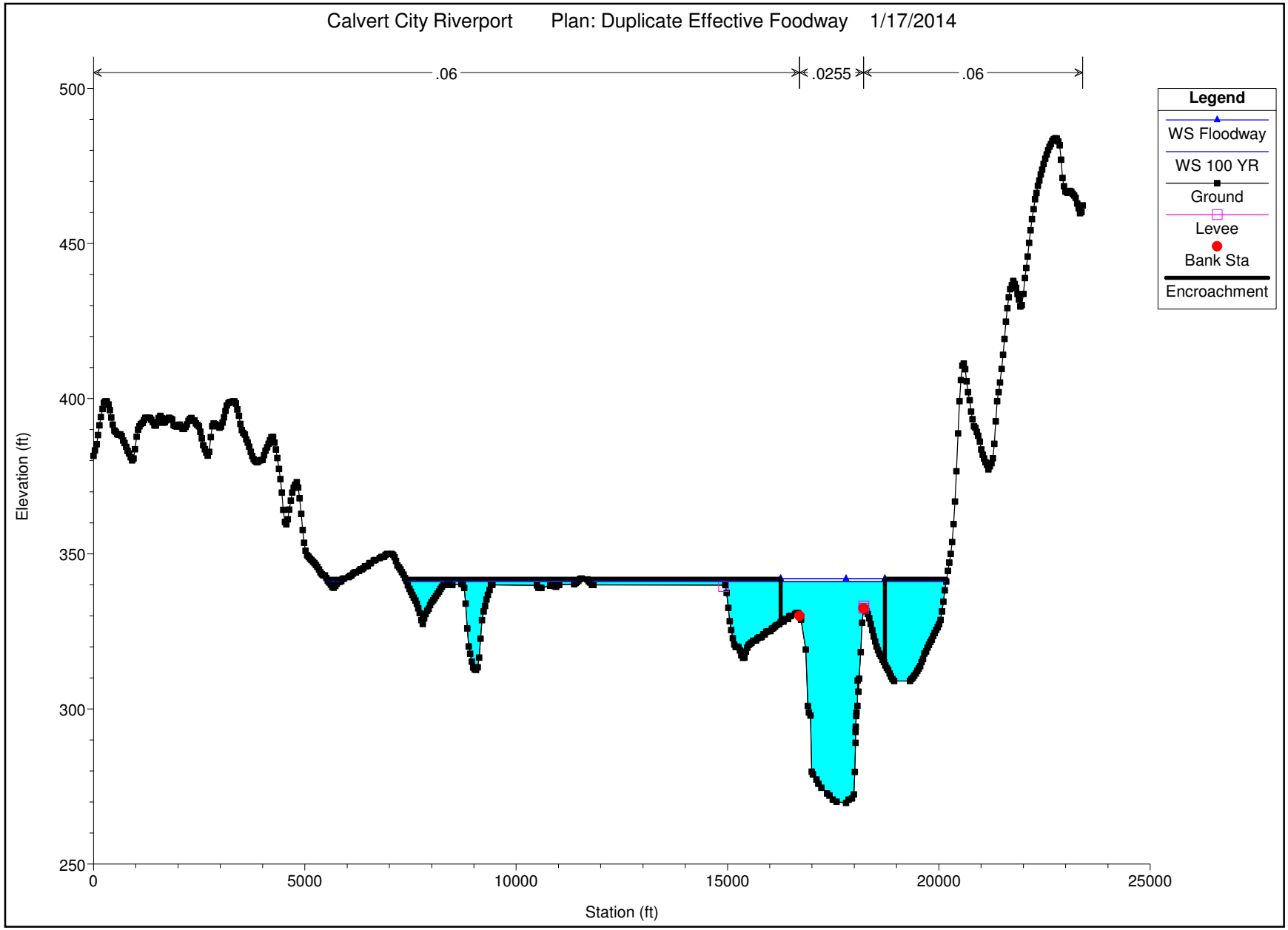
Station (ft)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Legend
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WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
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20000
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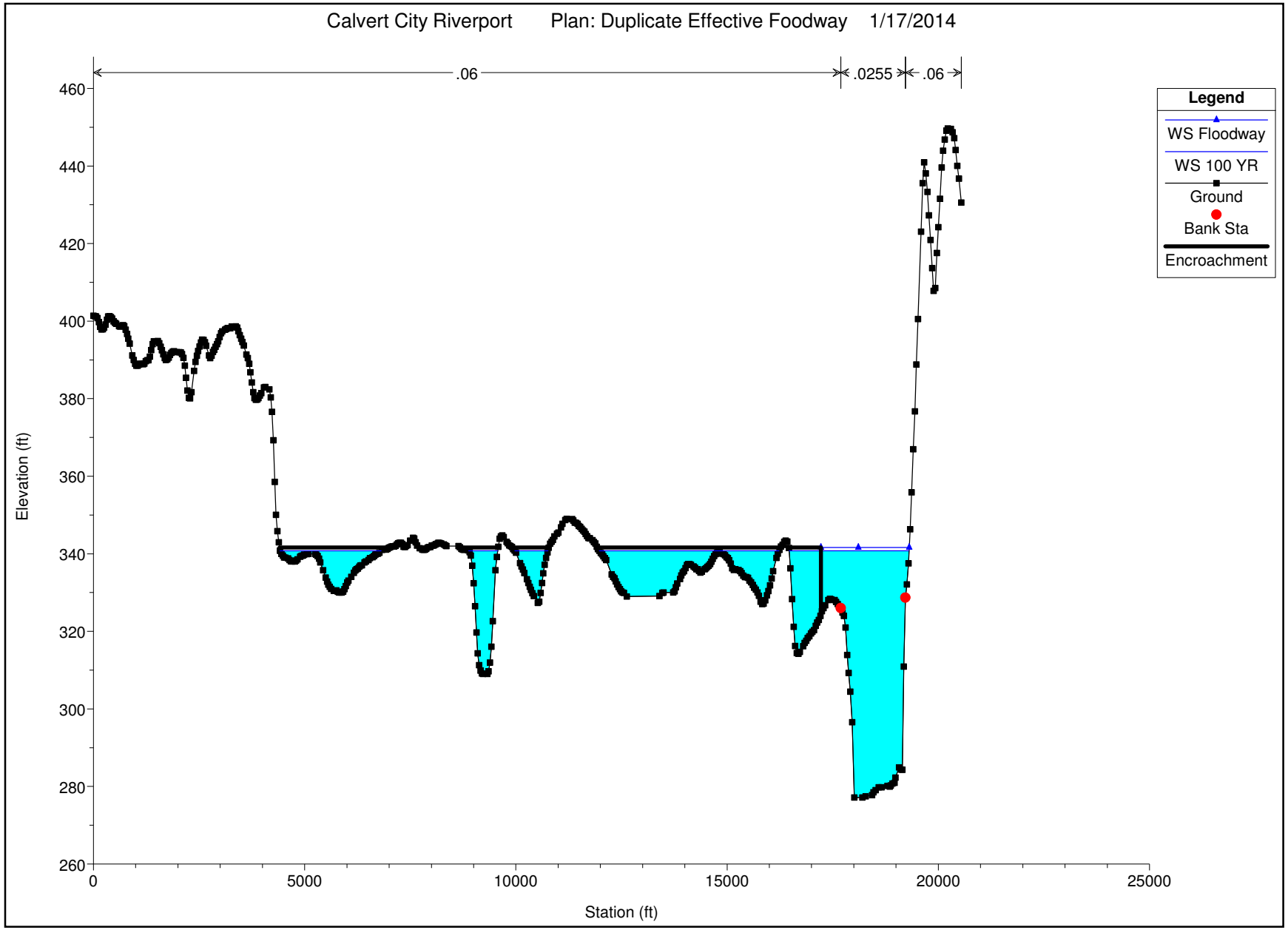
Station (ft)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WS Floodway
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Encroachment
Elevation (ft)
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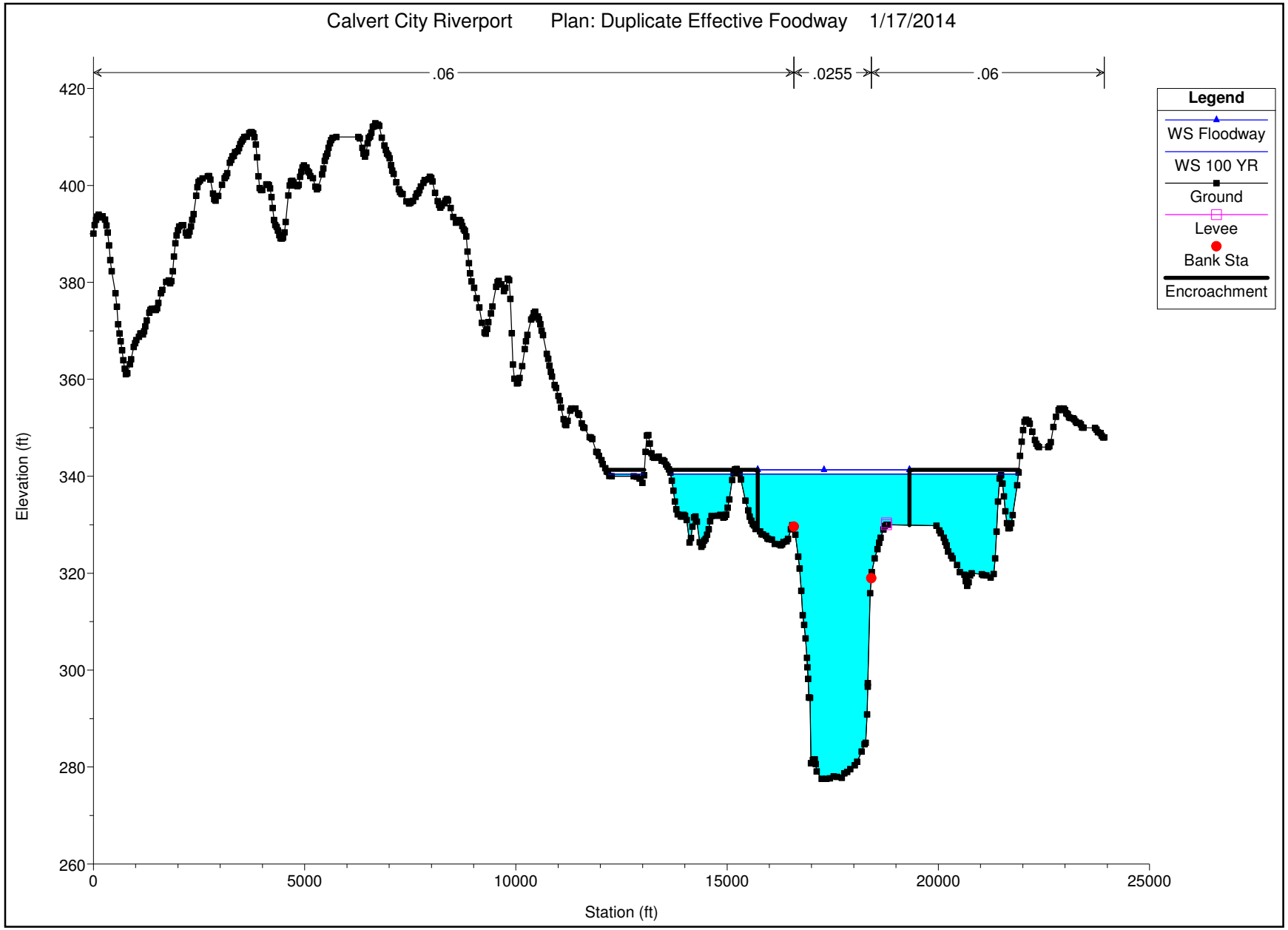
Station (ft)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Encroachment
Elevation (ft)
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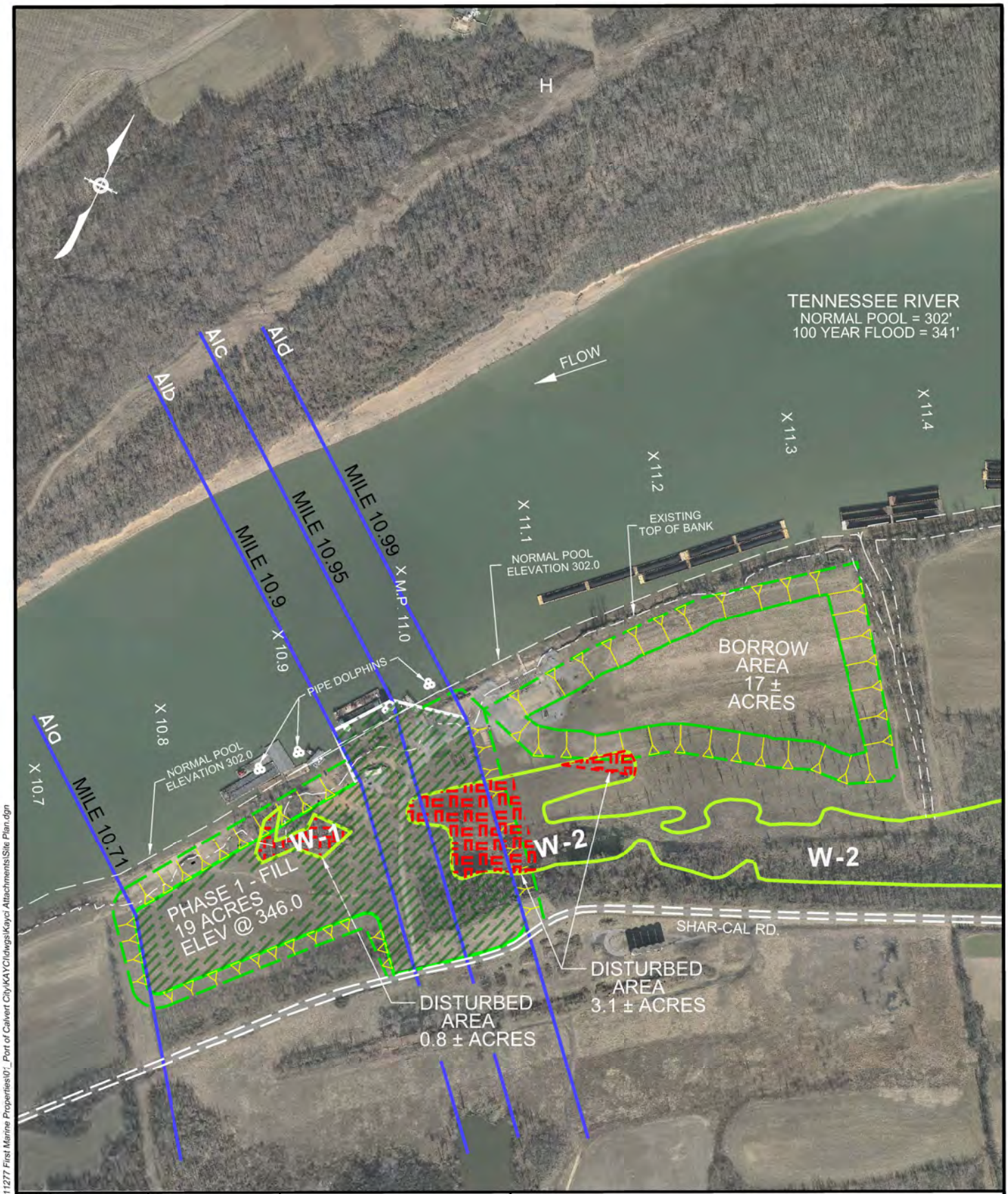
Station (ft)

Appendix III
Site Plan, Cross Sections, & Flood Mapping

ICA Engineering



PROJECT No.: 11277-01	DATE: 1/21/2014	STATE: KENTUCKY	PROJECT: FIRST MARINE PROPERTIES
ICA Engineering	2550 Irvin Cobb Drive Paducah, KY 42003 270.444.9691 www.icaeng.com	COUNTY: MARSHALL	TOPO QUAD: PORT OF CALVERT CITY
		SCALE: 0' 500'	DRAWING: PROPOSED SITE PLAN

E:_2011 JOBS\11277 First Marine Properties\01_Port of Calvert City\KAYCI\dwgs\Kayci Attachments\Site Plan.dgn
1/30/2014

ICA Engineering
2550 Irvin Cobb Drive
Paducah, KY 42003
270.444.9691
www.icaeng.com

ICA ENG. JOB NO.: 11277-01

DATE: 1-17-14

STATE: KENTUCKY

COUNTY: MARSHALL

WATER BODY: TENNESSEE RIVER

MILE POINT: 10.9

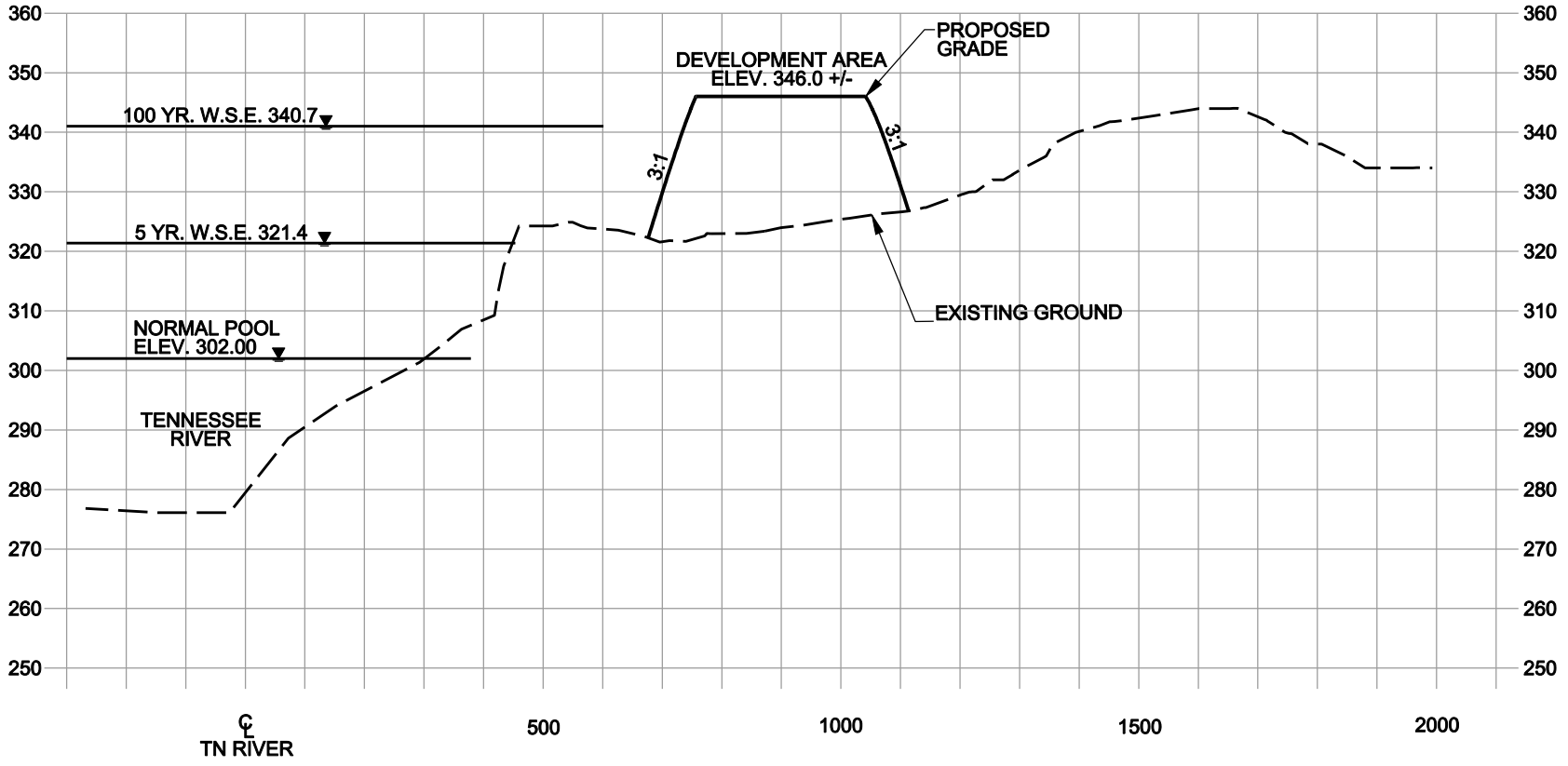
SCALE: 0' 0' HORIZONTAL 300' 30' VERTICAL

PROJECT: PORT OF CALVERT CITY

OWNER: FIRST MARINE PROPERTIES

DRAWING: SECTION A1a

NO.: 2



A1a SECTION
MILE 10.71

ICA Engineering
2550 Irvin Cobb Drive
Paducah, KY 42003
270.444.9691
www.icaeng.com

ICA ENG. JOB NO.: 11277-01

DATE: 1-21-14

STATE: KENTUCKY

COUNTY: MARSHALL

WATER BODY: TENNESSEE RIVER

MILE POINT: 10.9

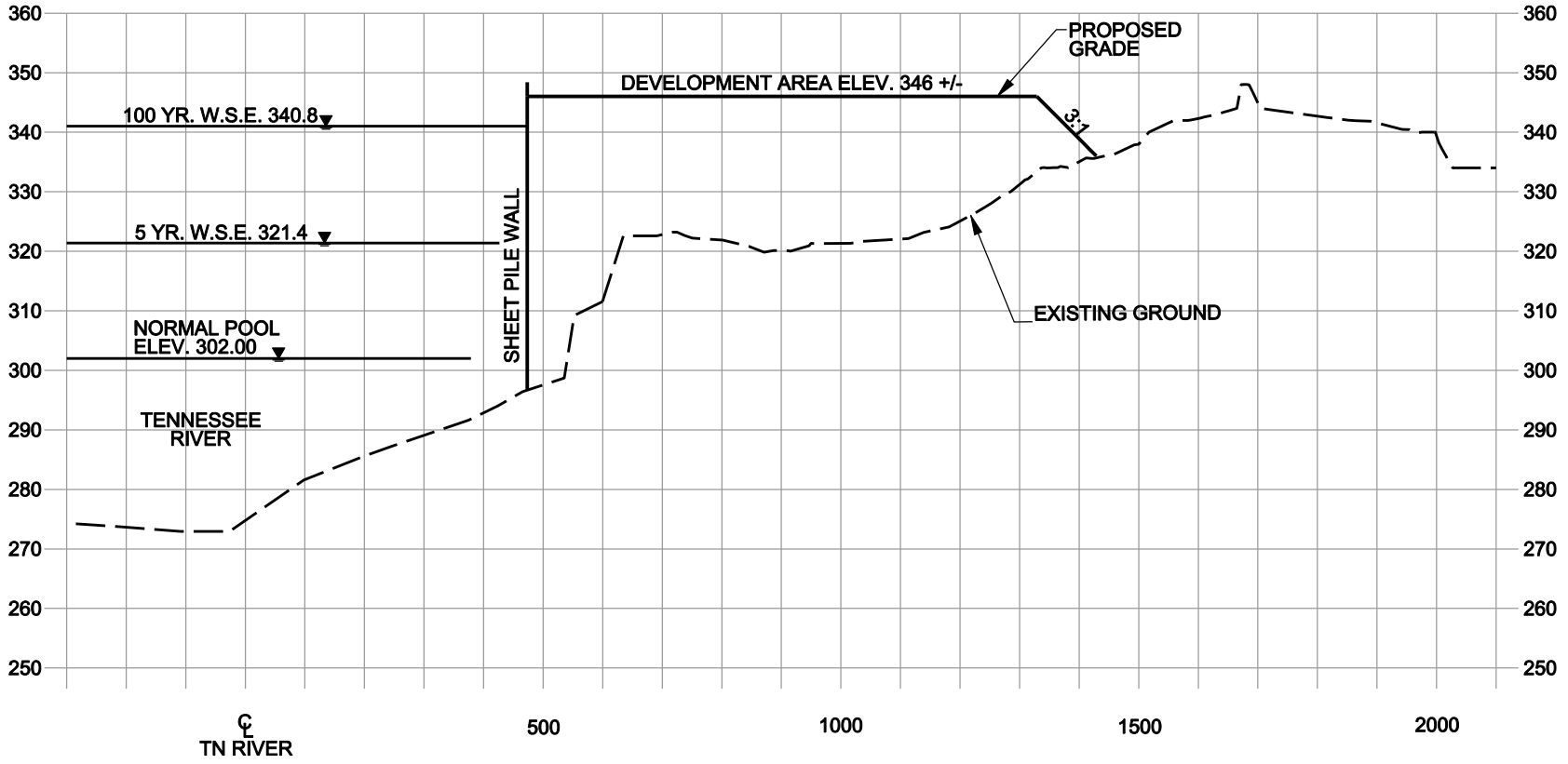
SCALE: 0' 300' HORIZONTAL; 0' 30' VERTICAL

PROJECT: PUBLIC PORT OF CALVERT CITY

OWNER: FIRST MARINE PROPERTIES

DRAWING: SECTION A1b

NO.: 3



A1b SECTION
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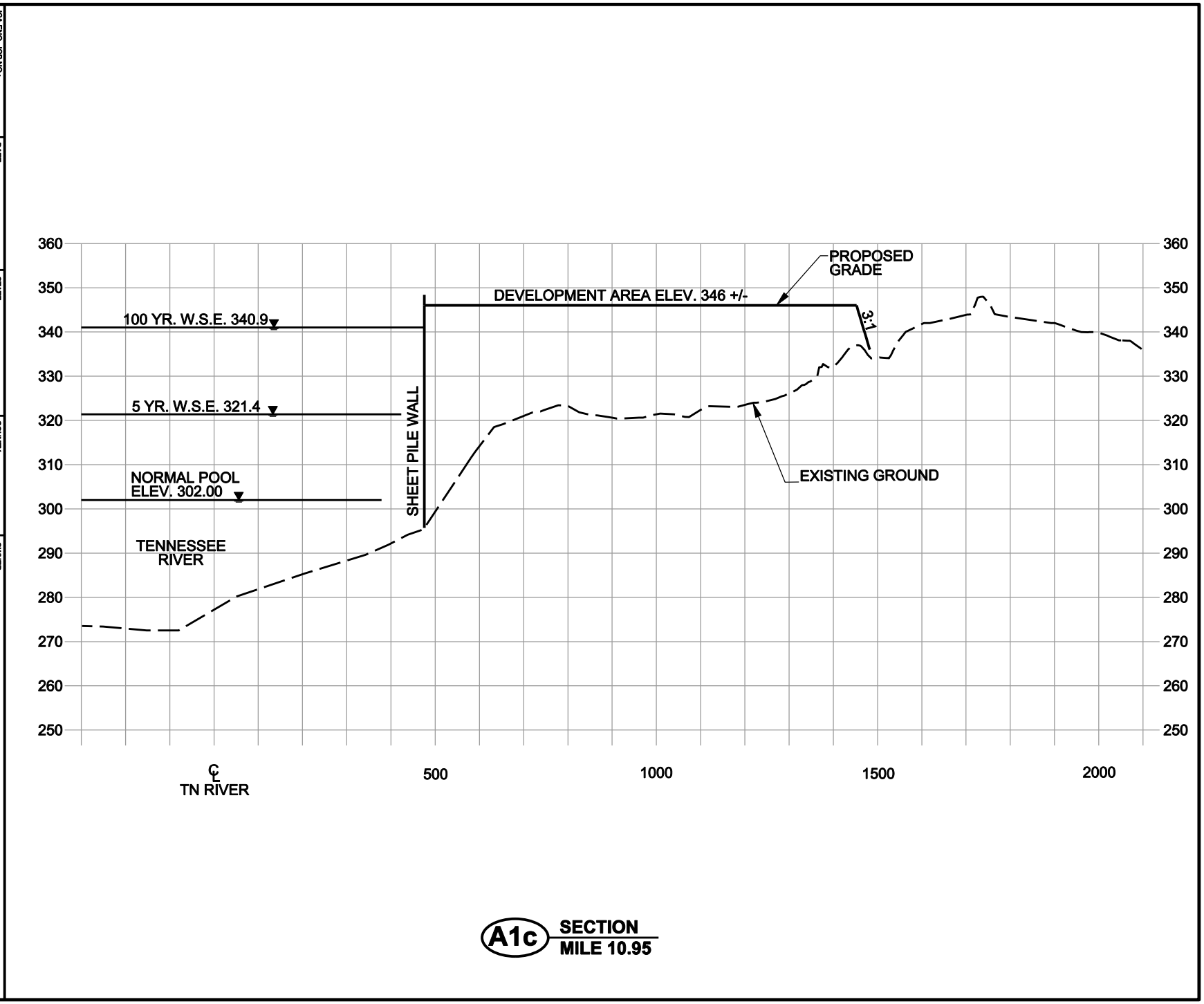


ICA Engineering
2550 Irvin Cobb Drive
Paducah, KY 42003
270.444.9691
www.icaeng.com

ICA ENG. JOB NO.: 11277-01
DATE: 1-21-14
STATE: KENTUCKY
COUNTY: MARSHALL
WATER BODY: TENNESSEE RIVER
MILE POINT: 10.9
SCALE: 0' 300' HORIZONTAL; 0' 30' VERTICAL
OWNER: FIRST MARINE PROPERTIES
PROJECT: PUBLIC PORT OF CALVERT CITY
DRAWING: SECTION A1c
NO.: 4

ICA Engineering
2550 Irvin Cobb Drive
Paducah, KY 42003
270.444.9691
www.icaeng.com

ICA ENG. JOB NO.: 11277-01

DATE: 1-21-14

STATE: KENTUCKY

COUNTY: MARSHALL

WATER BODY: TENNESSEE RIVER

MILE POINT: 10.9

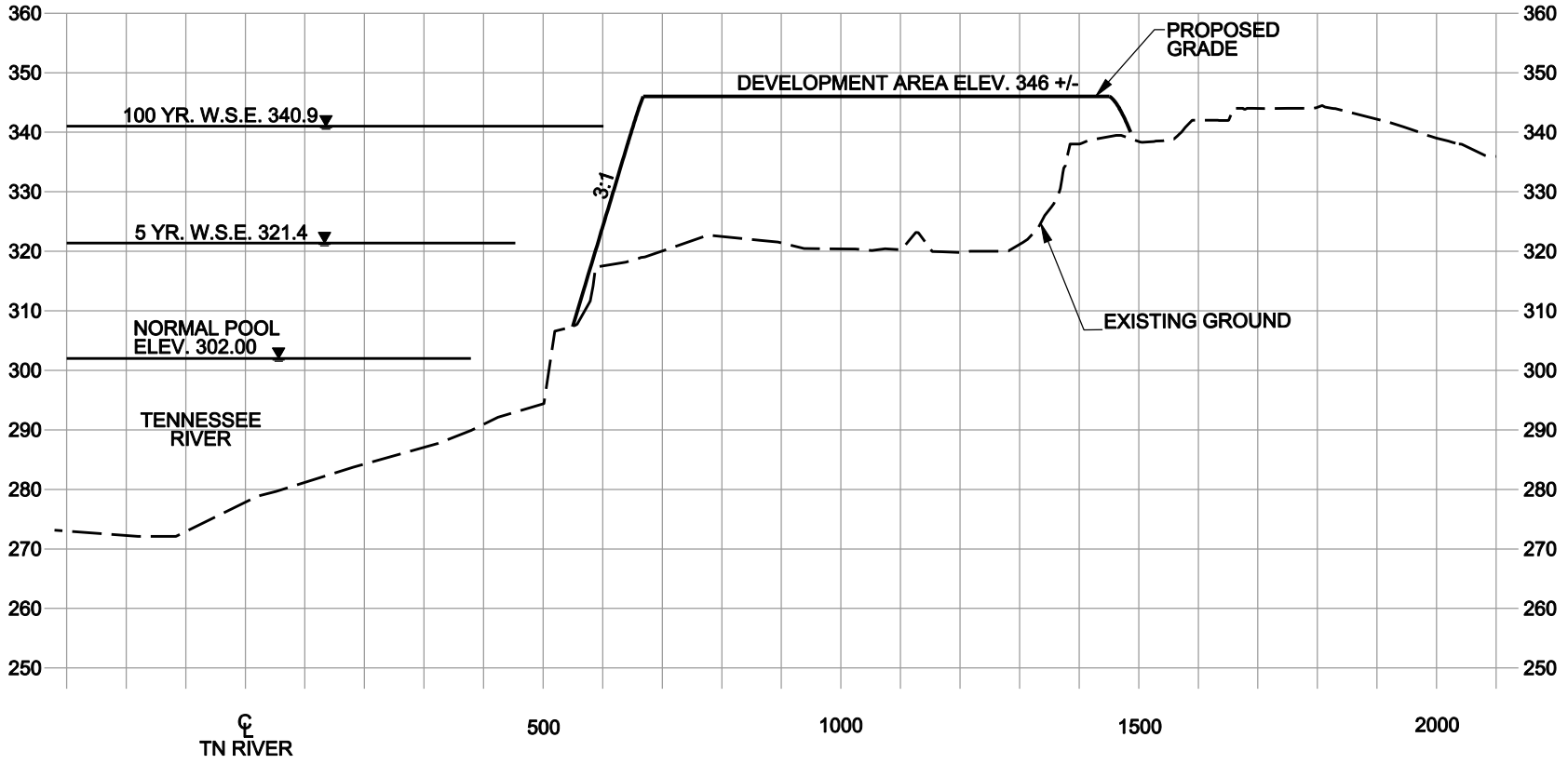
SCALE: 0' 0' HORIZONTAL 300' 30' VERTICAL

PROJECT: PUBLIC PORT OF CALVERT CITY

OWNER: FIRST MARINE PROPERTIES

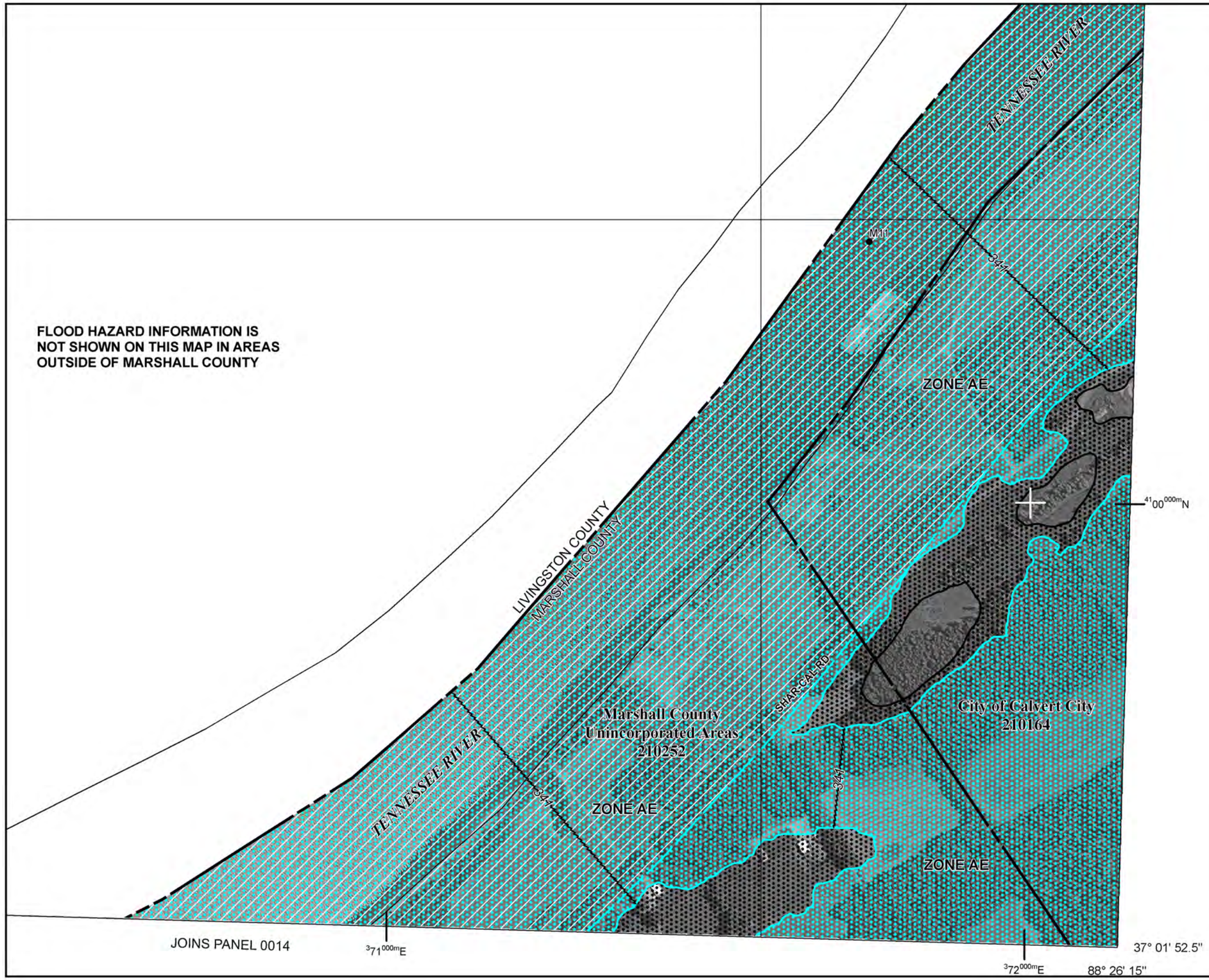
DRAWING: SECTION A1d

NO.: 5



A1d SECTION
MILE 10.99

FLOOD HAZARD INFORMATION IS NOT SHOWN ON THIS MAP IN AREAS OUTSIDE OF MARSHALL COUNTY



MAP SCALE 1" = 500'

60 0 500 1000 FEET

NFIP

PANEL 0012E

FIRM

FLOOD INSURANCE RATE MAP

MARSHALL COUNTY, KENTUCKY

AND INCORPORATED AREAS

PANEL 12 OF 325

(SEE LOCATOR DIAGRAM OR MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
CALVERT CITY, CITY OF	210164	0012	E
MARSHALL COUNTY	210252	0012	E

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

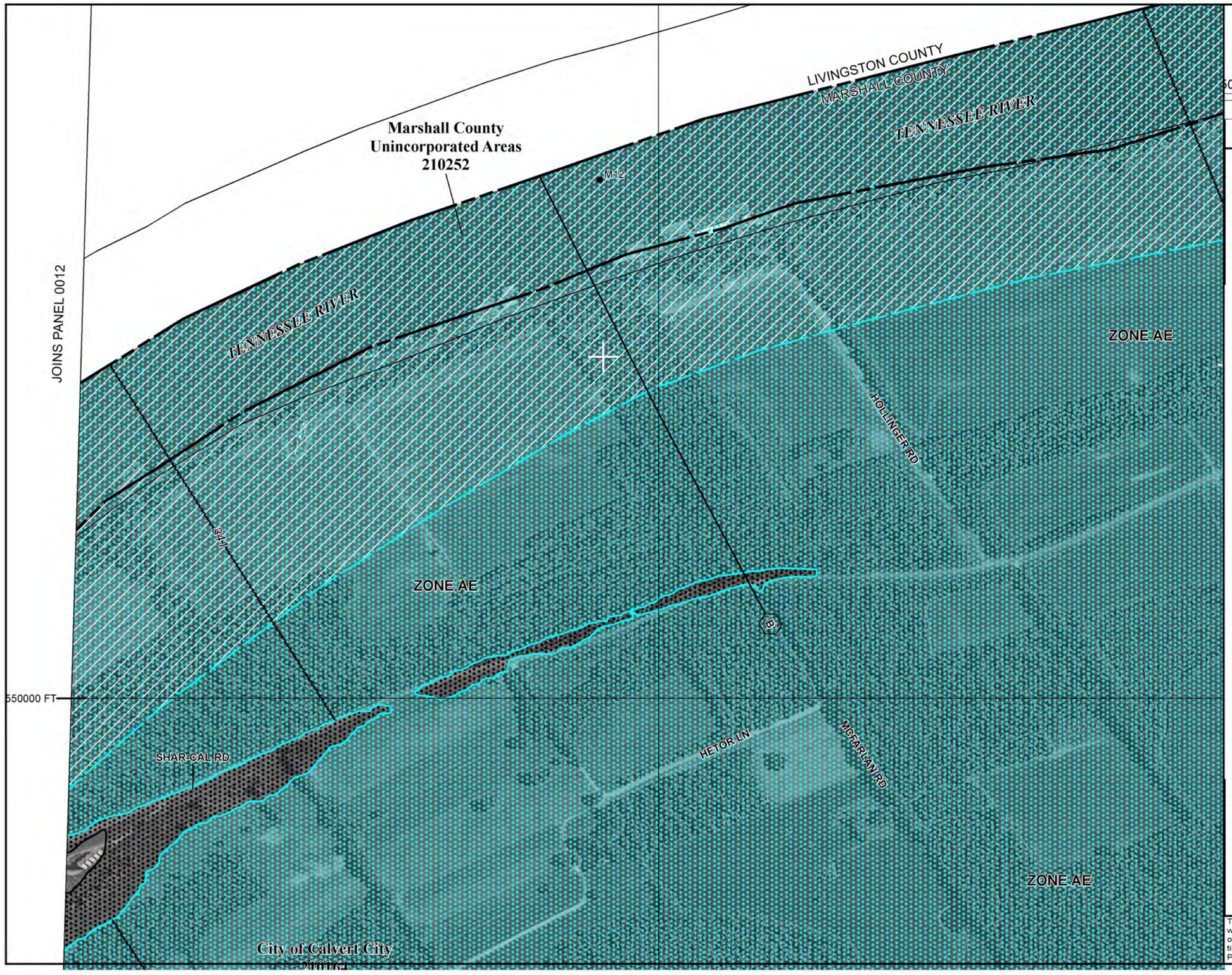
EFFECTIVE DATE
JUNE 2, 2011

MAP NUMBER
21157C0012E

Kentucky

State of Kentucky
Federal Emergency Management Agency

NATIONAL FLOOD INSURANCE PROGRAM



NFIP

PANEL 0016E

FIRM

FLOOD INSURANCE RATE MAP

MARSHALL COUNTY, KENTUCKY

AND INCORPORATED AREAS

PANEL 16 OF 325

(SEE LOCATOR DIAGRAM OR MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
CALVERT CITY, CITY OF	210164	0016	E
MARSHALL COUNTY	210252	0016	E

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

EFFECTIVE DATE
JUNE 2, 2011

MAP NUMBER
21157C0016E

Kentucky

State of Kentucky
Federal Emergency Management Agency

NATIONAL FLOOD INSURANCE PROGRAM

Appendix IV
Existing Conditions Model

ICA Engineering

HEC-RAS Plan: Existing River: Tennessee River Reach: Tennessee River

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Tennessee River	8.52	10 YR	388000.00	277.59	330.82	293.53	331.18	0.000047	4.86	98258.48	6426.53	0.13
Tennessee River	8.52	50 YR	480000.00	277.59	337.82	295.74	338.15	0.000038	4.82	149719.10	7786.96	0.12
Tennessee River	8.52	100 YR	517000.00	277.59	340.42	296.54	340.74	0.000035	4.81	170779.90	8922.88	0.12
Tennessee River	8.52	500 YR	600000.00	277.59	341.82	298.29	342.21	0.000042	5.35	183498.00	9251.29	0.13
Tennessee River	10.38	10 YR	388000.00	277.17	331.28		331.72	0.000058	5.49	89904.79	5542.77	0.15
Tennessee River	10.38	50 YR	480000.00	277.17	338.18		338.60	0.000049	5.53	137885.50	8855.83	0.14
Tennessee River	10.38	100 YR	517000.00	277.17	340.75		341.16	0.000045	5.51	163252.10	10952.77	0.13
Tennessee River	10.38	500 YR	600000.00	277.17	342.21		342.72	0.000054	6.15	180396.70	12789.94	0.15
Tennessee River	10.71	10 YR	388000.00	274.46	331.31		331.88	0.000082	6.12	71741.72	2749.55	0.17
Tennessee River	10.71	50 YR	480000.00	274.46	338.17		338.74	0.000069	6.24	105903.70	7511.21	0.16
Tennessee River	10.71	100 YR	517000.00	274.46	340.73		341.30	0.000065	6.27	128296.10	10395.44	0.16
Tennessee River	10.71	500 YR	600000.00	274.46	342.20		342.88	0.000076	6.93	144238.00	11392.91	0.17
Tennessee River	10.90	10 YR	388000.00	272.93	331.38		331.96	0.000074	6.16	72082.13	3093.44	0.16
Tennessee River	10.90	50 YR	480000.00	272.93	338.22		338.82	0.000065	6.36	103738.00	7452.29	0.16
Tennessee River	10.90	100 YR	517000.00	272.93	340.78		341.37	0.000061	6.39	126481.70	10378.91	0.16
Tennessee River	10.90	500 YR	600000.00	272.93	342.25		342.96	0.000073	7.08	142592.20	11646.54	0.17
Tennessee River	10.95	10 YR	388000.00	272.54	331.44		331.98	0.000076	5.94	74125.68	3297.69	0.16
Tennessee River	10.95	50 YR	480000.00	272.54	338.30		338.84	0.000064	6.07	106139.00	7493.45	0.16
Tennessee River	10.95	100 YR	517000.00	272.54	340.85		341.39	0.000060	6.09	129316.80	10564.19	0.15
Tennessee River	10.95	500 YR	600000.00	272.54	342.34		342.99	0.000071	6.74	146213.70	12192.42	0.17
Tennessee River	10.99	10 YR	388000.00	272.20	331.47		332.00	0.000072	5.88	76398.44	3406.46	0.16
Tennessee River	10.99	50 YR	480000.00	272.20	338.32		338.85	0.000062	6.02	107816.30	7355.54	0.15
Tennessee River	10.99	100 YR	517000.00	272.20	340.87		341.40	0.000058	6.06	131149.00	10599.73	0.15
Tennessee River	10.99	500 YR	600000.00	272.20	342.37		343.00	0.000069	6.71	147960.40	11993.21	0.16
Tennessee River	11.30	10 YR	388000.00	269.66	331.65	289.14	332.11	0.000054	5.45	81577.21	3187.08	0.14
Tennessee River	11.30	50 YR	480000.00	269.66	338.60	291.64	338.95	0.000040	5.13	144013.30	5182.35	0.12
Tennessee River	11.30	100 YR	517000.00	269.66	341.14	292.59	341.50	0.000038	5.19	180378.60	12810.46	0.12
Tennessee River	11.30	500 YR	600000.00	269.66	342.69	294.67	343.11	0.000044	5.71	200734.60	13407.06	0.13
Tennessee River	12.37	10 YR	388000.00	269.66	332.05	289.14	332.39	0.000043	4.77	110610.30	7908.55	0.13
Tennessee River	12.37	50 YR	480000.00	269.66	338.86	291.64	339.17	0.000034	4.70	172711.70	10413.51	0.12
Tennessee River	12.37	100 YR	517000.00	269.66	341.41	292.61	341.70	0.000032	4.67	202966.40	13780.16	0.11
Tennessee River	12.37	500 YR	600000.00	269.66	343.00	294.68	343.35	0.000037	5.17	225825.60	15005.18	0.12
Tennessee River	13.38	10 YR	388000.00	279.64	332.29	296.04	332.62	0.000045	4.59	84585.29	2108.86	0.13
Tennessee River	13.38	50 YR	480000.00	279.64	339.05	298.00	339.36	0.000038	4.58	129511.60	4331.10	0.12
Tennessee River	13.38	100 YR	517000.00	279.64	341.60	298.73	341.88	0.000034	4.46	176644.90	9775.39	0.11
Tennessee River	13.38	500 YR	600000.00	279.64	343.22	300.34	343.56	0.000039	4.93	193142.40	10575.15	0.12
Tennessee River	14.41	10 YR	388000.00	279.64	332.53	296.04	332.86	0.000041	4.64	91834.06	3679.50	0.12
Tennessee River	14.41	50 YR	480000.00	279.64	339.22	298.00	339.58	0.000037	4.87	117264.80	3899.60	0.12
Tennessee River	14.41	100 YR	517000.00	279.64	341.73	298.75	342.09	0.000036	4.95	127106.90	3956.53	0.12
Tennessee River	14.41	500 YR	600000.00	279.64	343.36	300.46	343.82	0.000043	5.54	133617.00	3998.17	0.13
Tennessee River	15.63	10 YR	388000.00	263.92	332.78	289.08	333.14	0.000044	4.86	92233.11	3530.77	0.13
Tennessee River	15.63	50 YR	480000.00	263.92	339.45	291.66	339.83	0.000040	5.09	116718.30	3857.91	0.13
Tennessee River	15.63	100 YR	517000.00	263.92	341.95	292.68	342.34	0.000039	5.17	126555.00	3988.22	0.12
Tennessee River	15.63	500 YR	600000.00	263.92	343.63	294.81	344.12	0.000047	5.78	133314.50	4045.46	0.14
Tennessee River	17.03	10 YR	388000.00	285.31	333.16	302.07	333.53	0.000063	4.98	99000.84	4972.07	0.15
Tennessee River	17.03	50 YR	480000.00	285.31	339.82	304.26	340.17	0.000049	4.96	132916.70	5212.18	0.13
Tennessee River	17.03	100 YR	517000.00	285.31	342.32	305.07	342.66	0.000046	4.96	146019.10	5296.06	0.13
Tennessee River	17.03	500 YR	600000.00	285.31	344.08	306.80	344.49	0.000053	5.48	155464.80	5439.08	0.14
Tennessee River	18.21	10 YR	388000.00	275.29	333.51	294.79	333.84	0.000041	4.81	115004.00	5861.95	0.12
Tennessee River	18.21	50 YR	480000.00	275.29	340.11	297.00	340.43	0.000035	4.89	156272.80	8011.90	0.12
Tennessee River	18.21	100 YR	517000.00	275.29	342.59	297.87	342.90	0.000033	4.90	177698.00	9147.14	0.12
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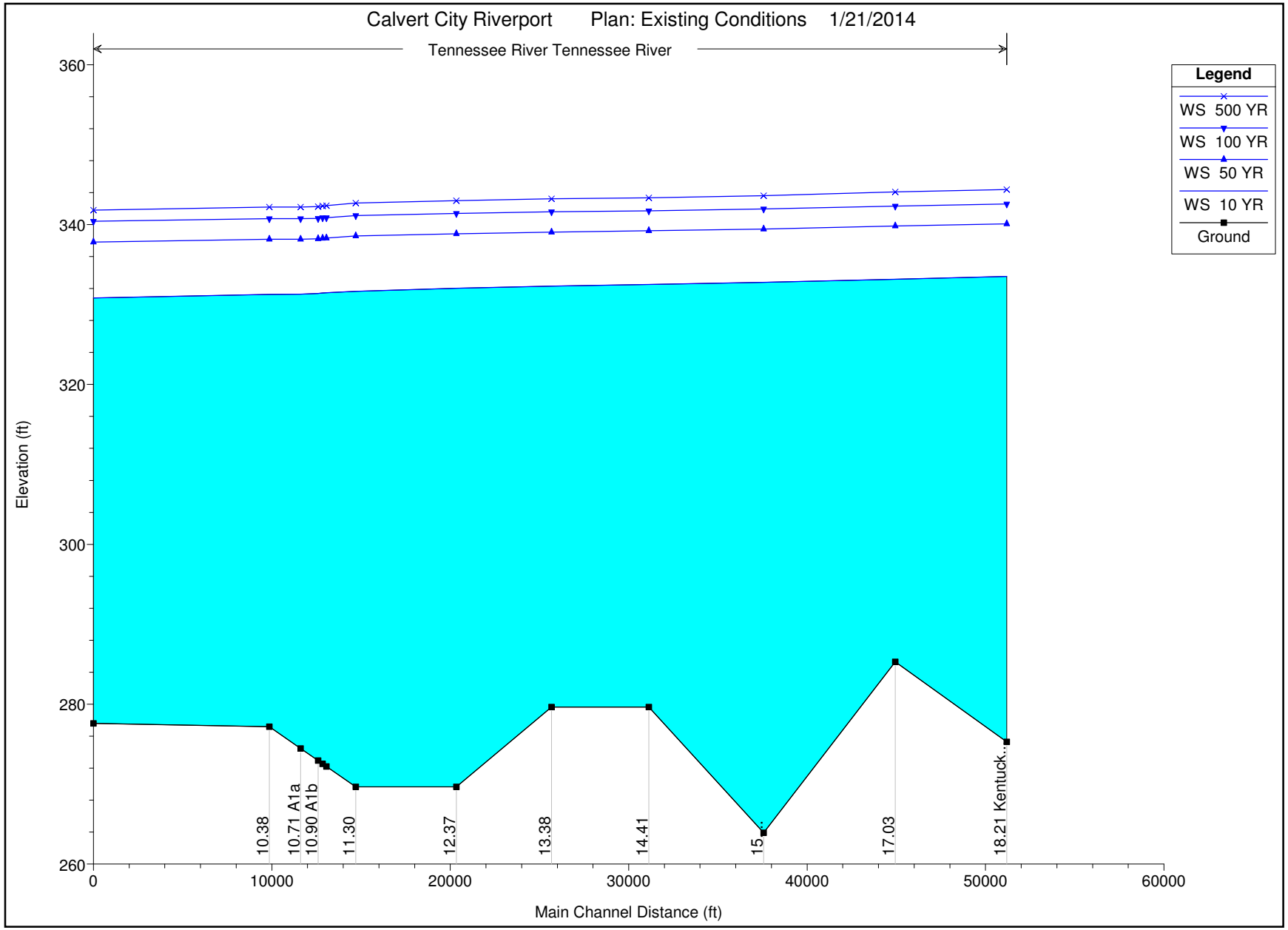
Calvert City Riverport Plan: Existing Conditions 1/21/2014
Tennessee River Tennessee River
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WS 100 YR
WS 50 YR
WS 10 YR
Ground
Elevation (ft)
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Main Channel Distance (ft)
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10.71 A1a
10.90 A1b
11.30
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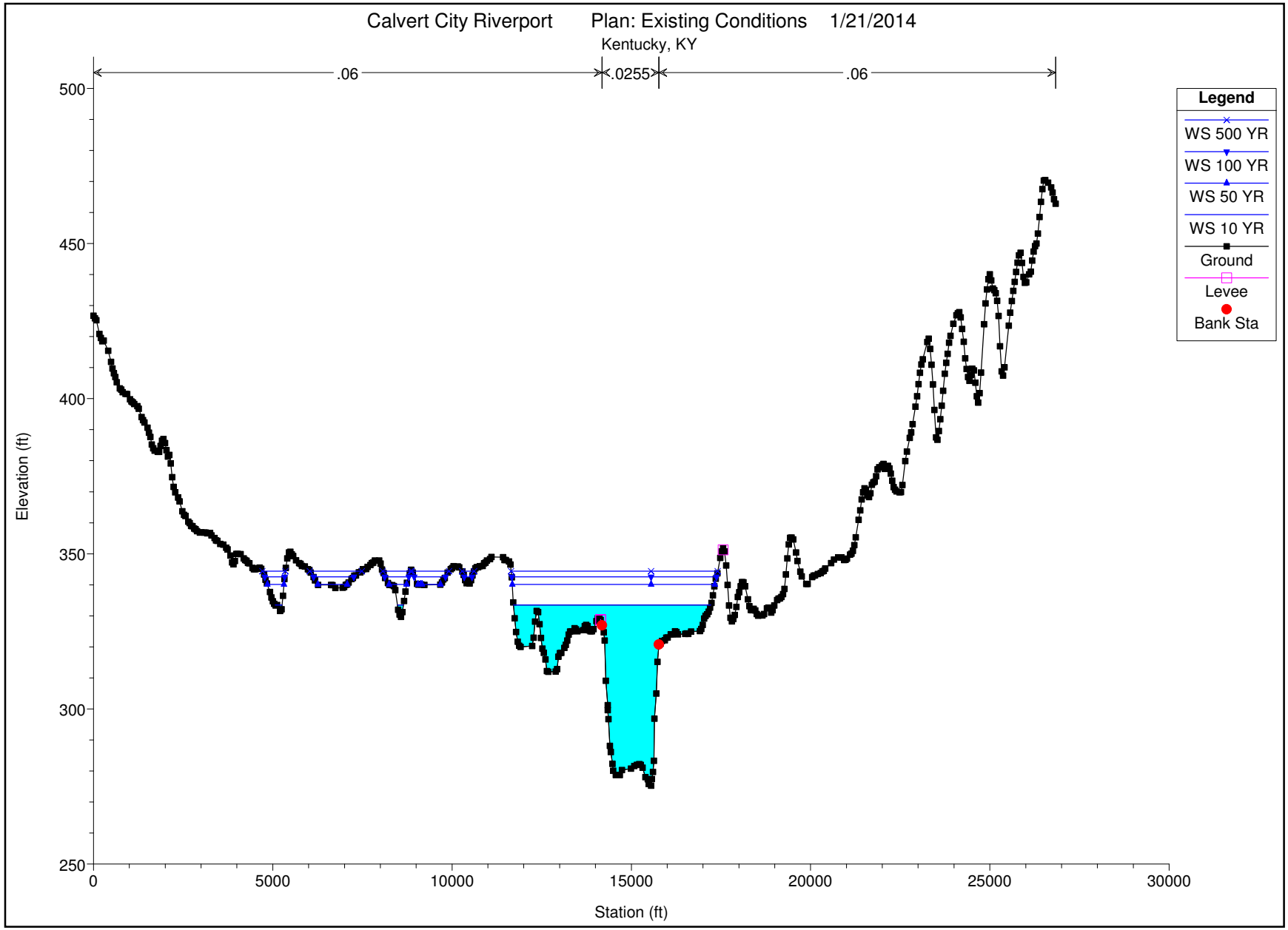
15...
17.03
18.21 Kentuck...


Calvert City Riverport
Plan: Existing Conditions
1/21/2014
Kentucky, KY
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Legend
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WS 100 YR
WS 50 YR
WS 10 YR
Ground
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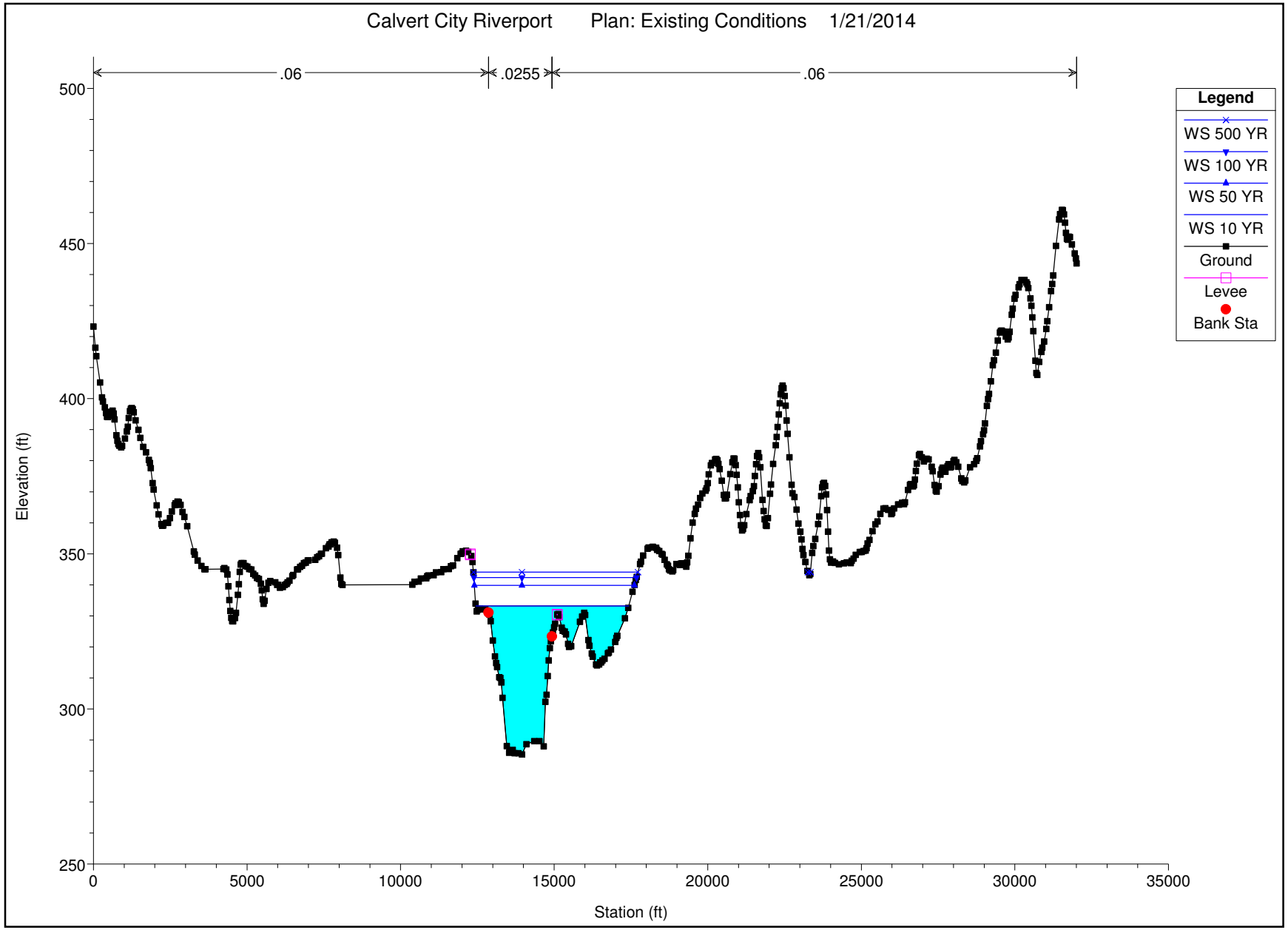
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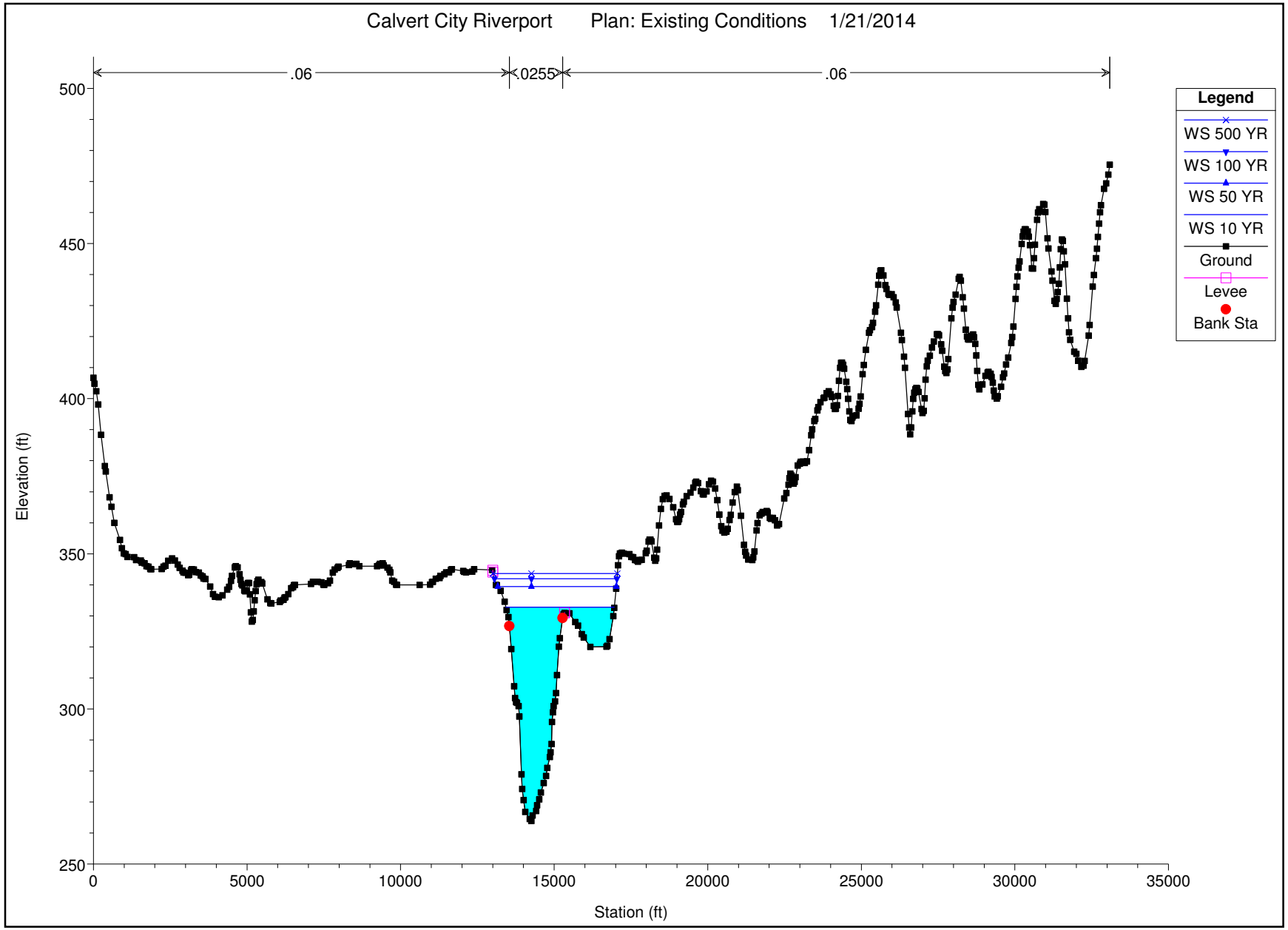
Calvert City Riverport
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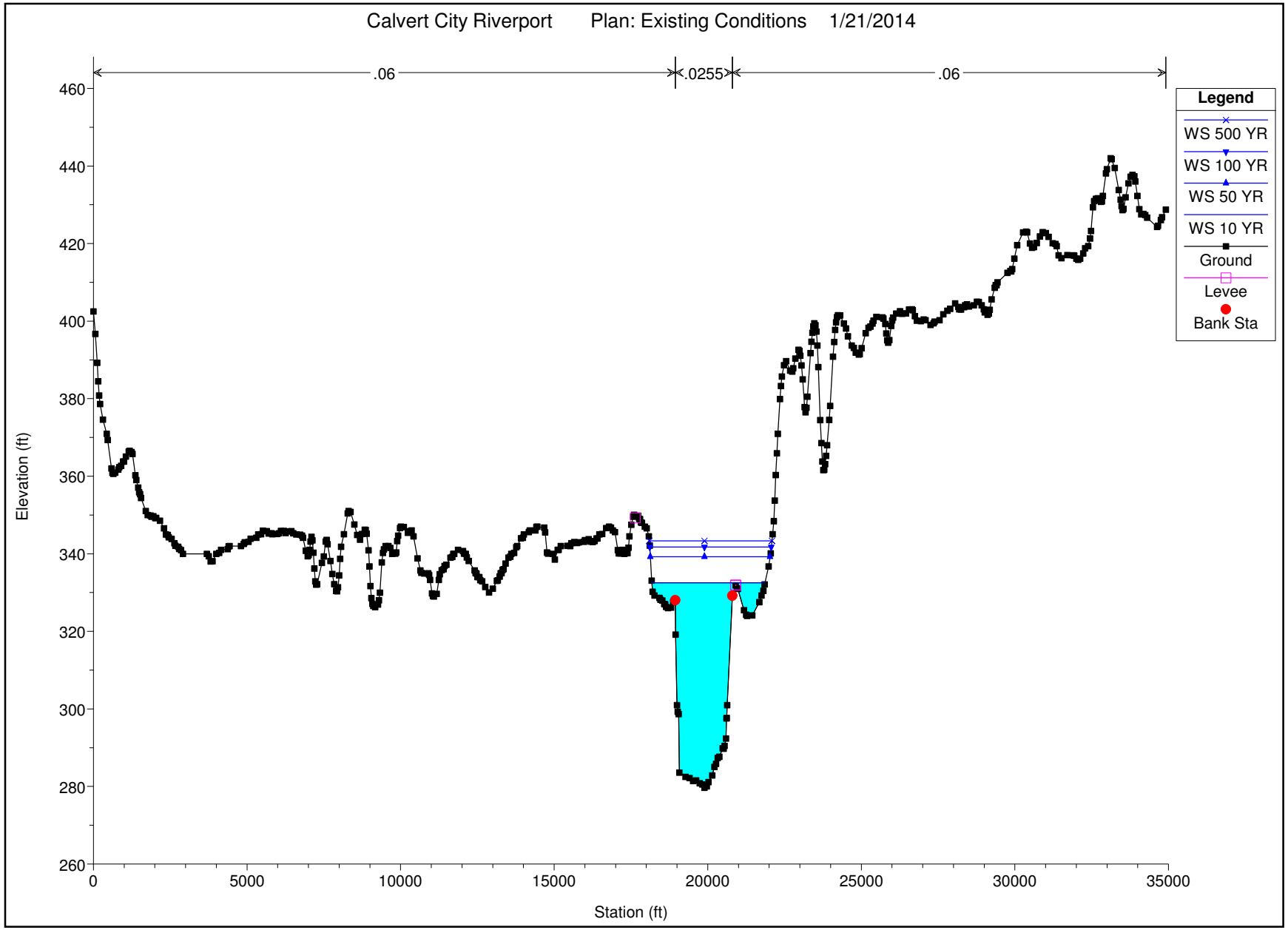
Calvert City Riverport Plan: Existing Conditions 1/21/2014
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WS 10 YR
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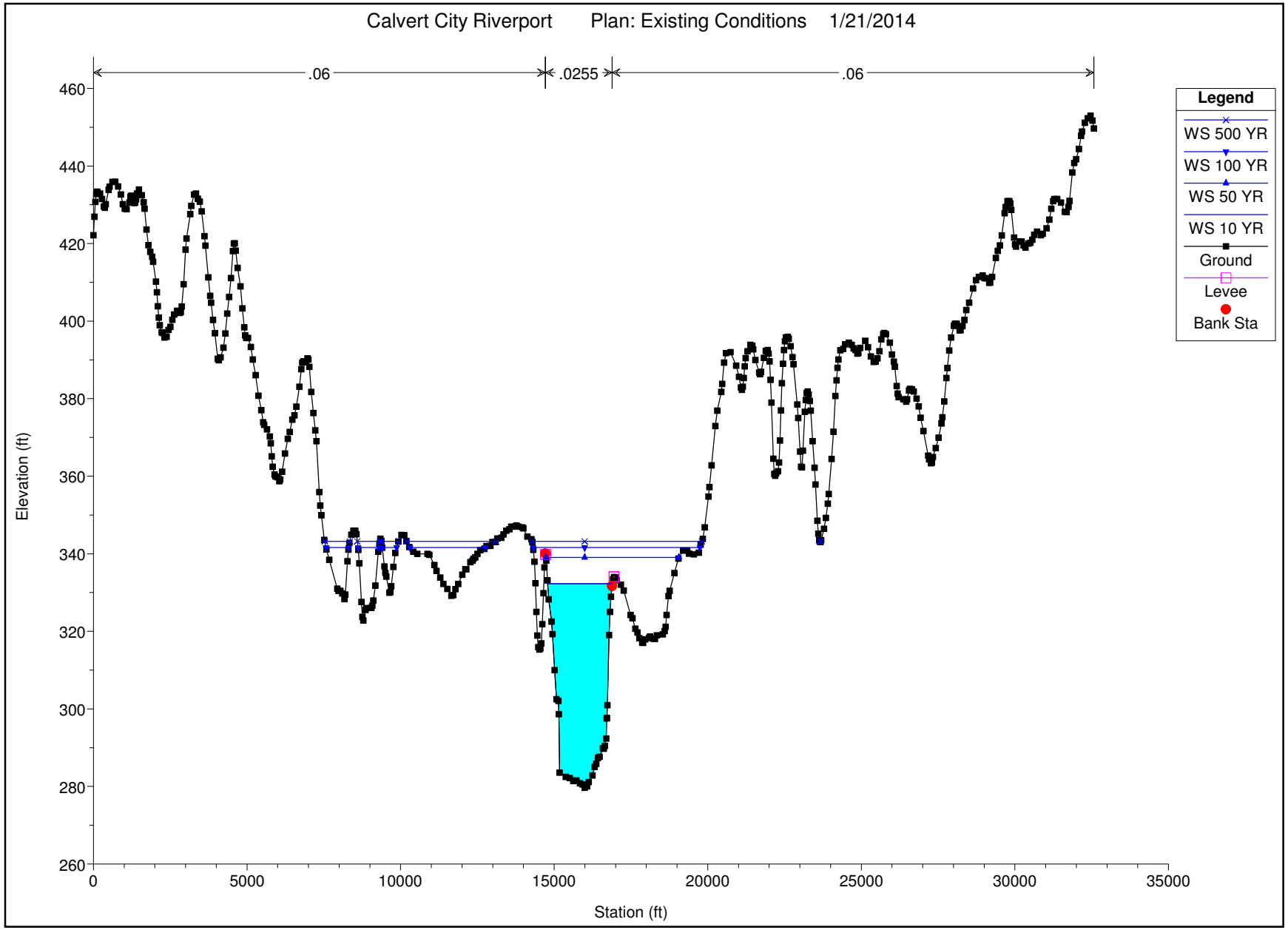
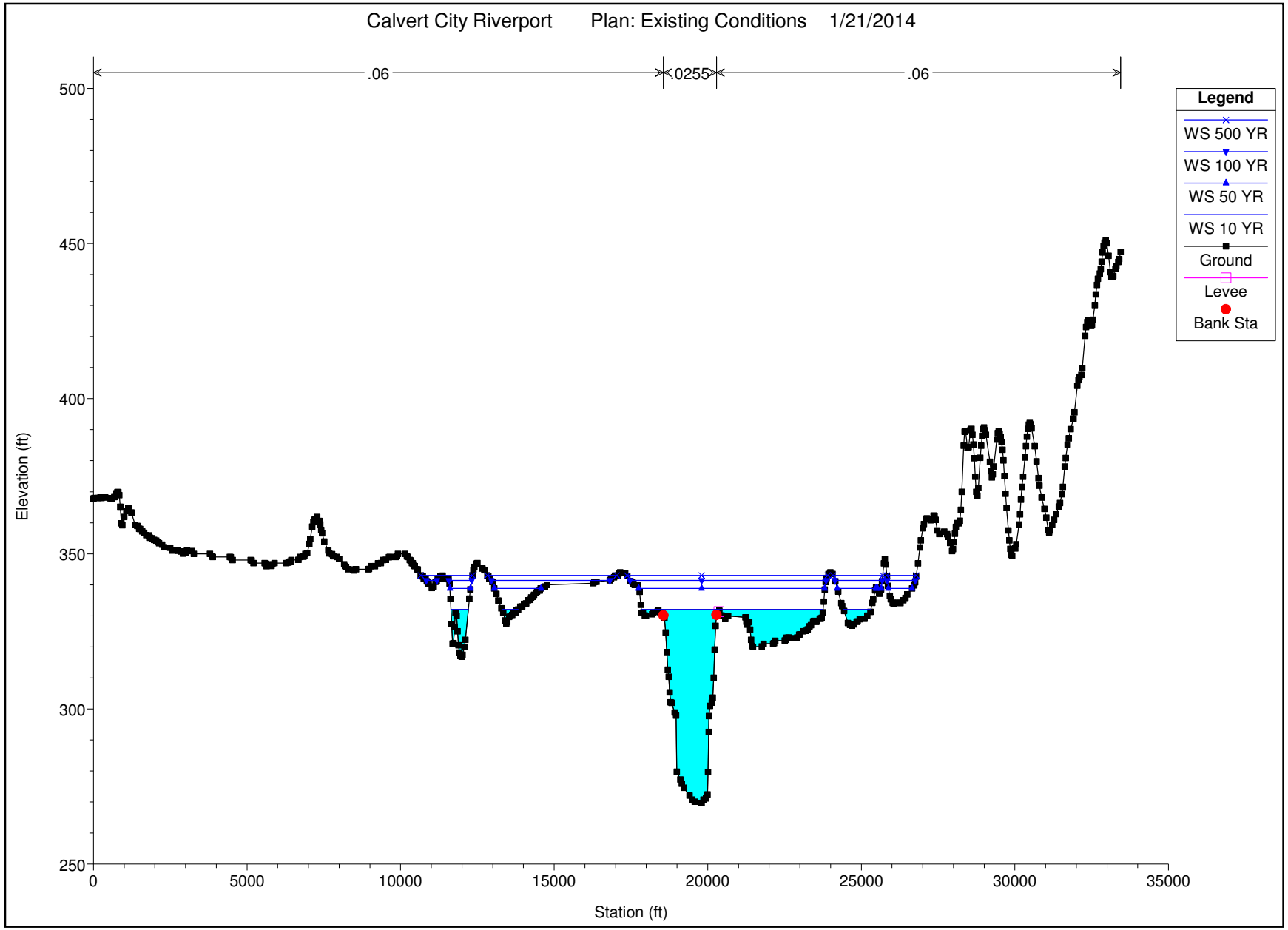
260
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Existing Conditions 1/21/2014
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Existing Conditions 1/21/2014
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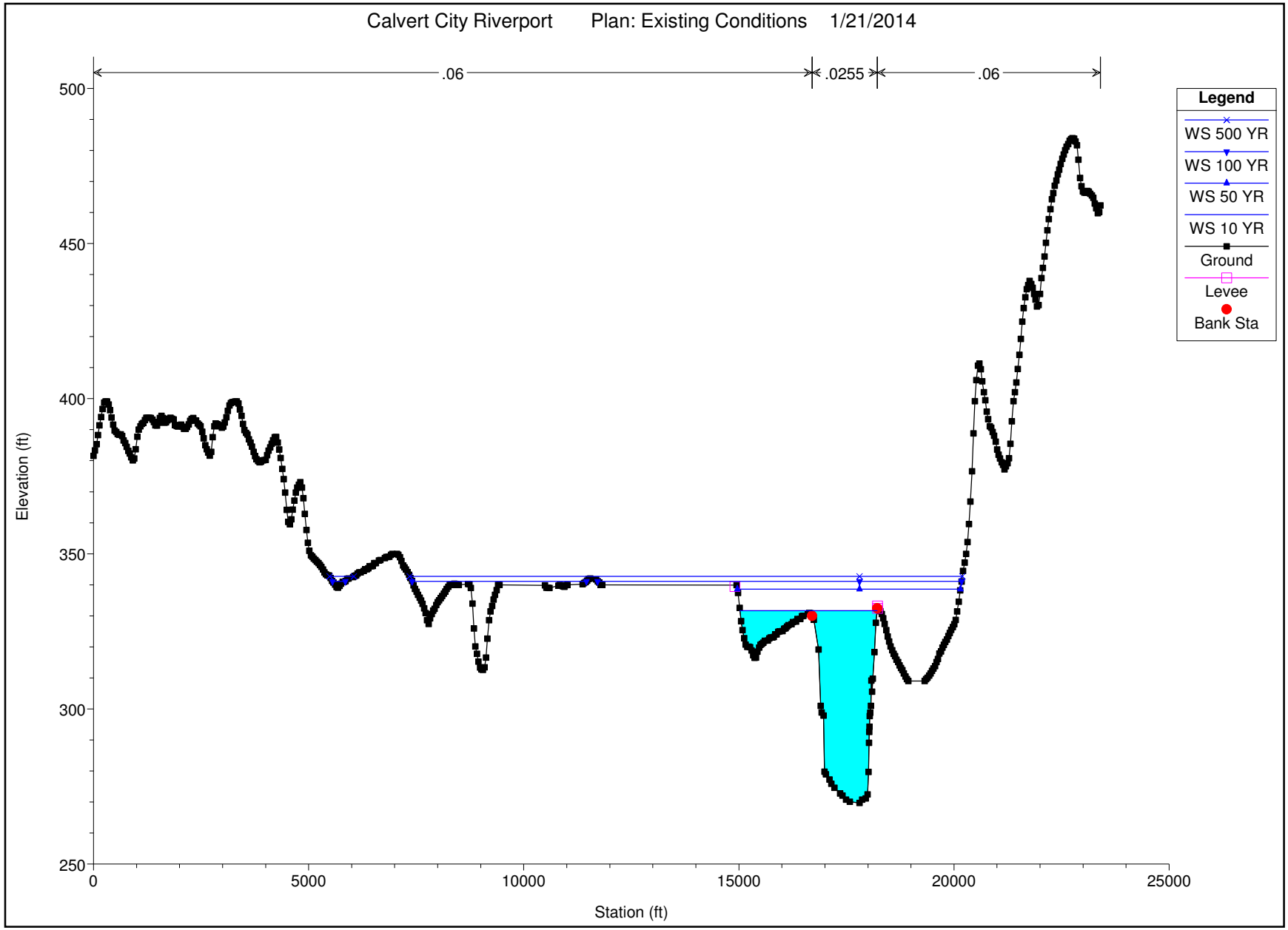
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
30000
35000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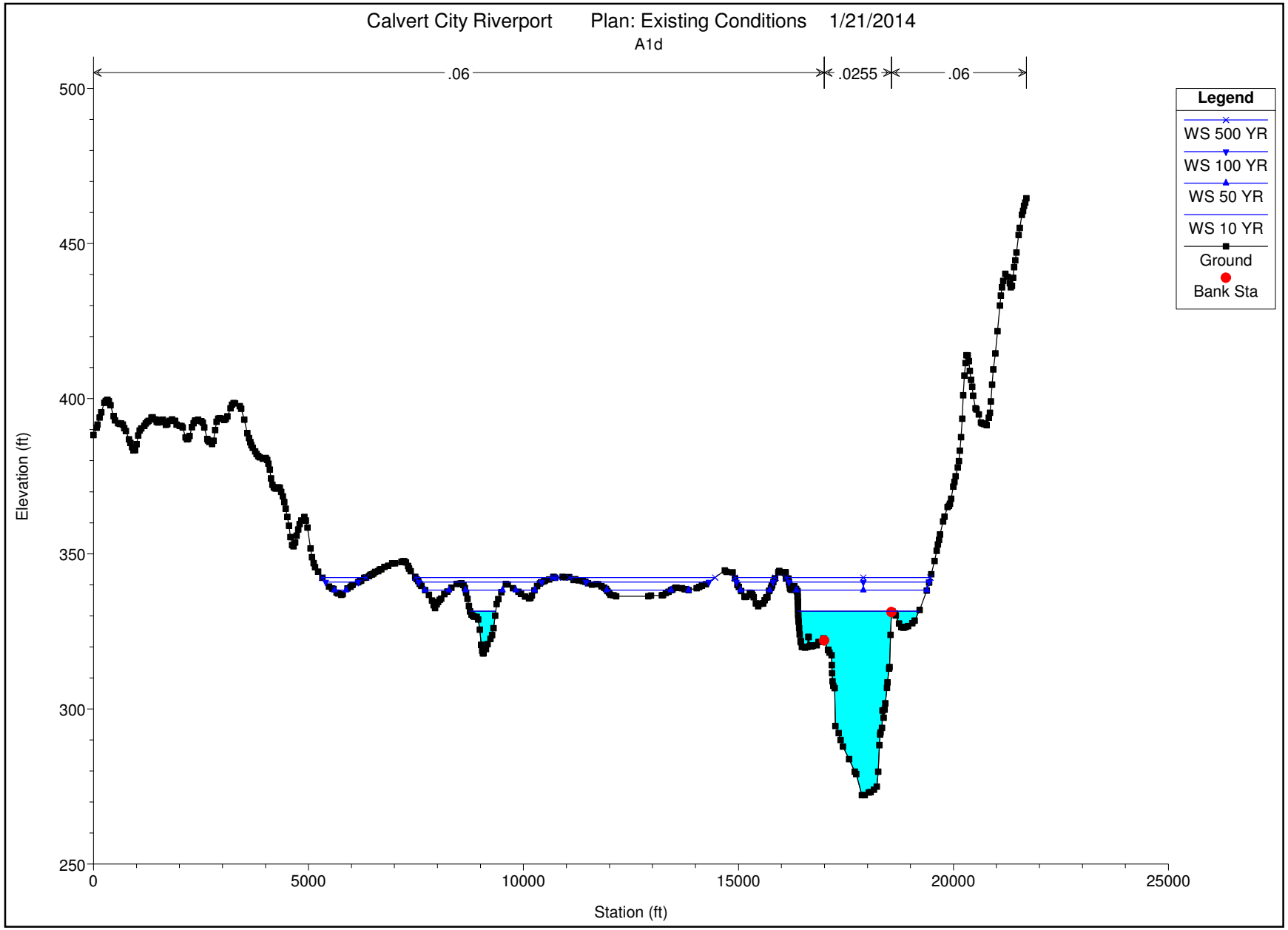
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)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Plan: Existing Conditions
1/21/2014
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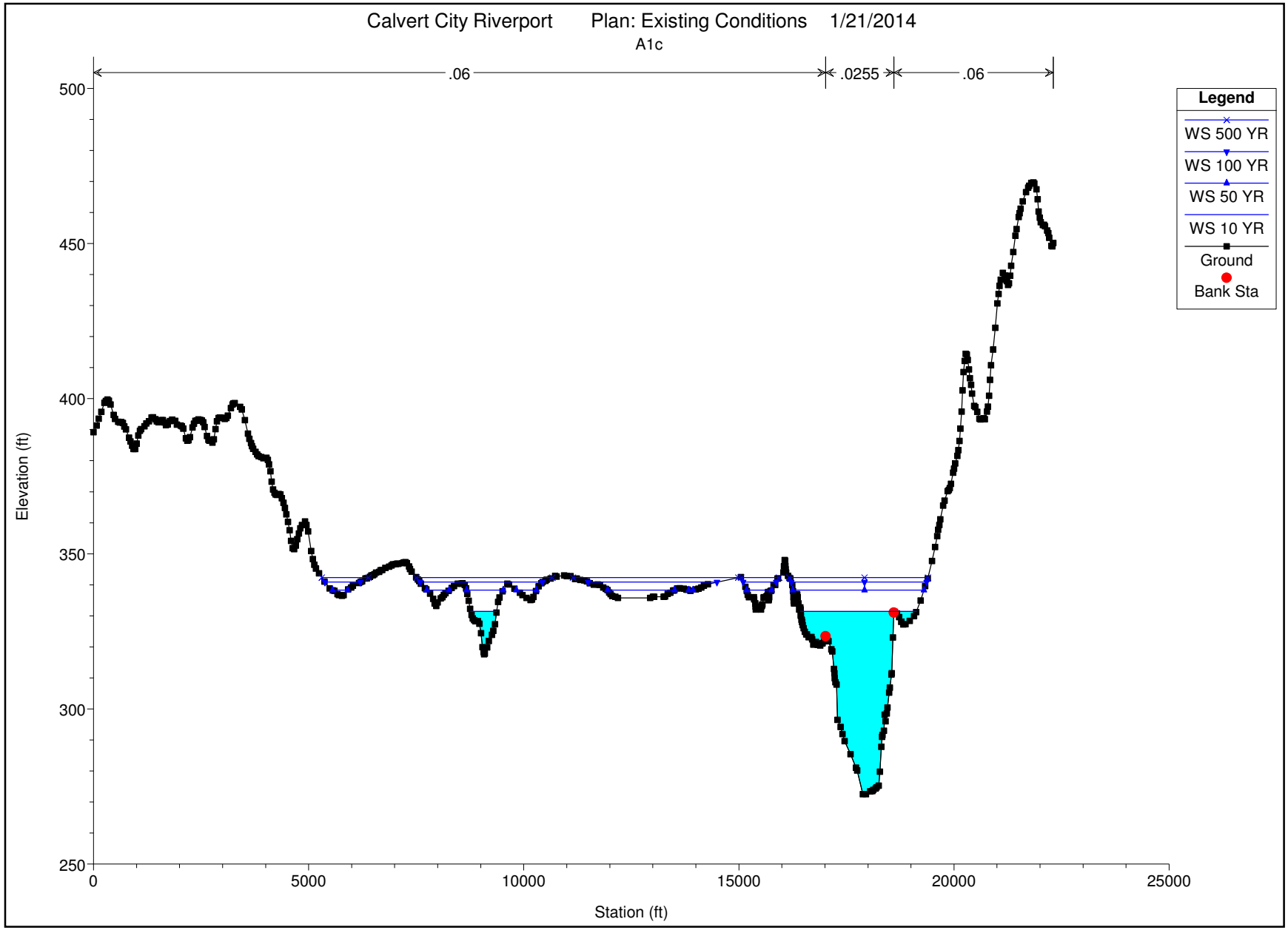
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)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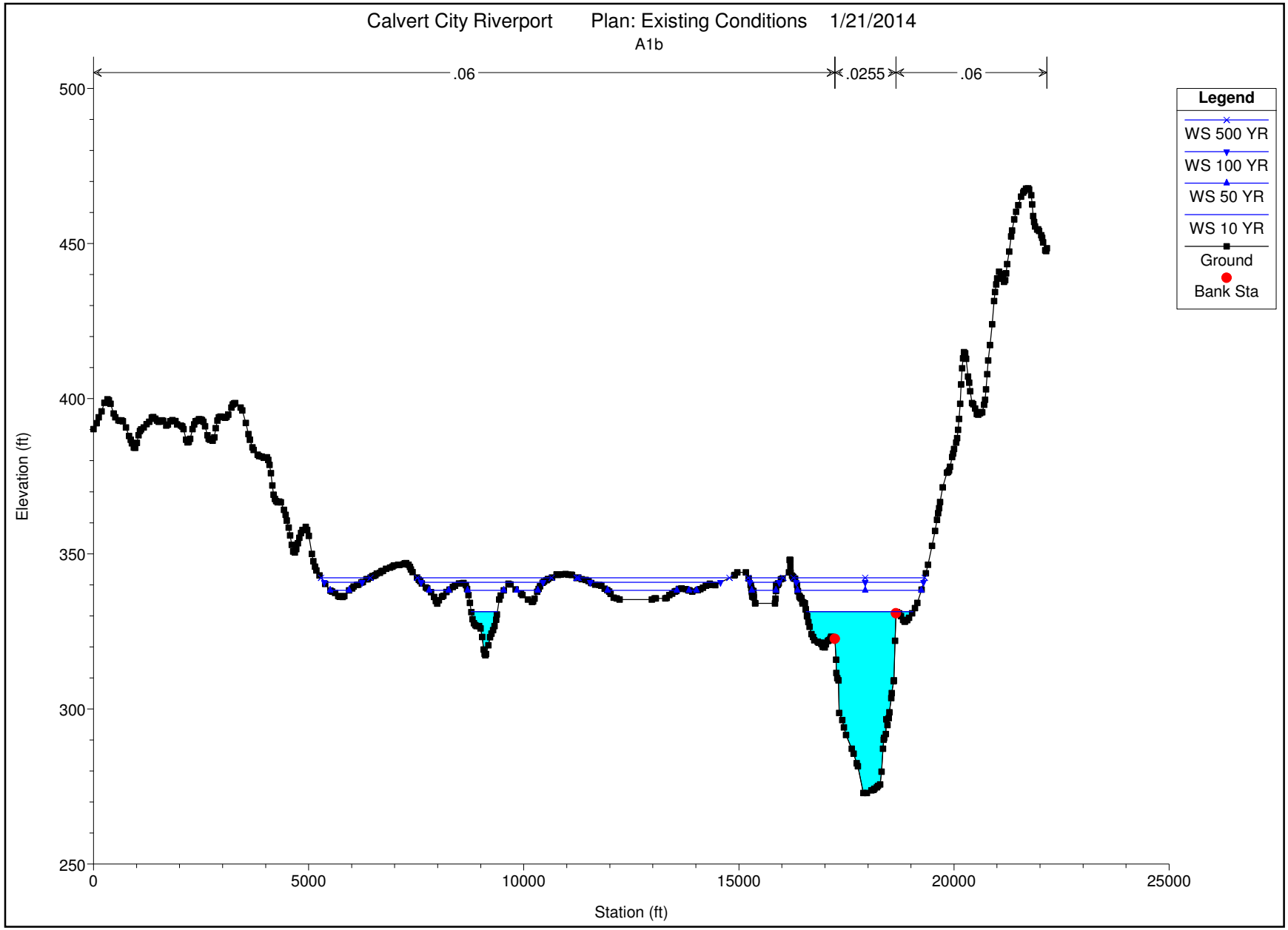
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)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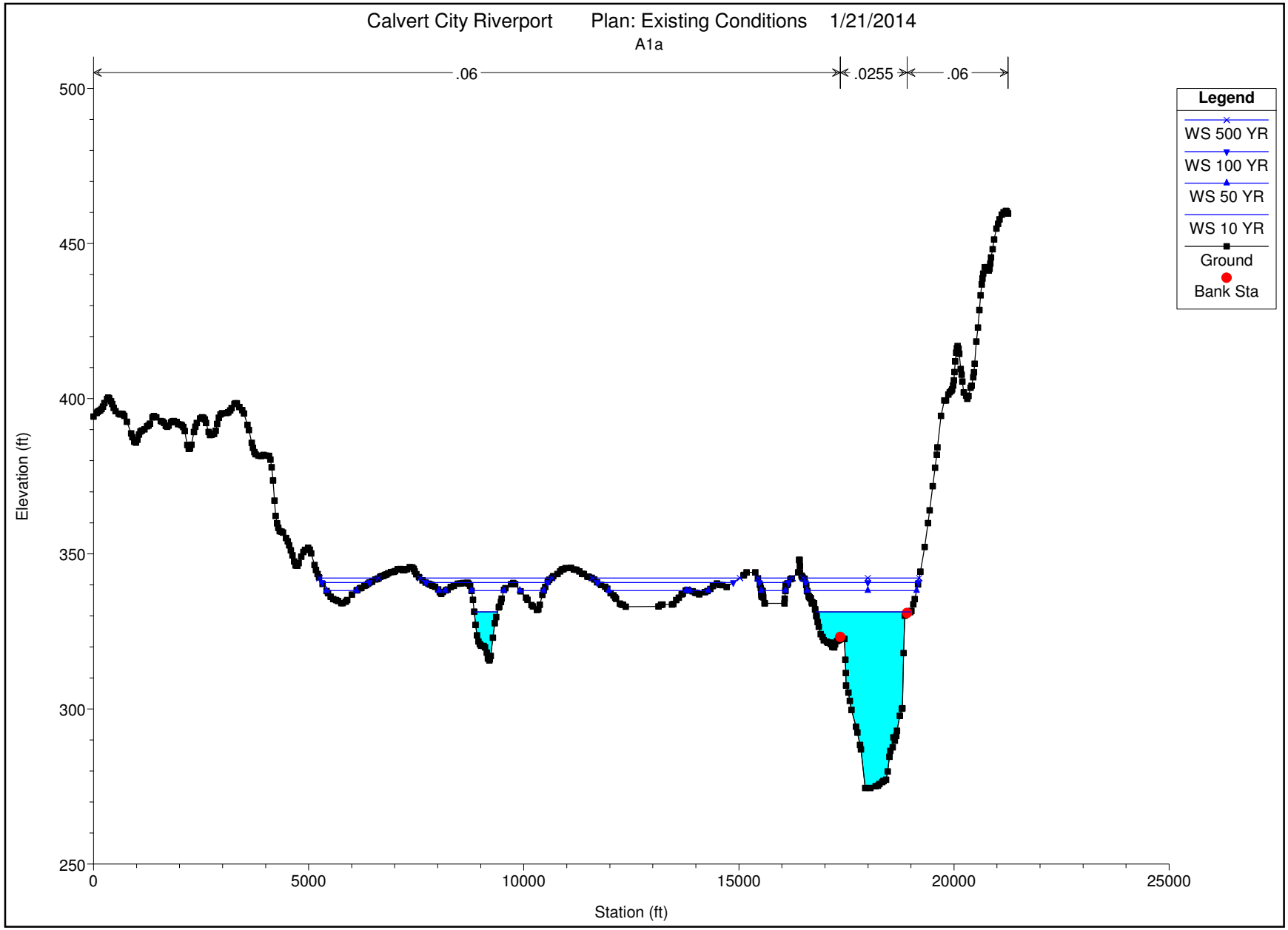
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)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Plan: Existing Conditions
1/21/2014
A1a
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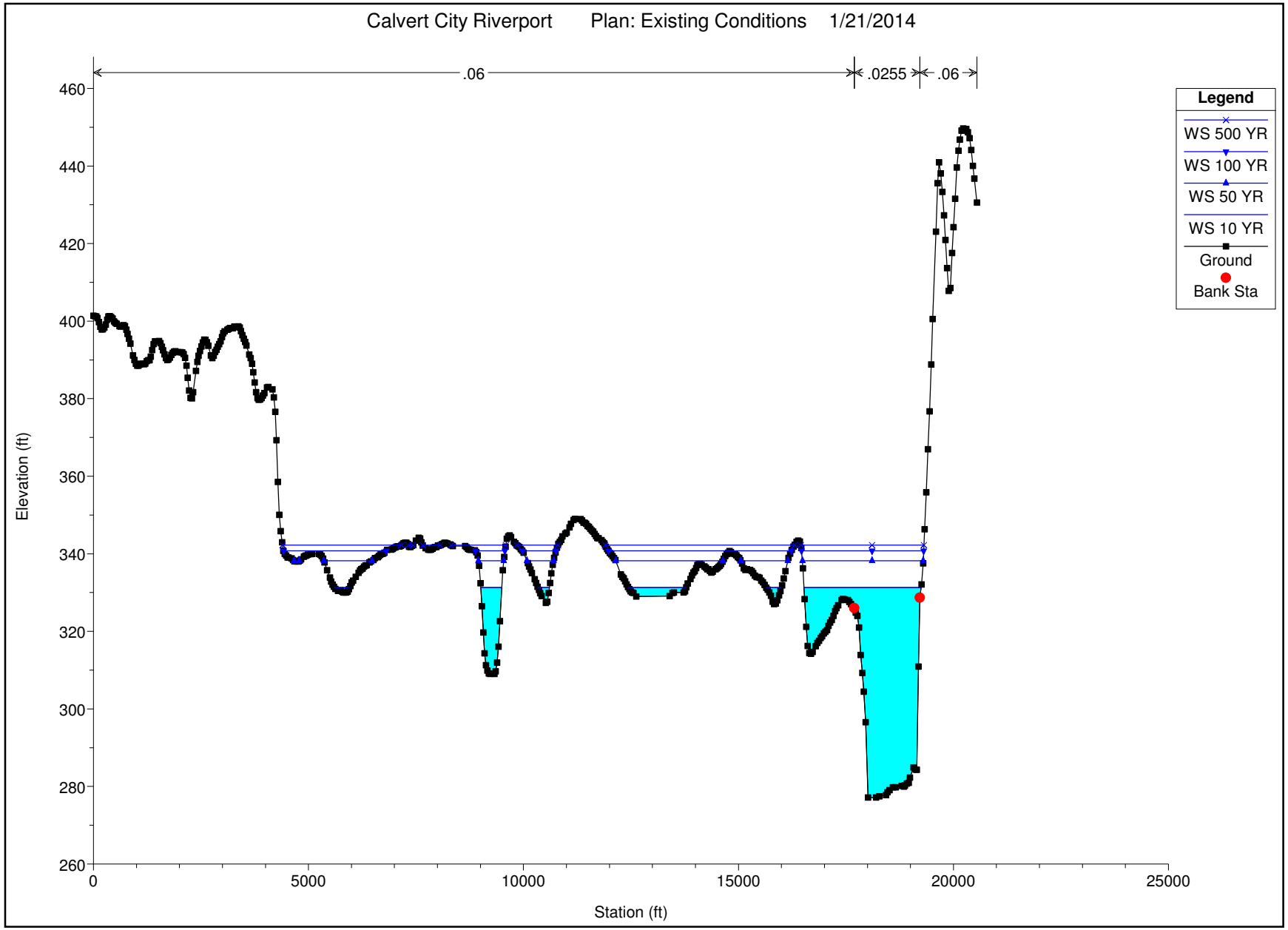
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)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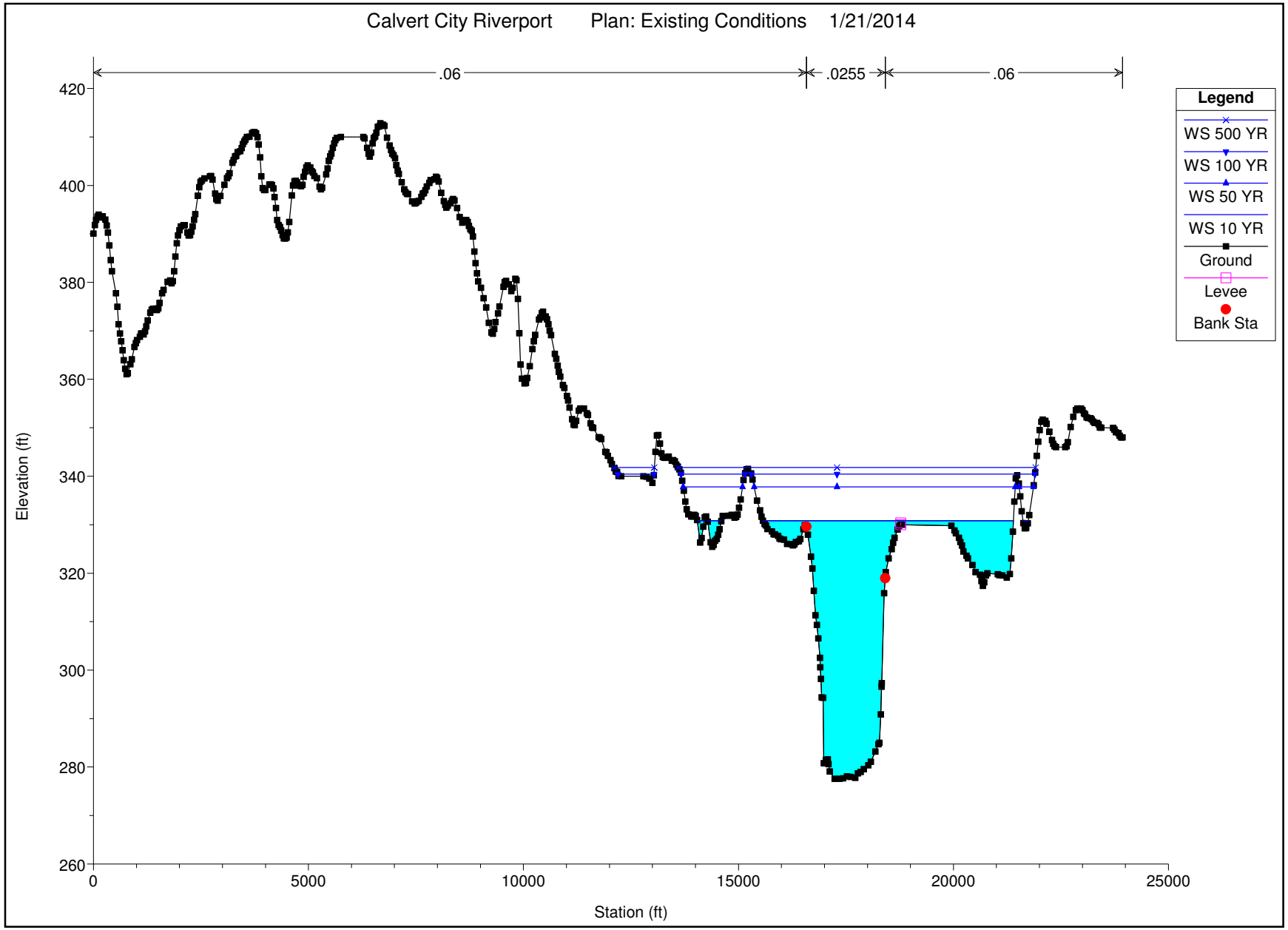
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
Station (ft)


Calvert City Riverport Plan: Existing Conditions 1/21/2014
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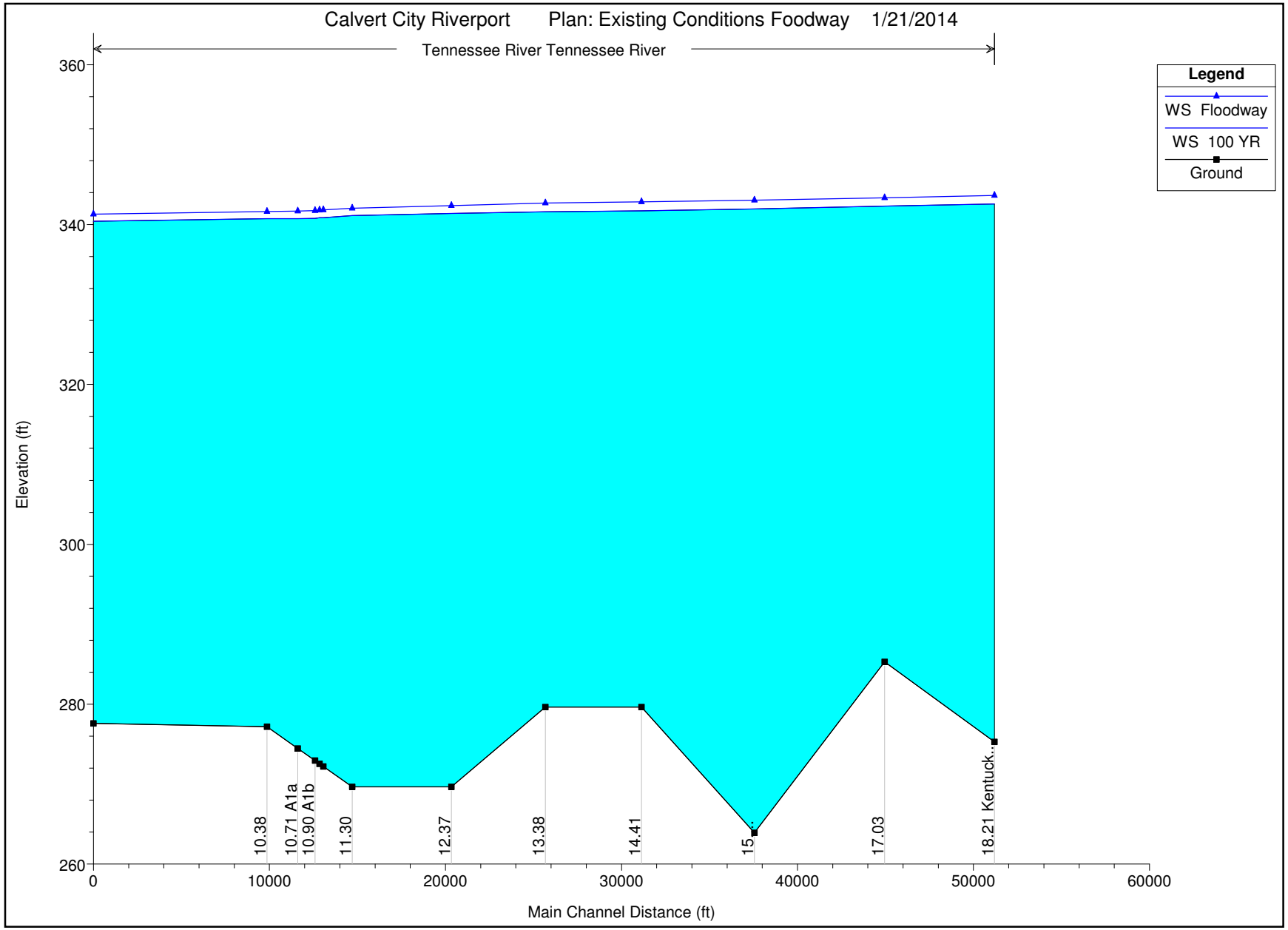
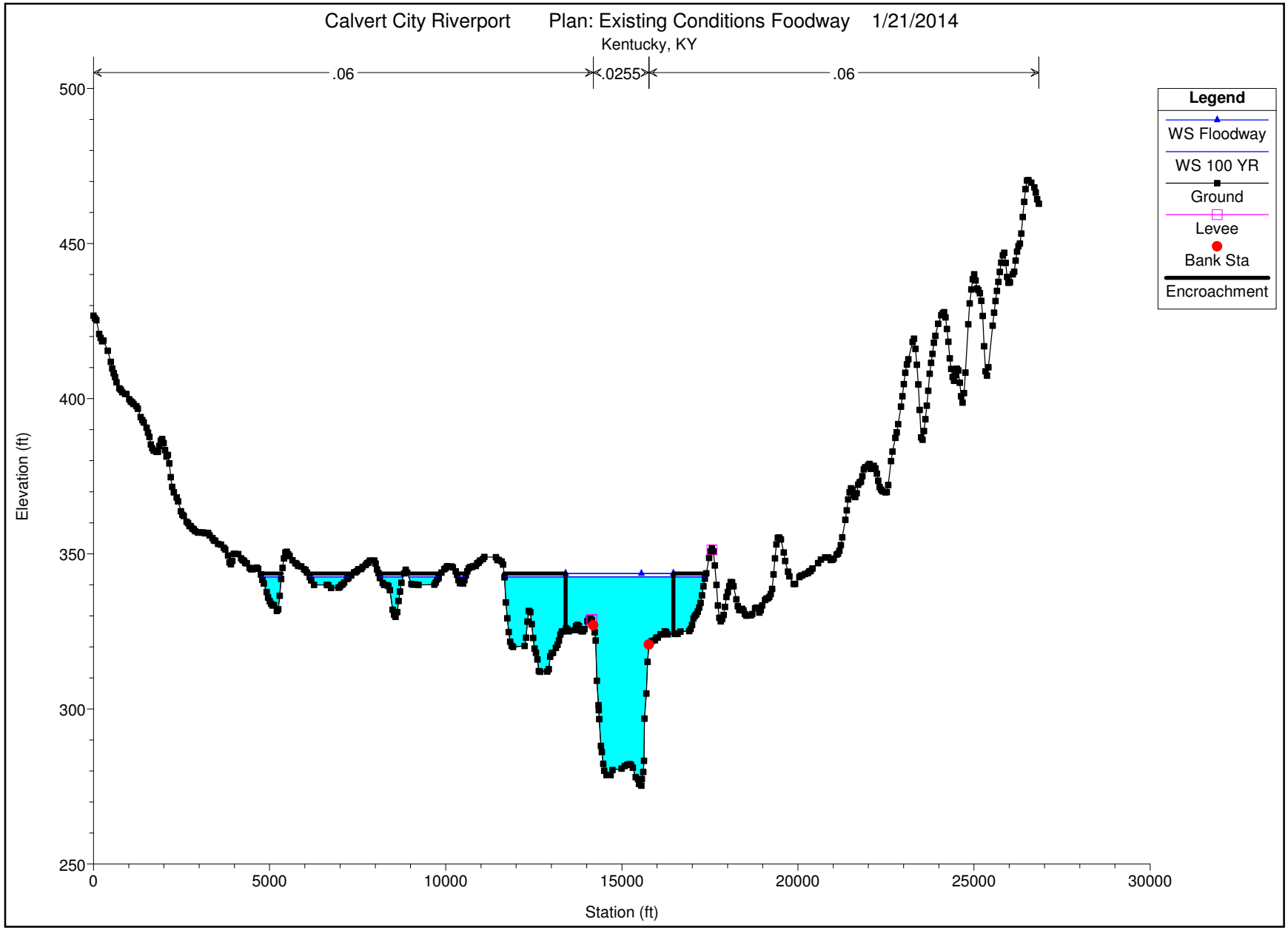
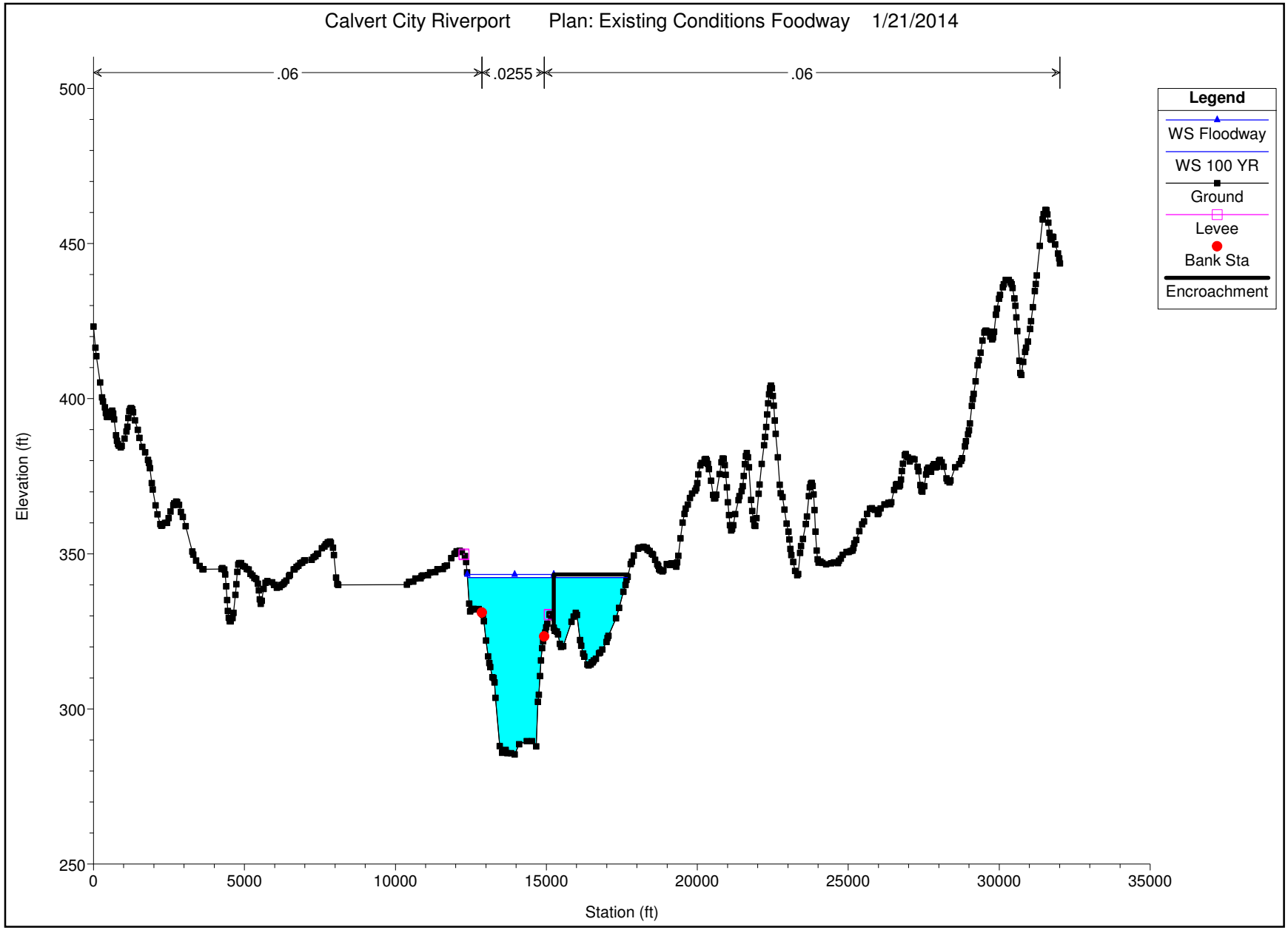
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
Station (ft)

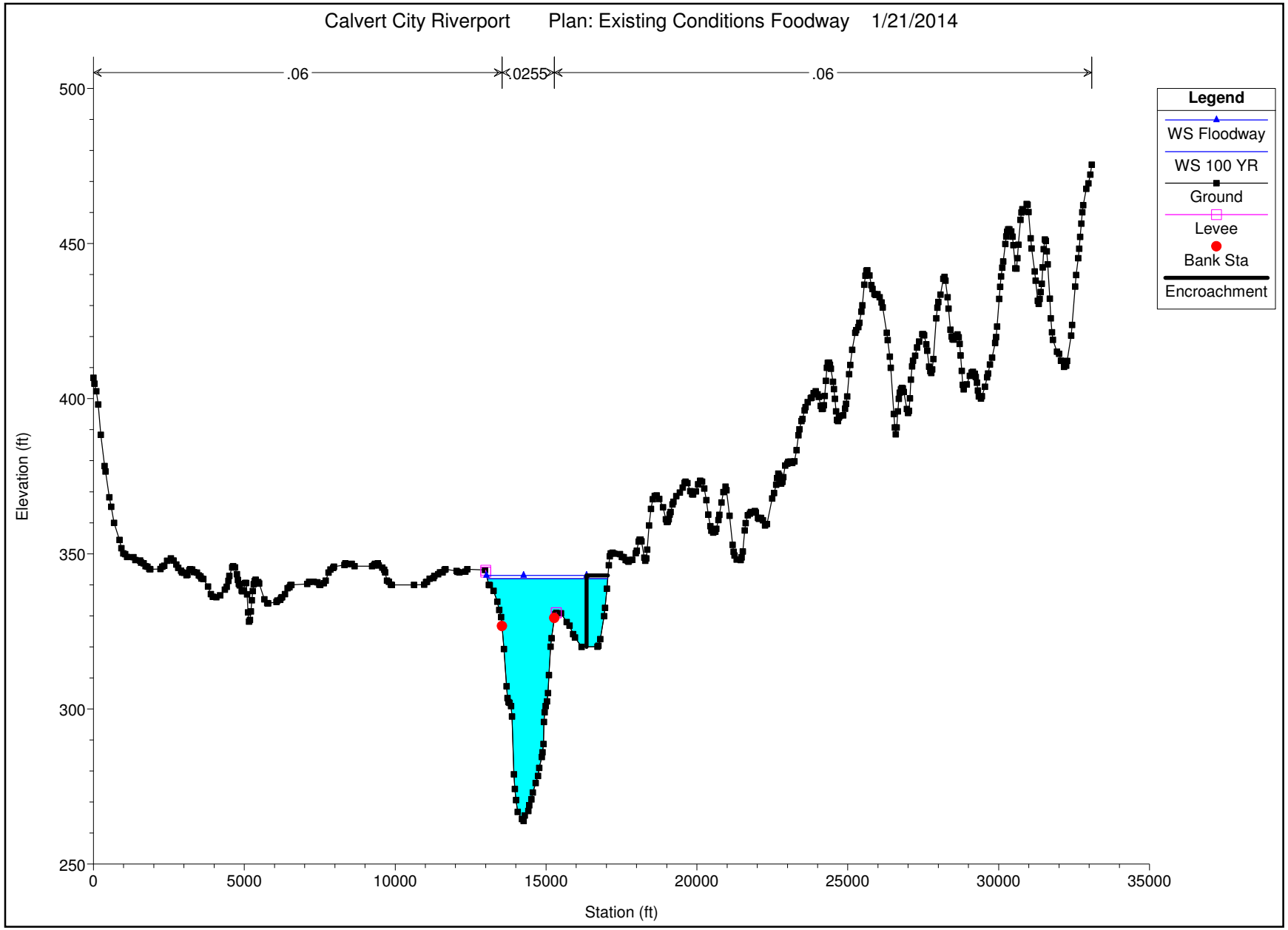
HEC-RAS Plan: Exist Floodway River: Tennessee River Reach: Tennessee River

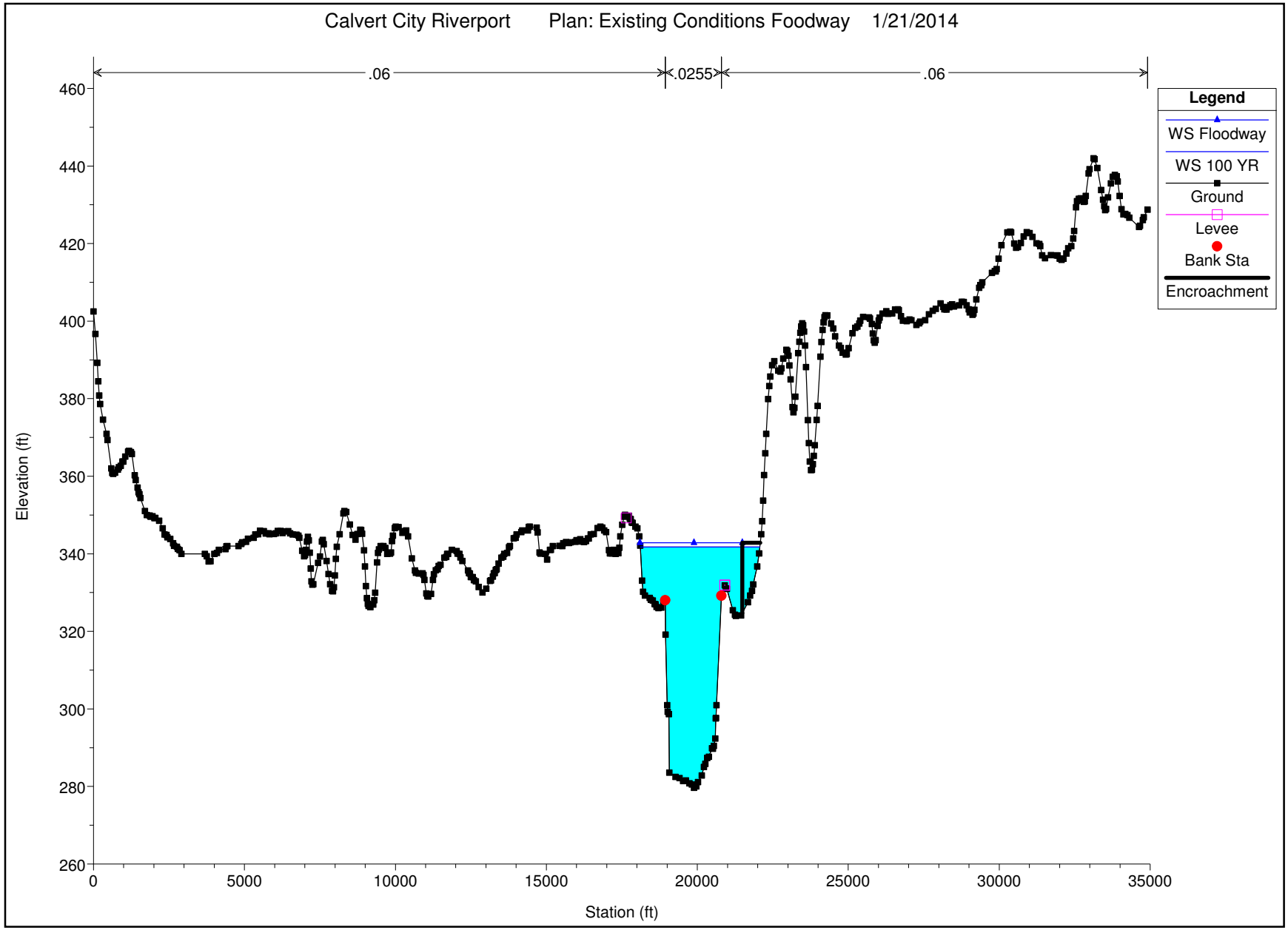
Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Tennessee River	8.52	100 YR	340.42		340.74	8922.88	19025.66	458334.70	39639.68		16580.49	18413.81	
Tennessee River	8.52	Floodway	341.32	0.90	341.71	3592.00	10733.19	496240.20	10026.67	15727.00	16580.49	18413.81	19319.00
Tennessee River	10.38	100 YR	340.75		341.16	10952.77	67300.30	449315.90	383.79		17692.81	19220.38	
Tennessee River	10.38	Floodway	341.64	0.89	342.22	2092.30	7282.30	509214.80	502.84	17220.00	17692.81	19220.38	19464.00
Tennessee River	10.71	100 YR	340.73		341.30	10395.44	36134.64	479633.10	1232.25		17359.46	18911.56	
Tennessee River	10.71	Floodway	341.70	0.97	342.35	1962.00	8668.36	507167.70	1163.99	17070.00	17359.46	18911.56	19032.00
Tennessee River	10.90	100 YR	340.78		341.37	10378.91	33137.97	479141.00	4721.00		17231.45	18653.52	
Tennessee River	10.90	Floodway	341.75	0.97	342.42	1930.00	7696.70	506502.40	2800.88	16955.00	17231.45	18653.52	18885.00
Tennessee River	10.95	100 YR	340.85		341.39	10564.19	30094.77	480496.30	6408.89		17015.28	18602.03	
Tennessee River	10.95	Floodway	341.82	0.97	342.44	1910.00	2205.39	511842.70	2951.97	16927.00	17015.28	18602.03	18837.00
Tennessee River	10.99	100 YR	340.87		341.40	10599.73	30322.57	478250.30	8427.14		16997.78	18556.74	
Tennessee River	10.99	Floodway	341.84	0.96	342.45	1889.00	4181.99	510926.30	1891.68	16838.00	16997.78	18556.74	18727.00
Tennessee River	11.30	100 YR	341.14		341.50	12810.46	25004.19	436442.90	55552.90		16705.15	18217.82	
Tennessee River	11.30	Floodway	342.04	0.90	342.55	2466.00	4967.11	501159.30	10873.61	16259.00	16705.15	18217.82	18725.00
Tennessee River	12.37	100 YR	341.41		341.70	13780.16	18804.71	438458.00	59737.38		18556.83	20288.50	
Tennessee River	12.37	Floodway	342.39	0.98	342.81	3215.50	6770.19	503892.50	6337.29	17702.50	18556.83	20288.50	20918.00
Tennessee River	13.38	100 YR	341.60		341.88	9775.39	21465.66	466138.60	29395.76		14714.13	16884.17	
Tennessee River	13.38	Floodway	342.70	1.10	343.02	3664.12	6234.03	493664.20	17101.84	14290.00	14714.13	16884.17	17960.00
Tennessee River	14.41	100 YR	341.73		342.09	3956.53	9053.83	494658.30	13287.84		18941.33	20800.00	
Tennessee River	14.41	Floodway	342.86	1.14	343.22	3389.42	9994.95	497313.80	9691.22	17978.50	18941.33	20800.00	21490.00
Tennessee River	15.63	100 YR	341.95		342.34	3988.22	1434.52	484908.40	30657.08		13539.42	15277.83	
Tennessee River	15.63	Floodway	343.06	1.11	343.46	3315.19	1837.56	496407.50	18754.88	12979.00	13539.42	15277.83	16341.00
Tennessee River	17.03	100 YR	342.32		342.66	5296.06	3439.84	456906.30	56653.85		12863.34	14926.95	
Tennessee River	17.03	Floodway	343.36	1.04	343.80	2868.02	4329.94	507331.30	5338.79	12344.00	12863.34	14926.95	15246.00
Tennessee River	18.21	100 YR	342.59		342.90	9147.14	58159.75	434836.10	24004.21		14187.33	15772.74	
Tennessee River	18.21	Floodway	343.66	1.07	344.09	3057.00	13813.57	487331.10	15855.39	13404.00	14187.33	15772.74	16461.00

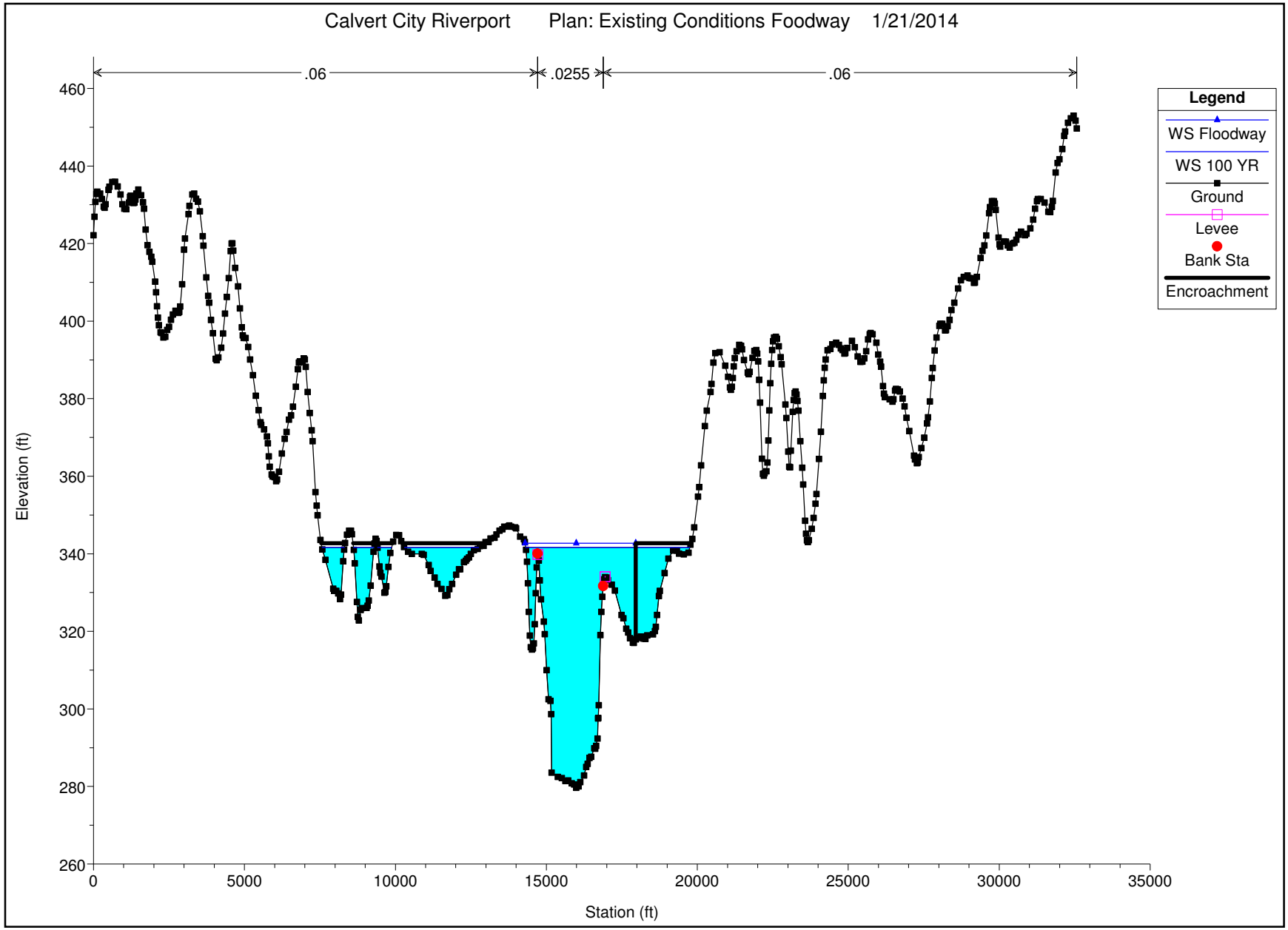

Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
Tennessee River Tennessee River
Legend
WS Floodway
WS 100 YR
Ground
Elevation (ft)
Main Channel Distance (ft)
360
340
320
300
280
260
0
10000
20000
30000
40000
50000
60000
10.38
10.71 A1a
10.90 A1b
11.30
12.37
13.38
14.41
15...
17.03
18.21 Kentuck...

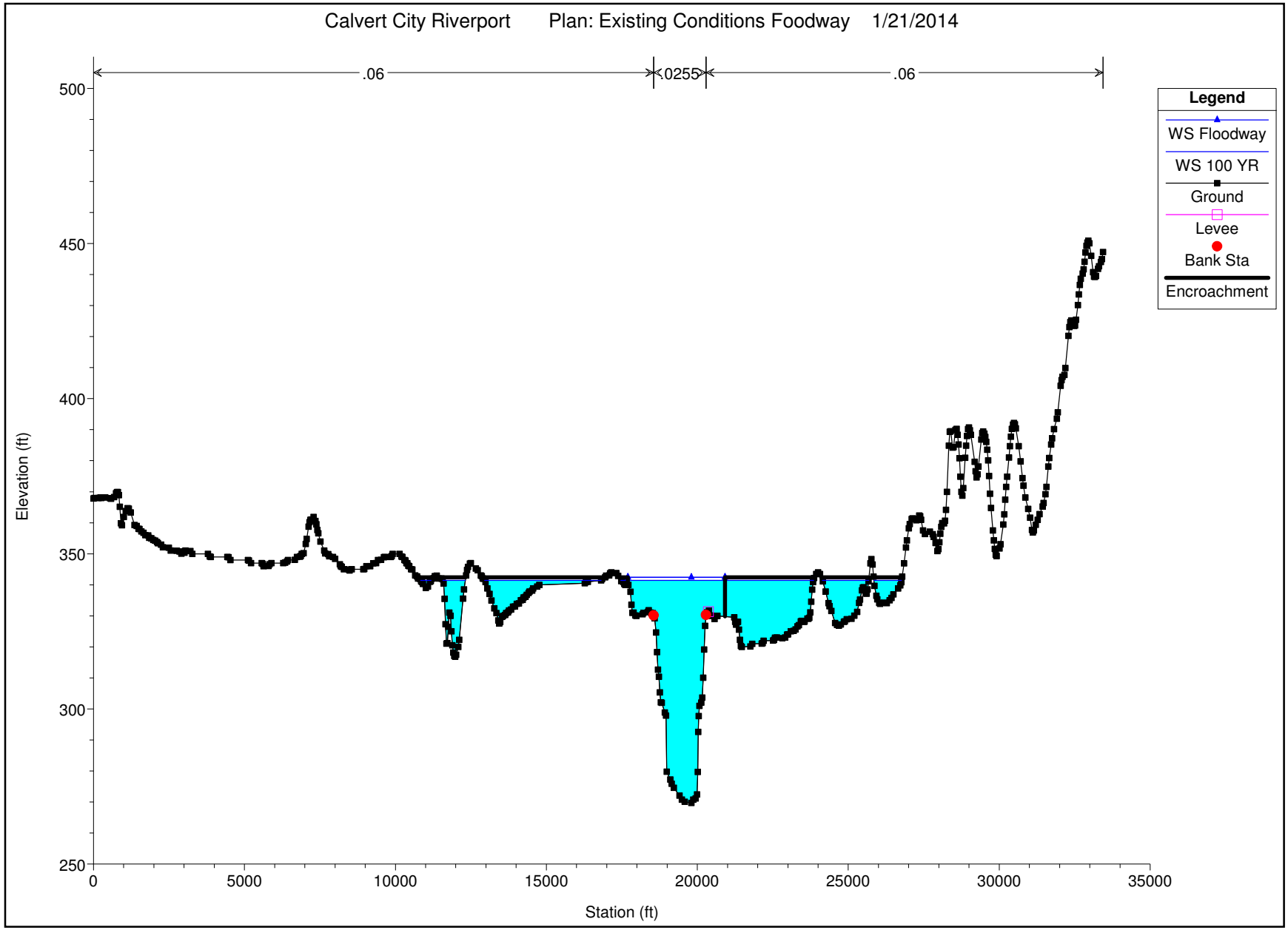

Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
Kentucky, KY
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
30000
Station (ft)

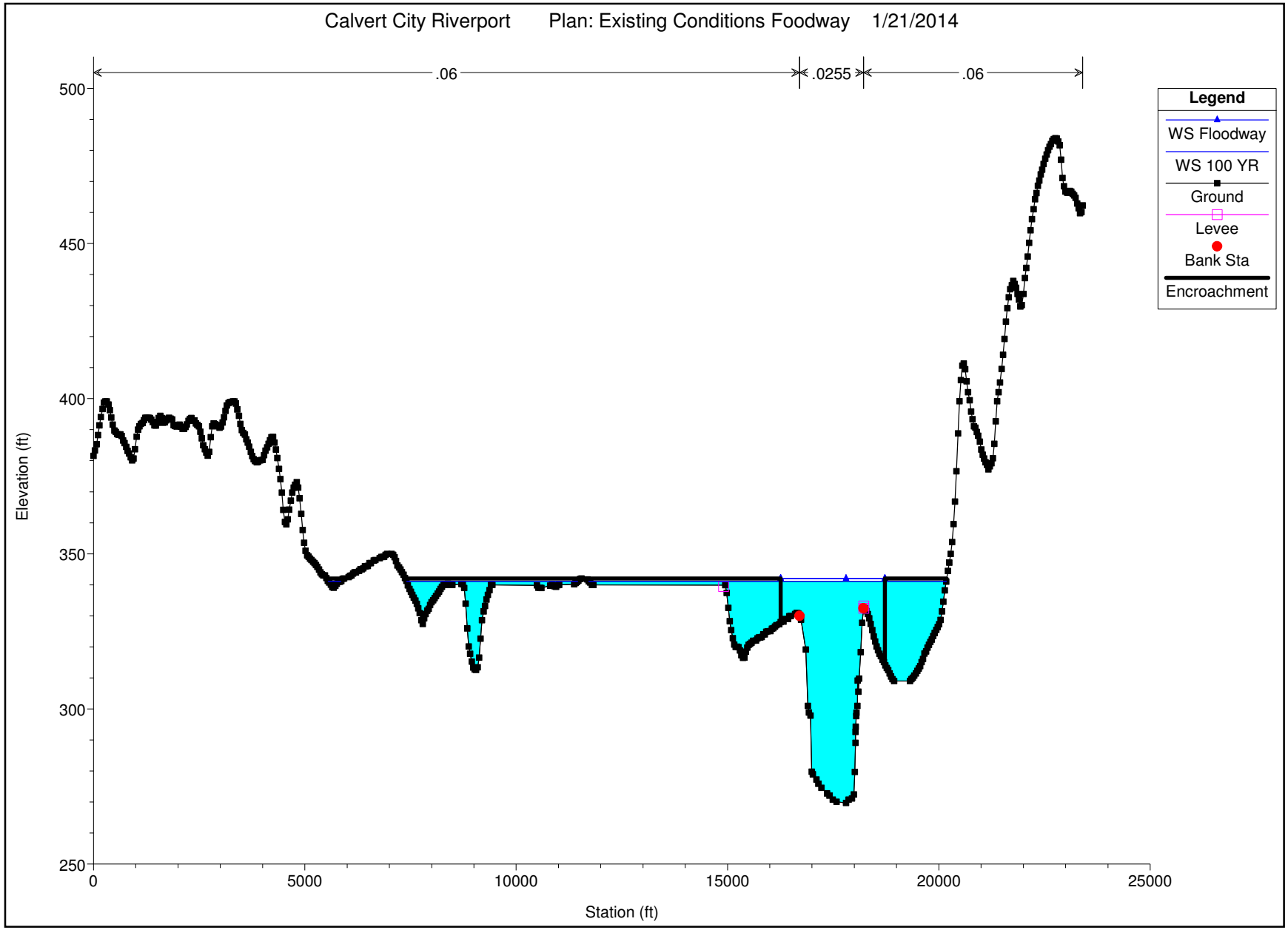

Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
.06
0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
.06
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.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
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400
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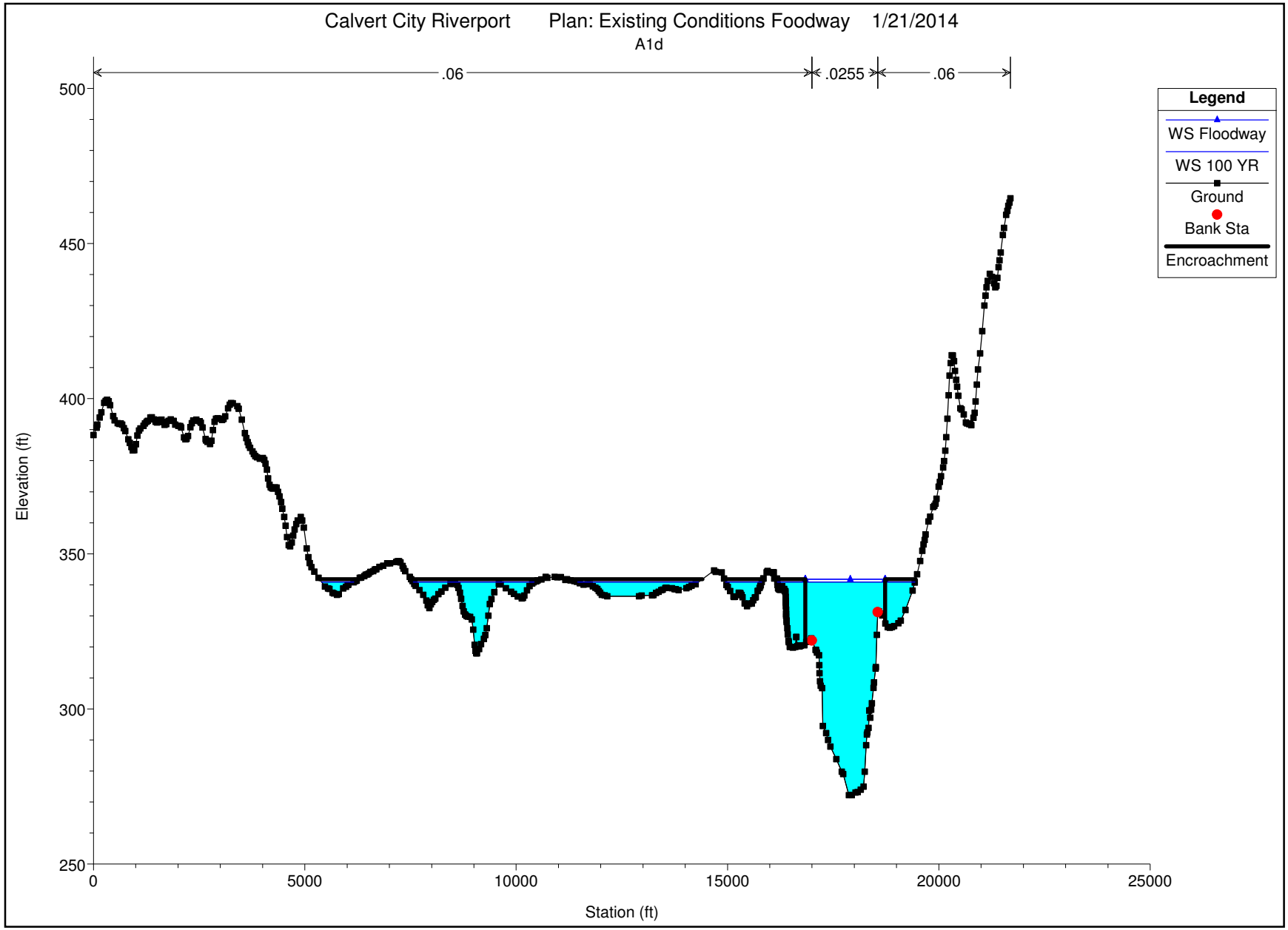
250
0
5000
10000
15000
20000
25000
Station (ft)


Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
A1d
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Bank Sta
Encroachment
Elevation (ft)
500
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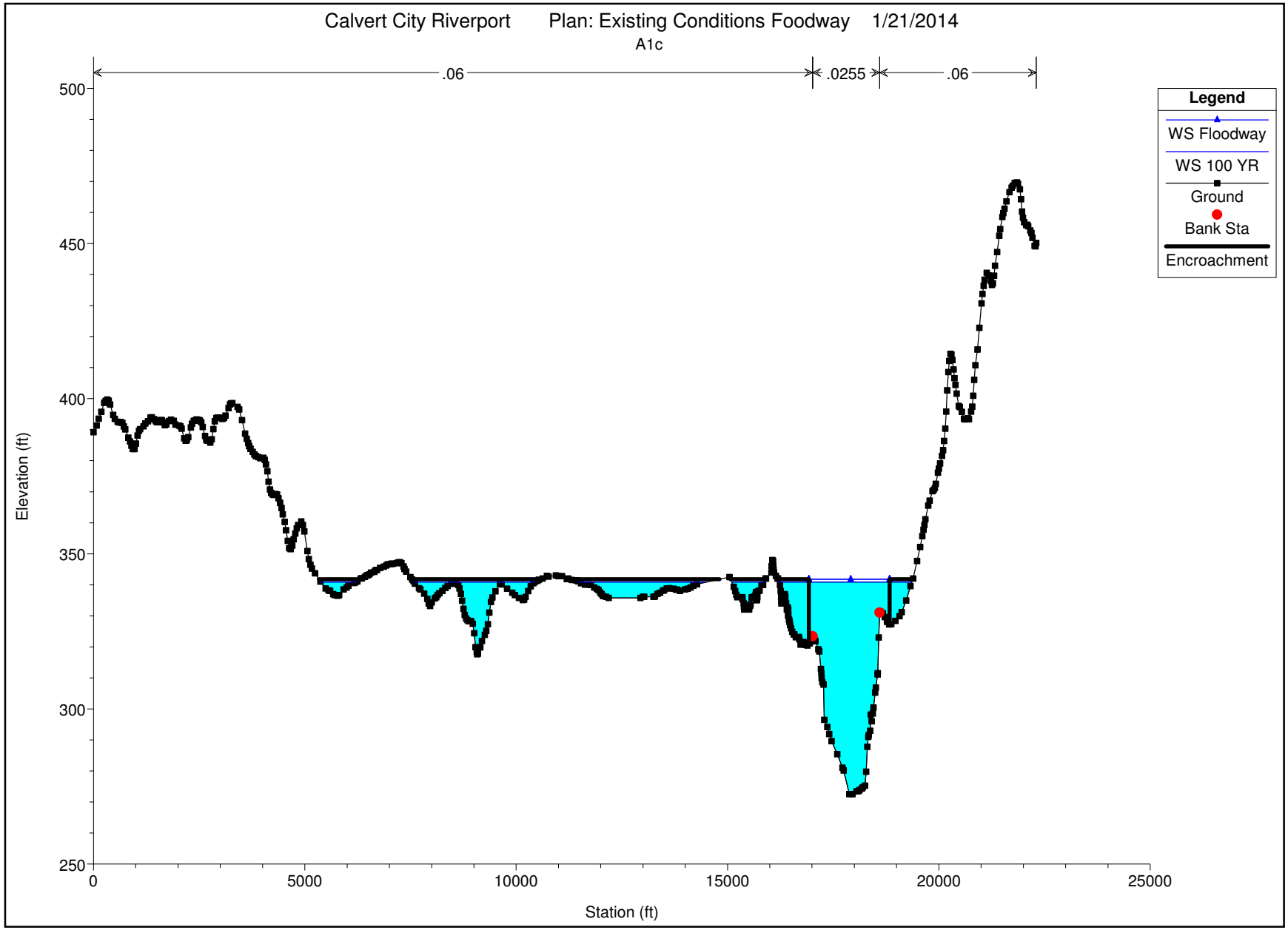
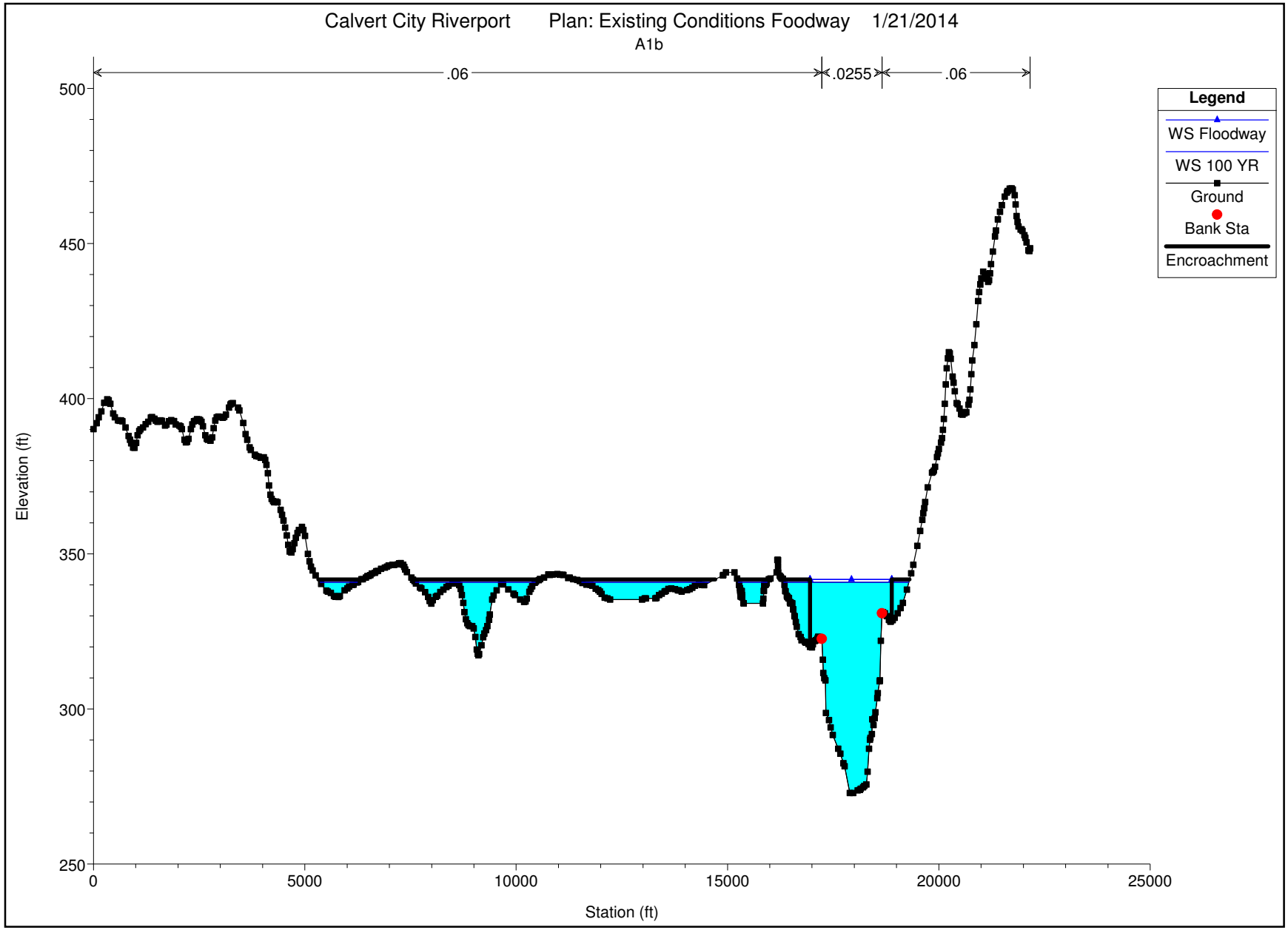
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)


Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
A1c
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Bank Sta
Encroachment
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)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A1b
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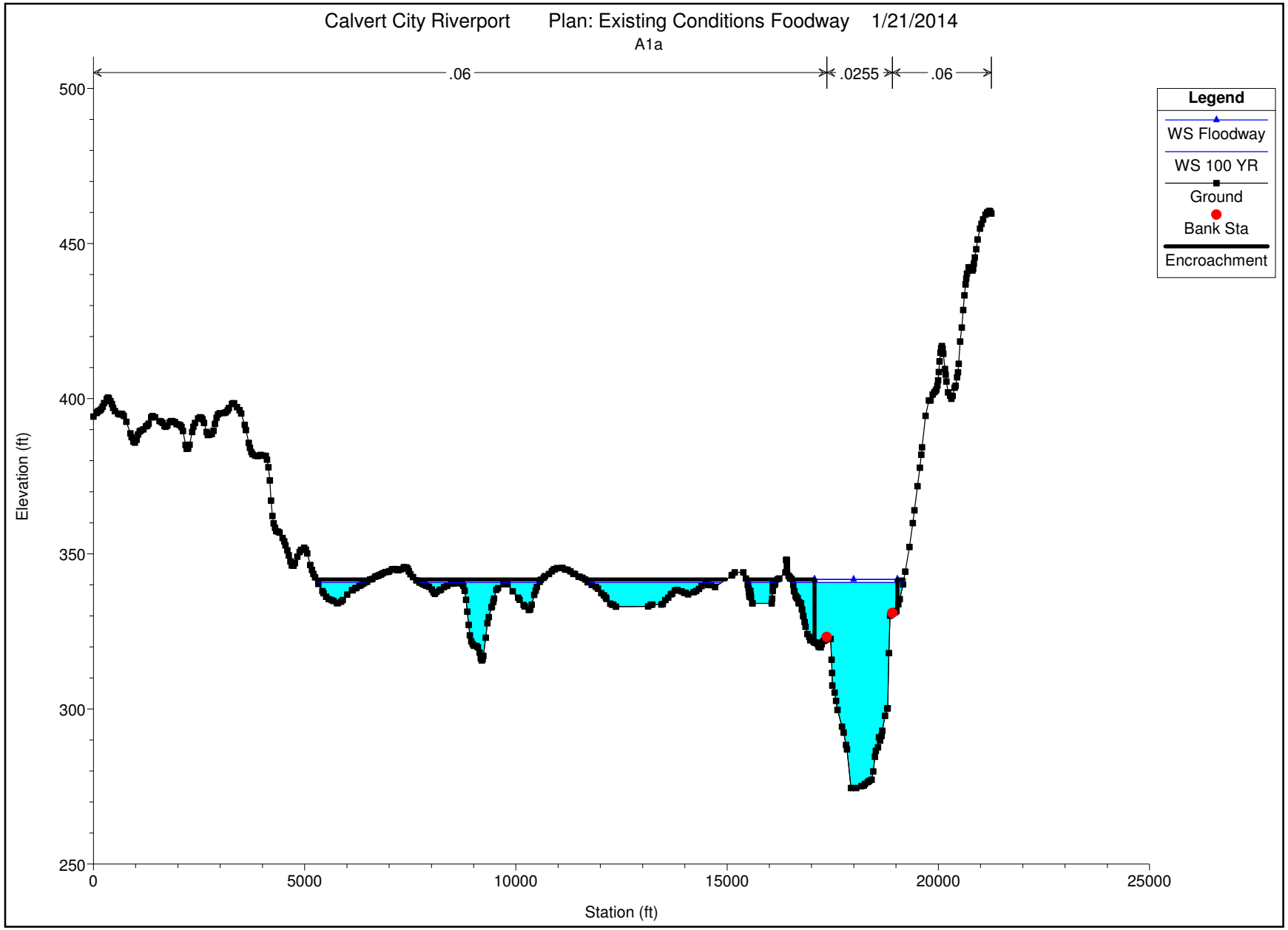
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Bank Sta
Encroachment
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)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A1a
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Bank Sta
Encroachment
Elevation (ft)
500
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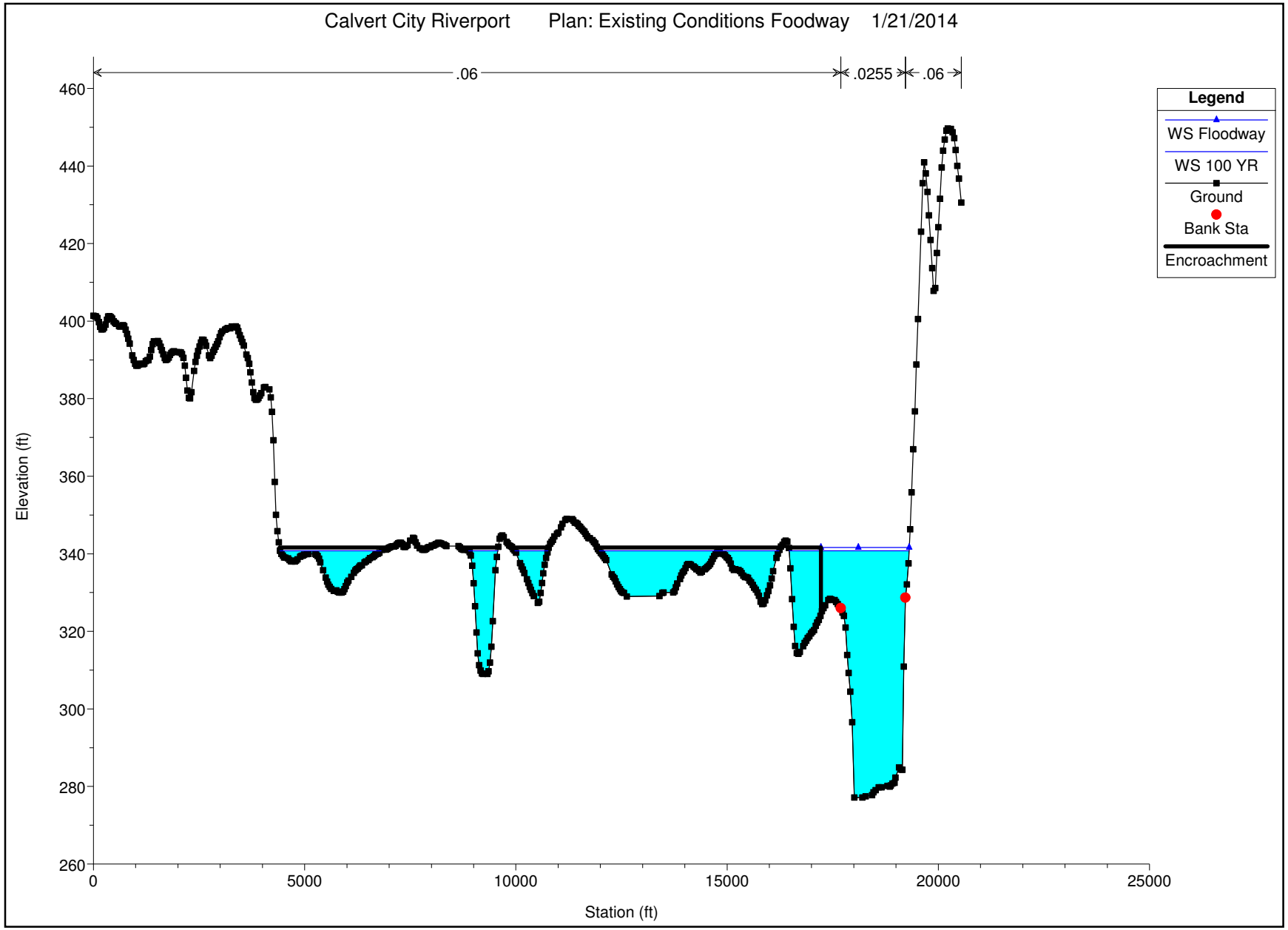
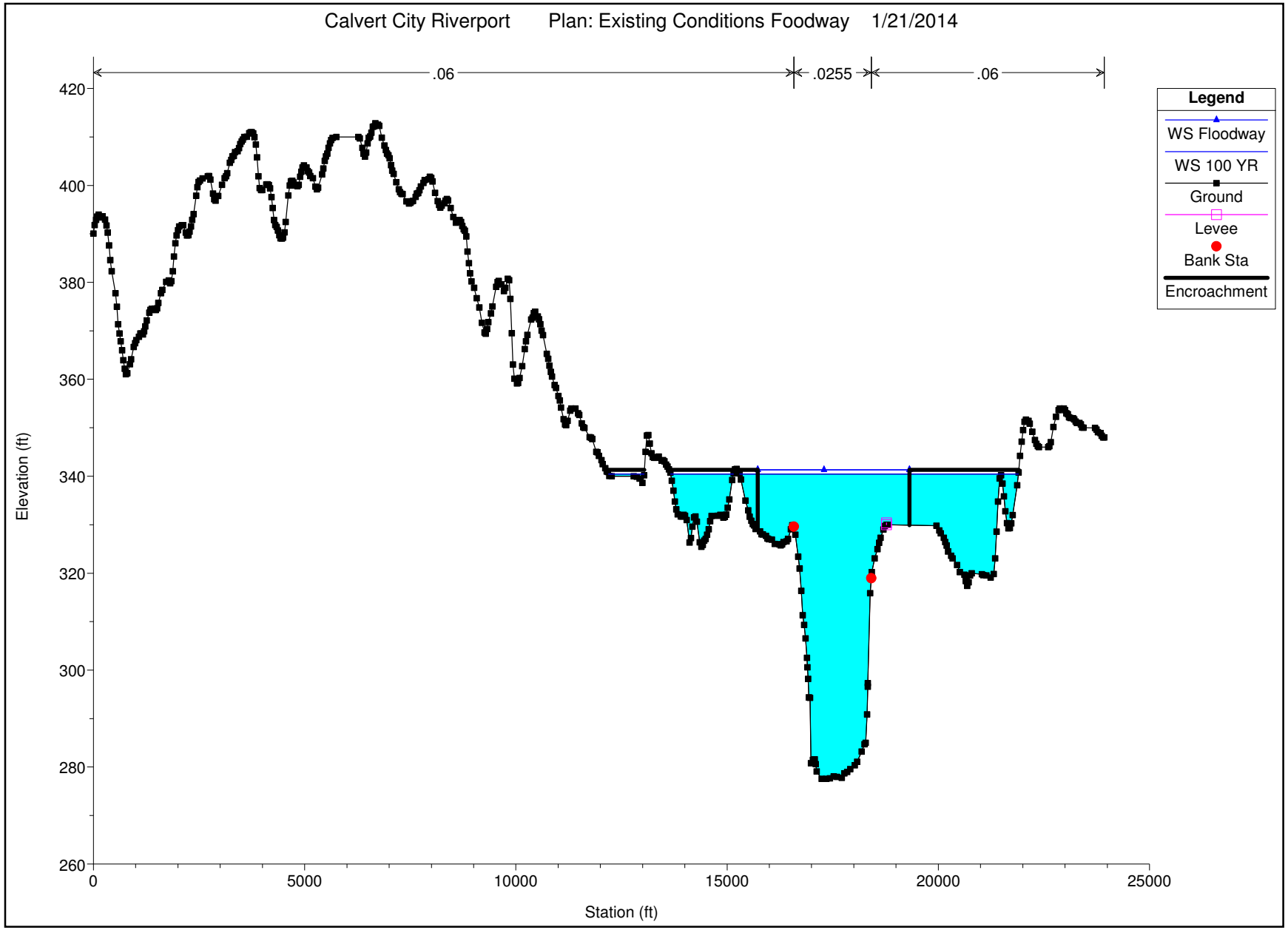
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)


Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Bank Sta
Encroachment
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
Station (ft)

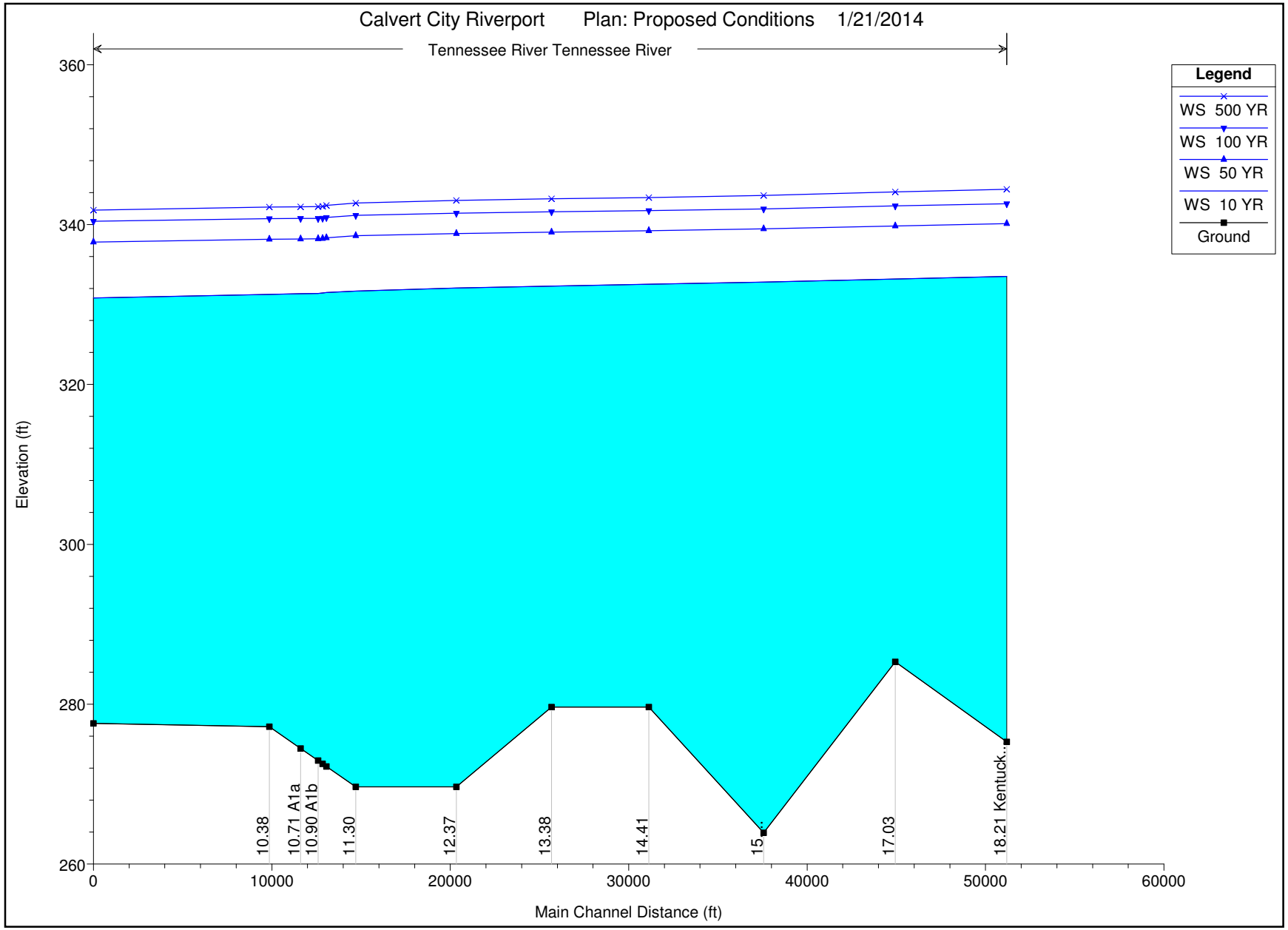

Calvert City Riverport Plan: Existing Conditions Foodway 1/21/2014
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
Station (ft)

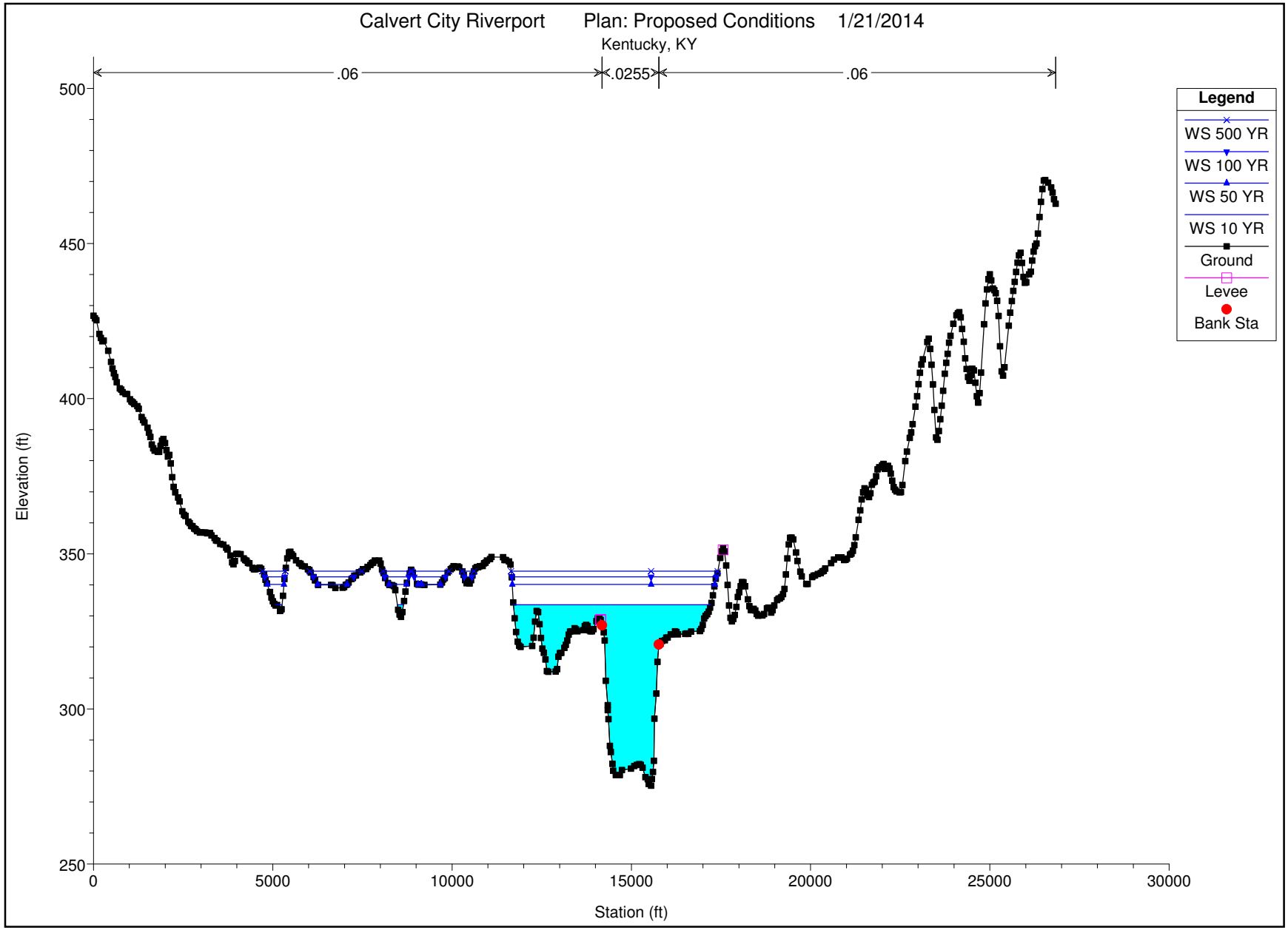
Appendix V
Proposed Conditions Model

ICA Engineering

HEC-RAS Plan: Proposed River: Tennessee River Reach: Tennessee River

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Tennessee River	8.52	10 YR	388000.00	277.59	330.82	293.53	331.18	0.000047	4.86	98258.48	6426.53	0.13
Tennessee River	8.52	50 YR	480000.00	277.59	337.82	295.74	338.15	0.000038	4.82	149719.10	7786.96	0.12
Tennessee River	8.52	100 YR	517000.00	277.59	340.42	296.54	340.74	0.000035	4.81	170779.90	8922.88	0.12
Tennessee River	8.52	500 YR	600000.00	277.59	341.82	298.29	342.21	0.000042	5.35	183498.00	9251.29	0.13
Tennessee River	10.38	10 YR	388000.00	277.17	331.28		331.72	0.000058	5.49	89904.79	5542.77	0.15
Tennessee River	10.38	50 YR	480000.00	277.17	338.18		338.60	0.000049	5.53	137885.50	8855.83	0.14
Tennessee River	10.38	100 YR	517000.00	277.17	340.75		341.16	0.000045	5.51	163252.10	10952.77	0.13
Tennessee River	10.38	500 YR	600000.00	277.17	342.21		342.72	0.000054	6.15	180397.10	12789.97	0.15
Tennessee River	10.71	10 YR	388000.00	274.46	331.34		331.87	0.000088	5.87	70320.61	2524.97	0.17
Tennessee River	10.71	50 YR	480000.00	274.46	338.21		338.73	0.000072	5.92	102654.80	7214.41	0.16
Tennessee River	10.71	100 YR	517000.00	274.46	340.77		341.29	0.000067	5.94	124309.90	10107.51	0.16
Tennessee River	10.71	500 YR	600000.00	274.46	342.24		342.86	0.000079	6.55	139919.60	11117.76	0.17
Tennessee River	10.90	10 YR	388000.00	272.93	331.40		331.97	0.000089	6.09	67934.41	2599.46	0.17
Tennessee River	10.90	50 YR	480000.00	272.93	338.24		338.83	0.000078	6.26	95605.20	6791.18	0.16
Tennessee River	10.90	100 YR	517000.00	272.93	340.79		341.38	0.000074	6.30	116549.50	9661.53	0.16
Tennessee River	10.90	500 YR	600000.00	272.93	342.26		342.97	0.000087	6.97	131630.10	10943.10	0.17
Tennessee River	10.95	10 YR	388000.00	272.54	331.43		331.99	0.000078	6.03	68938.42	2706.55	0.17
Tennessee River	10.95	50 YR	480000.00	272.54	338.26		338.84	0.000068	6.23	96252.97	6749.56	0.16
Tennessee River	10.95	100 YR	517000.00	272.54	340.81		341.39	0.000065	6.28	117475.30	9838.54	0.16
Tennessee River	10.95	500 YR	600000.00	272.54	342.28		342.99	0.000077	6.96	133116.10	11450.89	0.17
Tennessee River	10.99	10 YR	388000.00	272.20	331.50		332.01	0.000081	5.79	72305.82	3024.45	0.17
Tennessee River	10.99	50 YR	480000.00	272.20	338.34		338.87	0.000068	5.89	101194.60	6992.01	0.16
Tennessee River	10.99	100 YR	517000.00	272.20	340.90		341.42	0.000063	5.90	123505.80	10154.52	0.15
Tennessee River	10.99	500 YR	600000.00	272.20	342.40		343.02	0.000074	6.51	139749.50	11586.40	0.17
Tennessee River	11.30	10 YR	388000.00	269.66	331.68	289.14	332.13	0.000054	5.44	81645.12	3187.41	0.14
Tennessee River	11.30	50 YR	480000.00	269.66	338.61	291.64	338.97	0.000040	5.13	144092.30	5182.75	0.12
Tennessee River	11.30	100 YR	517000.00	269.66	341.16	292.59	341.51	0.000038	5.18	180576.50	12817.21	0.12
Tennessee River	11.30	500 YR	600000.00	269.66	342.71	294.67	343.13	0.000044	5.71	200958.00	13409.92	0.13
Tennessee River	12.37	10 YR	388000.00	269.66	332.07	289.14	332.41	0.000043	4.76	110774.50	7913.03	0.13
Tennessee River	12.37	50 YR	480000.00	269.66	338.88	291.64	339.18	0.000034	4.70	172867.40	10421.01	0.12
Tennessee River	12.37	100 YR	517000.00	269.66	341.43	292.61	341.71	0.000032	4.67	203176.30	13786.45	0.11
Tennessee River	12.37	500 YR	600000.00	269.66	343.02	294.68	343.37	0.000037	5.16	226071.20	15026.70	0.12
Tennessee River	13.38	10 YR	388000.00	279.64	332.31	296.04	332.64	0.000045	4.58	84627.71	2109.40	0.13
Tennessee River	13.38	50 YR	480000.00	279.64	339.07	298.00	339.37	0.000038	4.58	129575.00	4332.49	0.12
Tennessee River	13.38	100 YR	517000.00	279.64	341.61	298.73	341.89	0.000034	4.46	176790.80	9780.87	0.11
Tennessee River	13.38	500 YR	600000.00	279.64	343.24	300.34	343.57	0.000039	4.93	193311.20	10583.73	0.12
Tennessee River	14.41	10 YR	388000.00	279.64	332.55	296.04	332.87	0.000041	4.63	91906.73	3680.29	0.12
Tennessee River	14.41	50 YR	480000.00	279.64	339.24	298.00	339.59	0.000037	4.87	117321.10	3899.99	0.12
Tennessee River	14.41	100 YR	517000.00	279.64	341.74	298.75	342.11	0.000036	4.95	127165.00	3956.83	0.12
Tennessee River	14.41	500 YR	600000.00	279.64	343.38	300.46	343.83	0.000043	5.54	133679.60	3998.59	0.13
Tennessee River	15.63	10 YR	388000.00	263.92	332.80	289.08	333.16	0.000044	4.86	92301.53	3531.42	0.13
Tennessee River	15.63	50 YR	480000.00	263.92	339.47	291.66	339.85	0.000040	5.09	116773.00	3859.02	0.13
Tennessee River	15.63	100 YR	517000.00	263.92	341.96	292.68	342.35	0.000039	5.17	126612.70	3988.72	0.12
Tennessee River	15.63	500 YR	600000.00	263.92	343.65	294.81	344.13	0.000047	5.78	133376.70	4045.99	0.14
Tennessee River	17.03	10 YR	388000.00	285.31	333.18	302.07	333.54	0.000063	4.98	99094.16	4972.82	0.15
Tennessee River	17.03	50 YR	480000.00	285.31	339.84	304.26	340.18	0.000049	4.95	132989.10	5212.72	0.13
Tennessee River	17.03	100 YR	517000.00	285.31	342.33	305.07	342.67	0.000046	4.96	146093.90	5296.63	0.13
Tennessee River	17.03	500 YR	600000.00	285.31	344.10	306.80	344.51	0.000053	5.48	155546.30	5440.46	0.14
Tennessee River	18.21	10 YR	388000.00	275.29	333.53	294.79	333.86	0.000041	4.81	115110.10	5864.96	0.12
Tennessee River	18.21	50 YR	480000.00	275.29	340.12	297.00	340.44	0.000035	4.89	156381.60	8040.13	0.12
Tennessee River	18.21	100 YR	517000.00	275.29	342.60	297.87	342.92	0.000033	4.90	177824.80	9152.10	0.12
Tennessee River	18.21	500 YR	600000.00	275.29	344.42	299.74	344.79	0.000039	5.40	195169.70	10006.74	0.13


Calvert City Riverport Plan: Proposed Conditions 1/21/2014
Tennessee River Tennessee River
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Elevation (ft)
360
340
320
300
280
260
0
10000
20000
30000
40000
50000
60000
Main Channel Distance (ft)
10.38
10.71 A1a
10.90 A1b
11.30
12.37
13.38
14.41
15...
17.03
18.21 Kentuck...


Calvert City Riverport
Plan: Proposed Conditions
1/21/2014
Kentucky, KY
.06
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.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
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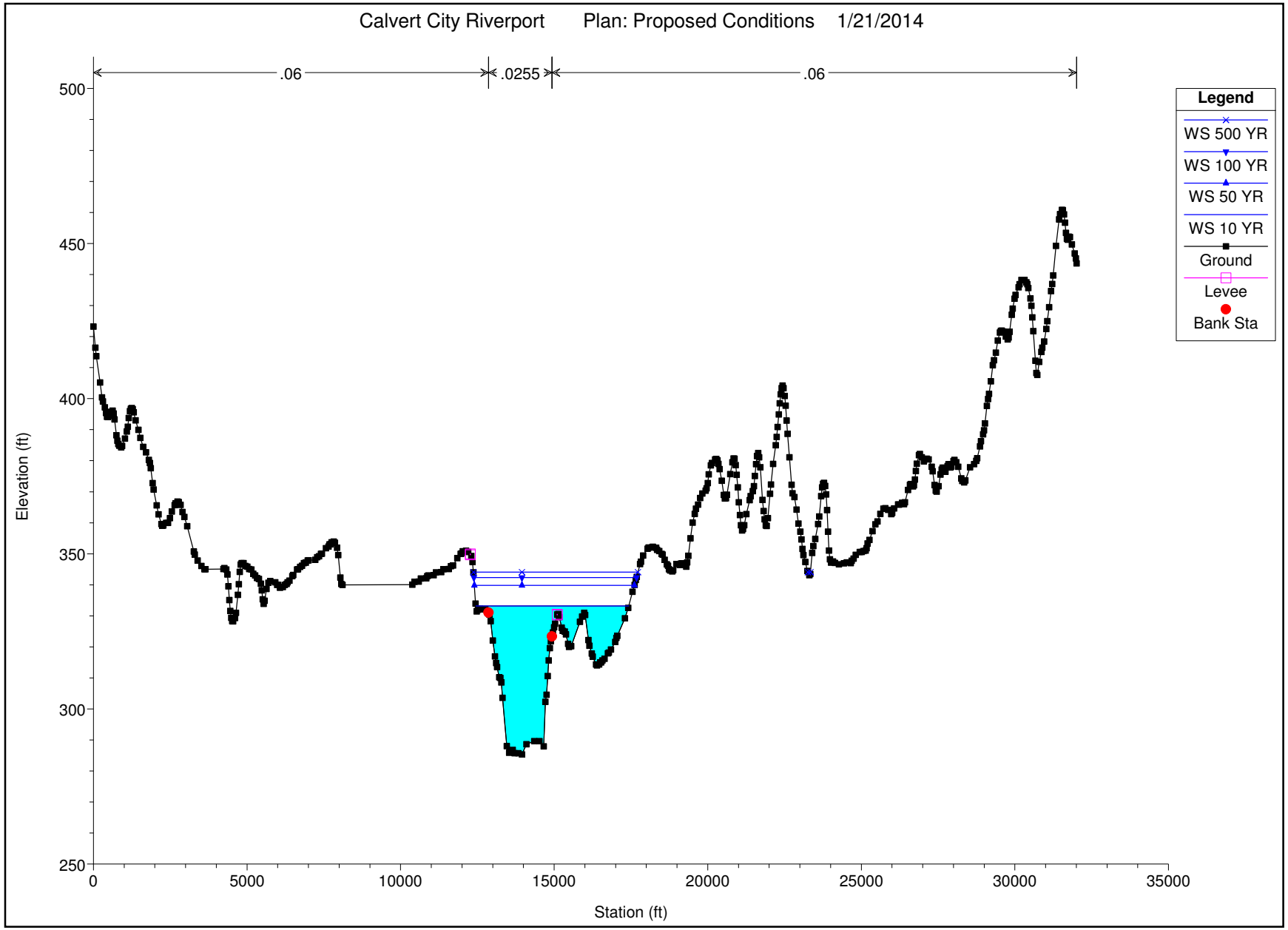
450
400
350
300
250
0
5000
10000
15000
20000
25000
30000
Station (ft)


Calvert City Riverport
Plan: Proposed Conditions
1/21/2014
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Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
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450
400
350
300
250
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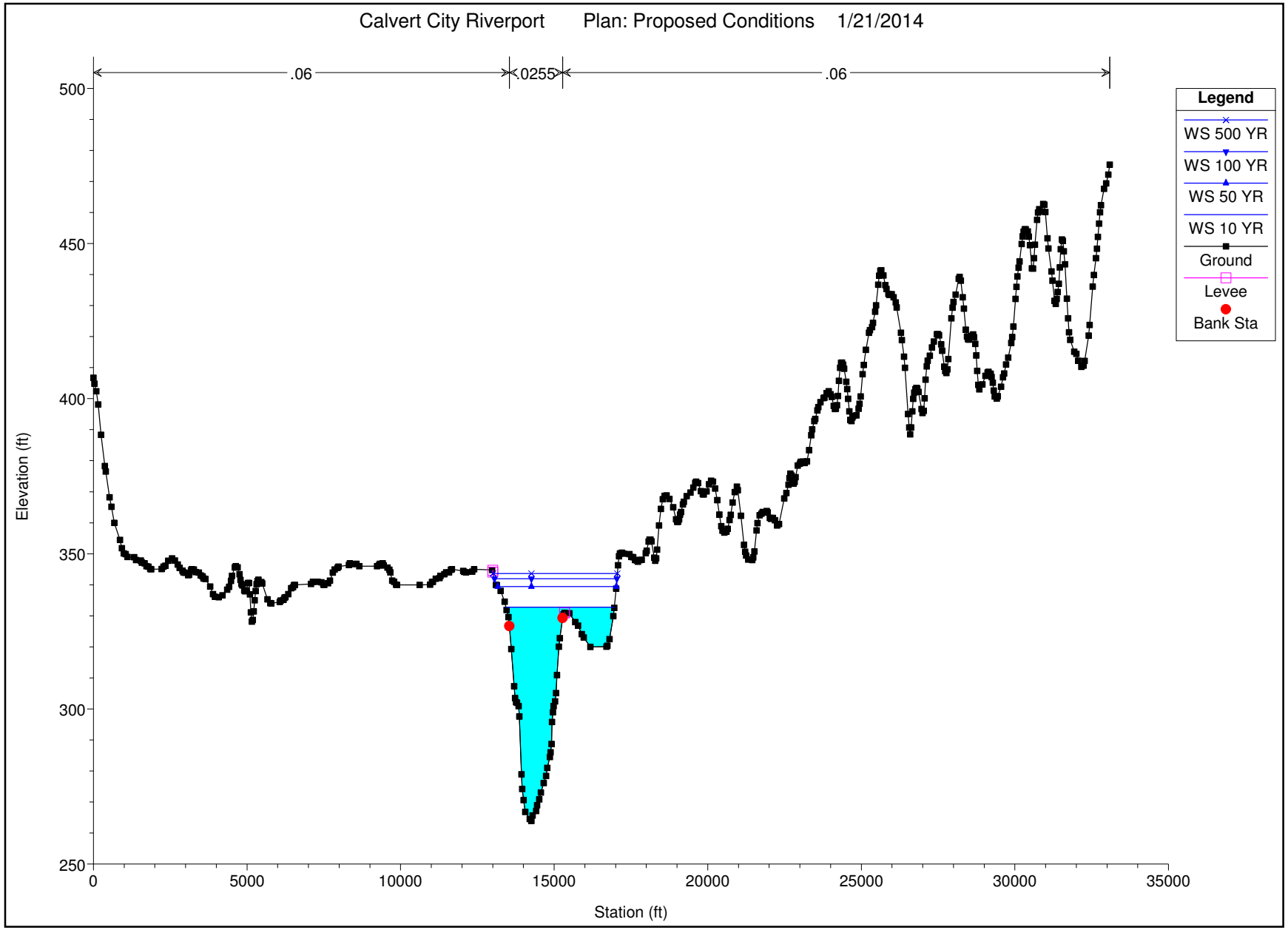
5000
10000
15000
20000
25000
30000
35000


Calvert City Riverport
Plan: Proposed Conditions
1/21/2014
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Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
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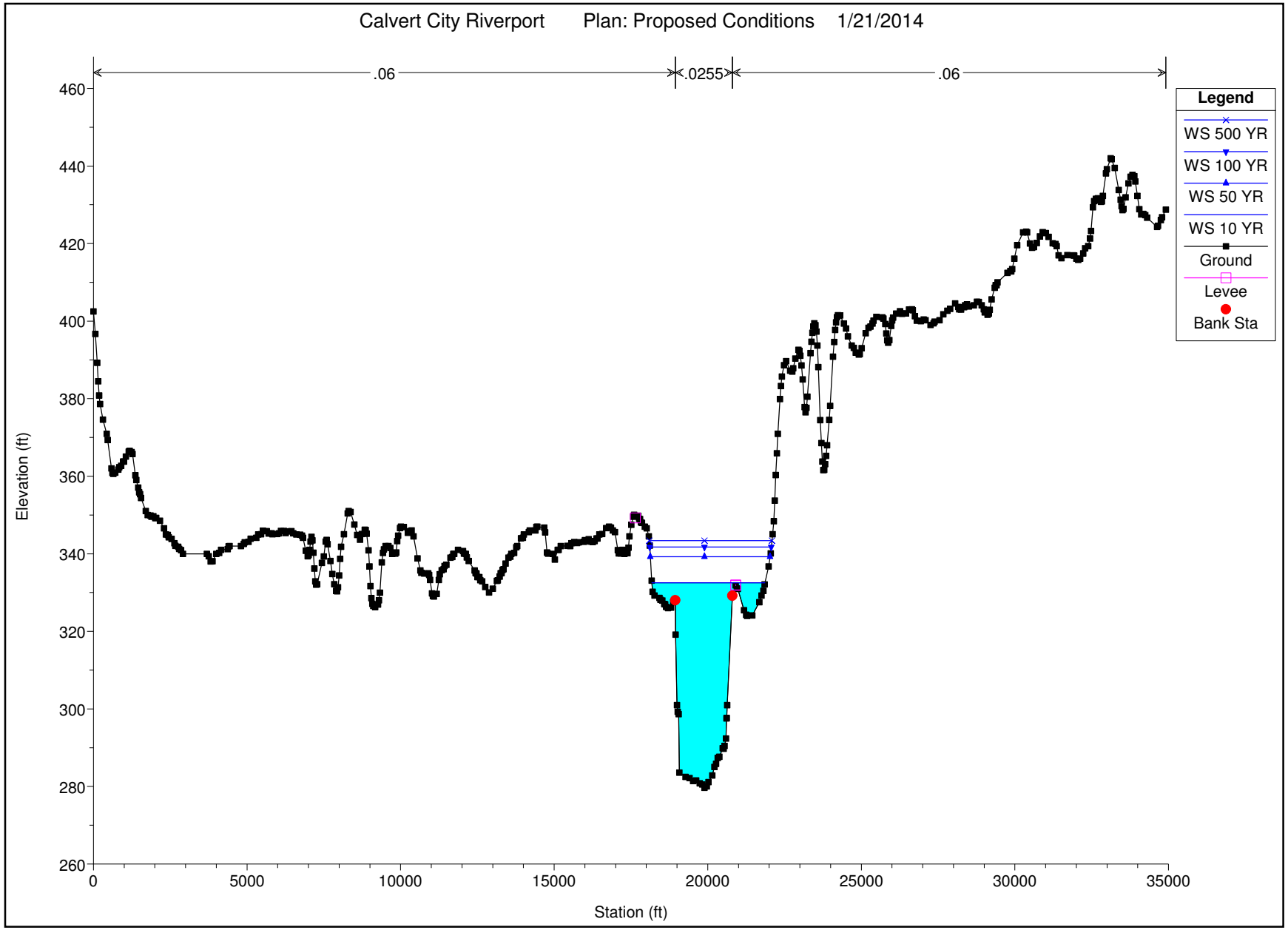
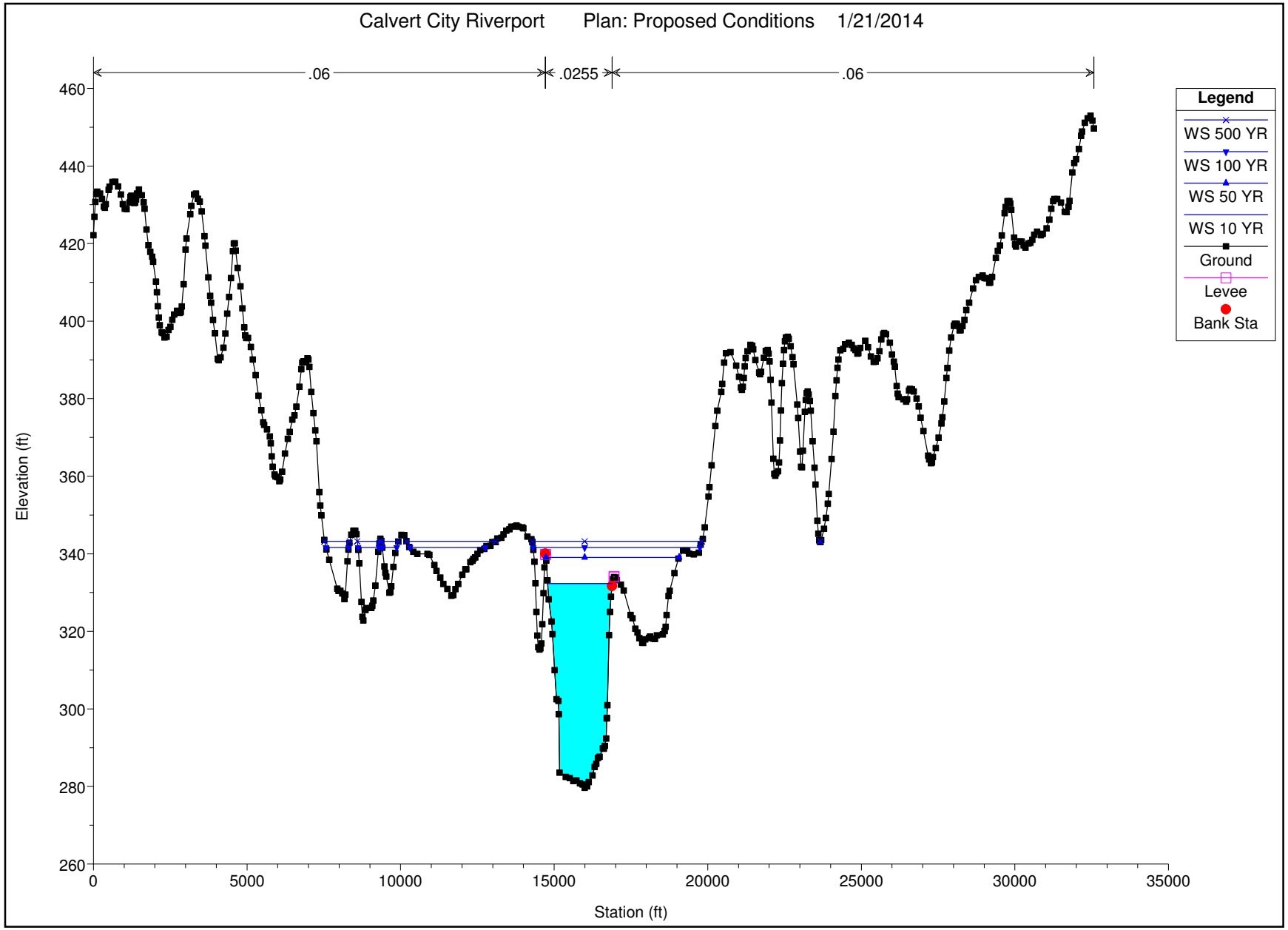
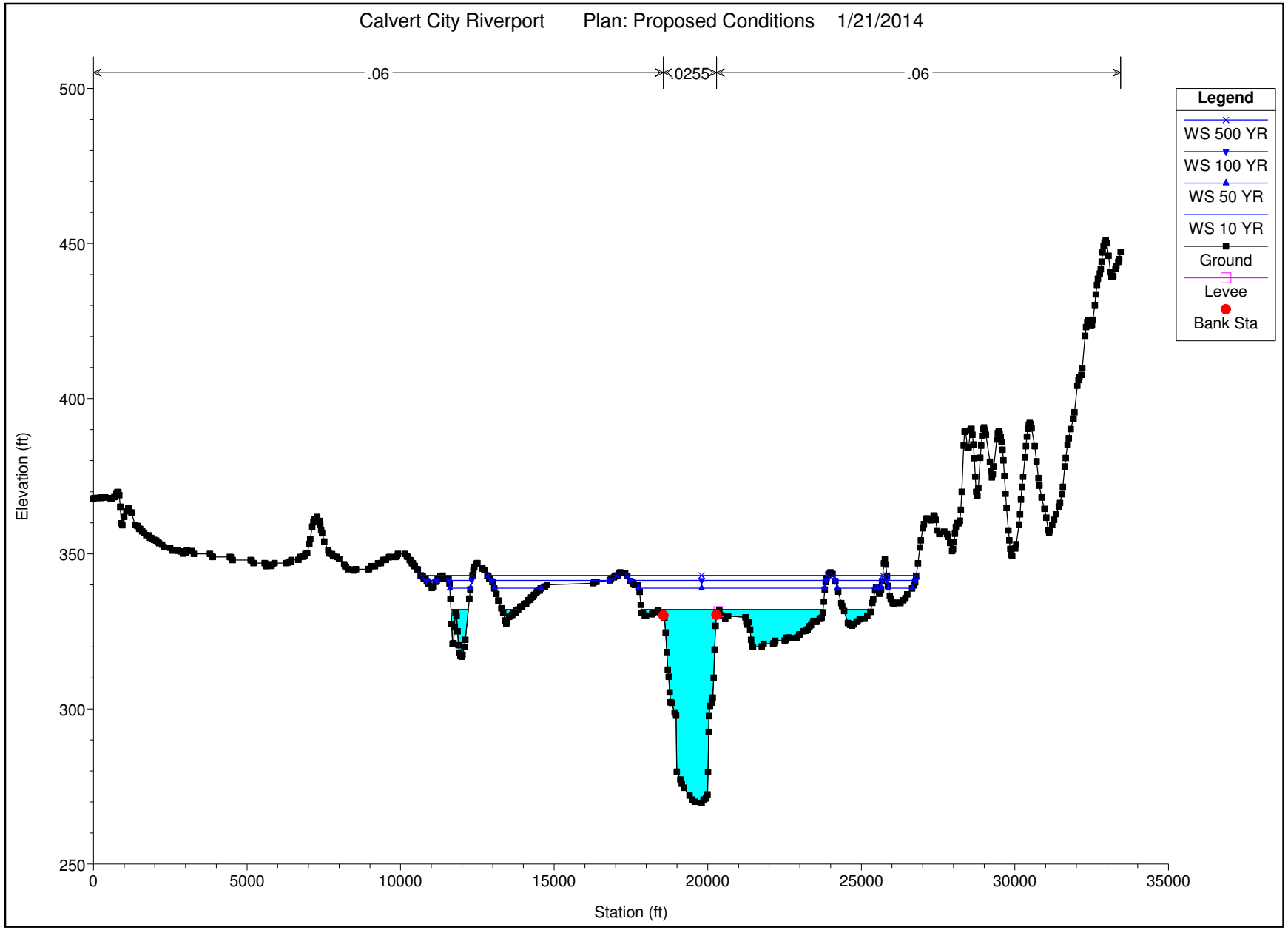
400
350
300
250
0
5000
10000
15000
20000
25000
30000
35000


Calvert City Riverport Plan: Proposed Conditions 1/21/2014
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Proposed Conditions 1/21/2014
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport Plan: Proposed Conditions 1/21/2014
.06
0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
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450
400
350
300
250
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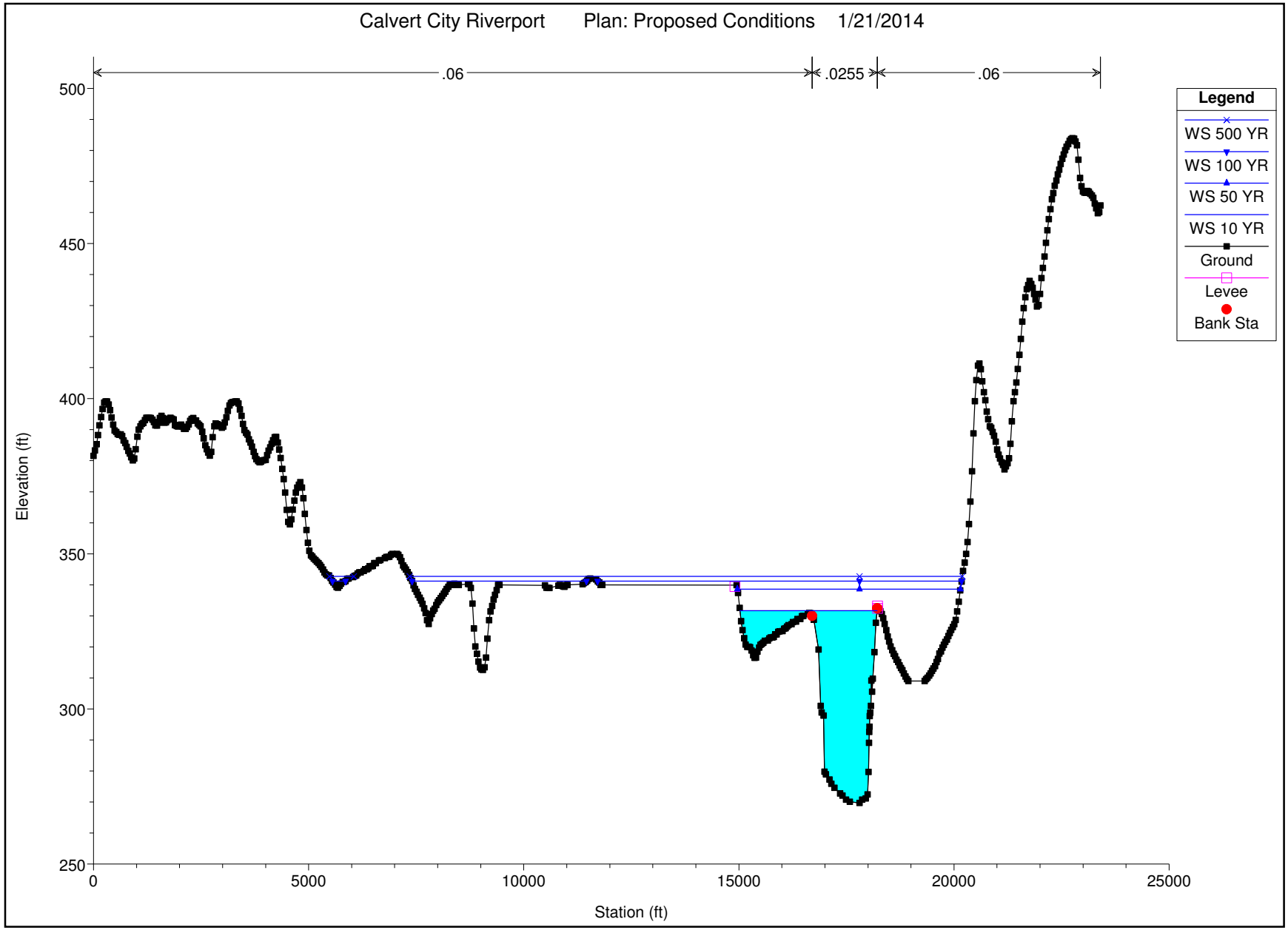
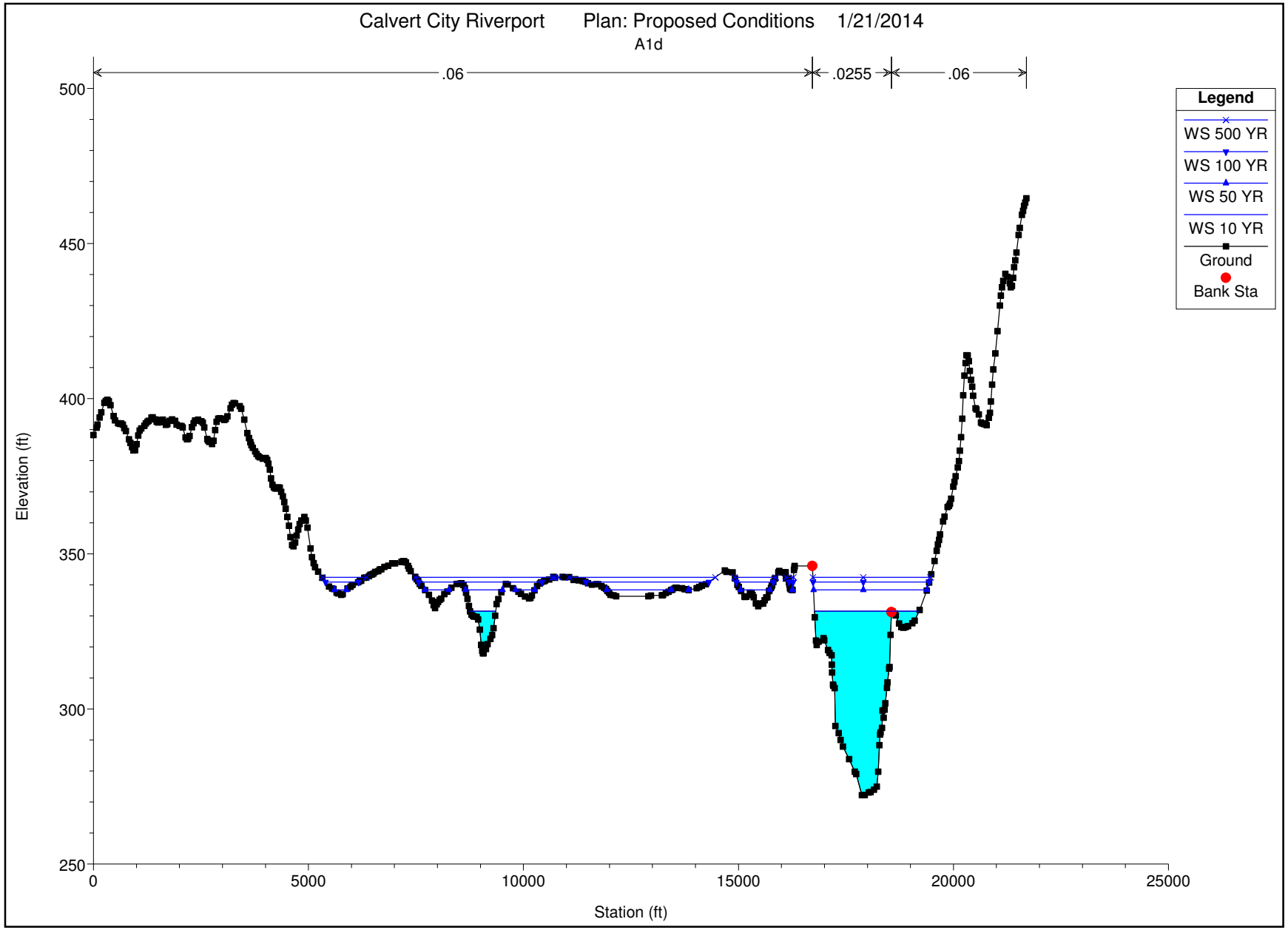
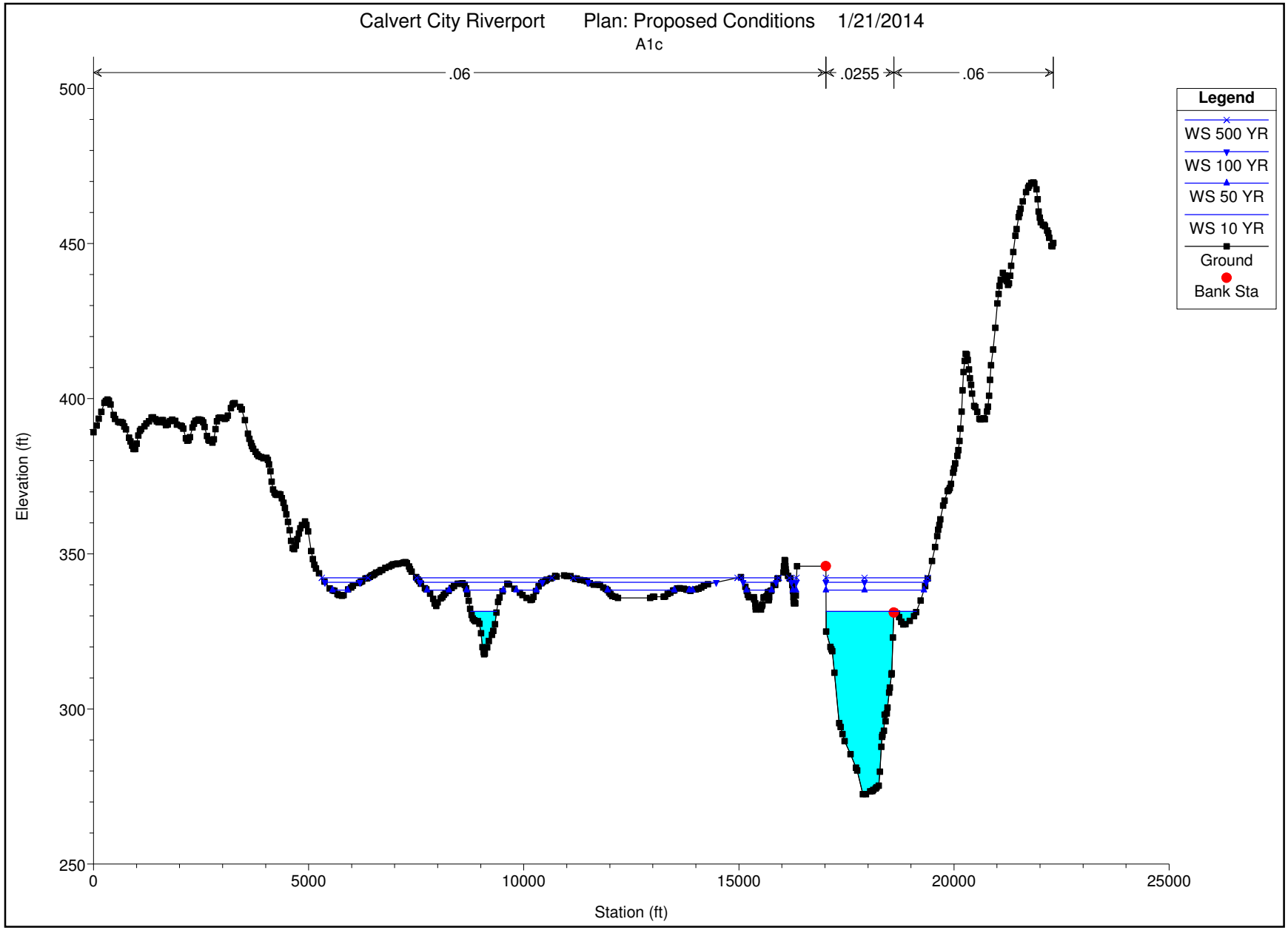
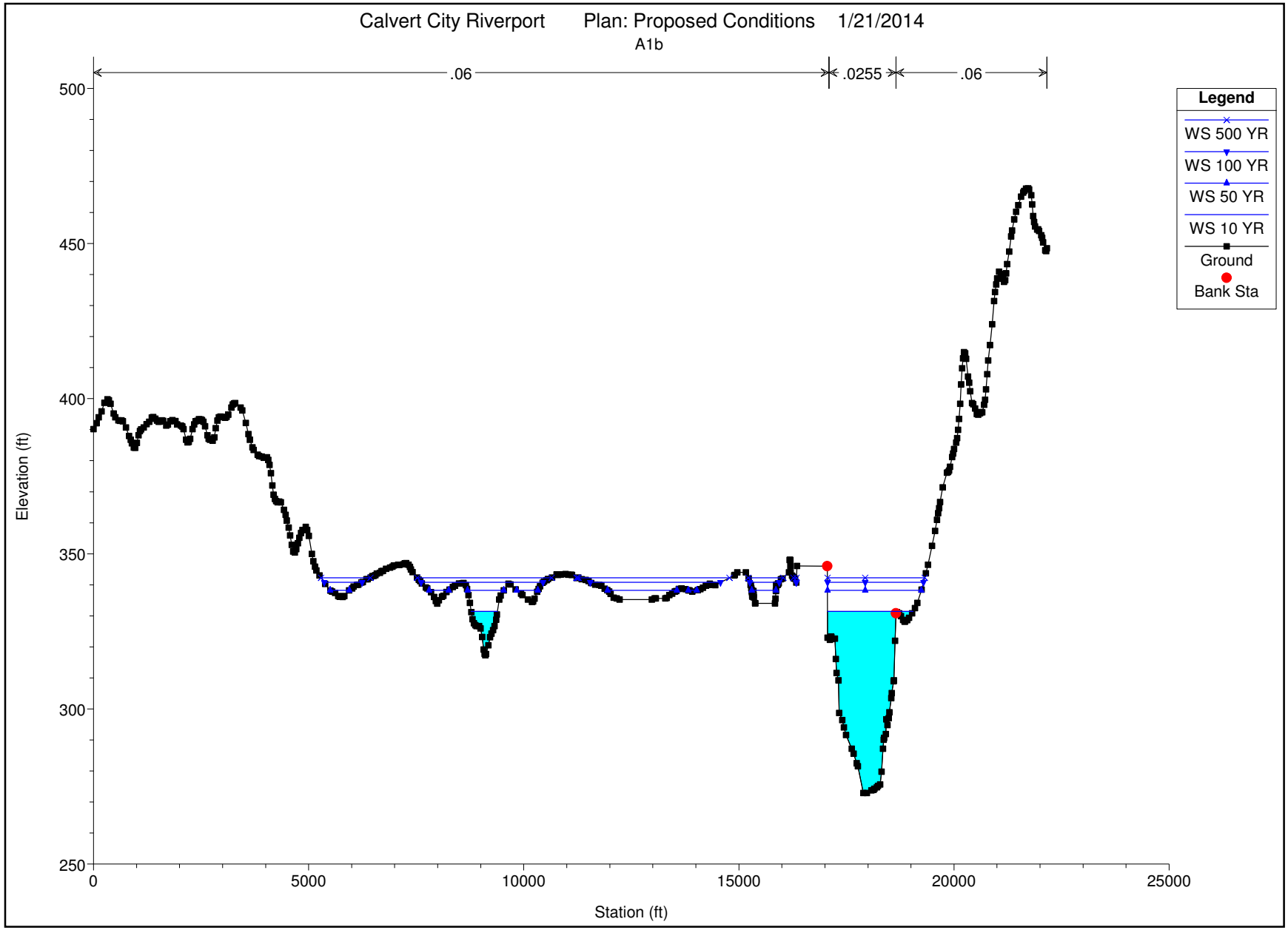
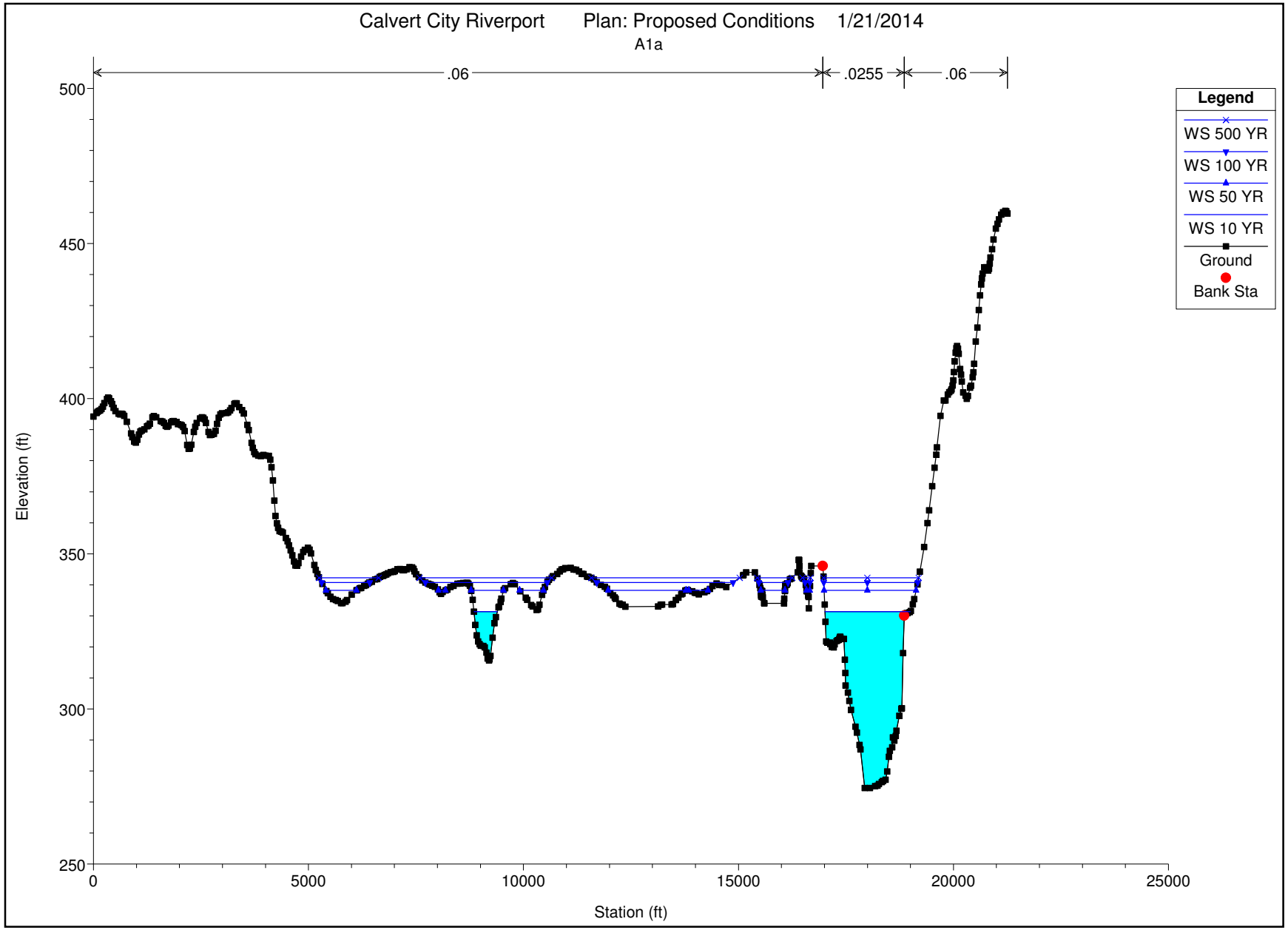
5000
10000
15000
20000
25000
30000
35000

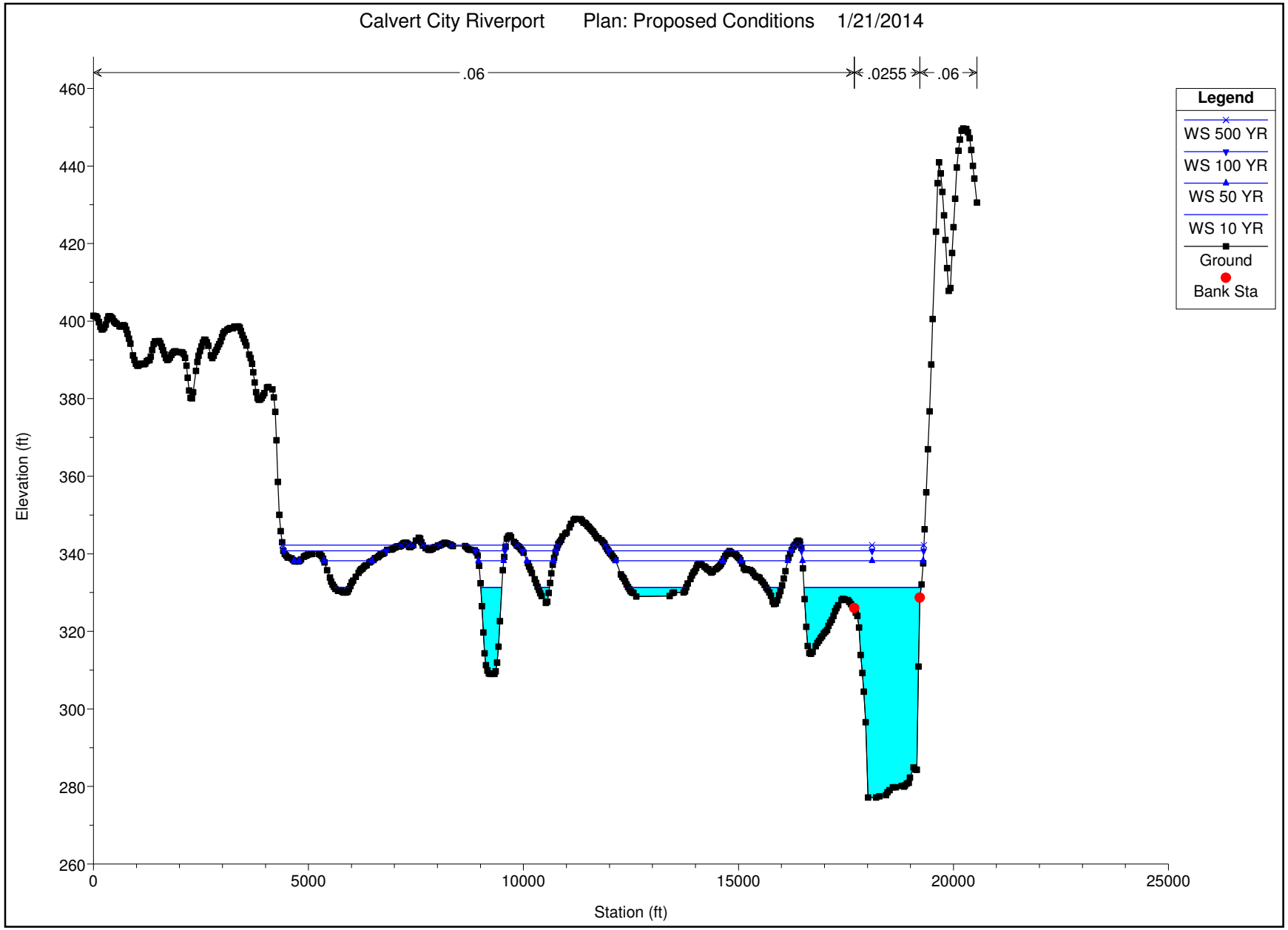

Calvert City Riverport
Plan: Proposed Conditions
1/21/2014
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)

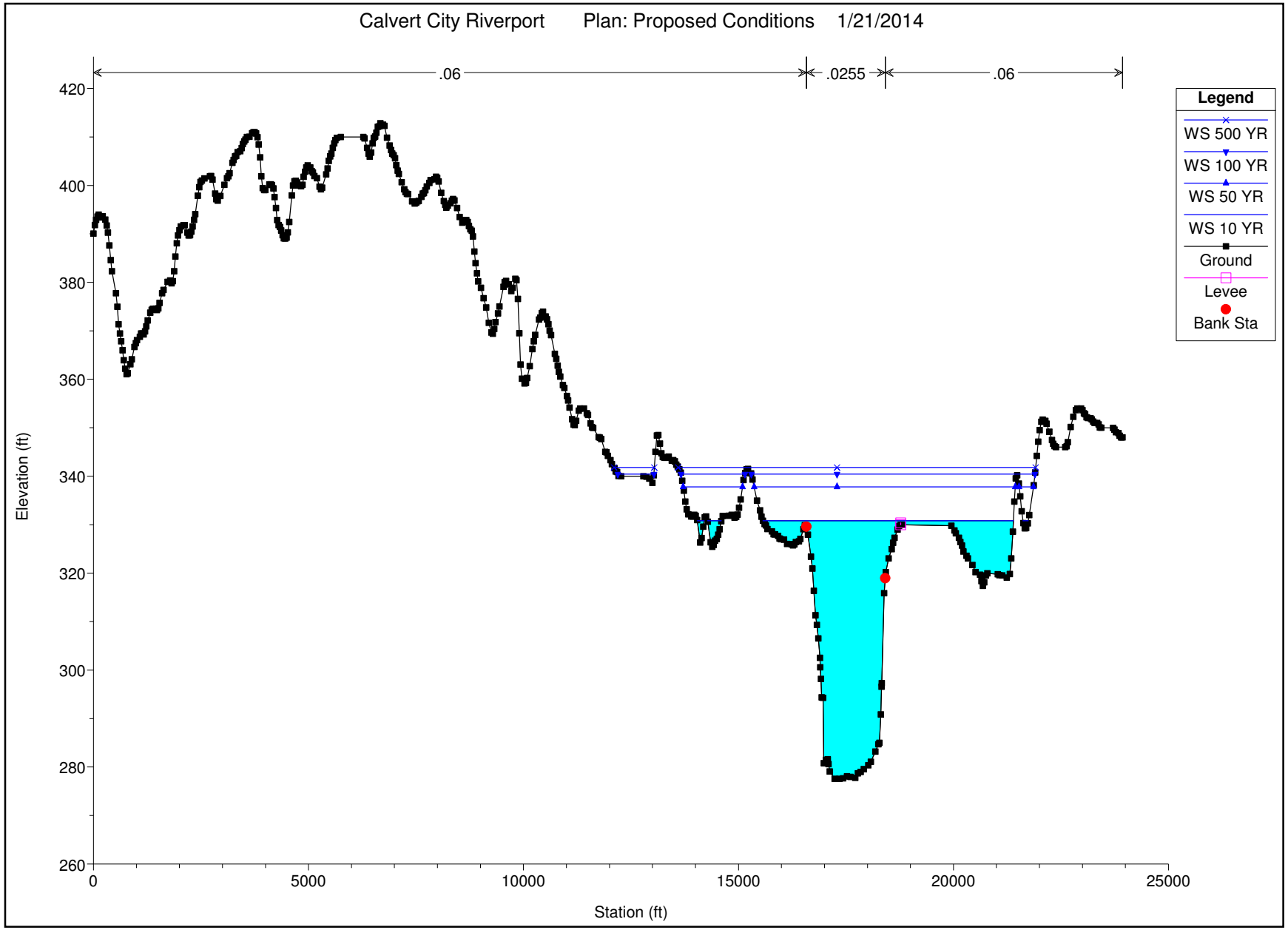

Calvert City Riverport Plan: Proposed Conditions 1/21/2014
A1d
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)


Calvert City Riverport Plan: Proposed Conditions 1/21/2014
A1c
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)


Calvert City Riverport
Plan: Proposed Conditions
1/21/2014
A1b
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)

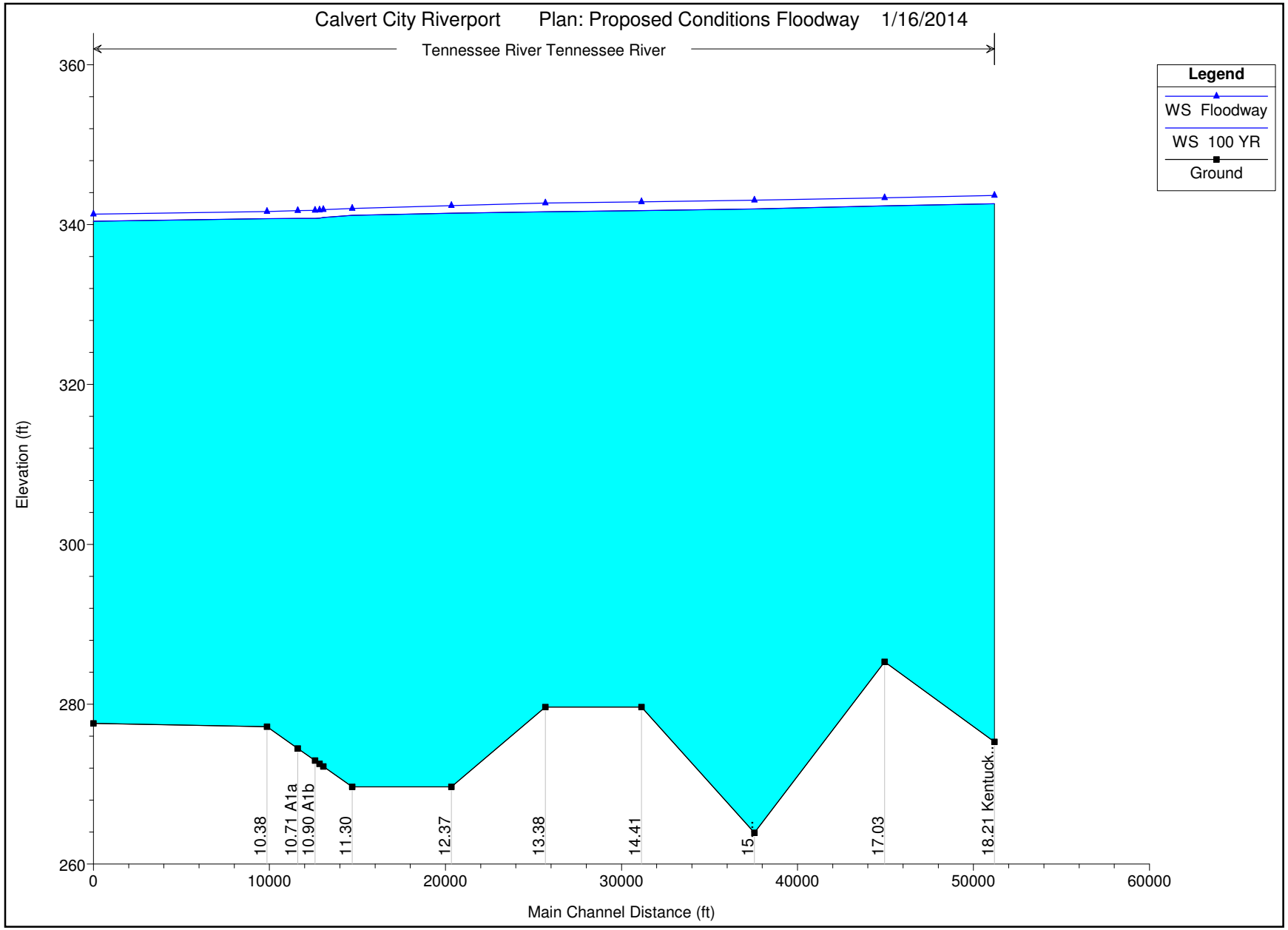

Calvert City Riverport Plan: Proposed Conditions 1/21/2014
A1a
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
500
450
400
350
300
250
0
5000
10000
15000
20000
25000
Station (ft)


Calvert City Riverport Plan: Proposed Conditions 1/21/2014
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Bank Sta
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
Station (ft)


Calvert City Riverport
Plan: Proposed Conditions
1/21/2014
.06
.0255
.06
Legend
WS 500 YR
WS 100 YR
WS 50 YR
WS 10 YR
Ground
Levee
Bank Sta
Elevation (ft)
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
Station (ft)

HEC-RAS Plan: Prop Floodway River: Tennessee River Reach: Tennessee River

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Tennessee River	8.52	100 YR	340.42		340.74	8922.88	19025.66	458334.70	39639.68		16580.49	18413.81	
Tennessee River	8.52	Floodway	341.32	0.90	341.71	3592.00	10733.19	496240.20	10026.67	15727.00	16580.49	18413.81	19319.00
Tennessee River	10.38	100 YR	340.75		341.16	10952.77	67300.30	449315.90	383.79		17692.81	19220.38	
Tennessee River	10.38	Floodway	341.64	0.89	342.22	2092.30	7282.30	509214.80	502.84	17220.00	17692.81	19220.38	19464.00
Tennessee River	10.71	100 YR	340.77		341.29	10107.51	23536.22	491703.60	1760.17		16962.13	18857.40	
Tennessee River	10.71	Floodway	341.74	0.97	342.33	1962.00		515210.00	1789.98	17070.00	16962.13	18857.40	19032.00
Tennessee River	10.90	100 YR	340.79		341.38	9661.53	19685.09	492129.40	5185.48		17058.45	18653.52	
Tennessee River	10.90	Floodway	341.78	0.99	342.42	1826.18		513959.70	3040.27	16955.00	17058.45	18653.52	18885.00
Tennessee River	10.95	100 YR	340.81		341.39	9838.54	17447.36	492959.90	6592.74		17024.59	18602.03	
Tennessee River	10.95	Floodway	341.80	0.99	342.44	1811.98		514016.60	2983.39	16927.00	17024.59	18602.03	18837.00
Tennessee River	10.99	100 YR	340.90		341.42	10154.52	16850.94	491338.90	8810.17		16719.44	18556.74	
Tennessee River	10.99	Floodway	341.87	0.97	342.46	1889.00		515070.30	1929.69	16838.00	16719.44	18556.74	18727.00
Tennessee River	11.30	100 YR	341.16		341.51	12817.21	25095.28	436332.30	55572.46		16705.15	18217.82	
Tennessee River	11.30	Floodway	342.03	0.88	342.55	2466.00	4966.31	501161.10	10872.62	16259.00	16705.15	18217.82	18725.00
Tennessee River	12.37	100 YR	341.43		341.71	13786.45	18847.58	438351.50	59800.93		18556.83	20288.50	
Tennessee River	12.37	Floodway	342.38	0.96	342.81	3215.50	6768.89	503894.80	6336.29	17702.50	18556.83	20288.50	20918.00
Tennessee River	13.38	100 YR	341.61		341.89	9780.87	21501.92	466068.60	29429.48		14714.13	16884.17	
Tennessee River	13.38	Floodway	342.70	1.09	343.02	3664.10	6233.64	493666.10	17100.22	14290.00	14714.13	16884.17	17960.00
Tennessee River	14.41	100 YR	341.74		342.11	3956.83	9065.23	494629.80	13304.94		18941.33	20800.00	
Tennessee River	14.41	Floodway	342.86	1.12	343.22	3389.40	9993.84	497316.00	9690.19	17978.50	18941.33	20800.00	21490.00
Tennessee River	15.63	100 YR	341.96		342.35	3988.72	1438.94	484877.50	30683.52		13539.42	15277.83	
Tennessee River	15.63	Floodway	343.06	1.10	343.46	3315.15	1837.06	496409.80	18753.18	12979.00	13539.42	15277.83	16341.00
Tennessee River	17.03	100 YR	342.33		342.67	5296.63	3445.74	456867.20	56687.06		12863.34	14926.95	
Tennessee River	17.03	Floodway	343.36	1.03	343.80	2868.01	4329.26	507332.50	5338.29	12344.00	12863.34	14926.95	15246.00
Tennessee River	18.21	100 YR	342.60		342.92	9152.10	58209.02	434769.50	24021.53		14187.33	15772.74	
Tennessee River	18.21	Floodway	343.66	1.06	344.09	3057.00	13812.39	487333.30	15854.35	13404.00	14187.33	15772.74	16461.00


Calvert City Riverport Plan: Proposed Conditions Floodway 1/16/2014
Tennessee River Tennessee River
Legend
WS Floodway
WS 100 YR
Ground
Elevation (ft)
360
340
320
300
280
260
0
10000
20000
30000
40000
50000
60000
Main Channel Distance (ft)
10.38
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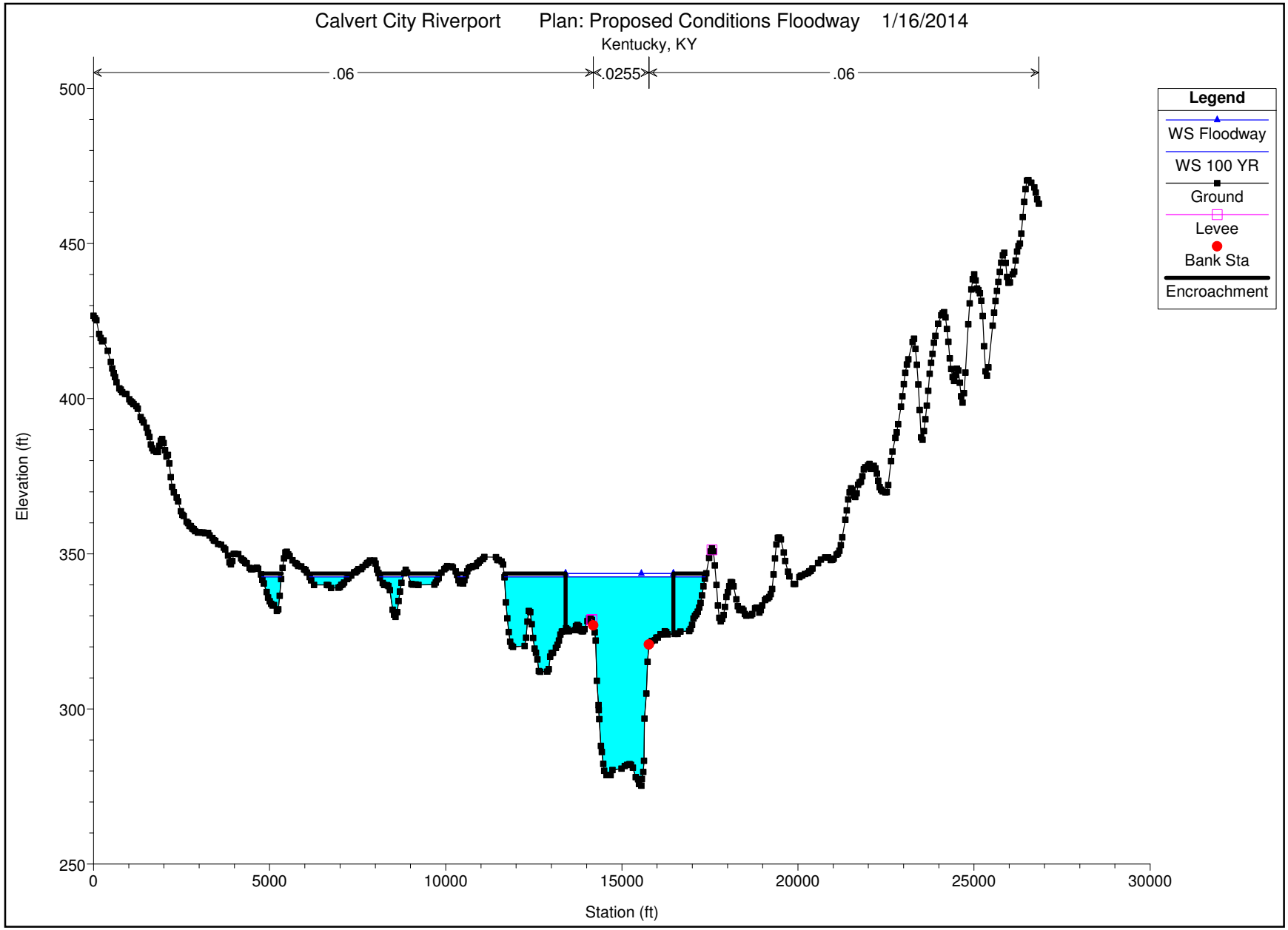
10.90 A1b
11.30
12.37
13.38
14.41
15...
17.03
18.21 Kentuck...


Calvert City Riverport
Plan: Proposed Conditions Floodway
1/16/2014
Kentucky, KY
.06
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.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
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300
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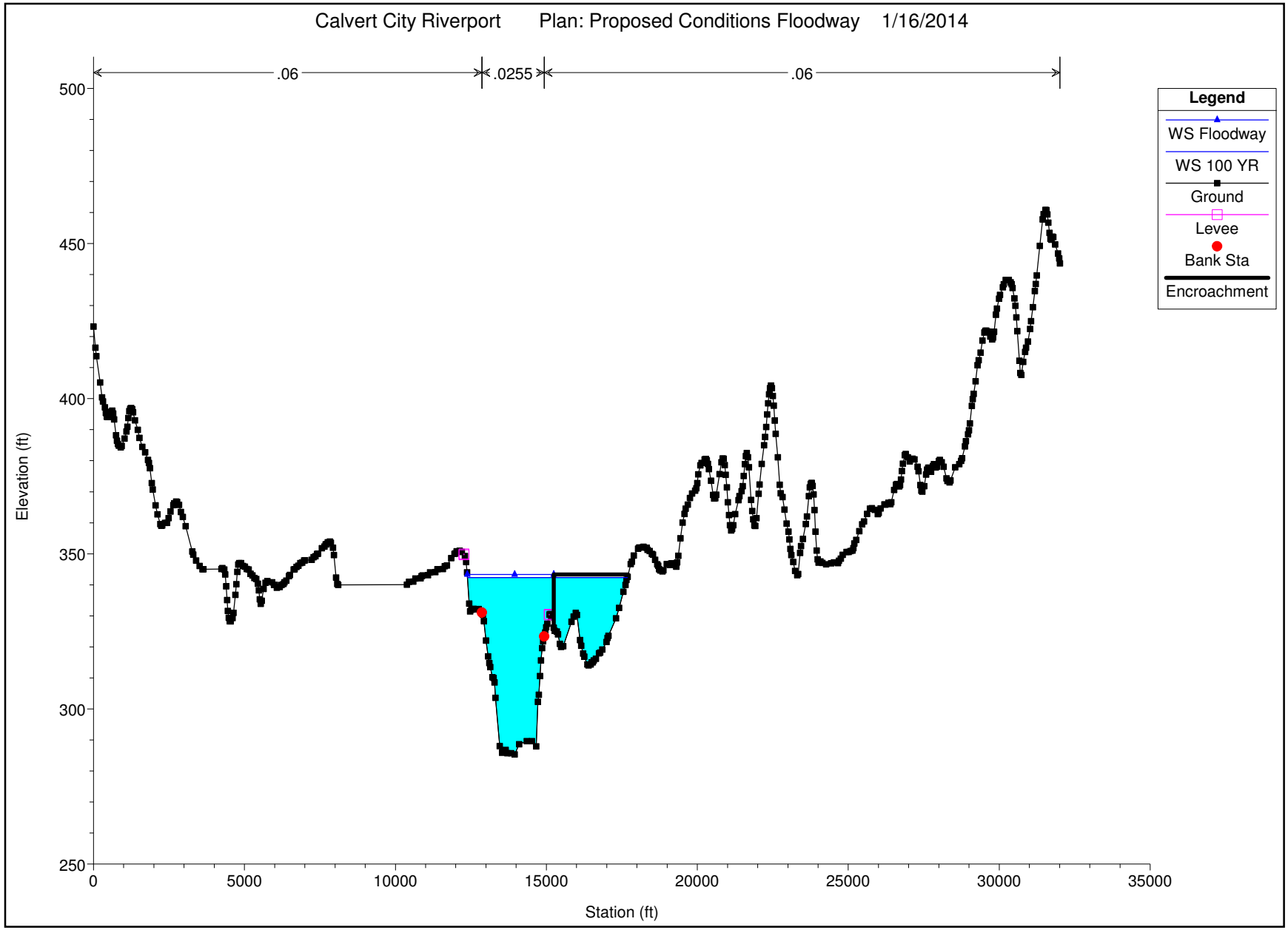
Station (ft)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Plan: Proposed Conditions Floodway
1/16/2014
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Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
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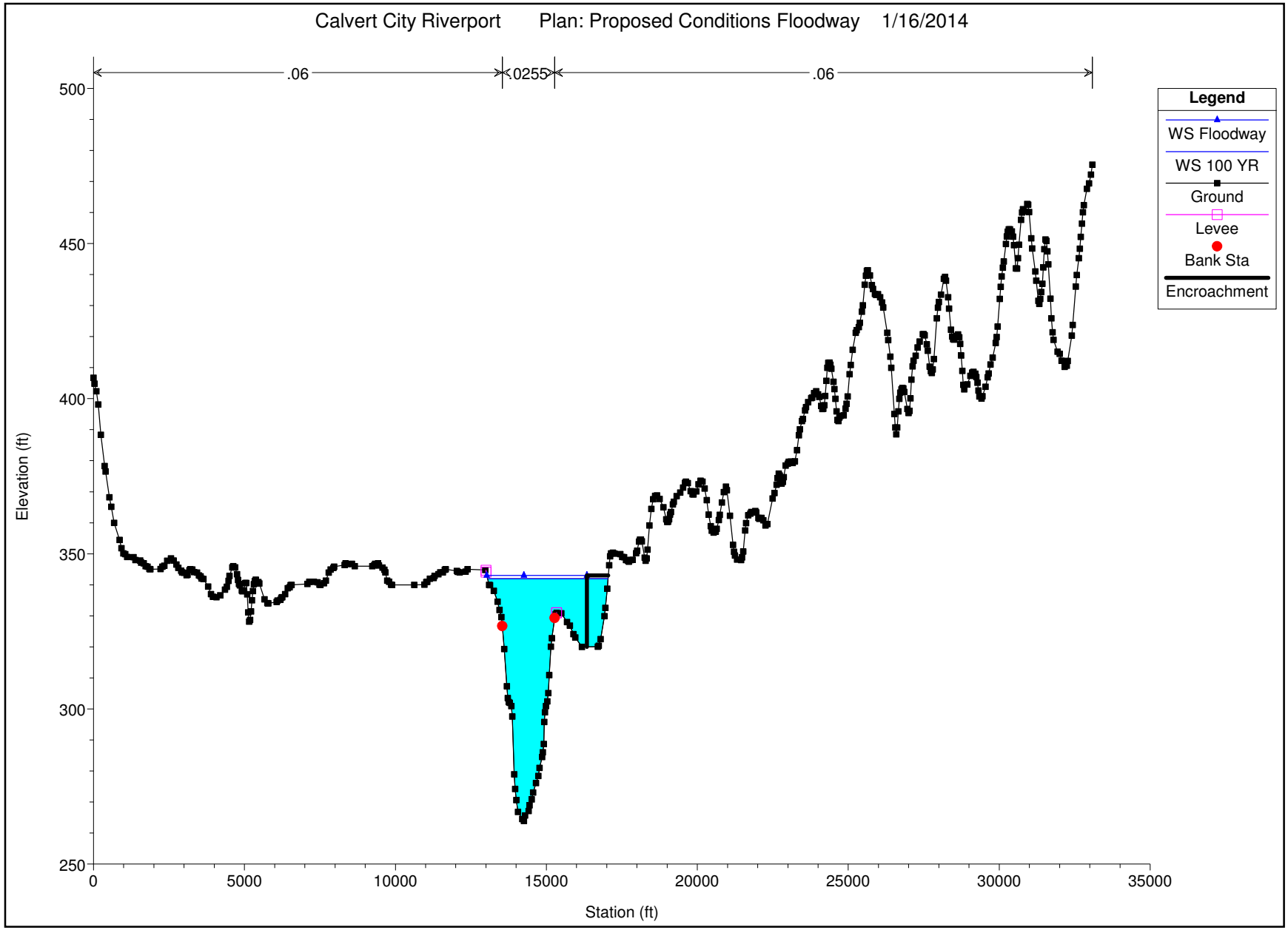
30000
35000
Station (ft)


Calvert City Riverport
Plan: Proposed Conditions Floodway
1/16/2014
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Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
500
450
400
350
300
250
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5000
10000
15000
20000
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30000
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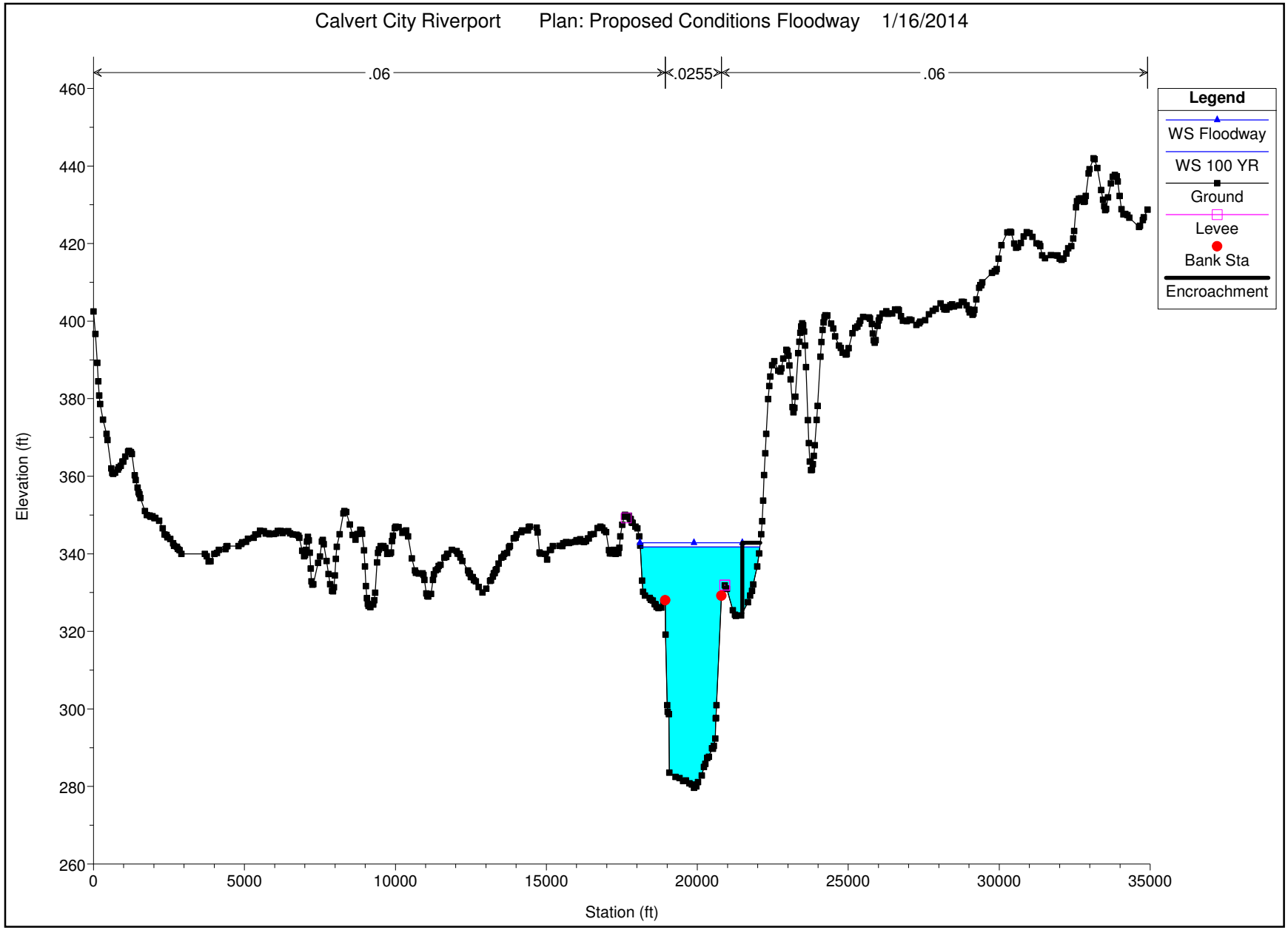
Station (ft)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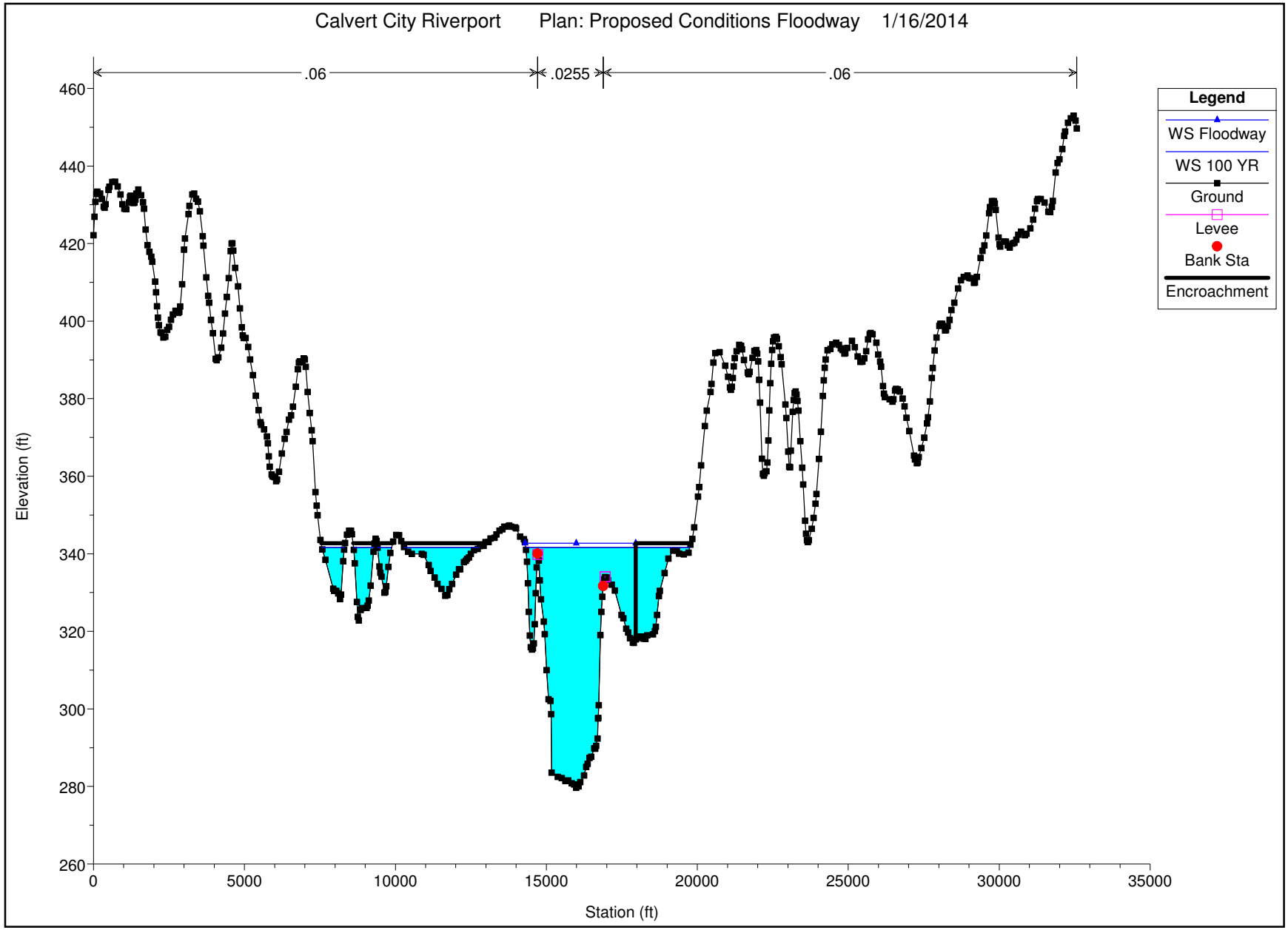
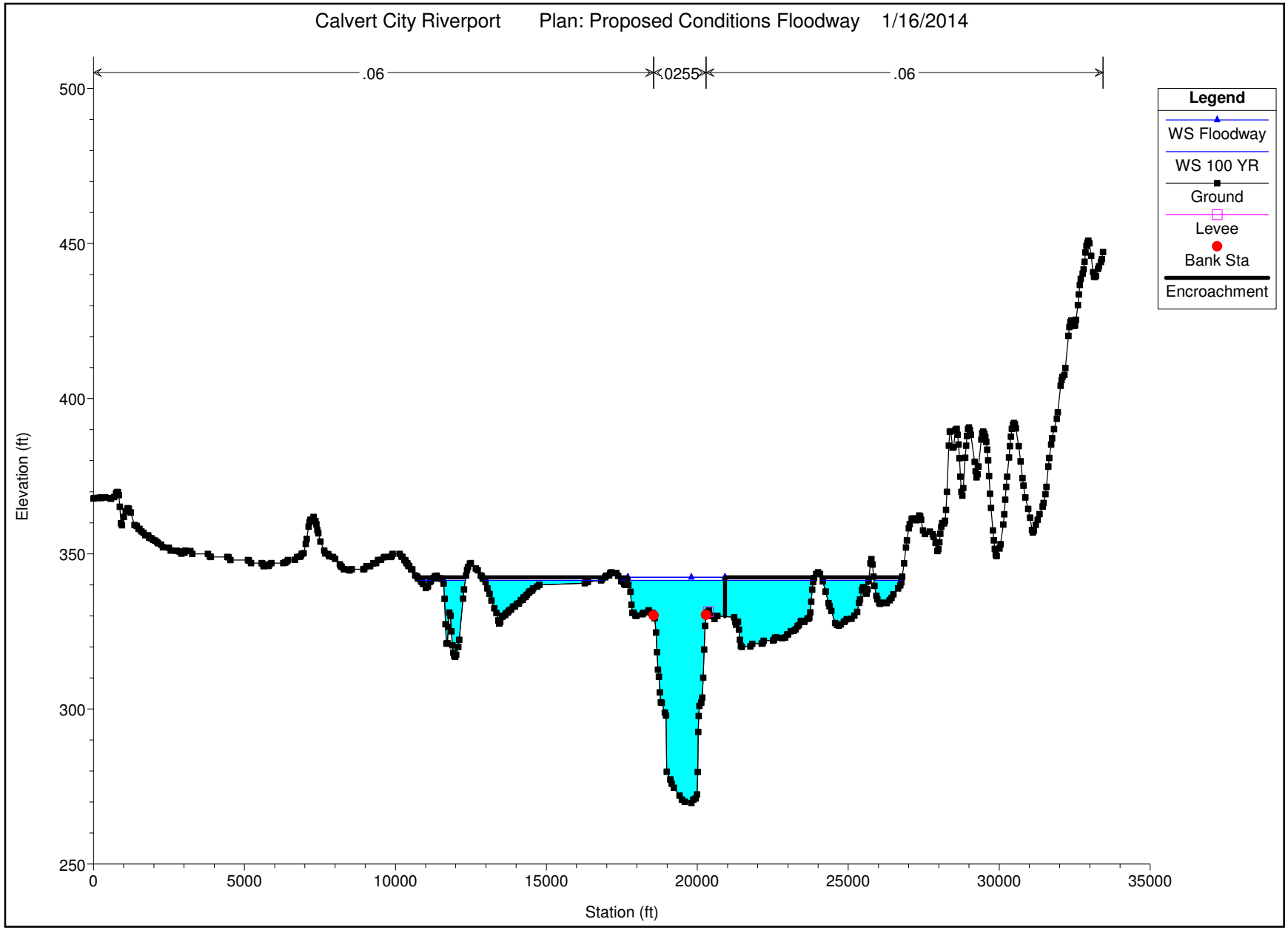
Plan: Proposed Conditions Floodway
1/16/2014
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport
Plan: Proposed Conditions Floodway
1/16/2014
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
460
440
420
400
380
360
340
320
300
280
260
0
5000
10000
15000
20000
25000
30000
35000
Station (ft)


Calvert City Riverport
Plan: Proposed Conditions Floodway
1/16/2014
.06
0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
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0
5000
10000
15000
20000
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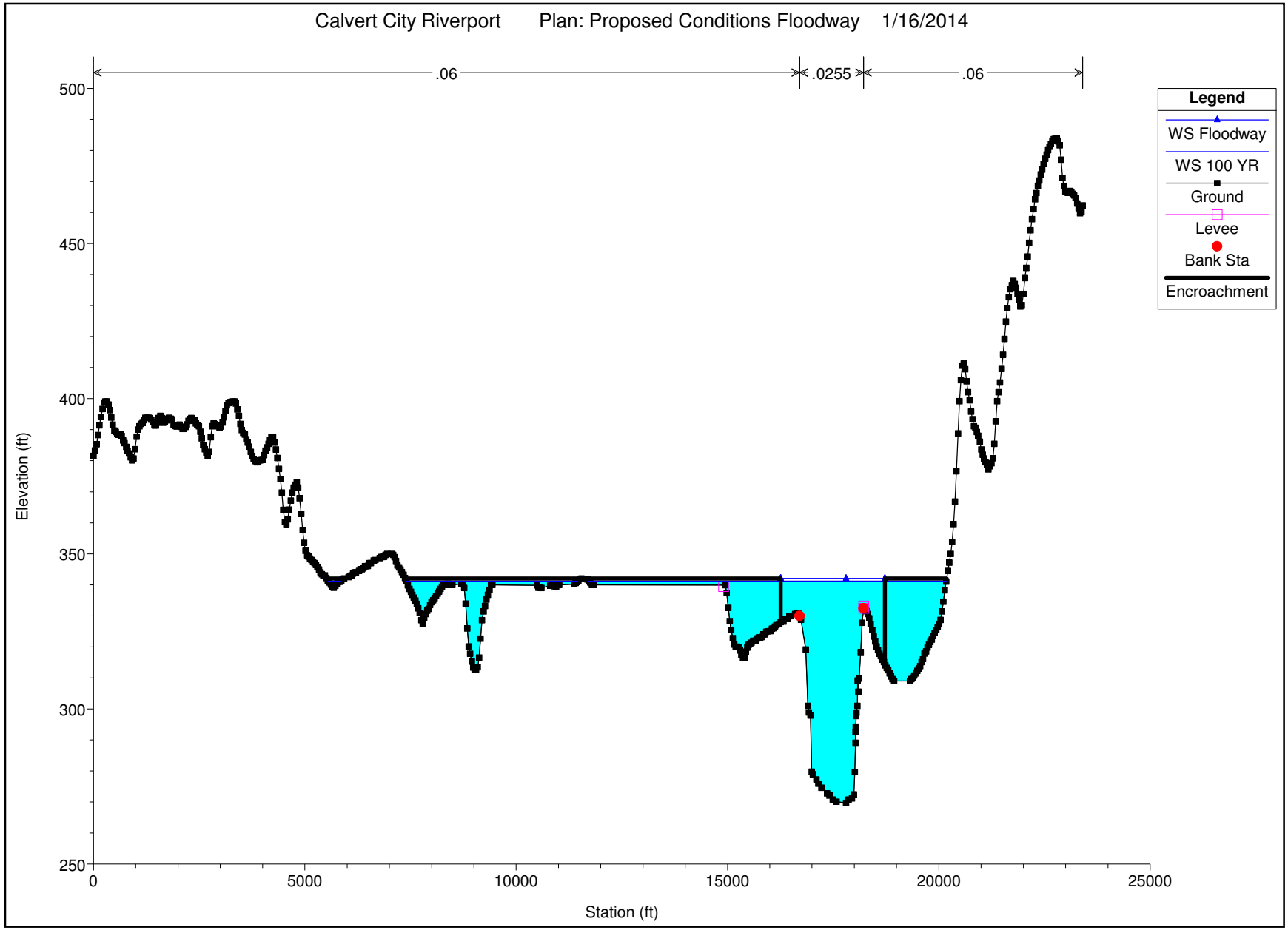
30000
35000
Station (ft)


Calvert City Riverport
Plan: Proposed Conditions Floodway
1/16/2014
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
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5000
10000
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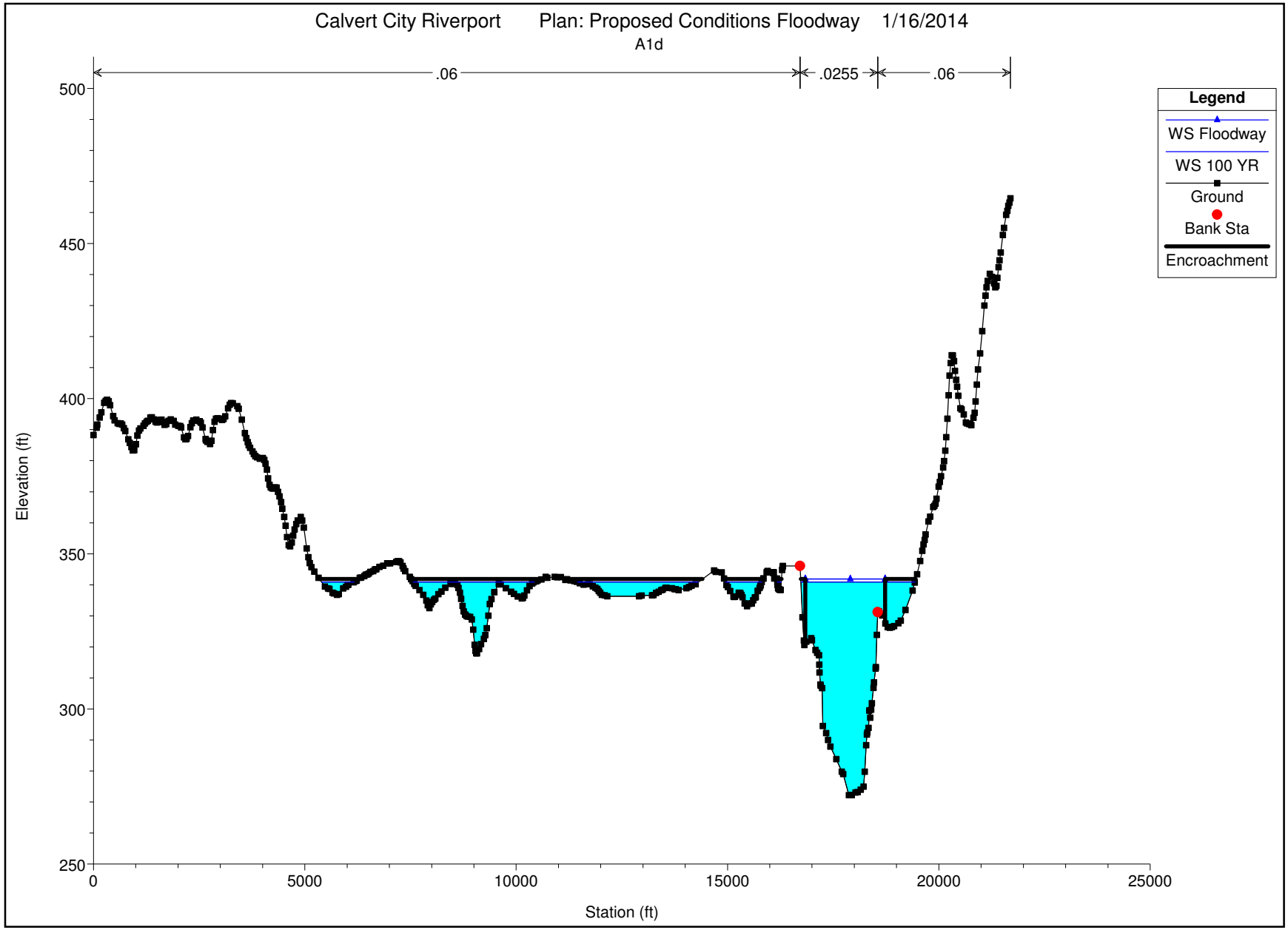
Station (ft)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Plan: Proposed Conditions Floodway
1/16/2014
A1d
.06
.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Bank Sta
Encroachment
Elevation (ft)
500
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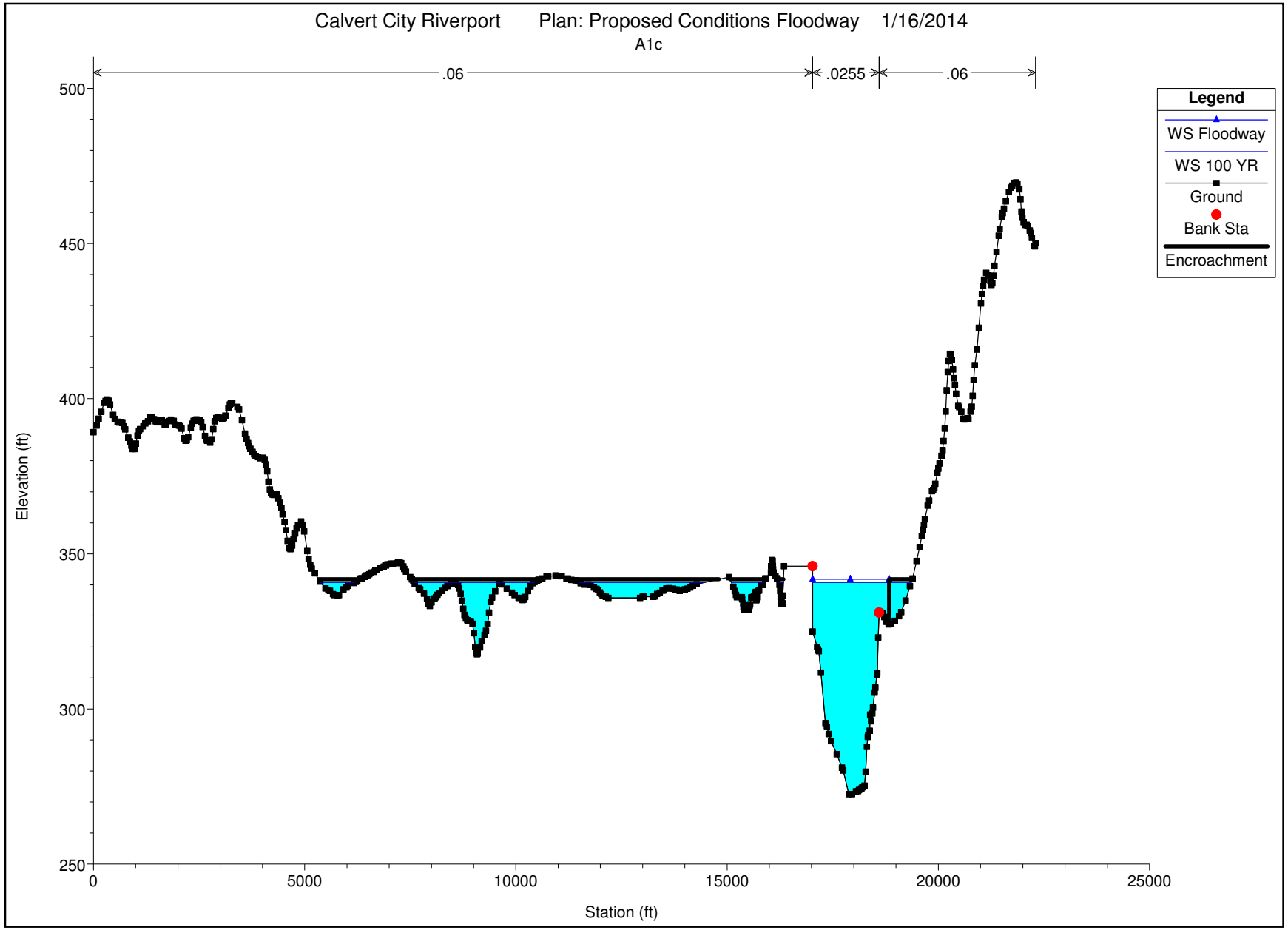
25000
Station (ft)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Plan: Proposed Conditions Floodway
1/16/2014
A1c
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.0255
.06
Legend
WS Floodway
WS 100 YR
Ground
Bank Sta
Encroachment
Elevation (ft)
500
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10000
15000
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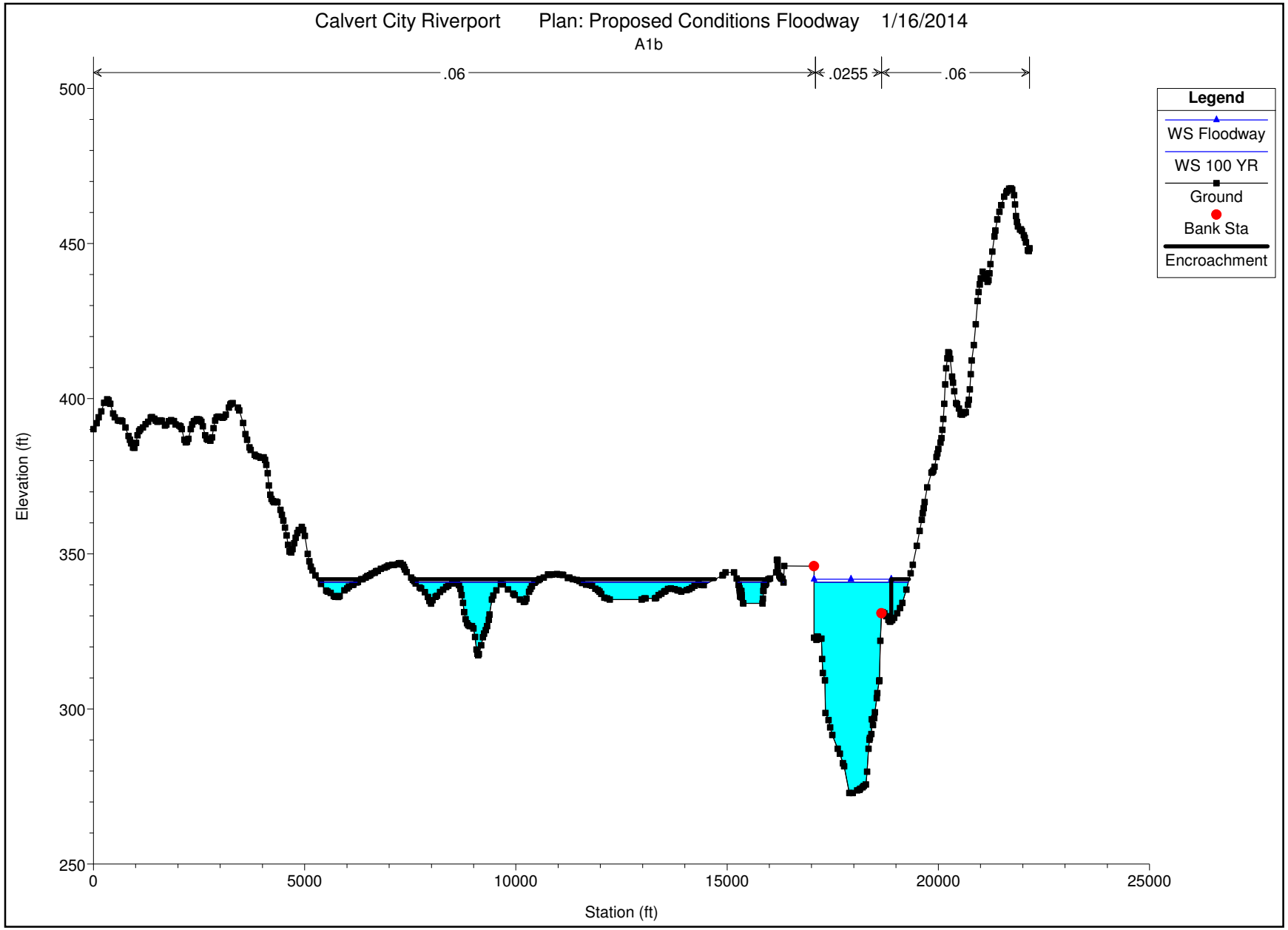
Station (ft)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.06
Legend
WS Floodway
WS 100 YR
Ground
Bank Sta
Encroachment
Elevation (ft)
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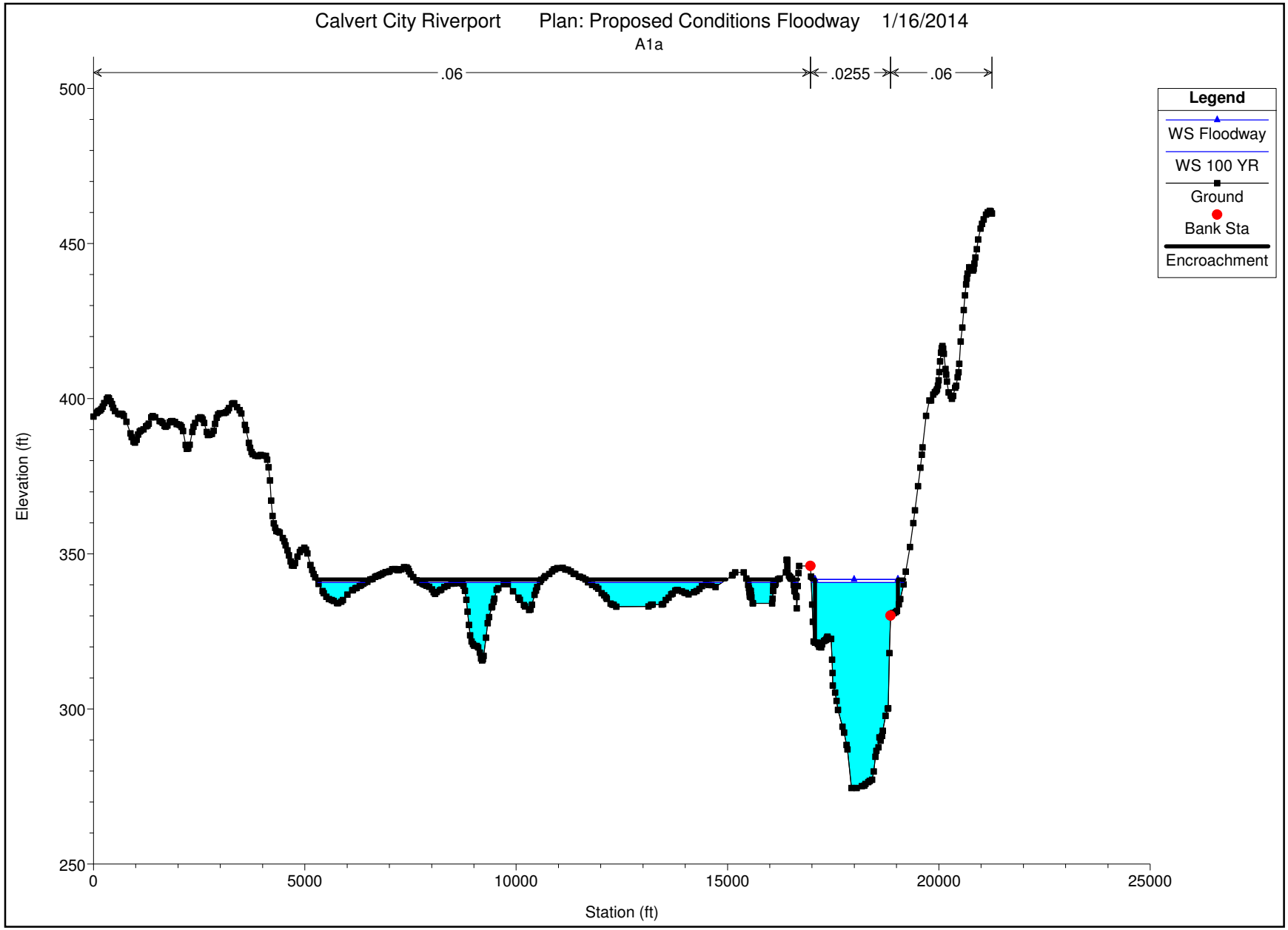
Station (ft)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Plan: Proposed Conditions Floodway
1/16/2014
A1a
.06
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Legend
WS Floodway
WS 100 YR
Ground
Bank Sta
Encroachment
Elevation (ft)
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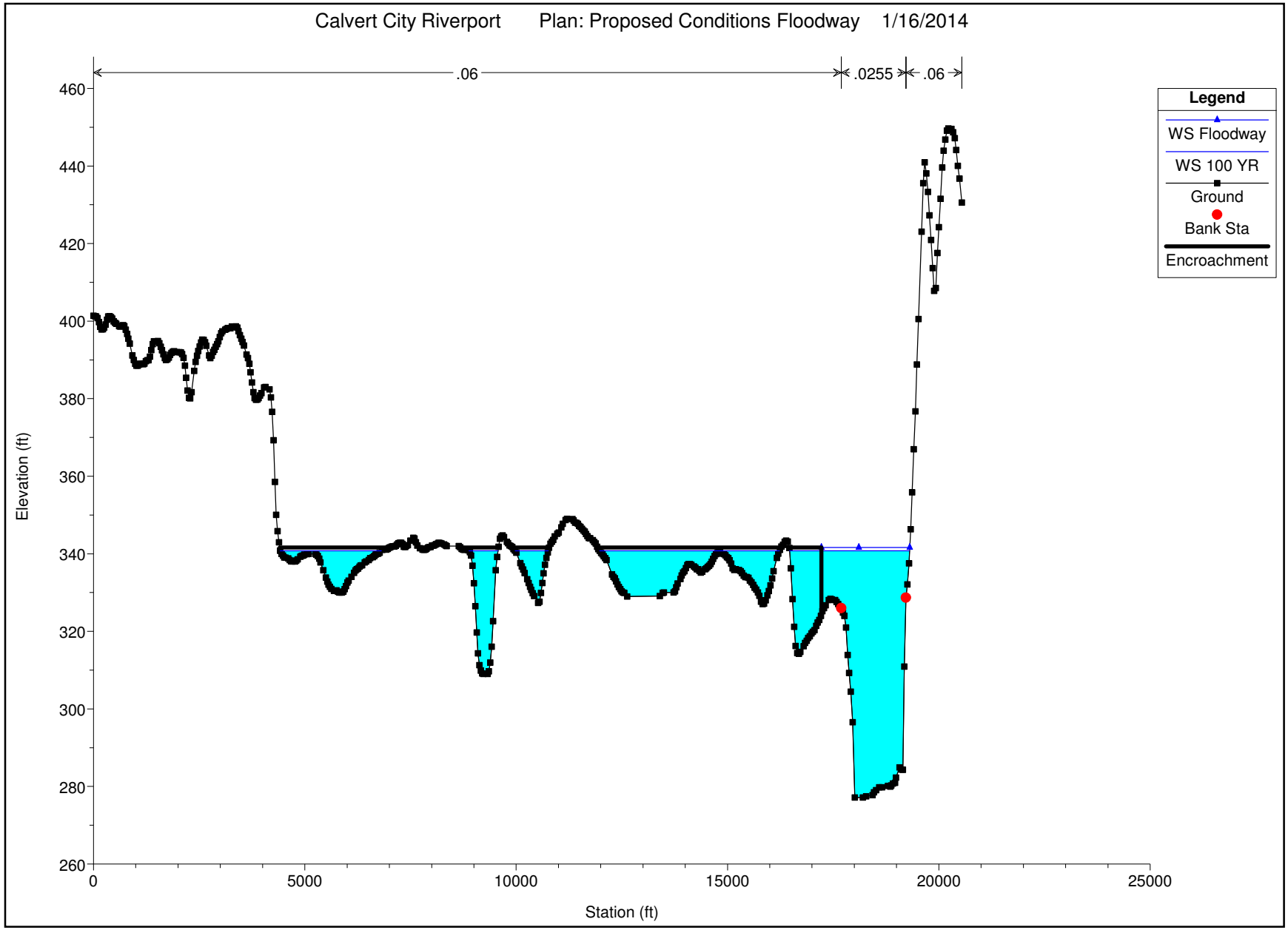
Station (ft)


Calvert City Riverport
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Elevation (ft)
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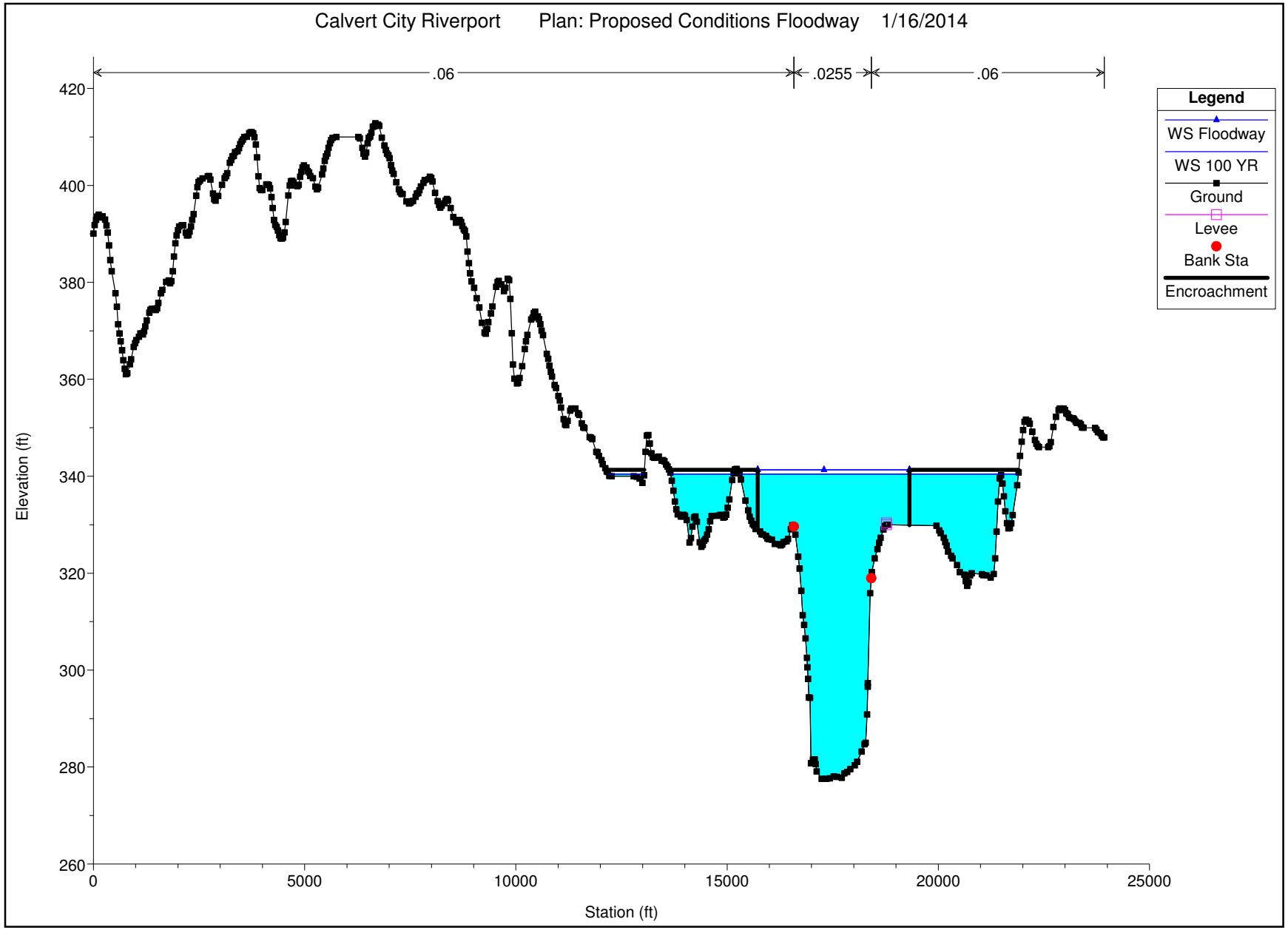
Station (ft)


Calvert City Riverport Plan: Proposed Conditions Floodway 1/16/2014
.06
.0255
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Legend
WS Floodway
WS 100 YR
Ground
Levee
Bank Sta
Encroachment
Elevation (ft)
420
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280
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15000
20000
25000
Station (ft)

Appendix VI
Engineering No-Impact Certification

ICA Engineering

FLOODWAY "NO-RISE / NO-IMPACT" CERTIFICATION

This document is to certify that I am a duly qualified engineer licensed to practice in the state of Kentucky. It is to further certify that the attached technical data supports the proposed Port of Calvert City by First Marine Properties, LLC will not impact the base flood elevations, floodway elevations, and floodway widths of the Tennessee River at published cross sections in the Flood Insurance Study for, Marshall County, Kentucky, dated June 2, 2011, and it will not impact the base flood elevations, floodway elevations, and floodway widths at the unpublished cross-sections in the area of the proposed development.

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Matt Brawley, PE
Senior Project Engineer

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Paducah, KY 42003

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270.444.9691