



**US Army Corps
of Engineers**
Philadelphia District

Tookany Creek Flood Risk Reduction Study

Hydraulic Modeling Appendix

Cheltenham Township Montgomery County, PA

PREPARED FOR:

CHELtenham TOWNSHIP

PREPARED BY:

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WITHOUT PROJECT CONDITION

1. Introduction

Flooding throughout Cheltenham Township is recurrent and spatially varied. The majority of the flooding occurs along Tookany Creek although tributary flooding also occurs. Many of the tributaries to Tookany Creek have less than 1.5 square miles at the mouth or at the damage area and were not studied because they do not meet the Federal Drainage Area Criteria. Based on Federal Criteria and consultation with Township officials Tookany and Rock Creeks were selected as the focus of the hydraulic modeling.

2. Overview

The Tookany Creek was studied from the corporate limit with Philadelphia to Church Street (upstream of Limekiln Pike), a distance of approximately 7.2 miles. Rock Creek was studied from its confluence with Tookany Creek to Dell Lane, a distance of 0.6 miles. Figure 2.1 is an overview of the study area.

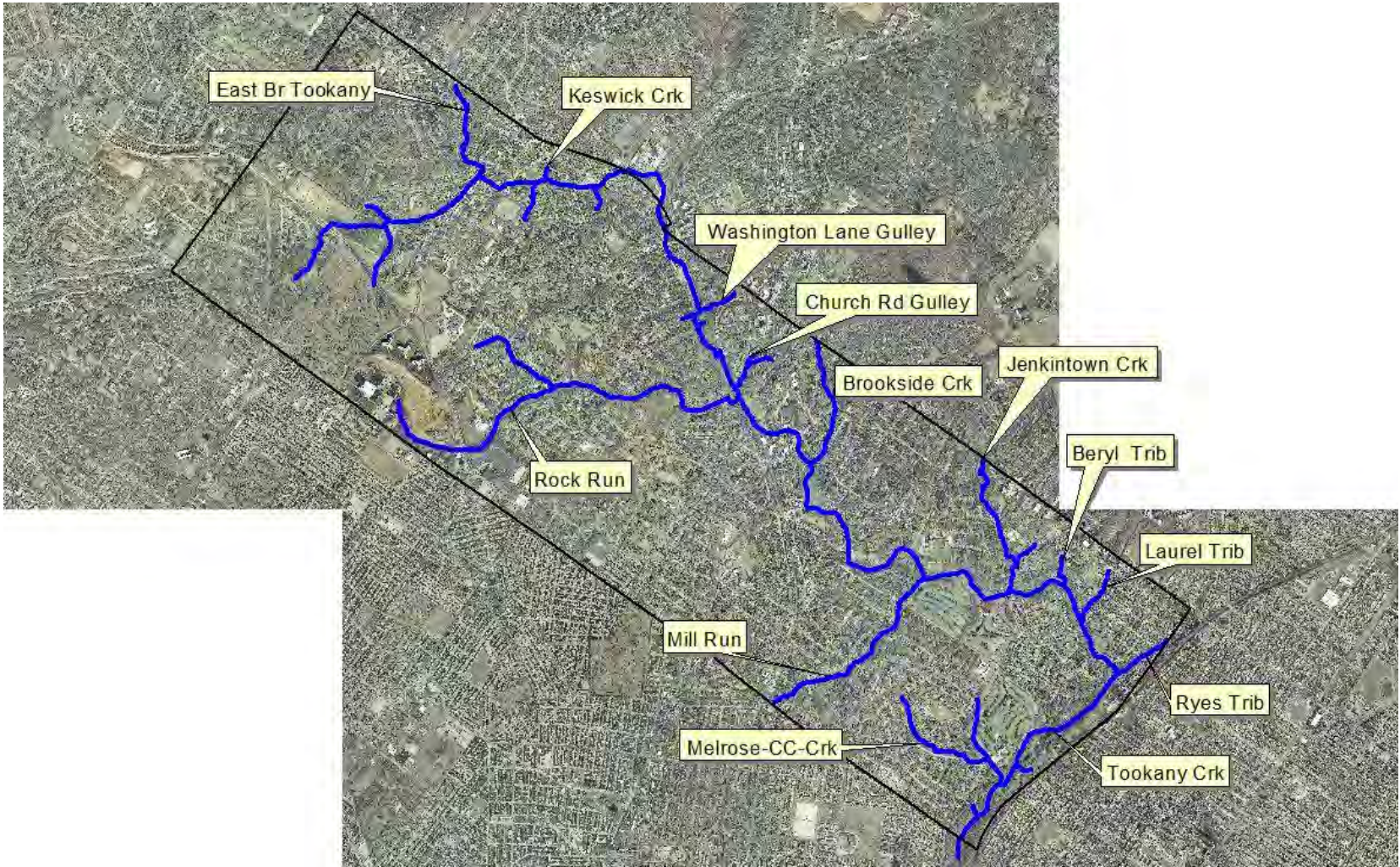


Figure 2.1, Overview of Study Area

3. Spatial Data

The horizontal datum used in this analysis was the North Atlantic Datum of 1983, while the coordinate system was the Pennsylvania South State Plane (feet). All data that wasn't natively in this coordinate systems/datum was transformed. Furthermore, the vertical datum used in this analysis was North American Vertical Datum of 1988 (ft-NAVD88). Depending upon the age of the original data source, the vertical datum reported for each piece of data was either ft-NAVD88 or National Geodetic Vertical Datum 1929 (ft-NGVD29). Differences between NGVD29 and NAVD88 slightly vary from location to location. For simplification, a uniform conversion factor of 1.02 ft (i.e. 100 ft NGVD29 = 98.98 ft NAVD88) was used to convert NGVD29 elevation data sources to NAVD88 for the study area.

Cross-sections were developed from a digital elevation model (DEM) obtained from the Pennsylvania Department of Conservation and Natural Resources (DCNR) (see the Hydrologic Appendix for references). The elevation points were aerially measured using light detection and ranging (LIDAR) and are approximately 3ft apart. The DEM was surveyed during 2008. The vertical datum is feet-NAVD88.

A mosaic was created from each individual DEM using tools within ArcGIS to form a complete elevation model of Tookany and Rock Creeks and their floodplains.

4. Hydraulic Model

Discharges, both historic and frequency, for without and with project conditions were transformed into water surface elevations using the USACE Hydrologic Engineering Center's (HEC's) River Analysis System (HEC-RAS) version 4.1. HEC-RAS is a gradually varied hydraulic model capable of analyzing both steady and unsteady flow conditions. For this study, the HEC-RAS models were run in steady state, subcritical mode. Mixed flow was considered but rejected because it resulted in numerous crossing water surface profiles.

4.1 Set Up – RAS

HEC-GeoRAS is a pre-processor program for HEC-RAS. It is a geo-spatial extension for ArcMap version 9.2 and was used to prepare and refine the HEC-RAS input files. Two HEC-RAS models were created within the area of interest: Tookany Creek and Rock Creek with lengths of 38,000 and 3100 feet, respectively. The limits of the RAS models were set to encompass major damage locations .

The locations of the modeled cross sections and bridges for Tookany Creek and Rock Creek are shown in Figures 4.1 and 4.2 respectively. There is overlap from one figure to the next. The numeric cross-section label is the distance in feet of the cross-section from the downstream start of the model. The HEC-RAS model results provide water surface elevations and velocities at all cross-section locations.

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Figure 4.1-Part 1, Tookany Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)



Figure 4.1-Part 2, Tookany Ceek – HEC-RAS Features (DCNR 2008 Orthographic Image)



Figure 4.1-Part 3, Tookany Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)



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Figure 4.1-Part 9, Tookany Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)



Figure 4.1-Part 10, Tookany Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)



Figure 4.1-Part 11, Tookany Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)



Figure 4.1-Part 12, Tookany Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)



Figure 4.1-Part 13, Tookany Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)

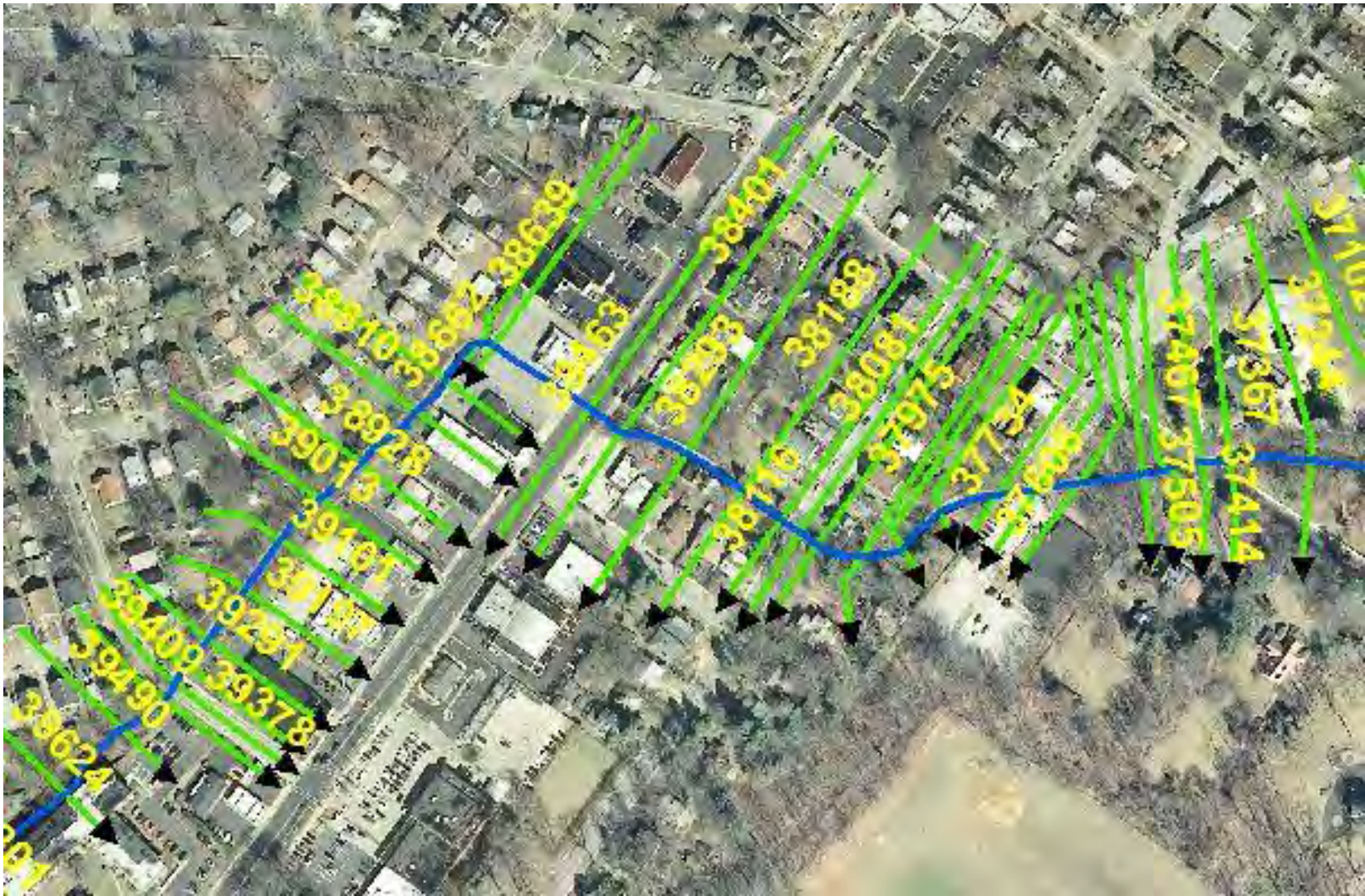


Figure 4.1-Part 14, Tookany Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)



Figure 4.1-Part 15, Tookany Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)



Figure 4.2, Rock Creek – HEC-RAS Features (DCNR 2008 Orthographic Image)

Tookany Creek was modeled with 261 cross-sections and 30 bridges and Rock Creek was modeled with 32 cross-sections and 4 bridges. Initially cross-section and bridge geometries were drawn from the LIDAR elevation models and then modified as necessary using various bridge surveys, recent field surveys, aerial photographs, previous FEMA Flood Insurance Study Models (FIS) and PADEP plans of previously constructed projects.

The raw cross-section geometries for both models were modified to reflect the following:

- Bridges were modeled assuming no debris blockage.
- Active flow widths at transition sections upstream and downstream of bridges were applied at 1:1 and 4:1 length to width ratios, respectively.
- Cross sections upstream and downstream of bridges were assigned contraction and expansion losses of 0.3 and 0.5, respectively.
- Buildings were added to cross-sections as blocked obstructions when they were a sizable fraction of the cross-section's area.
- Ineffective flow limits were placed upstream and downstream of large buildings.
- Bank stations of the cross-sections were defined as break in slope.
- Variable reach lengths were scaled in areas of floodplain curvature.
- Manning n values which quantify the effect of surface friction were assigned based on site visits and aerial photographs. The channel n values are tabulated below:

Model	Channel n	Overbank n
Tookany	0.035	0.02 – 0.12
Rock	0.021 – 0.045	0.03 – 0.10

Channel elmin elevations (ft-NGVD29) from the Flood Insurance Study (circa 1974) were compared (after conversion to ft-NAVD88) to channel elmin elevations from this study. The channel is vertically stable although there has been some localized shoaling and bank erosion which is reflected in the model's cross-sections.

The solution methods chosen for the Tookany and Rock Creek bridges are provided in Tables 4.2 and 4.3 respectively. Bridges with embankments were analyzed with the pressure and weir flow equations for high flow.

Table 4.2			
Tookany Creek – Bridge Modeling			
Road Crossing	Station ID	Low Flow	High Flow
Levick	6247	Energy	Pressure/Weir
Asbourne	9344	E,M,Y,HE*	Pressure/Weir
Central	9502	Energy	Pressure/Weir
Jenkintown	13837	Energy	Pressure/Weir
Tacony Parkway	17059	Energy	Energy
New Second St	17395	Energy	Energy
Harrison	19712	Energy	Pressure/Weir
Mill	20630	Energy	Pressure/Weir
High School	21358	Energy	Pressure/Weir
Church	22688	Energy	Energy
Forest	23878	Energy	Energy
Old York	24101	Energy	Energy
Church	24418	Energy	Pressure/Weir
Church	26274	Culvert	Pressure/Weir
Railroad	27439	Culvert	Pressure/Weir
Washington Lane	29210	E,M,Y,HE*	Energy
Access to Parking Lot	30878	Energy	Energy
Greenwood	31202	Energy	Pressure/Weir
Railroad	32380	Energy	Pressure/Weir
Abandoned RR	33183	Culvert	Pressure/Weir
Railroad	34163	Energy	Pressure/Weir
Rice's Mill	35691	E,M,Y,HE*	Pressure/Weir
Waverly	37417	Energy	Energy
Library Access	37670	Culvert	Pressure/Weir
D/S Bickley	37977	Energy	Energy
Bickley	38082	Energy	Energy
Easton	38532	Culvert	Pressure/Weir
Springhouse	39377	Energy	Energy
Limekiln	40470	Culvert	Pressure/Weir
Church	41767	Culvert	Energy

*Energy(E), Momentum(M), Yarnell(Y), Highest Energy(HE); Bridge has a pier.

Road Crossing	Station ID	Low Flow	High Flow
Widener	753	Culvert	Pressure/Weir
Sepentine	1518	Culvert	Pressure/Weir
Rock	2434	Culvert	Pressure/Weir
Dell	2866	Culvert	Pressure/Weir

The left overbank of Tookany Creek along Brookdale Avenue is protected by levees constructed by PADEP. However, for large events the levees are flanked at the upstream end and/or overtopped. When this occurs, horizontal ineffective flow limits were used to limit the flow water to an elevation equal to the downstream left overbank elevation of Rice’s Mill Road. In the model the levee was assumed not to fail during overtopping. This is consistent with past project performance.

The starting conditions for Tookany and Rock Creeks are listed in Table 4.4.

Model	Type of Boundary	Value
Tookany	Known WSEL	USGS Gage 01467086 Rating Curve with FIS extension
Rock Creek	Known WSEL	Extrapolated from X-25806 and X-26003 of the Tookany Model to station 26060*

*Peak on peak is assumed. The peak frequency water surface elevation (WSEL) on the Tookany is the starting wsel for the Rock Creek model of the same frequency.

Flow change locations for Tookany Creek and Rock Creek were set at locations of noticeable drainage area increase. The flow change locations are presented in Table 4.5 and the locations for Tookany Creek are shown on Figure 4.3.

Table 4.5 Flow Change Locations for RAS Models			
Model	Location Label	Drainage Area (sq. mi.)	Flow Change Cross-section*
Tookany	T11	0.66	X-42534
	T10A	1.04	X-41478
	T10	1.24	X-40262
	T9	1.3	X-39291
	T8	2.06	X-38662
	T7	2.9	X-36541
	T6B	3.19	X-33238
	T6A	4.54	X-31960
	T6	5.47	X-30997
	T5	7.54	X-26003
	T4A	8.24	X-22969
	T4	9.5	X-21757
	T3	11.8	X-16258
	T2	14.5	X-13656
T1A	15.5	X-9809	
T1	16.59	X-4256	
Rock Creek	R18	1.62	X-3162
	R19	1.72	X-2554
	R20	1.90	X-1693

*The cross-section where the flow is applied is upstream of the location where the flow was calculated.

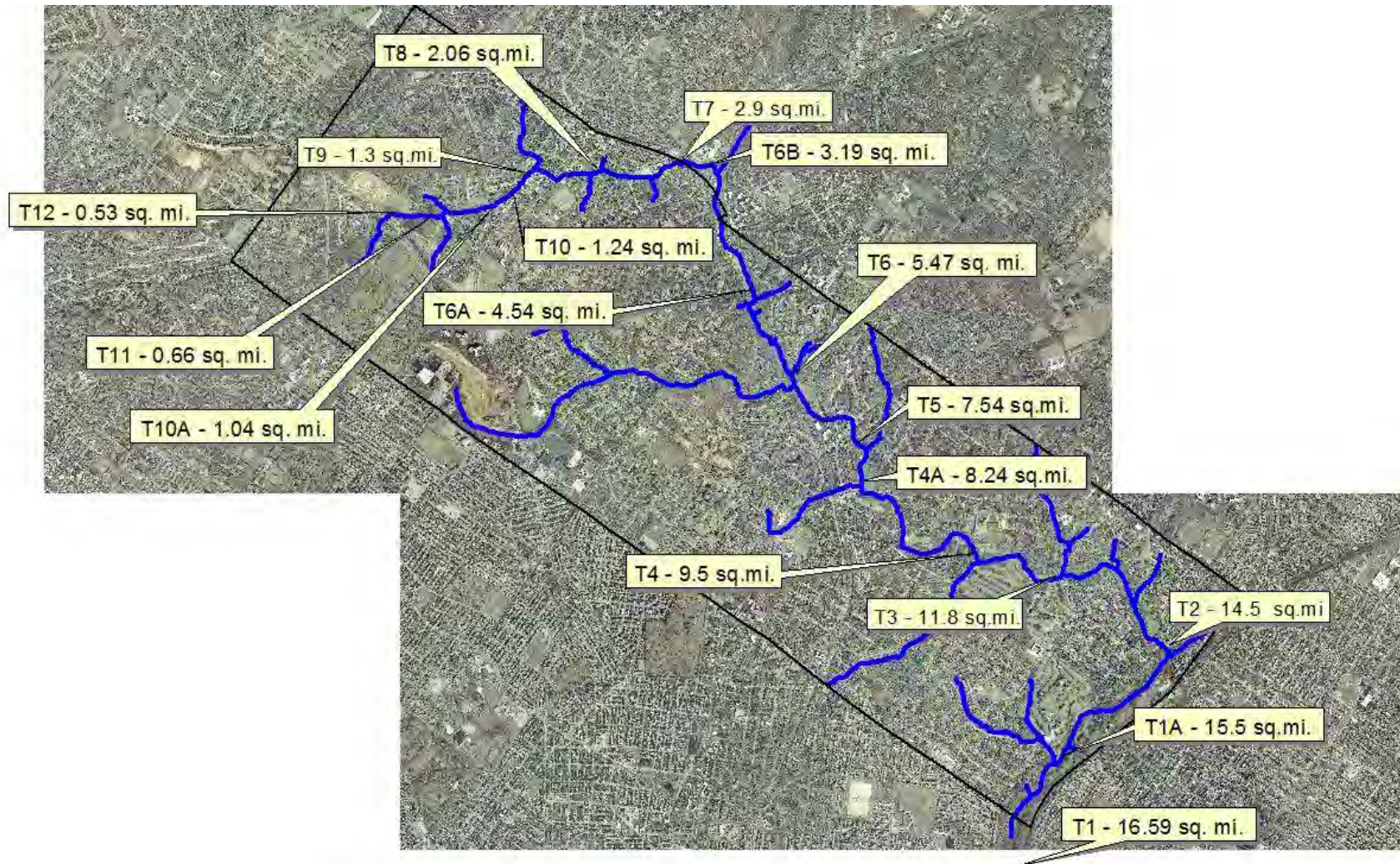


Figure 4.3, Flow Change Locations for Tookany Creek

4.2 Calibration - RAS

After the flooding of Tropical Storm Lee (TS Lee) in 2011, Cheltenham Township officials requested flood history and high water mark information from their residents. The responses were tabulated in GIS format and in combination with personal communication with the residents during site visits were used in the calibration. The locations of these flood data are shown in Figure 4.4. However, not all of the responses were useful for calibration.

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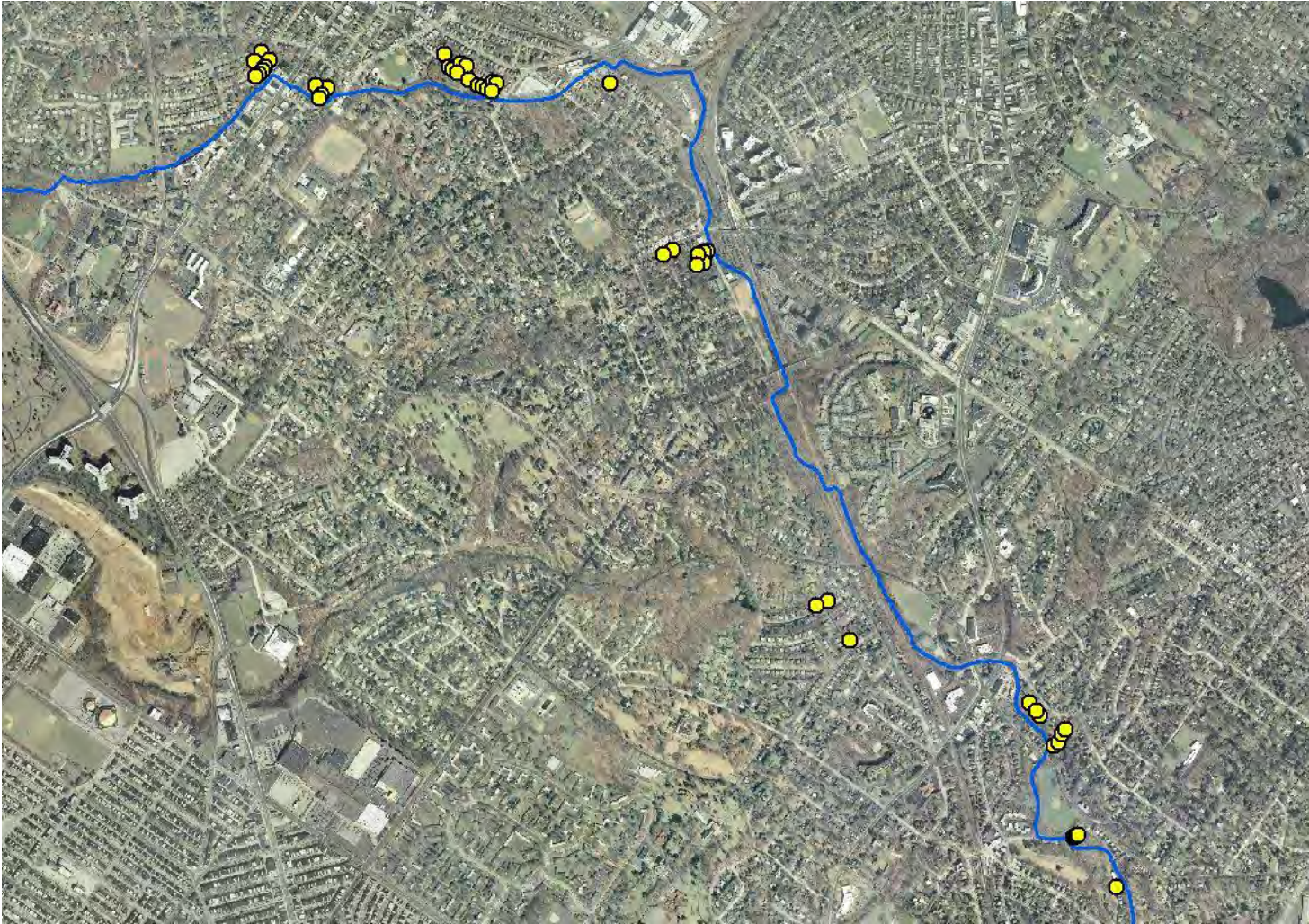


Figure 4.4, Response Locations from High Water Mark Questionnaire

The flows for TS Lee at various locations were estimated from the GSSHA rainfall runoff model and were converted to water surface elevations with the RAS models. The estimated TS Lee flows on Tookany and Rock Creeks are provided in Table 4.6.

Table 4.6		
September 2011 (TS Lee) Discharges at Flow Change Locations		
Location Label	X-section	TS Lee Discharge (cfs)
Tookany		
T10	40262	1320
T9	39291	1713
T8	38662	1258
T7	36541	1766
T6B	33238	2676
T6A	31960	2676
T6	30997	3387
T5	26003	4442
T4A	22969	4787
T4	21757	5229
T3	16258	5613
T2	13656	6236
T1A	9809	6165
T1	4256	6135
Rock		
R18	3162	1264
R19	2554	1277
R20	1693	1201

The Lee flow estimates vary from approximately a 100yr event at the upstream end to approximately a 25yr event at the downstream end of the study area.

Demolition and construction projects were completed by others after TS Lee flooding. To ensure meaningful calibration results, the HEC-RAS models were setup to reflect 2011 conditions. An aerial photograph dated 2011 was used to ensure the HEC-RAS models reflected the condition of the floodplain at the time of the TS Lee event.

The parameters that were adjusted in order to best match the available calibration information include:

- Ineffective flow areas
- Blocked obstructions
- Manning's roughness values

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4.2.a Calibration Results – RAS

High water marks for the September 2011 event (TS Lee) were not surveyed. The elevations were estimated by adding reported maximum depth of flood water to estimates of ground elevation from a 1ft contour map. The high water marks were spatially located and assigned stream stationing. A comparison between the high water marks (HWM) and the calculated water surface elevations (RAS W.S.) are provided for the September 2011 event for Tookany and Rock Creek in Tables 4.7 and 4.8, respectively, and shown on Figures 4.5 and 4.6. Agreement between the high water marks and the computed HEC-RAS water surface elevations is excellent. The HEC-RAS model is suitable for the purposes of this technical effort.

**Table 4.7
Tookany Creek High Water Mark Comparison– September 2011 Event**

HWM Station		RAS W.S. (ft-NAVD)	HWM (ft-NAVD)	Delta W.S. (feet)	RAS EG (ft-NAVD)
Bridge Reach	X-section				
Harrison - Mill	20270	139.95	140.5	-0.55	140.68
Mill - High School	20656	143.78	145.0	-1.22	144.76
	21208	145.13	145.5	-0.37	145.60
High School - Church	21416	147.14	148.0	-0.86	147.29
Church - Forest	23275	154.68	155.0	-0.32	154.98
Wooden Br - Greenwood	30997	203.12	203.0	0.12	203.54
Greenwood - RR	31266	207.03	207.0	0.03	207.12
RR - Long Culvert	34583	222.13	222.0	0.13	222.15
Long Culvert - Rices Mill	35034	222.29	222.0	0.29	222.35
Rices Mill - Waverly	35823	223.06	223.86	-0.80	223.30
	36541	224.13	224.53	-0.40	224.42
Library - Unnamed Culvert	37824	232.91	233.0	-0.09	233.13
	37907	232.90	233.3	-0.40	233.15
Unnamed Culvert - Bickley	38082	232.88	233.5	-0.62	233.60
Bickley - Easton	38115	233.49	234.0	-0.51	234.14
	38148	233.50	234.0	-0.50	234.17
Easton - Springhouse	38662	238.28	237.5	0.78	238.29

Table 4.8 Rock Creek High Water Mark Comparison - September 2011 Event					
HWM Station		RAS W.S. (ft-NAVD)	HWM (ft-NAVD)	Delta W.S. (feet)	RAS EG (ft-NAVD)
Bridge Reach	X-section				
Just Upstream Widener	864	189.91	190.00	-0.09	189.96

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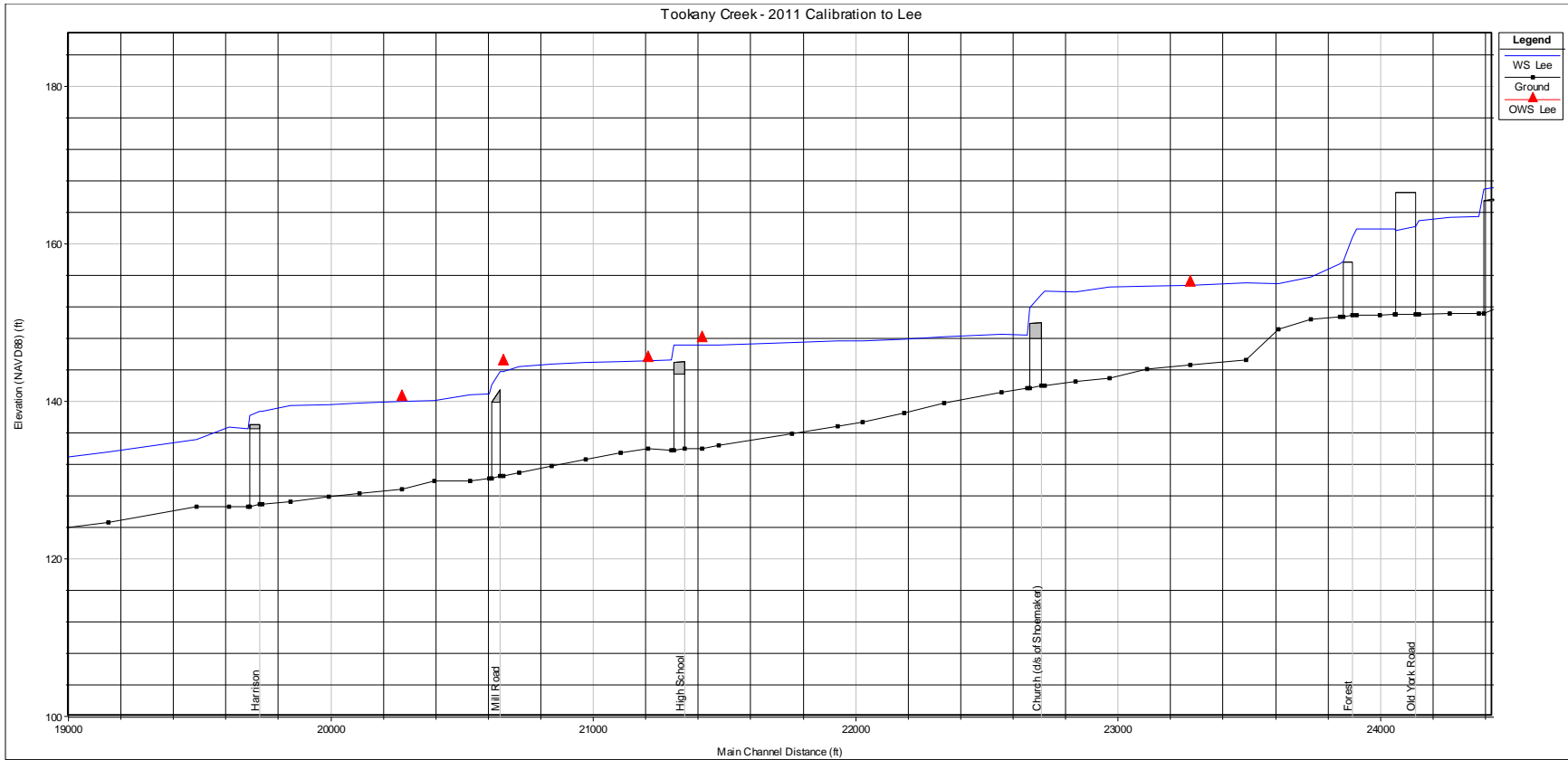


Figure 4.5-Part 1, Tookany Creek Tropical Storm Lee Calibration Water Surface Elevation Profile

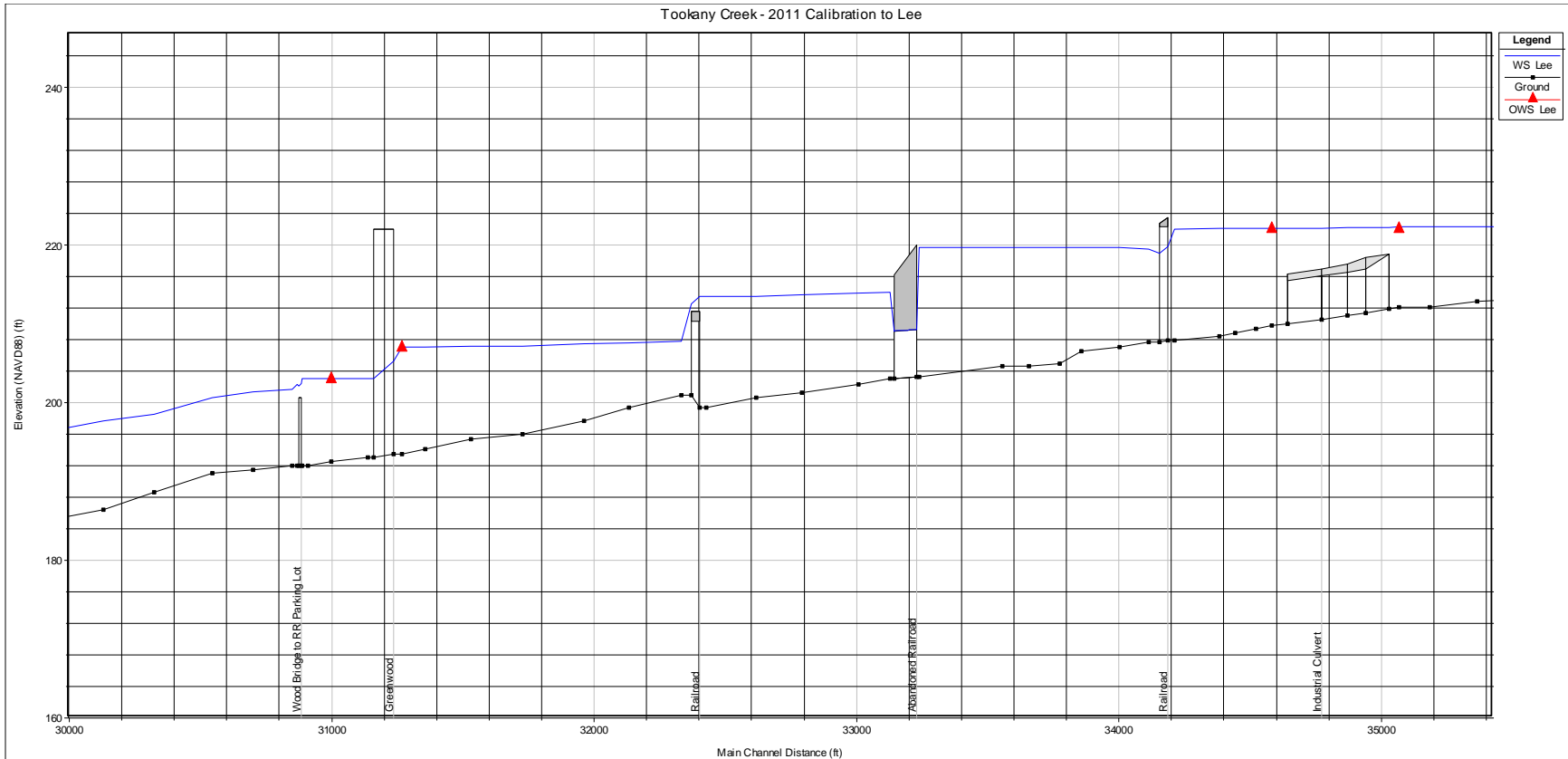


Figure 4.5-Part 2, Tookany Creek Tropical Storm Lee Calibration Water Surface Elevation Profile

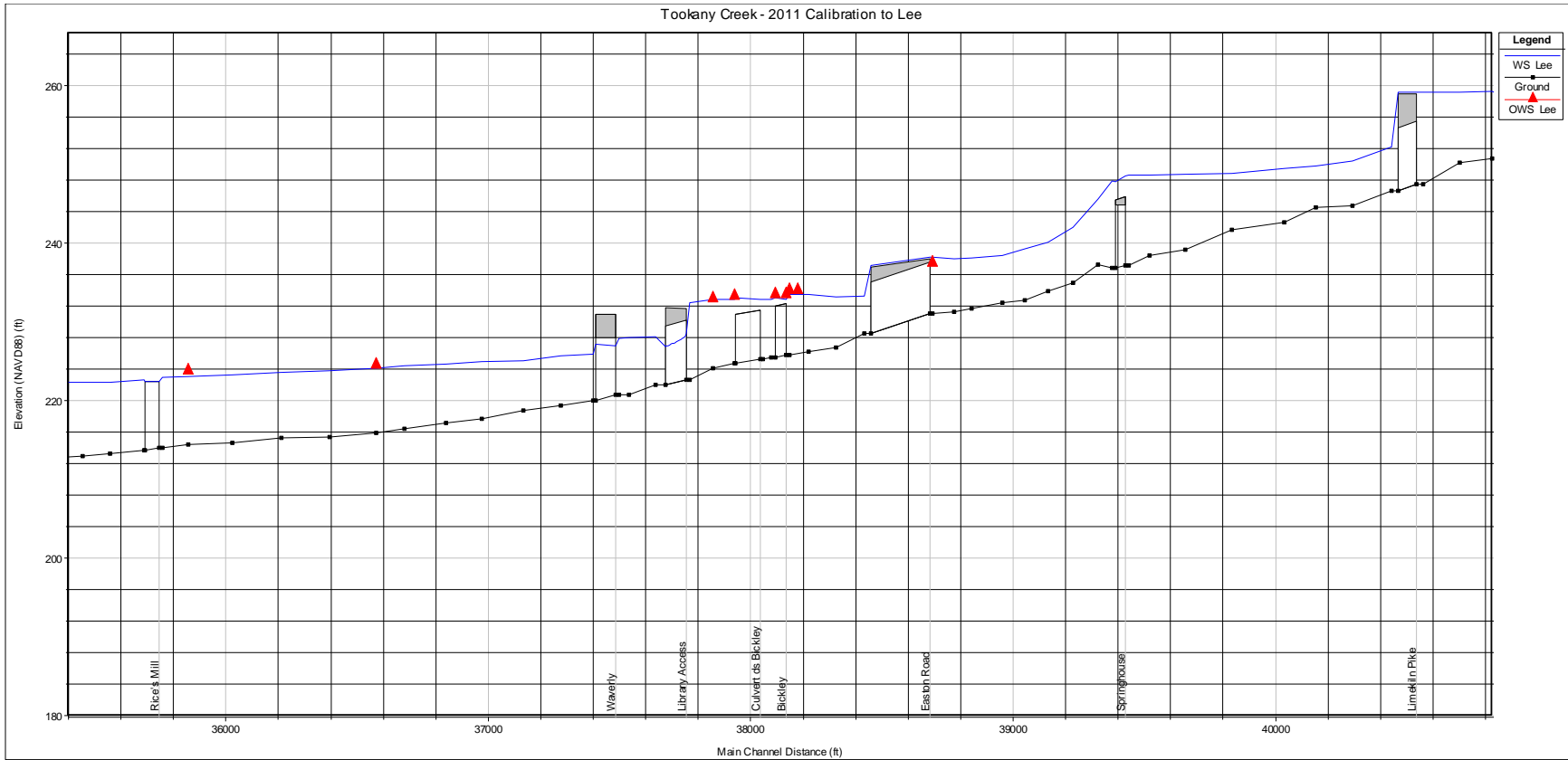


Figure 4.5-Part 3, Tookany Creek Tropical Storm Lee Calibration Water Surface Elevation Profile

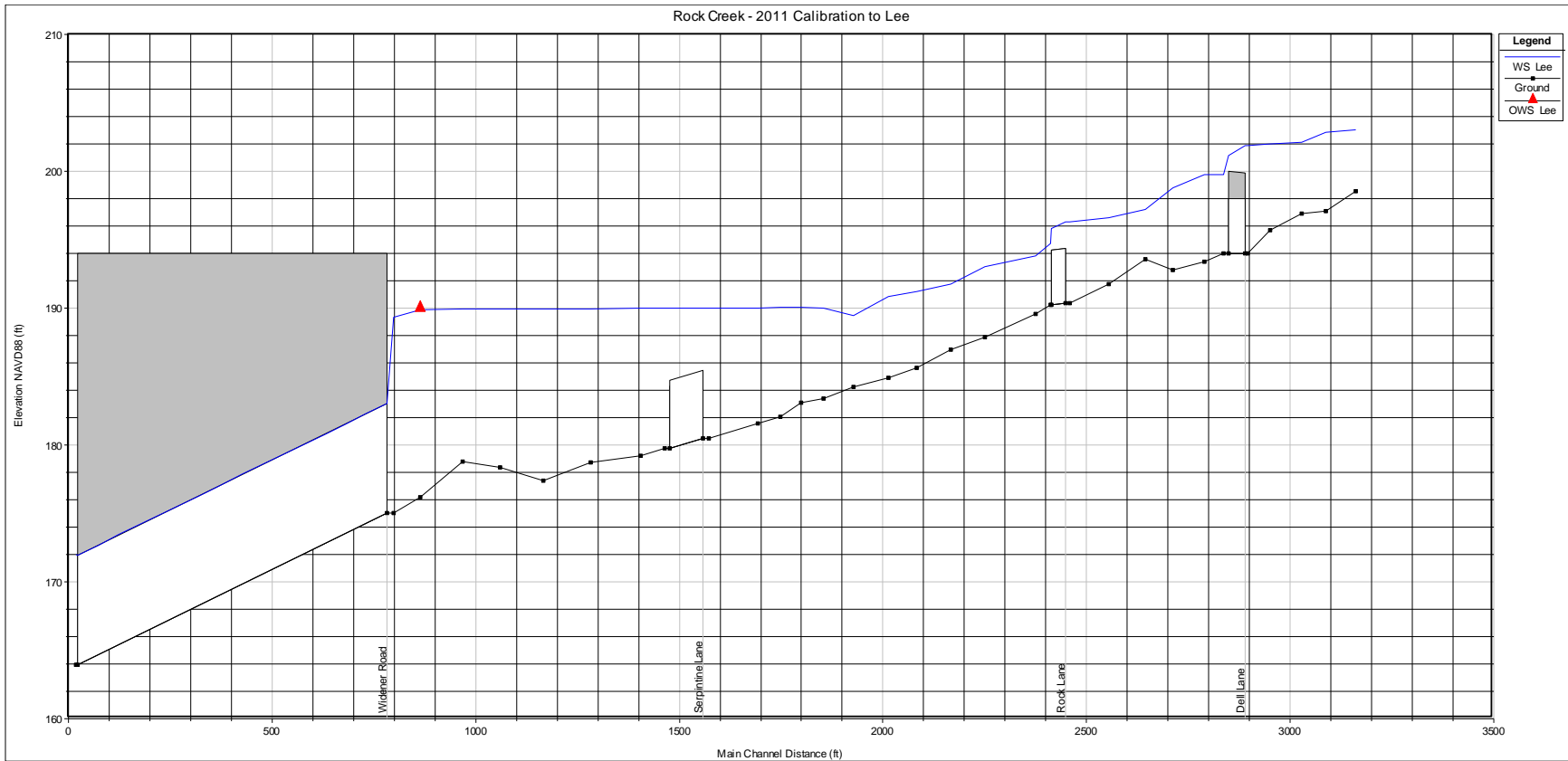


Figure 4.6, Rock Creek – Tropical Storm Lee Calibration Water Surface Elevation Profile

4.3 Without Project Frequency Water Surface Profiles

The calibrated HEC-RAS model can be used with frequency discharges computed as described in the Hydrologic Appendix to determine the without project flooding potential across a range of flow conditions. The frequency discharges computed at each flow change location and input to the HEC-RAS models are provided in Table 4.9.

Location Label	X-section	Discharge (cfs)							
		2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany									
T10	40262	530	804	1059	1317	1476	1680	1963	2192
T9	39291	499	740	921	1146	1297	1476	1724	1925
T8	38662	512	718	804	1001	1082	1231	1438	1606
T7	36541	675	1004	1192	1483	1562	1778	2077	2319
T6B	33238	1079	1622	1910	2376	2514	2861	3343	3732
T6A	31960	1092	1641	1928	2399	2522	2871	3354	3745
T6	30997	1289	1995	2413	3001	3179	3619	4227	4720
T5	26003	1615	2516	3088	3842	4136	4708	5500	6141
T4A	22969	1746	2754	3391	4218	4556	5186	6059	6765
T4	21757	1826	2822	3560	4429	4837	5506	6432	7182
T3	16258	2097	3086	3961	4928	5390	6135	7167	8002
T2	13656	2568	3666	4589	5708	6539	7443	8695	9709
T1A	9809	2580	3720	4571	5687	6529	7432	8683	9695
T1	4256	2590	3760	4590	5710	6580	7490	8750	9770
Rock									
R18	3162	562	861	1064	1324	1396	1590	1857	2073
R19	2554	545	821	1109	1379	1525	1736	2028	2265
R20	1693	545	841	1013	1260	1333	1518	1773	1980

The flows in Table 4.9 were determined by prorating the statistically derived frequency flows at the Adams Ave. gage to the upstream locations using the GSSHA frequency flow ratios between Adams Ave. and the various upstream locations.

The calibrated 2011 hydraulic models were modified to reflect 2014 conditions. Based on an aerial photographic comparison between the years 2011 and 2014, the following geometry changes were made to the 2011 RAS model:

The RR bridge opening under Greenwood Avenue on the left overbank was made smaller because of recent construction.

A wall on the left overbank of the upstream face of South Keswick Avenue was deleted.

A blocked obstruction was placed downstream of Limekiln Pike Bridge on the right overbank because of the construction of a building.

The calibrated Tookany Creek model with the 2014 geometric updates was run with downstream starting conditions based on the rating curve of USGS Gage 01467086, Tacony Creek above Adams Ave, Philadelphia, PA. For flows greater than 6000 cfs starting WSELs (SWSELs) were taken from an extension of the USGS rating curve based on data from the City of Philadelphia Flood Insurance Study, Revised Jan 17, 2007. The SWSELs for the Rock Creek model for each frequency were taken from the frequency Tookany Creek model. SWSELs for both Tookany and Rock Creeks are presented in Table 4.10.

Table 4.10		
Without Project SWSELs for Tookany and Rock Creek Models		
Event	WSEL (ft-NAVD88)	
	Tookany	Rock
2 year	67.37	168.00
5 year	69.12	169.32
10 year	70.57	170.12
25 year	72.92	171.11
50 year	74.00	171.48
100 year	74.66	172.23
250 year	75.64	172.91
500 year	76.49	173.27

The without project (2014) condition frequency water surface profiles for the two hydraulic models are provided as Figures 4.7 and 4.8.

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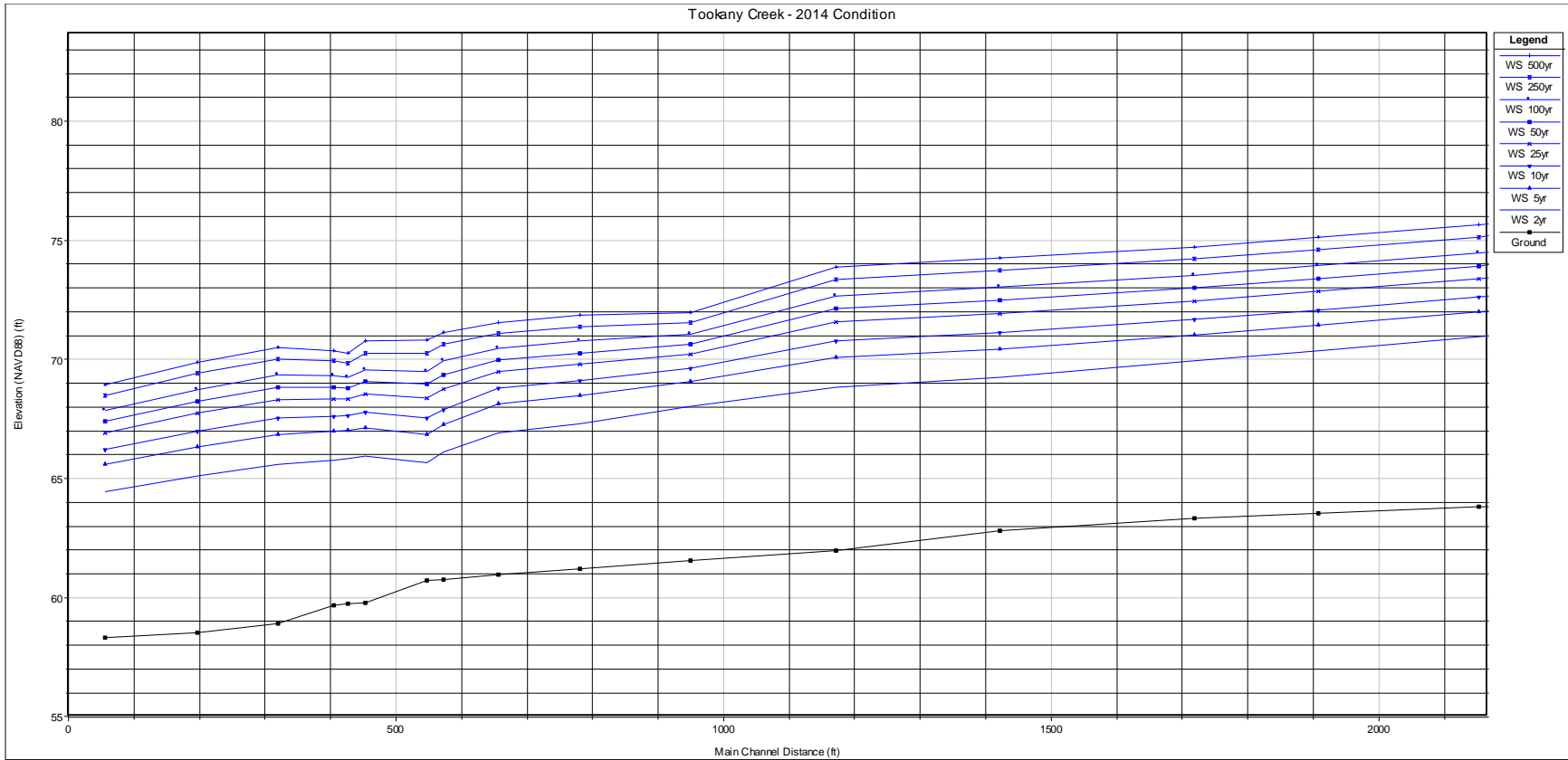


Figure 4.7–Part 1, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

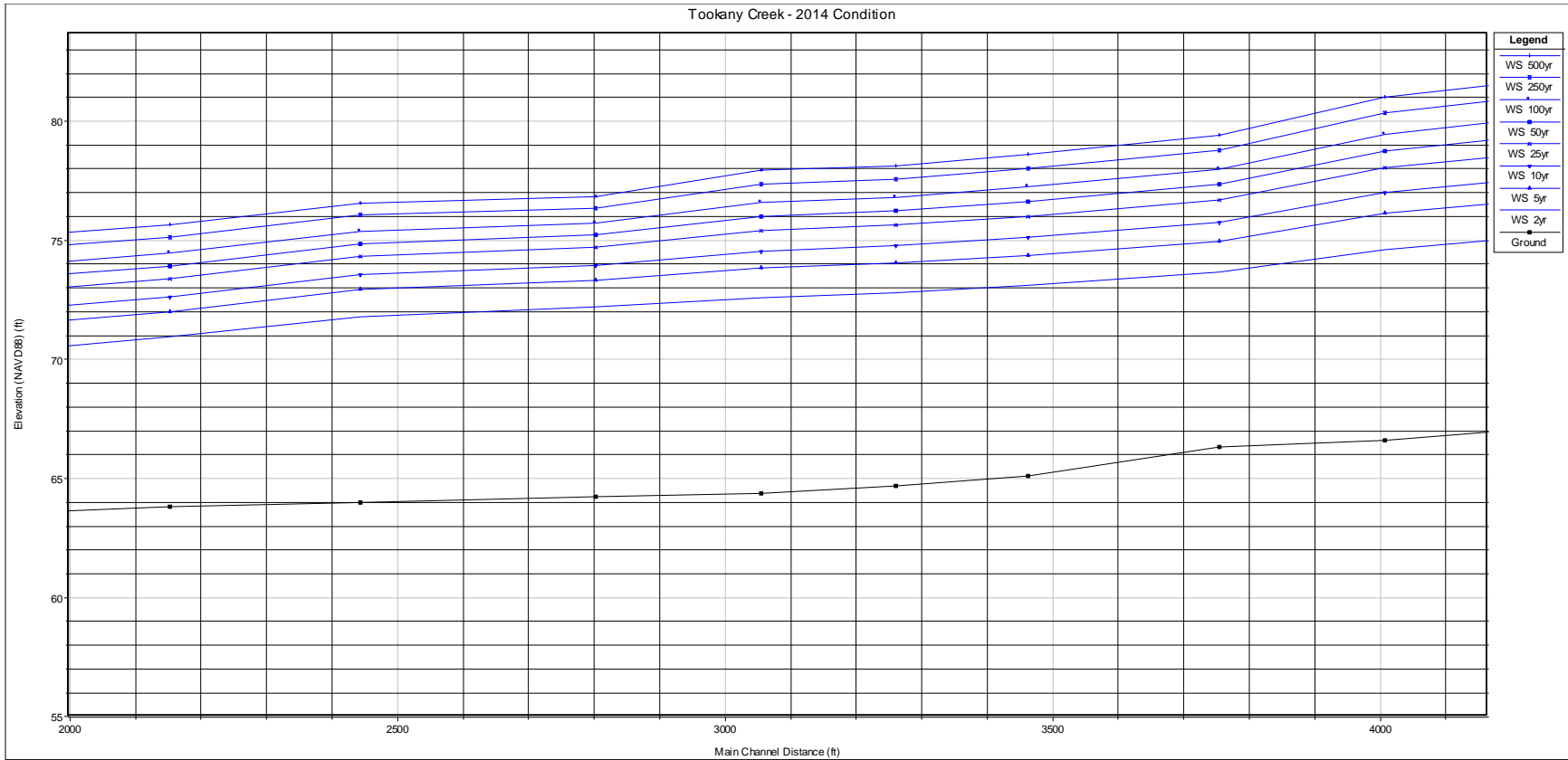


Figure 4.7-Part 2, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

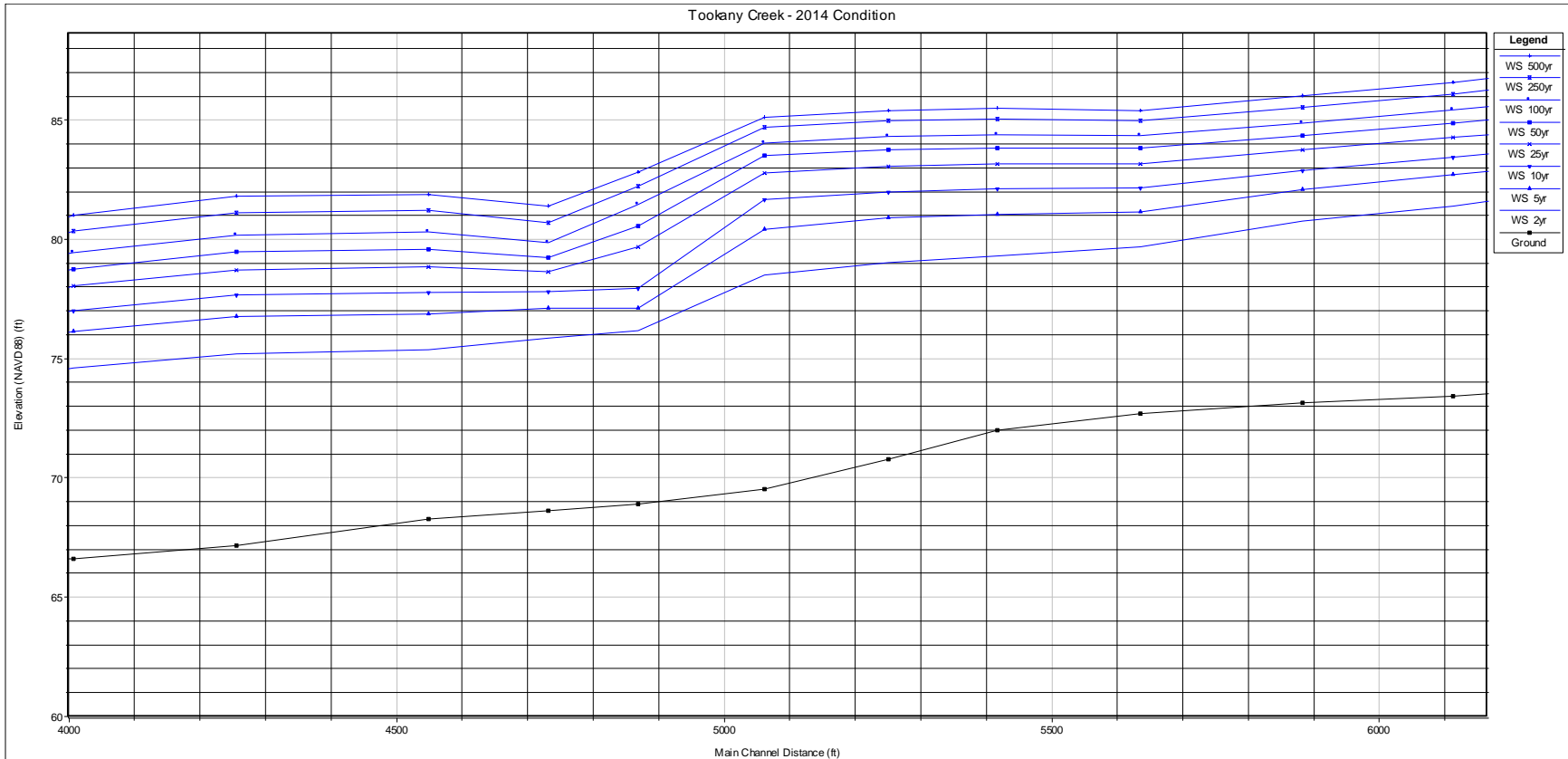


Figure 4.7-Part 3, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

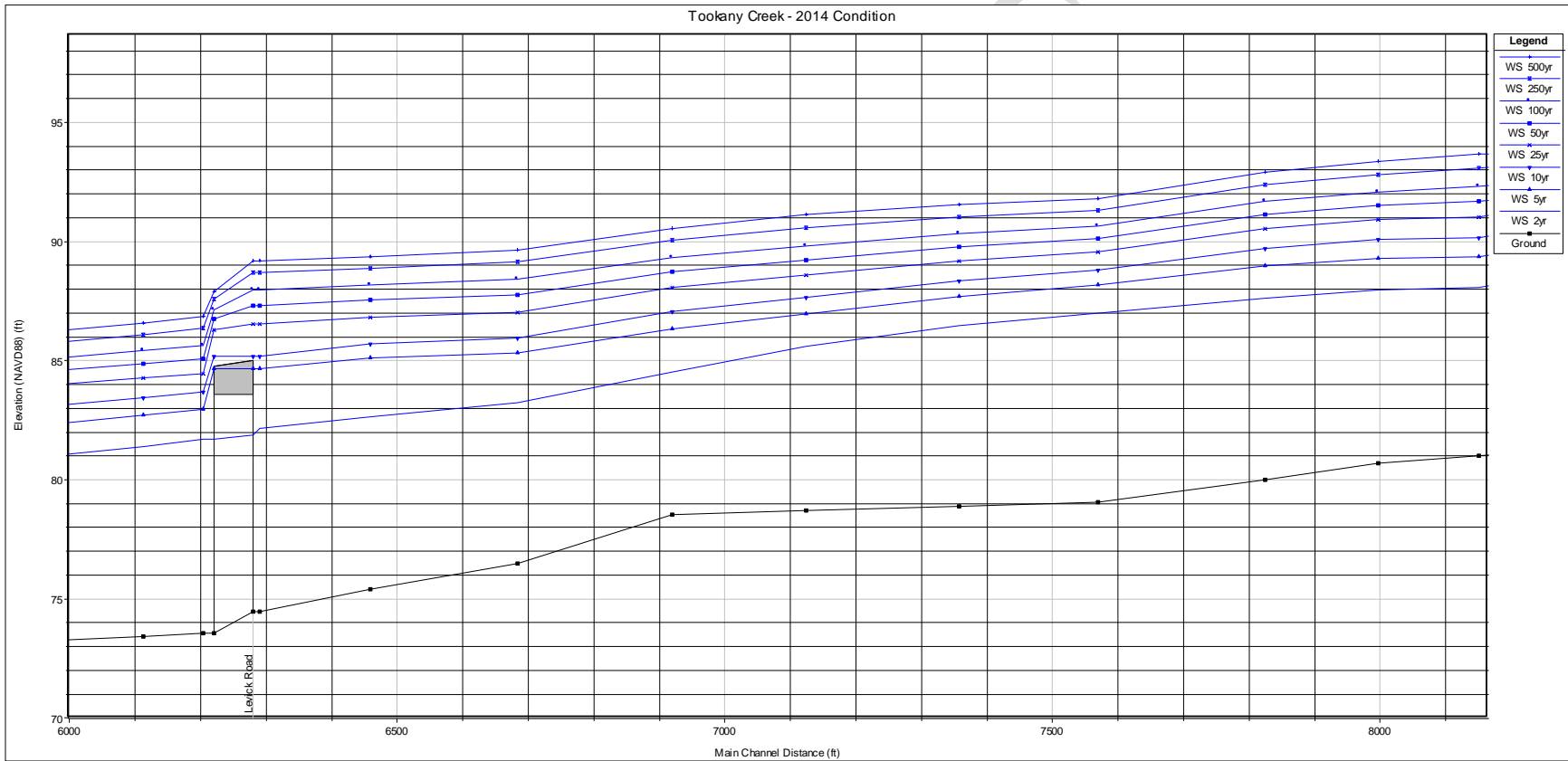


Figure 4.7-Part 4, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

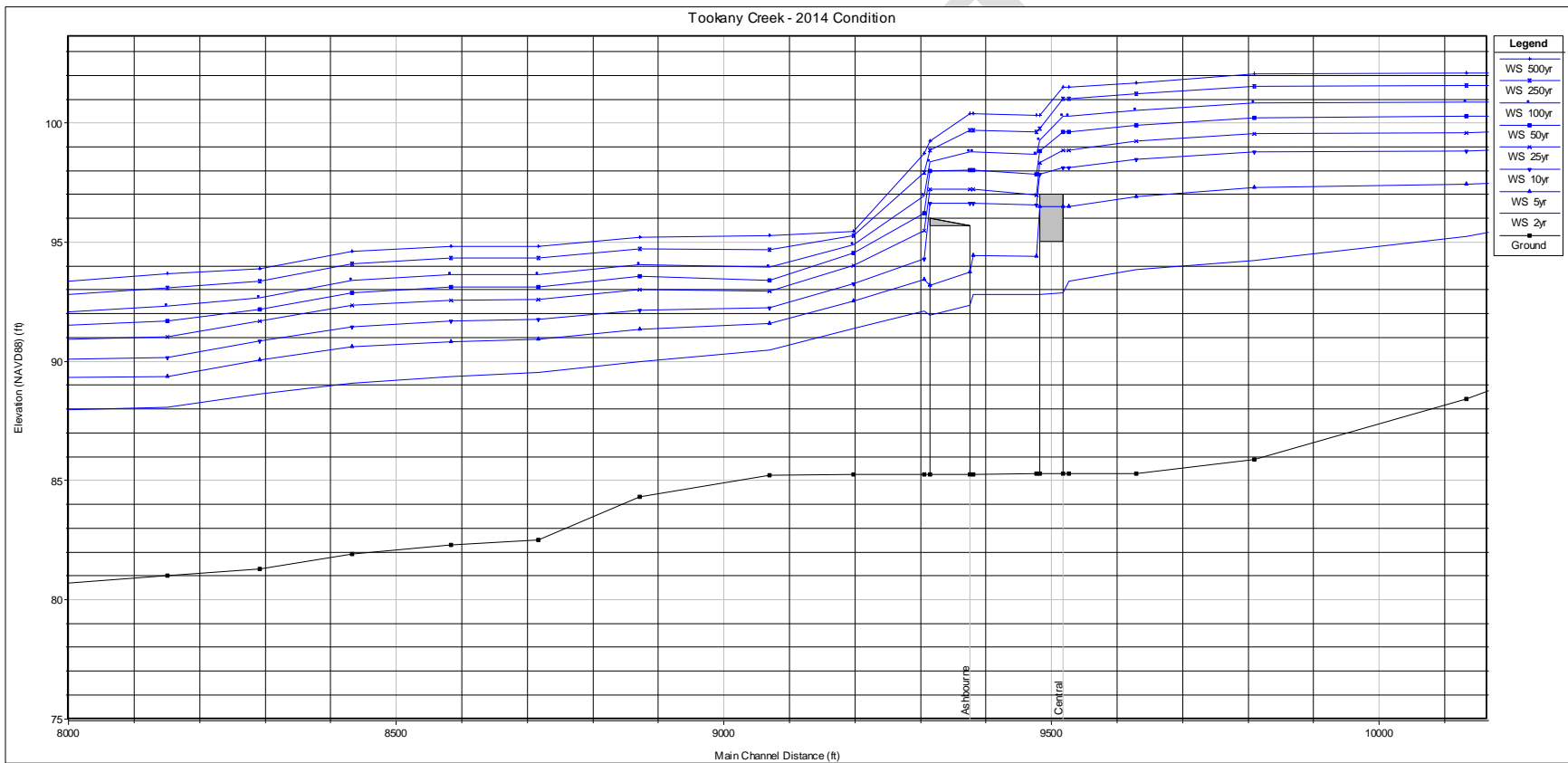


Figure 4.7-Part 5, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

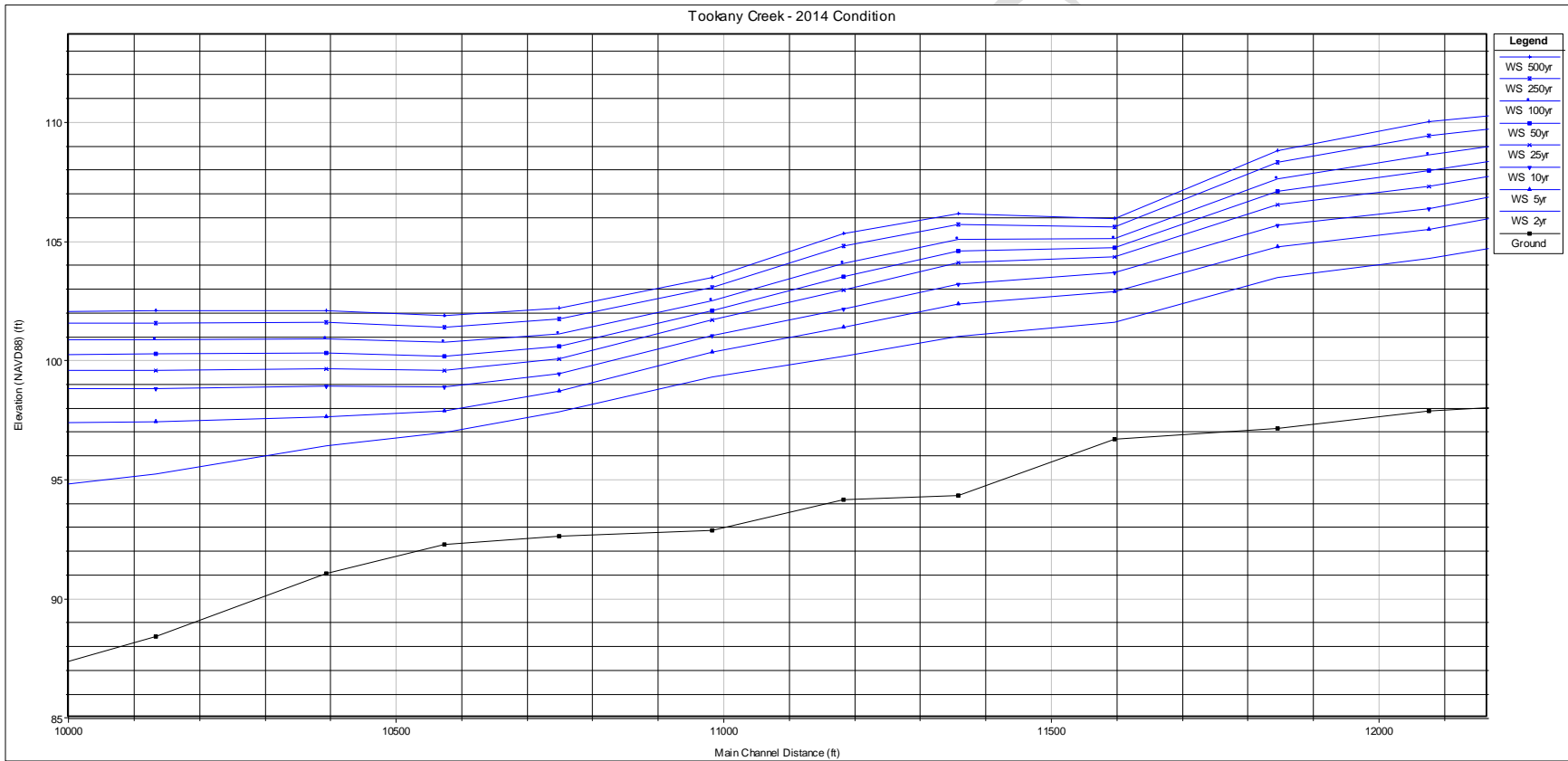


Figure 4.7-Part 6, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

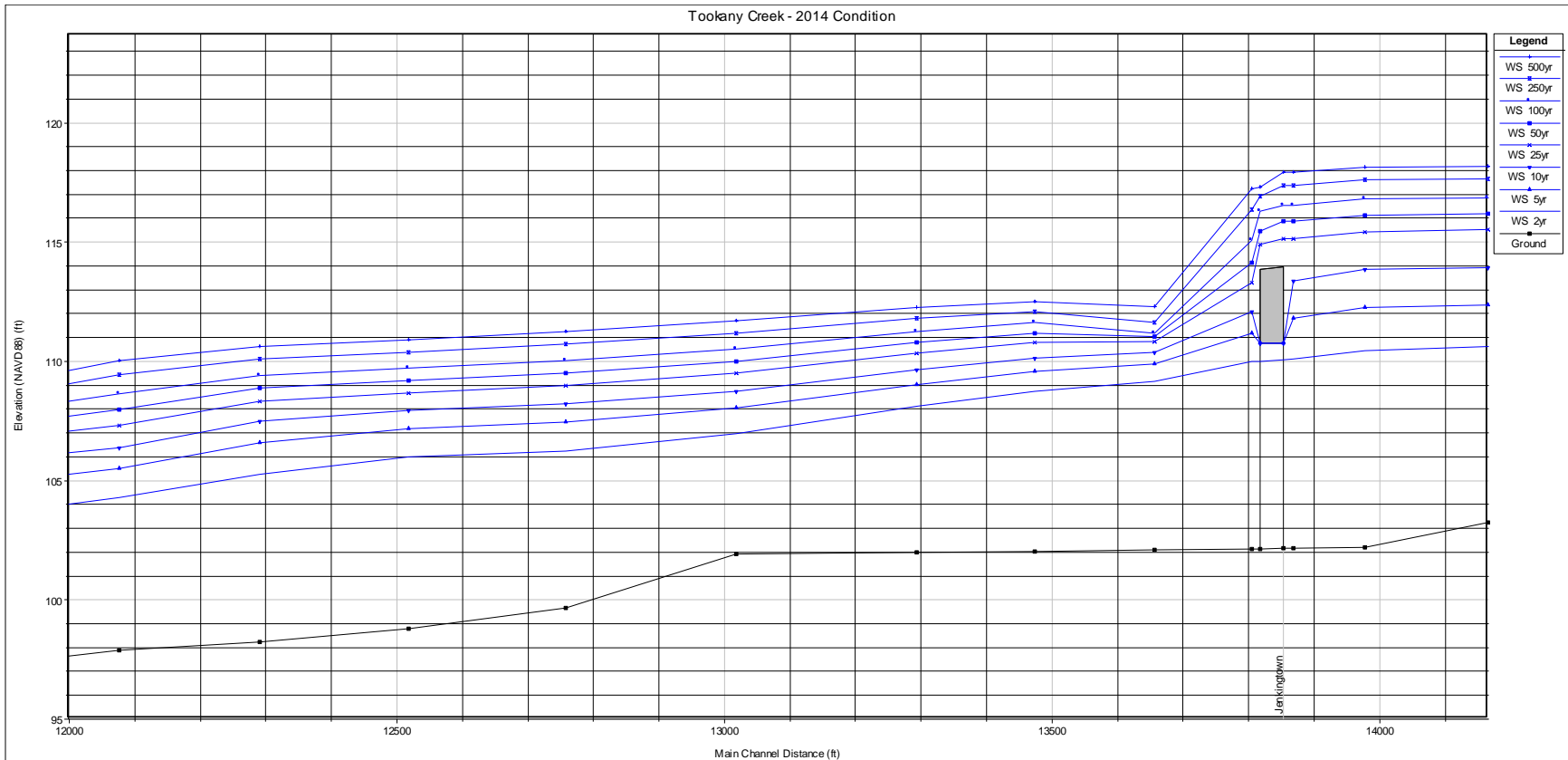


Figure 4.7-Part 7, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

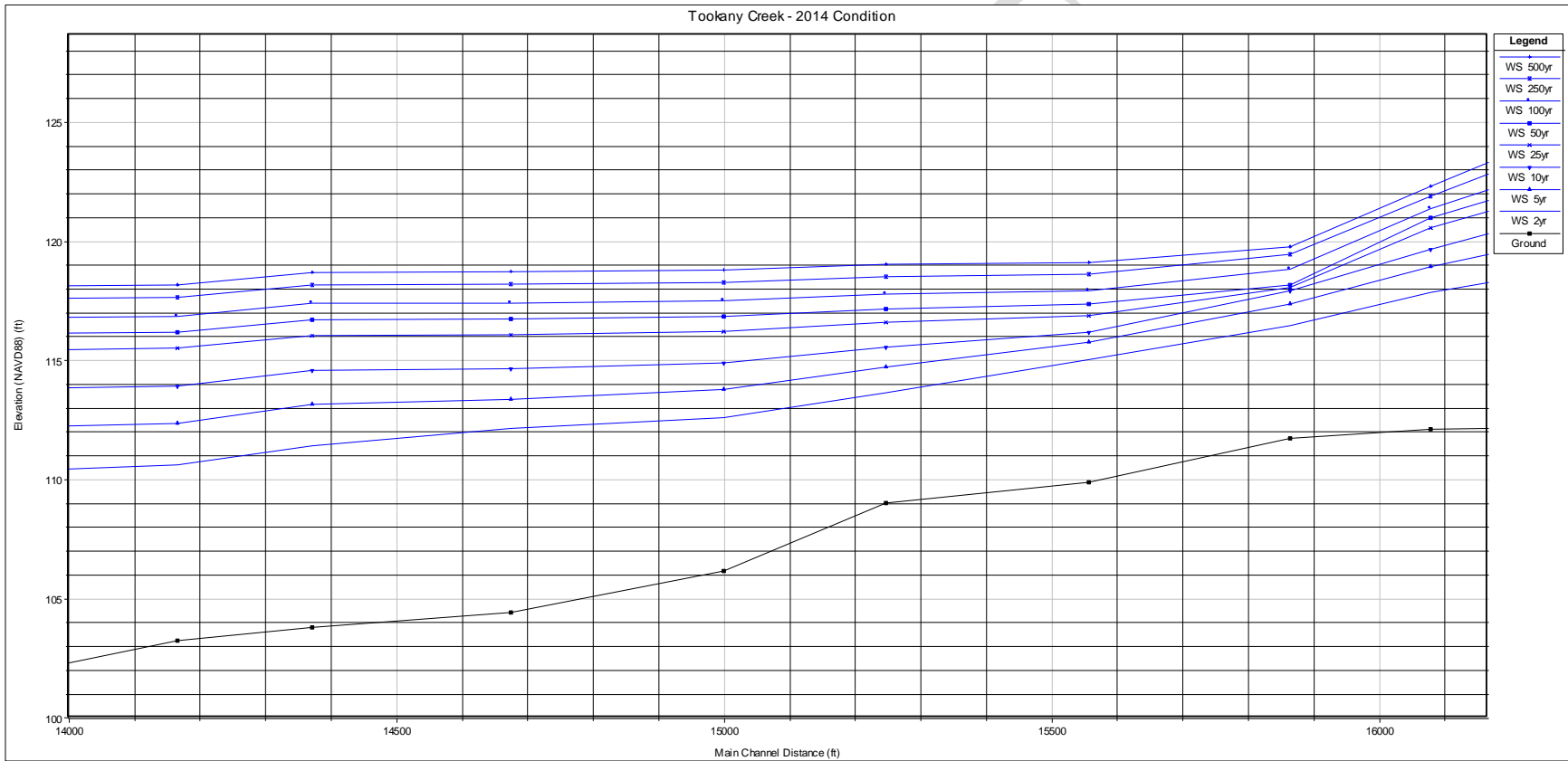


Figure 4.7-Part 8, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

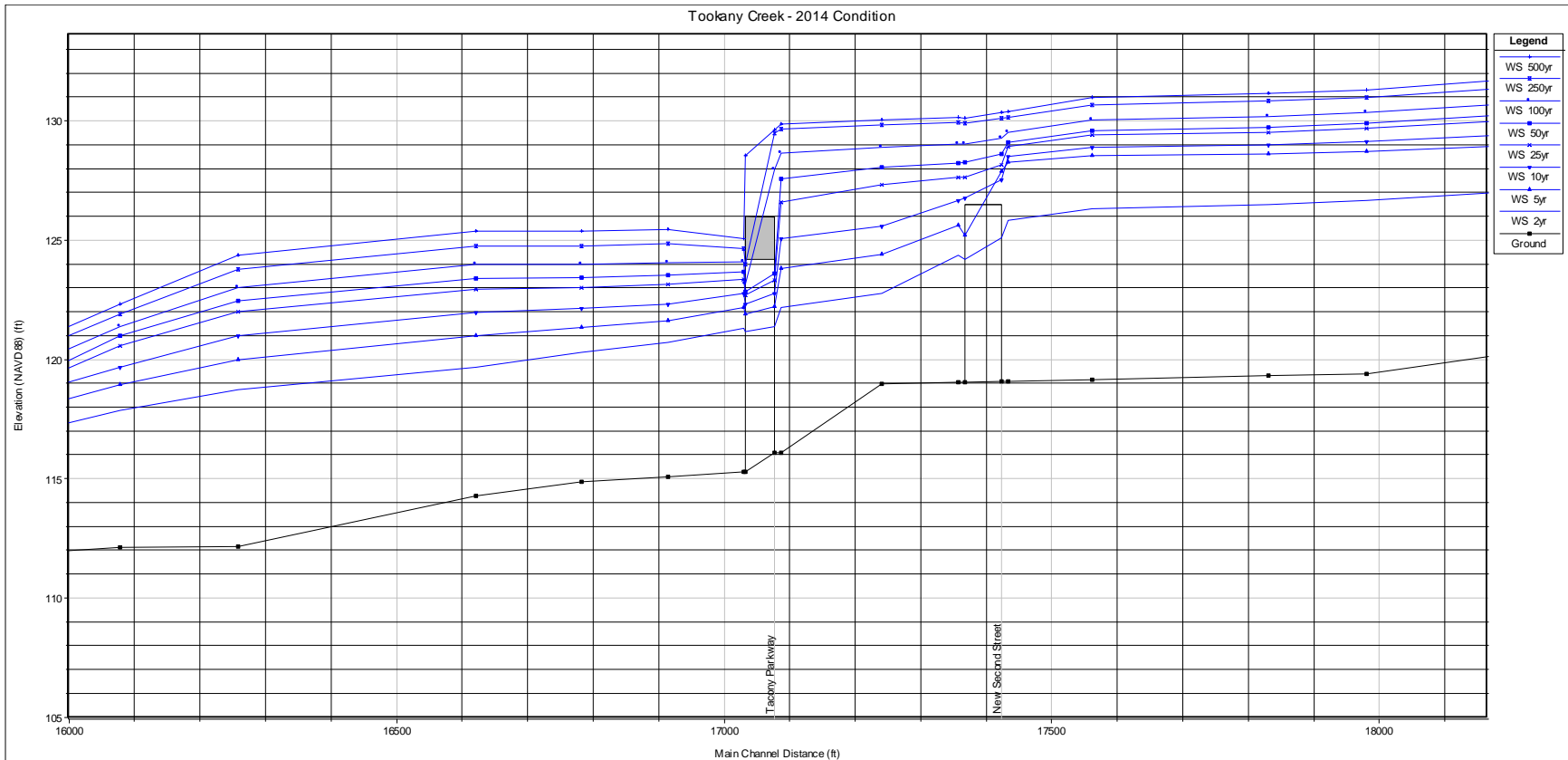


Figure 4.7-Part 9, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

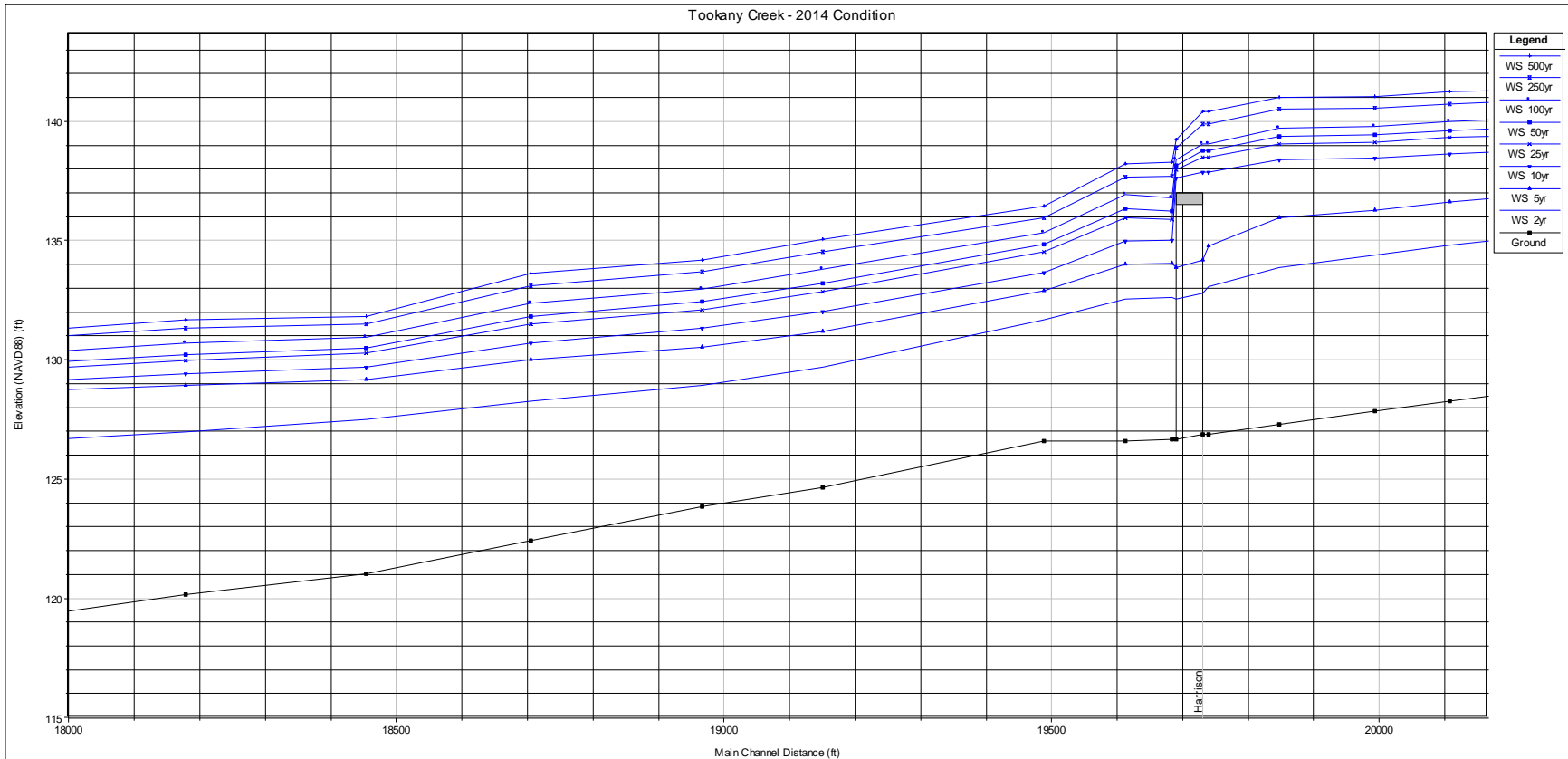


Figure 4.7-Part 10, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

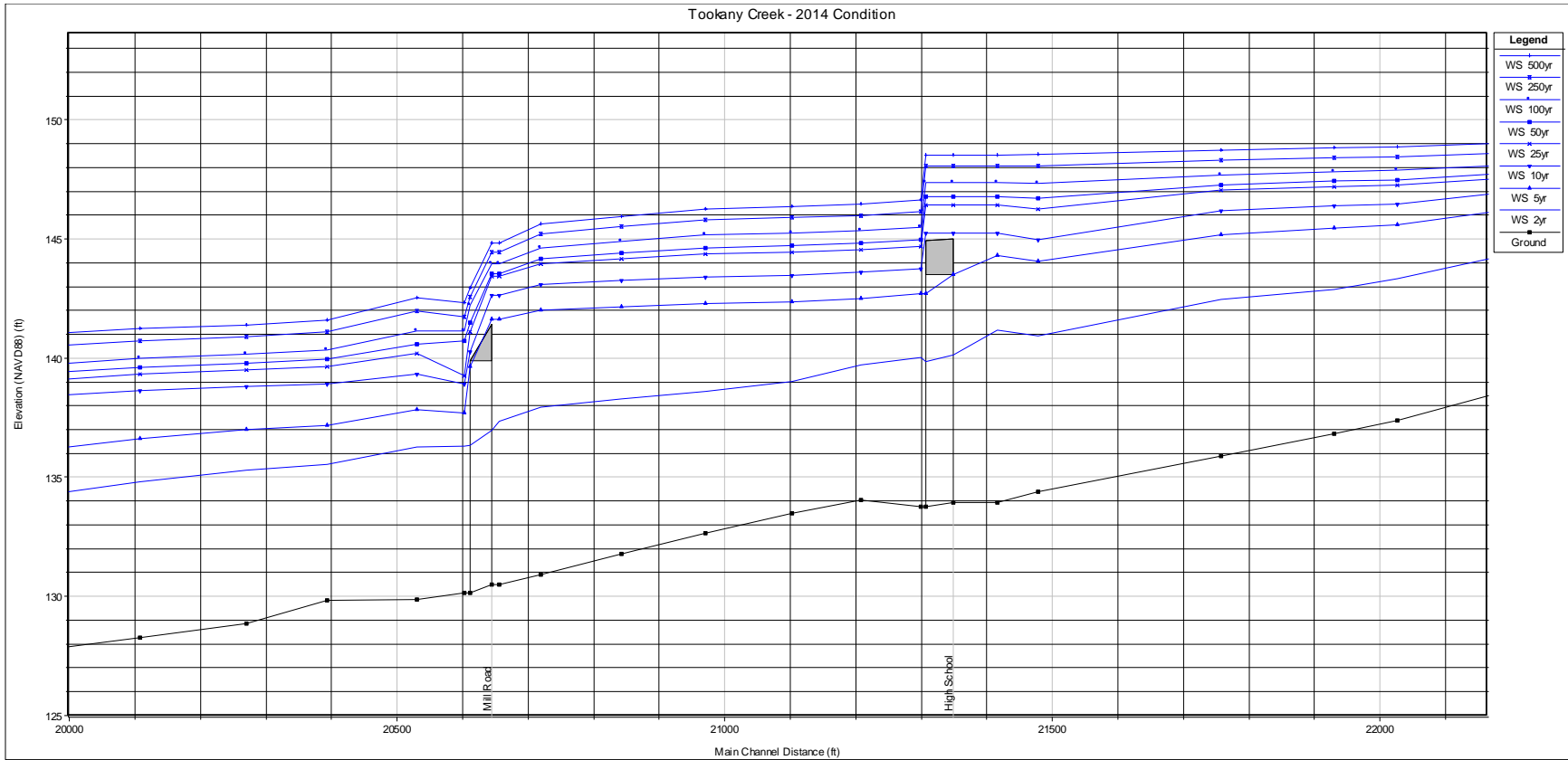


Figure 4.7-Part 11, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

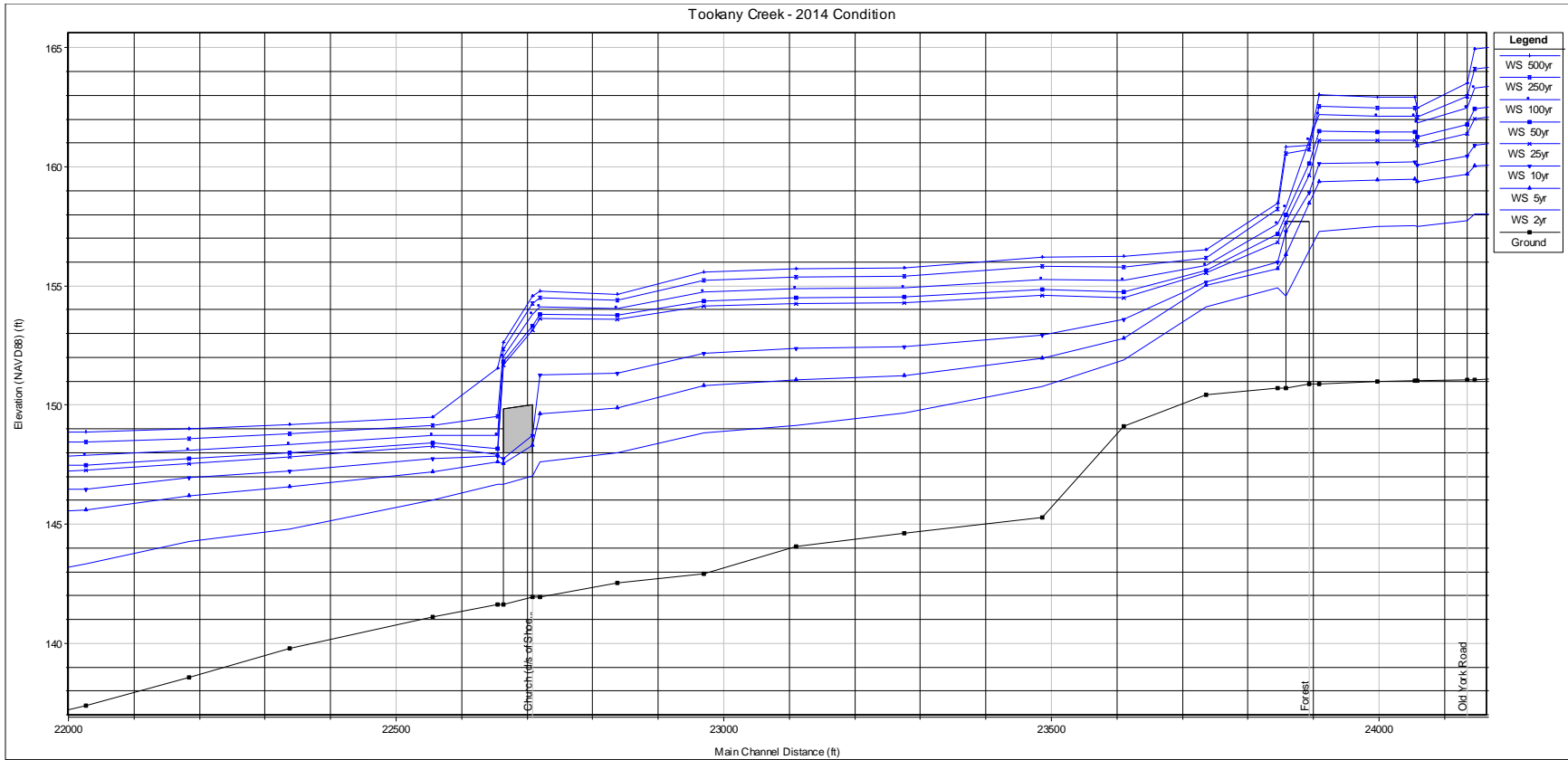


Figure 4.7-Part 12, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

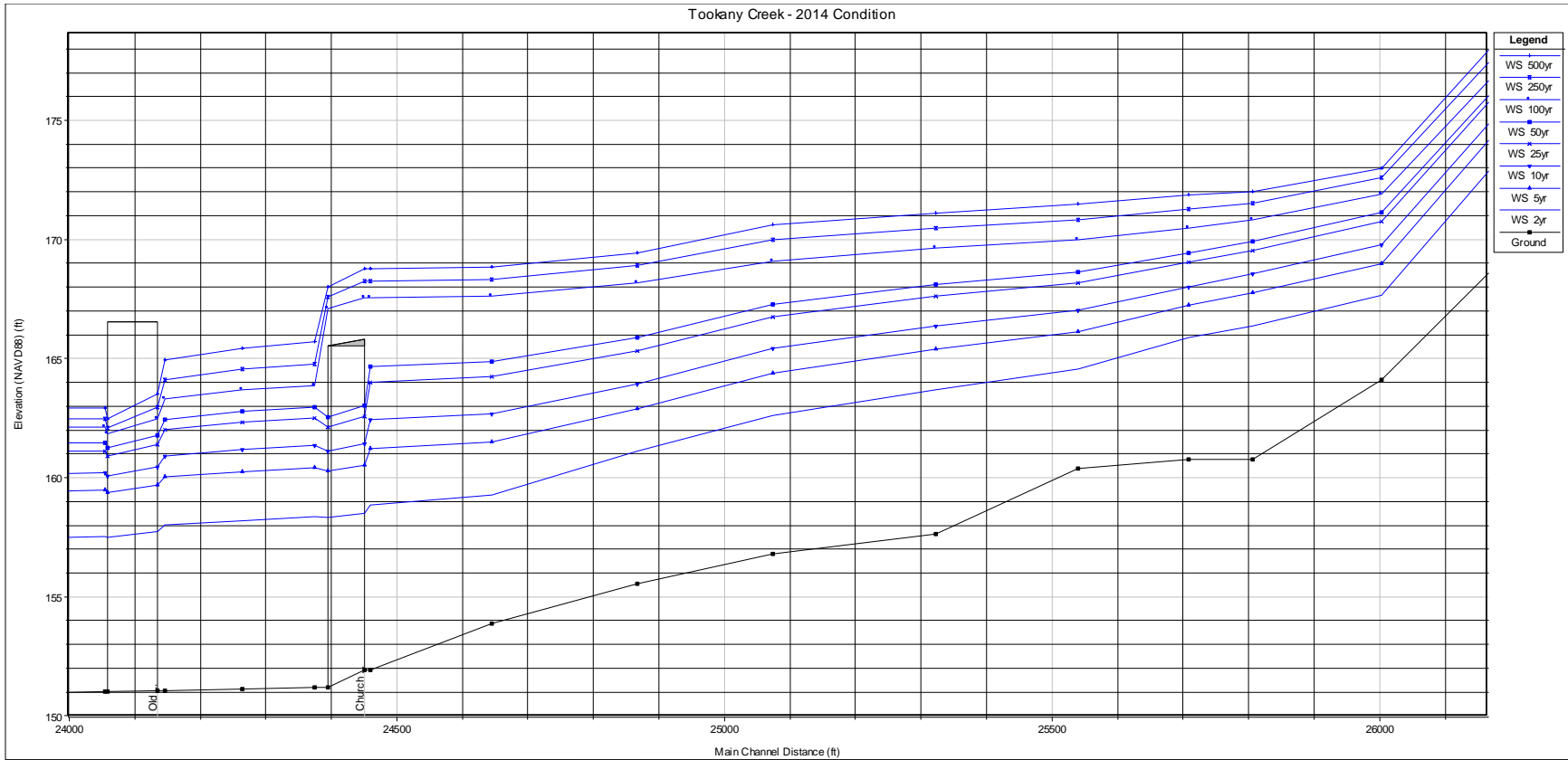


Figure 4.7-Part 13, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

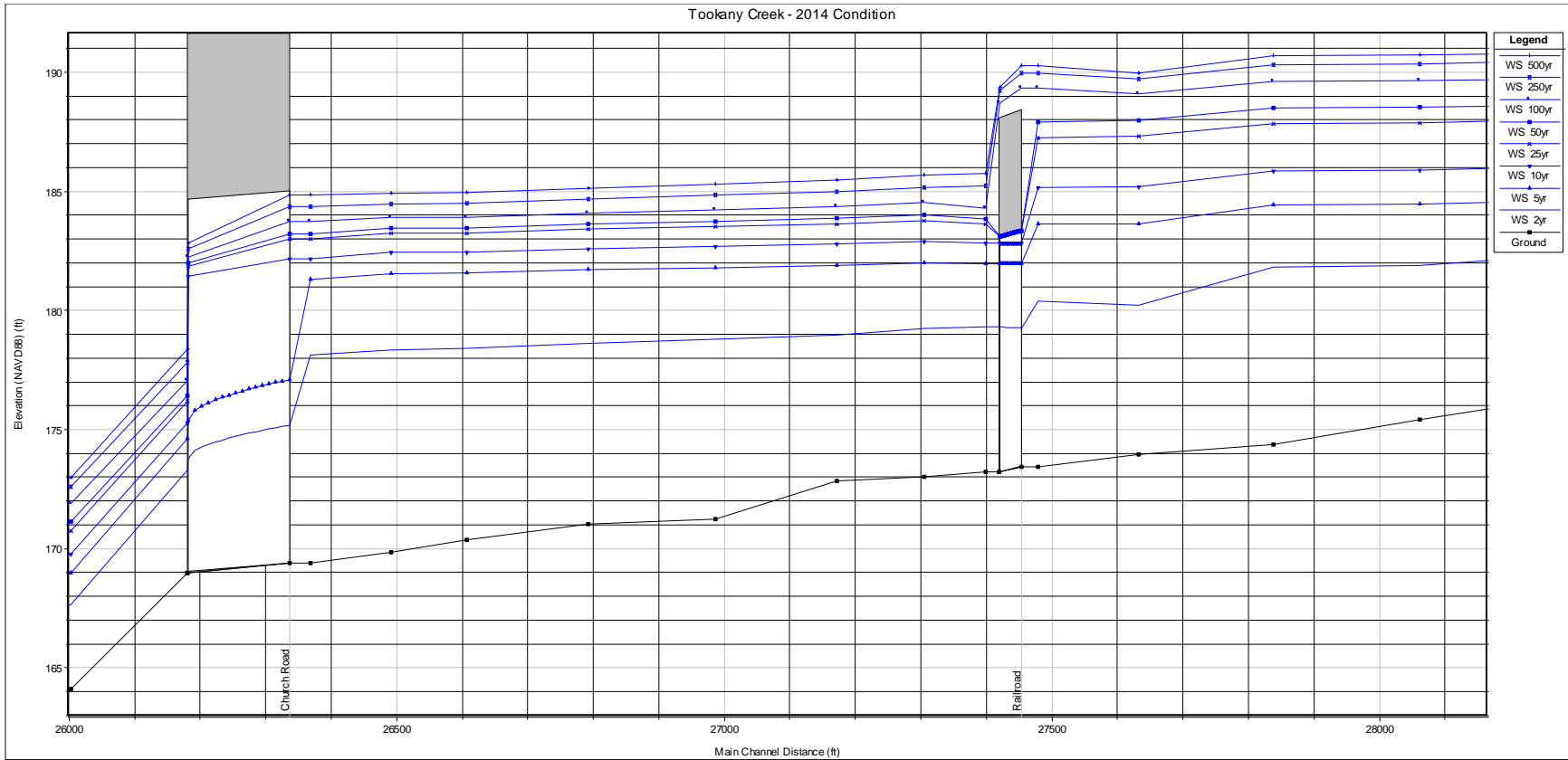


Figure 4.7-Part 14, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

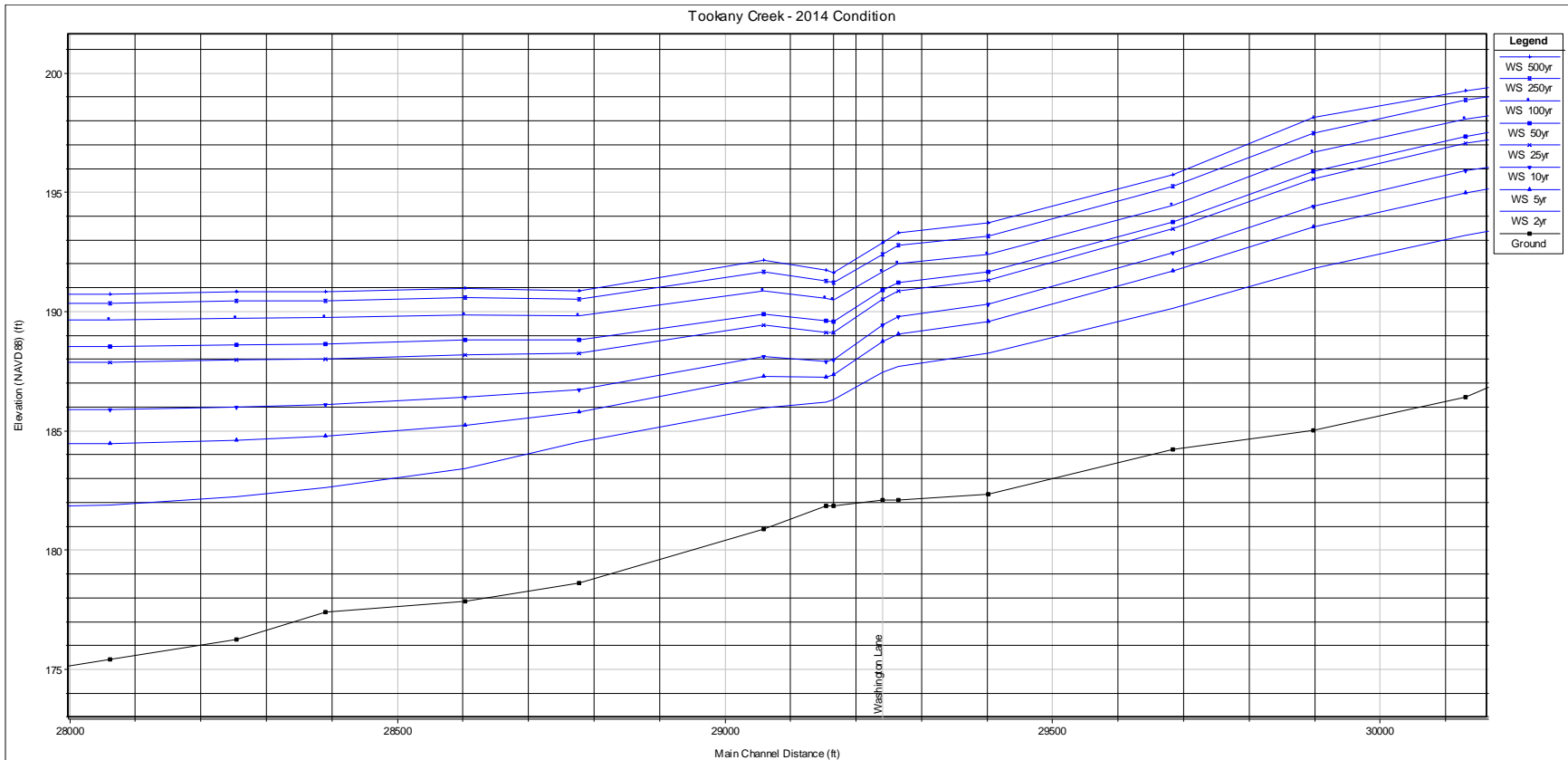


Figure 4.7-Part 15, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

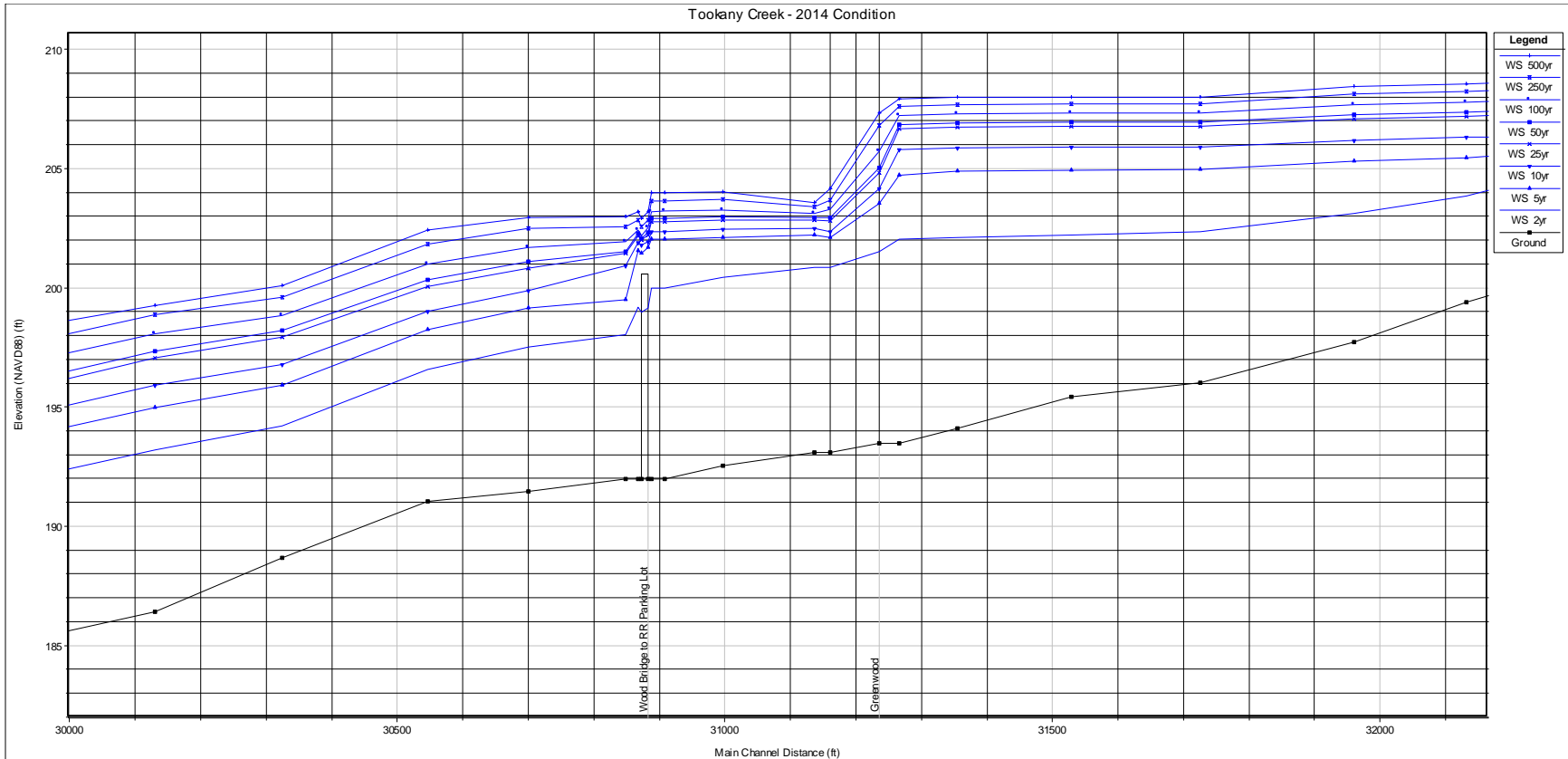


Figure 4.7-Part 16, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

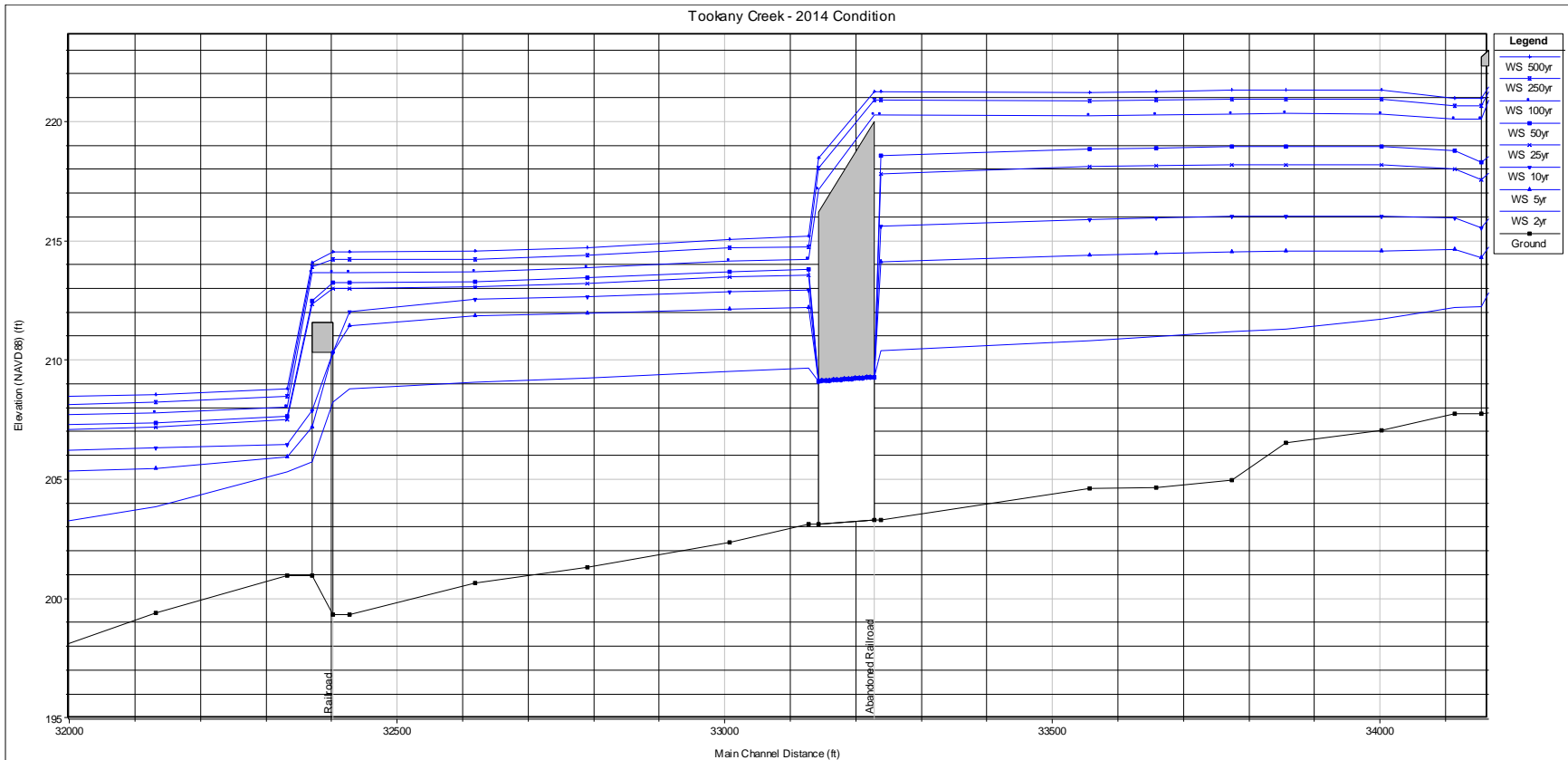


Figure 4.7-Part 17, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

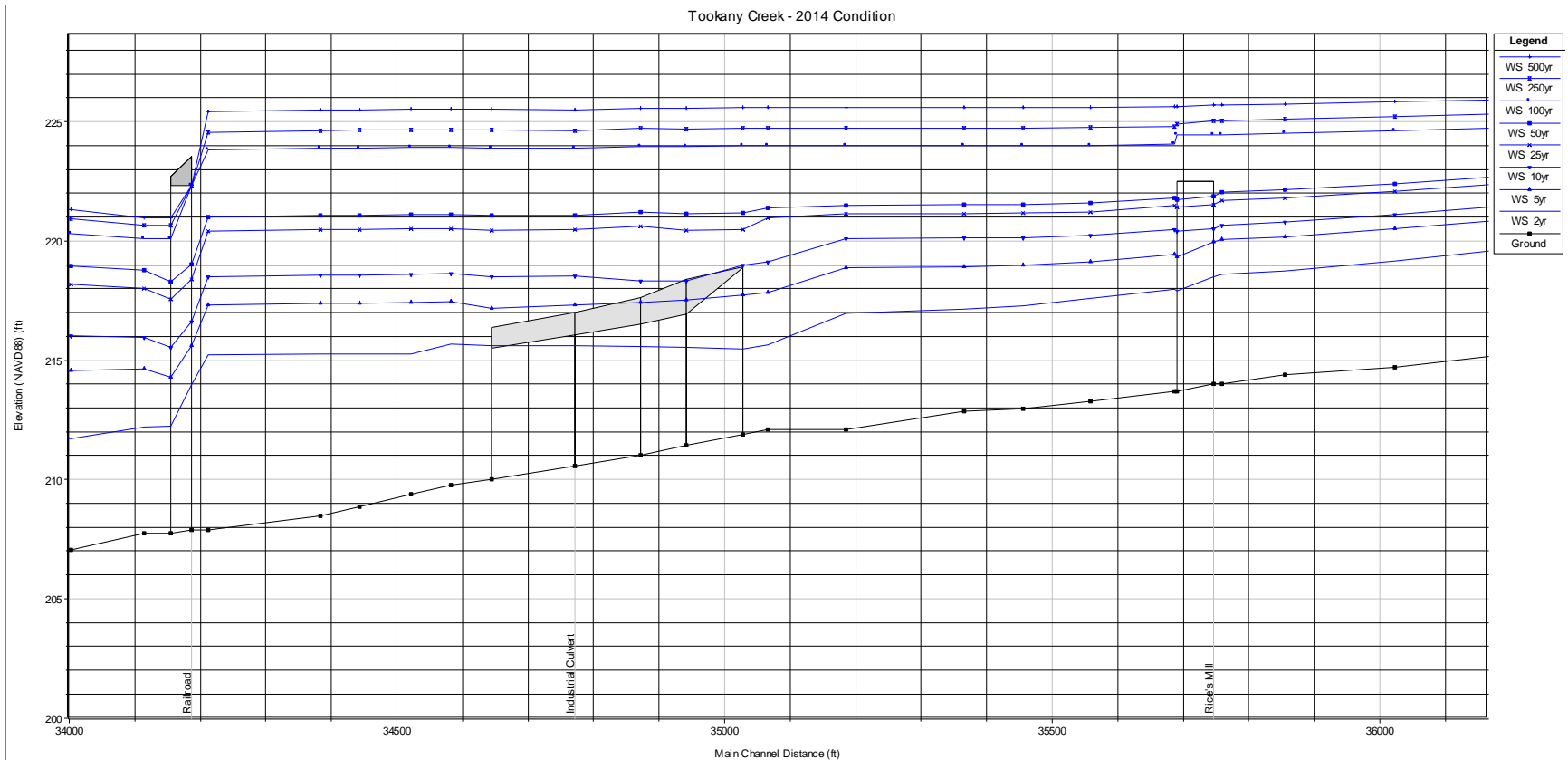


Figure 4.7-Part 18, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

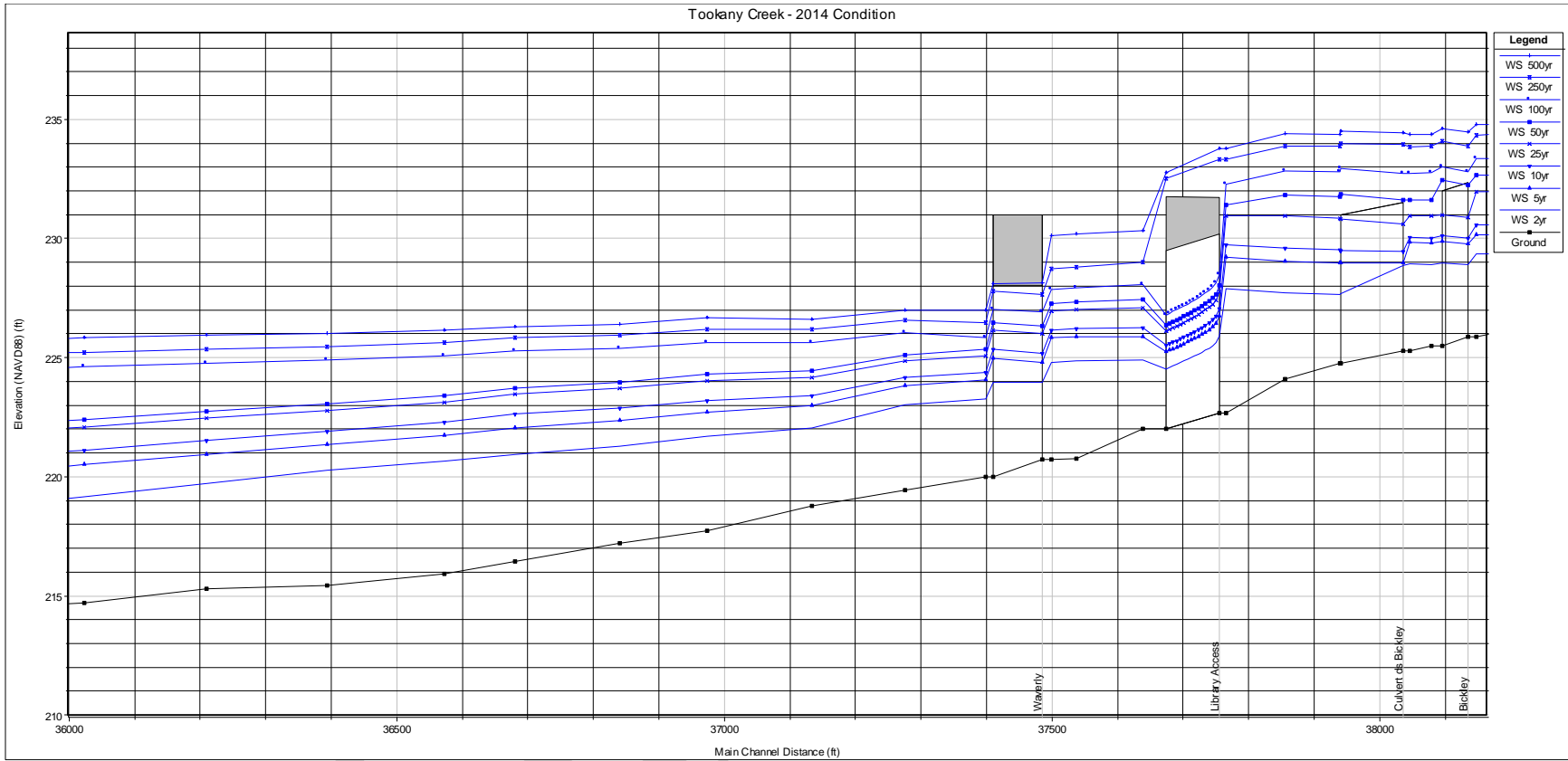


Figure 4.7-Part 19, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

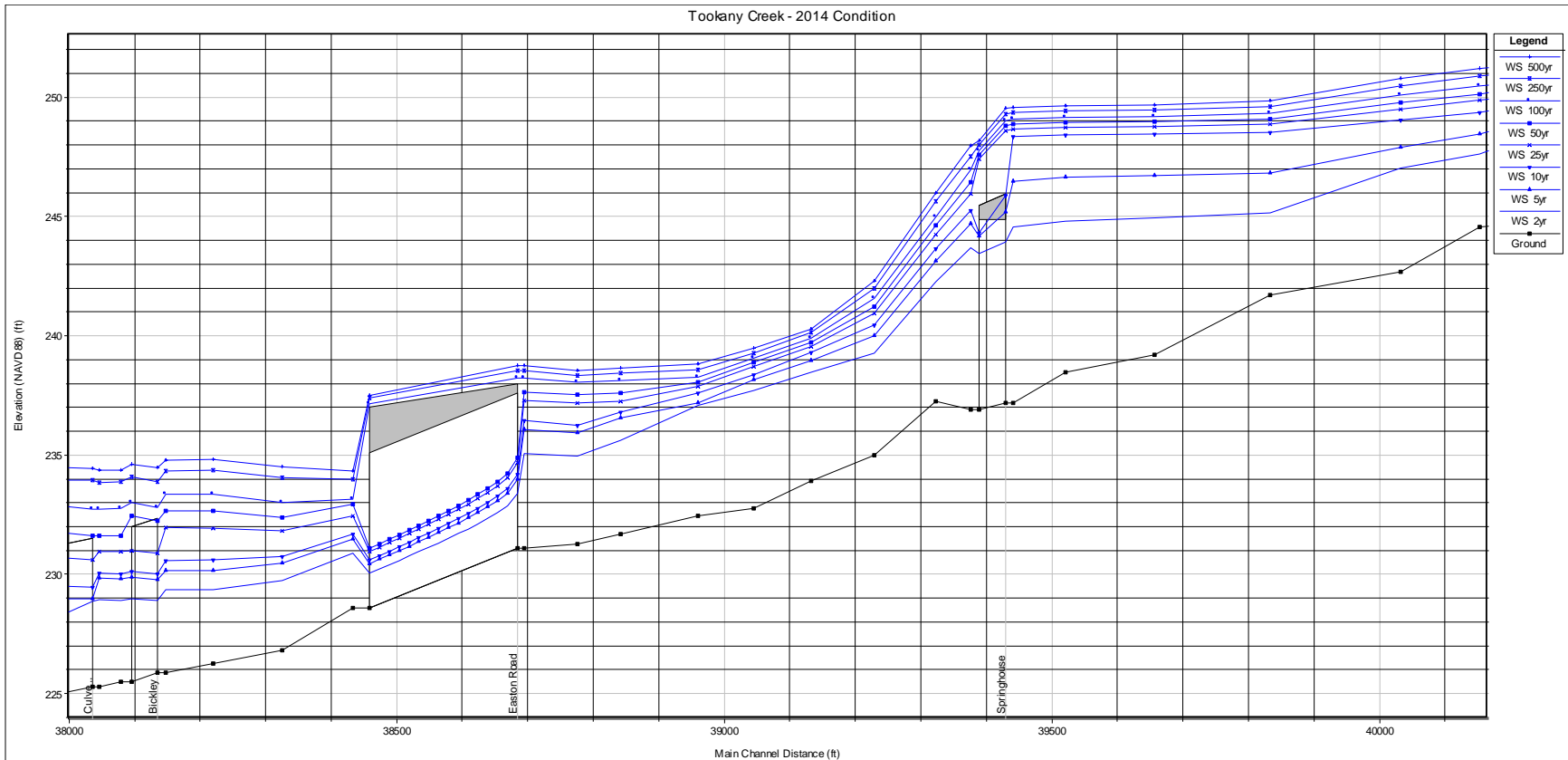


Figure 4.7-Part 20, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

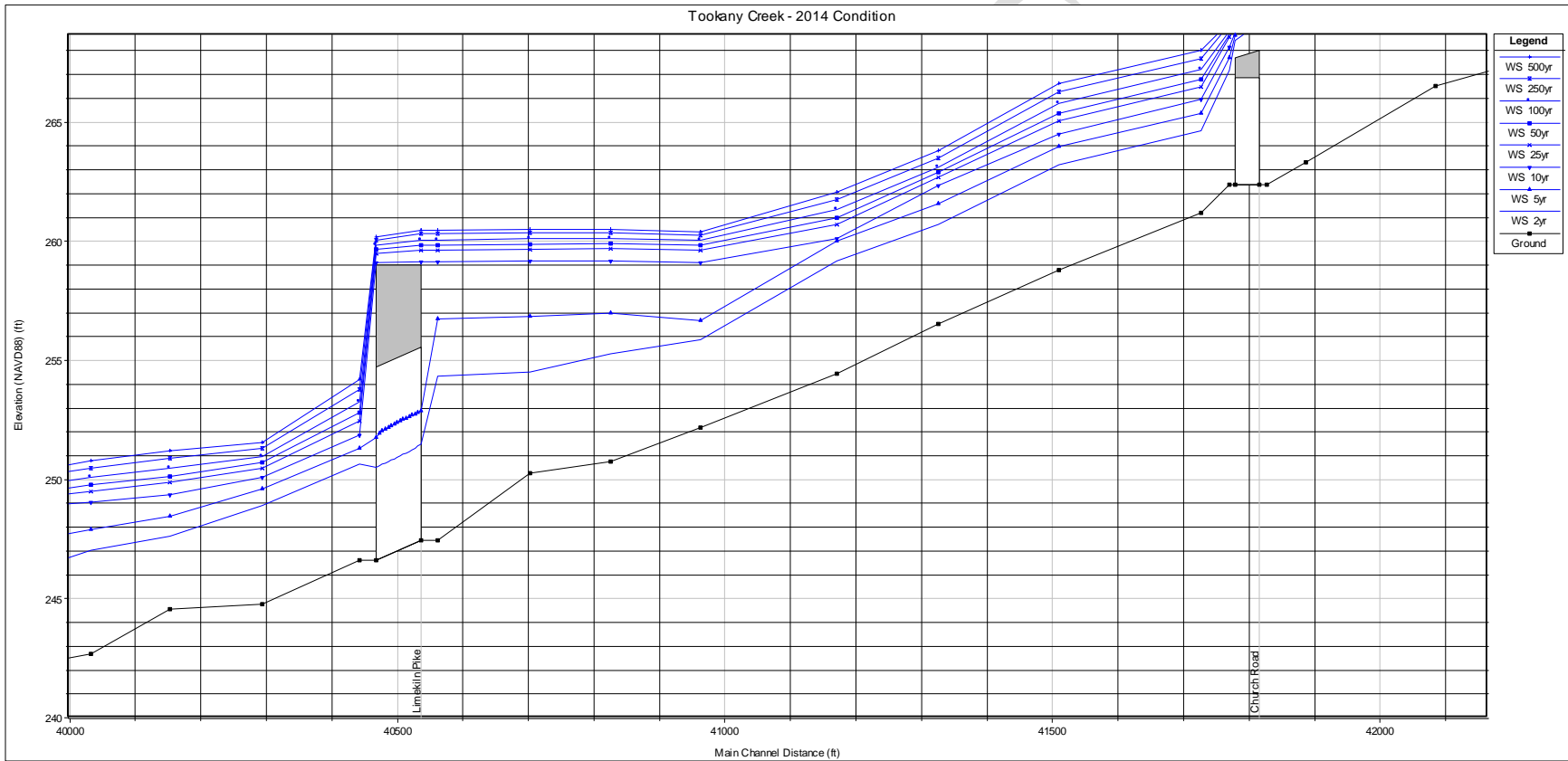


Figure 4.7-Part 21, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

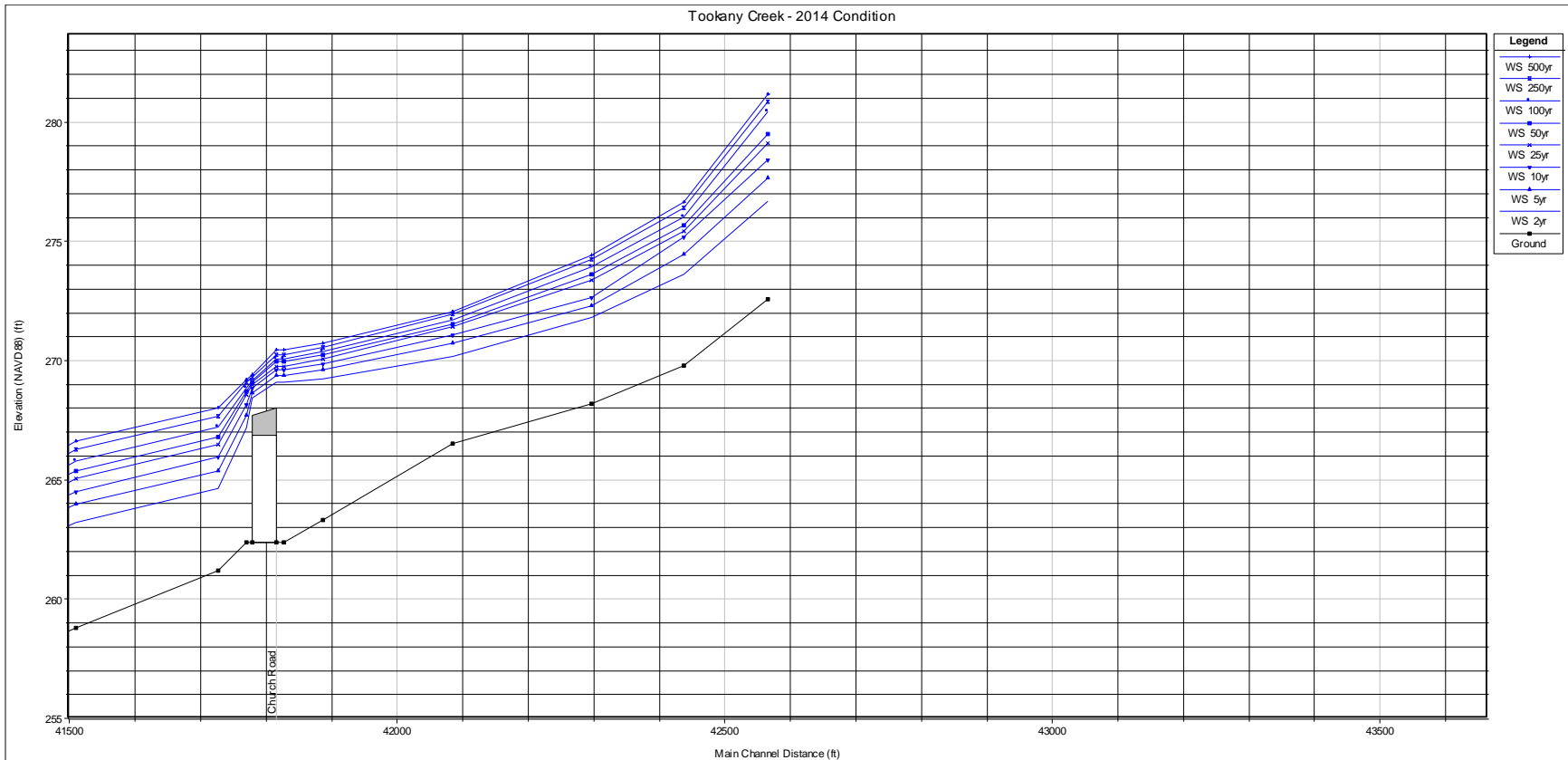


Figure 4.7-Part 22, Tookany Creek – Without Project Frequency Water Surface Elevation Profiles

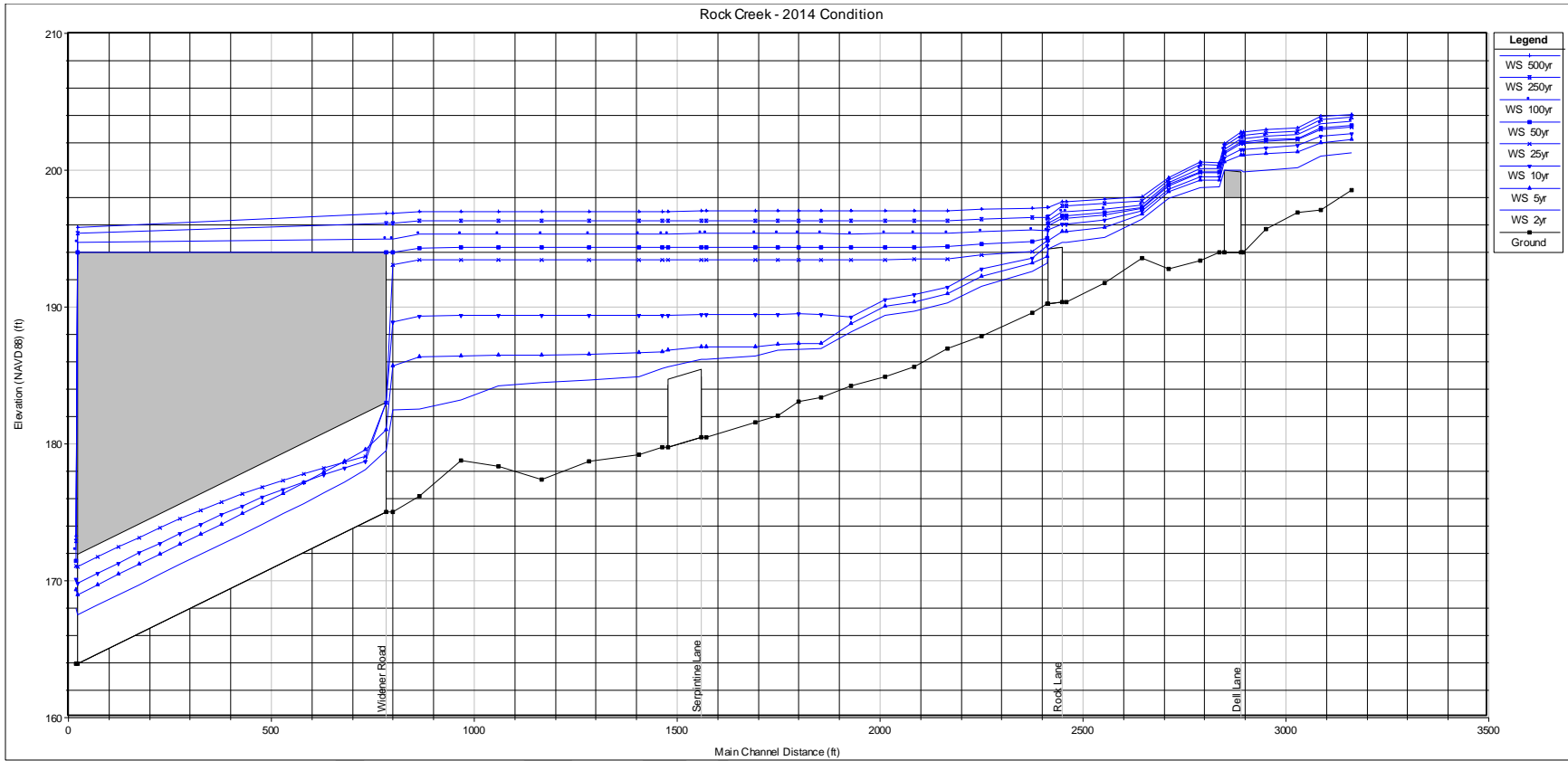


Figure 4.8, Rock Creek – Without Project Frequency Water Surface Elevation Profiles

The without project condition frequency water surface elevations at the economic index locations are provided in Table 4.11. (See the Economic Appendix for details.)

Table 4.11								
Without Project Condition Frequency Water Surface Elevations at Economic Index Stations								
Economic Index Station	WSEL (ft-NAVD88)							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany								
X-4731	75.86	77.09	77.81	78.63	79.24	79.85	80.69	81.38
X-8872	89.98	91.34	92.16	93.02	93.57	94.05	94.71	95.22
X-12076	104.29	105.52	106.39	107.32	107.98	108.65	109.45	110.03
X-15556	115.06	115.78	116.20	116.90	117.36	117.93	118.62	119.12
X-18967	128.93	130.54	131.31	132.10	132.44	132.98	133.69	134.19
X-21416	141.18	144.31	145.26	146.43	146.79	147.38	148.06	148.53
X-23275	149.66	151.22	152.46	154.31	154.52	154.91	155.39	155.75
X-26368	178.12	181.28	182.18	183.02	183.23	183.73	184.37	184.84
X-30700	197.51	199.14	199.87	200.83	201.09	201.70	202.48	202.93
X-34003	211.72	214.56	216.03	218.19	218.94	220.32	220.94	221.30
X-36541	220.65	221.75	222.29	223.14	223.40	225.09	225.64	226.17
X-39344	243.68	244.69	245.26	245.97	246.44	246.97	247.53	247.97
Rock Creek								
X-1572	186.19	187.07	189.47	193.47	194.37	195.39	196.31	197.04

4.4 Without Project Hydraulic Uncertainty

The water surface elevations above are output calculated using the “best” estimates of hydraulic input parameters. However, to determine a reasonable range of water surface elevation outputs the without project hydraulic model was modified to reflect reasonable but “low” and “high” estimates of input parameters. Table 4.12 summarizes the changes to the models to calculate a reasonable range of frequency water surface elevations.

	“Low”	“High”
Manning’s n Value	n*0.85	n*1.15
Bridge Expansion and Contraction Coefficients	0.2 and 0.4	0.4 and 0.6
Bridge Debris	None	Floating debris for bridges w/ pier

All Manning n values for “best” condition were multiplied by 0.85 and 1.15 for “low” and “high” conditions respectively. The aim was to adjust the n values while still maintaining values reasonable for the ground cover.

Tookany Creek has three bridges with a pier while Rock Creek has no bridges with a pier. The floating pier debris was assumed 8ft wide and 4ft high.

For Tookany Creek the starting water surface elevations (SWSELs) were kept the same as the “best” SWSELs since the SWSELs are from a USGS stream gage rating curve. For Rock Creek the SWSELs were changed to reflect the Tookany WSELs at the mouth of Rock Creek for the same condition. For example, the frequency SWSELs for Rock Creek for “low” condition were the “low” Tookany frequency WSELs at the confluence of Rock Creek.

Frequency water surface elevations profiles were calculated for Tookany and Rock Creeks for both “low” and “high” conditions. The frequency water surface elevation results are summarized by calculating for each frequency, a standard deviation at the Economic Index Stations. The standard deviation is defined as: (“high” WSEL – “low” WSEL) /4. The Without project standard deviations are provided in Table 4.13.

Table 4.13								
Tookany and Rock Creeks - Without Project Frequency Standard Deviations at the Economic Index Stations								
Tookany Creek Without Project Standard Deviations								
Index Station	Events							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
4731	0.2675	0.2975	0.3125	0.3675	0.3975	0.43	0.4675	0.4775
8872	0.245	0.2525	0.2425	0.235	0.2225	0.24	0.2725	0.295
12076	0.225	0.255	0.265	0.25	0.2375	0.22	0.205	0.2
15557	0.125	0.1425	0.195	0.255	0.2175	0.1875	0.18	0.1925
18967	0.23	0.25	0.265	0.2775	0.2975	0.32	0.3525	0.37
21416	0.185	0.43	0.085	0.0425	0.06	0.0675	0.0675	0.0675
23275	0.18	0.385	0.435	0.15	0.1475	0.1525	0.16	0.1575
26368	0	0	0	0	0	0	0	0
30700	0.1975	0.2425	0.2475	0.255	0.2575	0.23	0.19	0.1375
34004	0.2125	0.1525	0.1475	0.1425	0.1425	0.05	0.0425	0.0375
36541	0.1875	0.2075	0.235	0.26	0.3	0.3825	0.1025	0.0825
39344	0.085	0.1	0.12	0.13	0.14	0.145	0.14	0.14
Rock Creek Without Project Standard Deviations								
Index Station	Events							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
1525	0.045	0.055	0.0375	0.3225	0.2075	0.1575	0.1525	0.2325

WITH PROJECT CONDITION

5.1 Overview

The with project analysis concentrated on hydrologic solutions on Tookany and Rock Creeks. Detailed description of the various storage area plans can be found in the Hydrologic Appendix. Figure 5.1 shows the locations of all of the storage areas that were analyzed and a summary of the plan combinations is provided in Table 5.1.

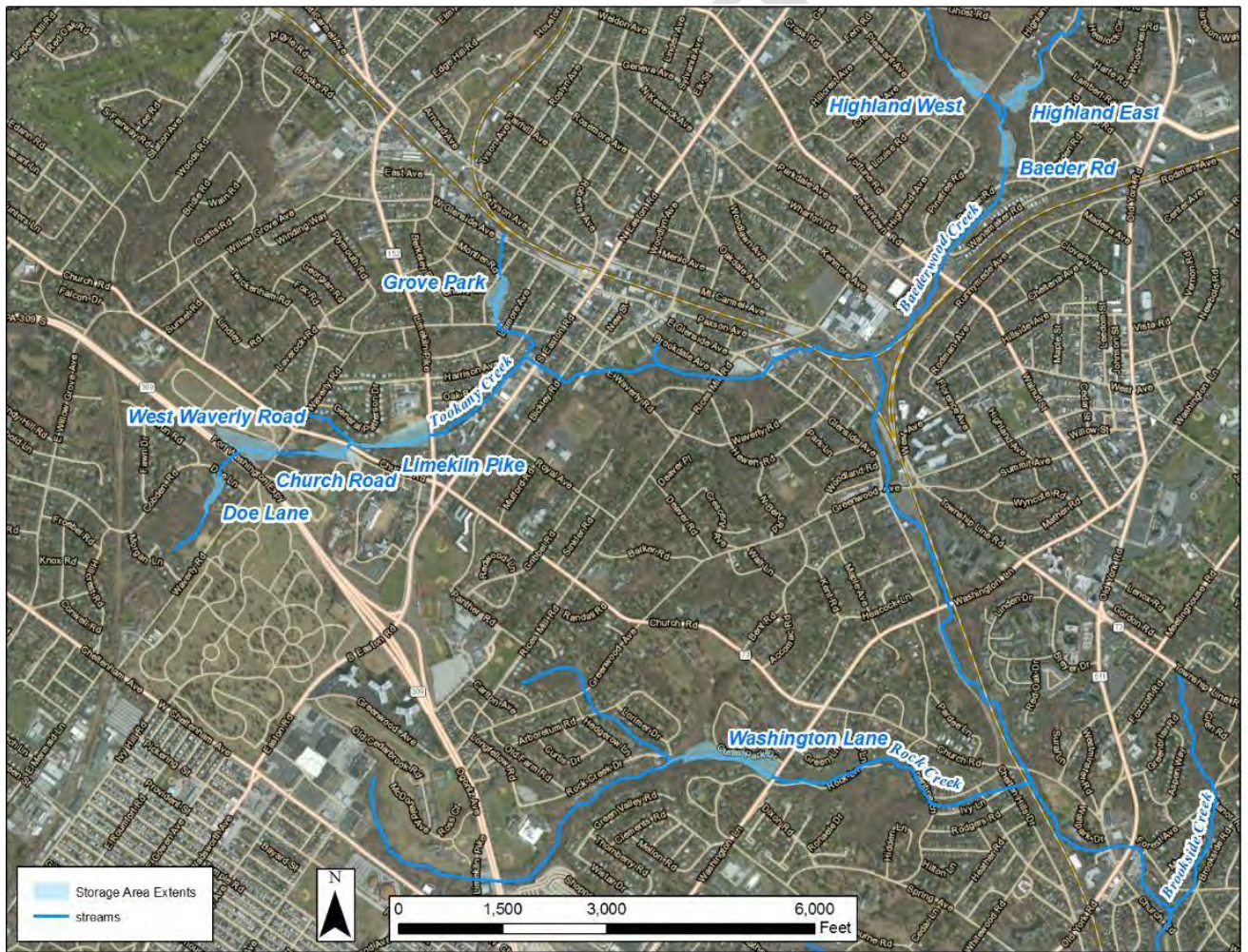


Figure 5.1, Locations of all Storage Areas Analyzed

Plan	Location of Proposed Storage Areas		
	Tookany Creek	Rock Creek	Baeder Run
D1	Doe Lane, West Waverly, Church Rd, Limekiln, Grove Park		
D28	Doe Lane, West Waverly, Grove Park		
D9			Highland West, Highland East, Baeder Rd
D12			Highland West
D15		Washington Lane	
D27	Doe Lane, West Waverly, Church Rd, Limekiln, Grove Park	Washington Lane	Highland West, Highland East, Baeder Rd
D30	Doe Lane, West Waverly, Grove Park	Washington Lane	Highland West

5.2 Starting Conditions

For Tookany Creek the starting condition for with project condition is the same as that used for without project condition, that is, the USGS gage rating curve with a Flood Insurance Study extension. However, the frequency starting water surface elevation (SWSEL) for Rock Creek (Tookany river station 26060) varies because each storage plan changes the Tookany frequency flows and hence the frequency water surface elevations at the mouth of Rock Creek. The frequency SWSELs for Rock Creek were calculated from the extrapolation of the frequency WSELs of Tookany cross-sections X-25806 and X-26003 to station 26060. The Rock Creek SWSELs for various storage plans are provided in Table 5.2.

Table 5.2							
With Plan SWSEL for Rock Creek Model (ft-NAVD88)							
Event	Storage Plan						
	D1	D28	D9	D12	D15	D27	D30
2 year	167.93	167.98	167.99	168.01	168.07	167.88	167.99
5 year	169.21	169.29	169.19	169.27	169.31	168.95	169.24
10 year	170.01	170.09	169.95	170.05	169.91	169.46	169.81
25 year	170.98	171.07	170.91	171.03	170.86	170.34	170.75
50 year	171.32	171.43	171.25	171.40	171.06	170.52	170.95
100 year	172.09	172.19	172.03	172.16	171.84	171.13	171.60
250 year	172.78	172.87	172.73	172.85	172.65	172.19	172.57
500 year	173.17	173.24	173.15	173.22	173.13	172.76	173.07

5.3 With Plan Results

For each storage plan, the calculated flows were input into the without project HEC-RAS models for Tookany and Rock Creeks to calculate with plan WSELs. Flows and WSELs (at the Economic Index Stations) for plans D1, D28, D9, D12, D15, D27 and D30 are tabulated in Tables 5.3 through 5.16, inclusive.

Plan D27 provides the largest net benefits and is recommended as the Tentatively Selected Plan. Frequency water surface profiles for Plan D27 are presented as Figures 5.2 and 5.3. Flow and WSEL reductions of Plan D27 relative to without project condition are provided for Tookany and Rock Creeks on Figures 5.4 and 5.5 respectively. Results for individual bridge segments are provided.

Table 5.3
Plan D1 Frequency Discharges at Flow Change Locations

Location Label	X-section	Discharge (cfs)							
		2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany									
T10	40262	282	415	464	578	679	773	902	1006
T9	39291	283	414	463	576	632	720	840	937
T8	38662	399	555	593	737	777	885	1033	1152
T7	36541	583	835	939	1168	1210	1377	1608	1794
T6B	33238	993	1477	1700	2115	2175	2476	2890	3224
T6A	31960	1010	1495	1734	2157	2220	2527	2950	3290
T6	30997	1217	1877	2257	2808	2980	3392	3960	4417
T5	26003	1554	2441	3007	3741	4010	4564	5328	5944
T4A	22969	1703	2690	3319	4129	4455	5071	5920	6603
T4	21757	1807	2765	3491	4343	4761	5419	6327	7057
T3	16258	2097	3046	3890	4839	5332	6069	7085	7903
T2	13656	2580	3682	4526	5630	6508	7408	8648	9646
T1A	9809	2594	3736	4514	5616	6497	7395	8633	9630
T1	4256	2603	3775	4538	5645	6551	7457	8706	9711
R18	3162	3162	562	861	1064	1324	1396	1590	1857
R19	2554	2554	545	821	1109	1379	1525	1736	2028
R20	1693	1693	545	841	1013	1260	1333	1518	1773

Note: Plan D1 consists of five storage areas basins on the Upper Tookany: Doe Lane, West Waverly, Church Rd, Limekiln, Grove Park.

**Table 5.4
Plan D1 Frequency Water Surface Elevations at Economic Index Stations**

Economic Index Station	WSEL (ft-NAVD88)							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany								
X-4731	75.88	77.11	77.77	78.59	79.22	79.83	80.66	81.34
X-8872	90.00	91.35	92.10	92.97	93.55	94.03	94.69	95.19
X-12076	104.30	105.53	106.34	107.26	107.95	108.63	109.42	109.99
X-15556	115.06	115.76	116.16	116.83	117.32	117.89	118.58	119.07
X-18967	128.89	130.46	131.24	132.03	132.37	132.91	133.61	134.11
X-21416	141.14	144.27	145.14	146.33	146.72	147.31	147.99	148.46
X-23275	149.59	151.12	152.33	154.24	154.46	154.85	155.32	155.67
X-26368	177.78	180.77	181.87	182.75	182.99	183.48	184.11	184.55
X-30700	197.33	198.87	199.60	200.51	200.80	201.38	202.13	202.67
X-34003	211.33	213.92	214.91	217.13	217.48	218.73	220.37	220.82
X-36541	220.31	221.19	221.53	222.27	222.43	222.92	223.85	225.11
X-39344	242.45	243.27	243.53	244.08	244.27	244.62	245.07	245.41
Rock Creek								
X-1572	186.19	187.07	189.47	193.47	194.37	195.33	196.32	196.99

Note: Plan D1 consists of five storage areas on the Upper Tookany: Doe Lane, West Waverly, Church Rd, Limekiln, Grove Park.

**Table 5.5
Plan D28 Frequency Discharges at Flow Change Locations**

Location Label	X-section	Discharge (cfs)							
		2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany									
T10	40262	389	665	813	1011	1109	1262	1473	1643
T9	39291	482	710	813	1012	1192	1357	1584	1766
T8	38662	485	702	760	945	1036	1179	1377	1535
T7	36541	646	981	1126	1401	1482	1687	1970	2197
T6B	33238	1039	1573	1842	2292	2428	2763	3226	3598
T6A	31960	1054	1595	1864	2319	2444	2782	3248	3621
T6	30997	1265	1964	2362	2939	3116	3547	4142	4619
T5	26003	1591	2500	3063	3810	4098	4664	5446	6073
T4A	22969	1736	2742	3372	4195	4526	5152	6016	6708
T4	21757	1821	2813	3542	4406	4814	5480	6398	7134
T3	16258	2102	3084	3945	4908	5373	6116	7141	7963
T2	13656	2584	3682	4579	5697	6539	7443	8691	9691
T1A	9809	2598	3736	4567	5681	6525	7427	8672	9669
T1	4256	2606	3775	4587	5706	6578	7488	8743	9749
R18	3162	3162	3162	562	861	1064	1324	1396	1590
R19	2554	2554	2554	545	821	1109	1379	1525	1736
R20	1693	1693	1693	545	841	1013	1260	1333	1518

Note: Plan D28 consists of three storage areas on the Upper Tookany: Doe Lane, West Waverly, Grove Park.

Table 5.6
Plan D28 Frequency Water Surface Elevations at Economic Index Stations

Economic Index Station	WSEL (ft-NAVD88)							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany								
X-4731	75.88	77.11	77.80	78.63	79.24	79.85	80.69	81.37
X-8872	90.00	91.35	92.15	93.01	93.56	94.05	94.71	95.21
X-12076	104.31	105.53	106.39	107.32	107.98	108.65	109.45	110.02
X-15556	115.06	115.78	116.19	116.89	117.35	117.92	118.61	119.10
X-18967	128.92	130.53	131.29	132.08	132.42	132.96	133.67	134.16
X-21416	141.17	144.30	145.23	146.40	146.77	147.36	148.04	148.51
X-23275	149.64	151.20	152.43	154.29	154.51	154.89	155.37	155.72
X-26368	178.00	181.15	182.08	182.92	183.15	183.67	184.28	184.74
X-30700	197.45	199.07	199.78	200.73	201.00	201.60	202.36	202.84
X-34003	211.57	214.34	215.65	217.78	218.48	220.13	220.81	221.19
X-36541	220.54	221.67	222.18	222.96	223.16	224.00	225.45	225.88
X-39344	243.73	244.70	245.05	245.75	246.40	246.89	247.50	247.91
Rock Creek								
X-1572	186.19	187.07	189.47	193.47	194.37	195.37	196.39	197.04

Note: Plan D28 consists of three storage areas on the Upper Tookany: Doe Lane, West Waverly, Grove Park.

Table 5.7
Plan D9 Frequency Discharges at Flow Change Locations

Location Label	X-section	Discharge (cfs)							
		2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany									
T10	40262	530	804	1059	1317	1476	1680	1963	2192
T9	39291	499	740	921	1146	1297	1476	1724	1925
T8	38662	512	718	804	1001	1082	1231	1438	1606
T7	36541	675	1004	1192	1483	1562	1778	2077	2319
T6B	33238	1066	1569	1799	2238	2335	2658	3108	3475
T6A	31960	1078	1588	1819	2262	2352	2678	3130	3501
T6	30997	1275	1928	2285	2843	2998	3412	3989	4461
T5	26003	1606	2437	2961	3683	3957	4504	5266	5889
T4A	22969	1718	2667	3263	4059	4383	4989	5832	6522
T4	21757	1809	2748	3427	4263	4675	5322	6221	6957
T3	16258	2080	3014	3823	4756	5242	5967	6976	7801
T2	13656	2558	3678	4399	5473	6423	7311	8547	9558
T1A	9809	2574	3732	4431	5512	6429	7318	8555	9567
T1	4256	2584	3771	4460	5549	6484	7381	8628	9649
R18	3162	3162	562	861	1064	1324	1396	1590	1857
R19	2554	2554	545	821	1109	1379	1525	1736	2028
R20	1693	1693	545	841	1013	1260	1333	1518	1773

Note: Plan D9 consists of three storage areas on Baeder Run: Highland West, Highland East, Baeder Rd.

Table 5.8
Plan D9 Frequency Water Surface Elevations at Economic Index Stations

Economic Index Station	WSEL (ft-NAVD88)							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany								
X-4731	75.85	77.11	77.71	78.52	79.18	79.78	80.61	81.30
X-8872	89.97	91.35	92.03	92.90	93.51	93.99	94.65	95.16
X-12076	104.27	105.53	106.22	107.14	107.89	108.56	109.36	109.95
X-15556	115.04	115.74	116.13	116.75	117.26	117.82	118.52	119.02
X-18967	128.90	130.43	131.17	131.96	132.30	132.86	133.52	134.05
X-21416	141.14	144.26	145.02	146.25	146.63	147.23	147.91	148.40
X-23275	149.64	151.08	152.22	154.05	154.41	154.78	155.27	155.63
X-26368	178.05	181.00	181.92	182.81	183.01	183.50	184.12	184.59
X-30700	197.48	198.99	199.65	200.56	200.83	201.41	202.17	202.71
X-34003	211.69	214.33	215.43	217.69	218.21	219.64	220.68	221.08
X-36541	220.65	221.75	222.26	223.13	223.34	224.15	225.64	226.16
X-39344	243.68	244.69	245.26	245.97	246.44	246.97	247.53	247.97
Rock Creek								
X-1572	186.19	187.07	189.47	193.47	194.37	195.35	196.38	196.99

Note: Plan D9 consists of three storage areas on Baeder Run: Highland West, Highland East, Baeder Rd.

Table 5.9
Plan D12 Frequency Discharges at Flow Change Locations

Location Label	X-section	Discharge (cfs)							
		2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany									
T10	40262	530	804	1059	1317	1476	1680	1963	2192
T9	39291	499	740	921	1146	1297	1476	1724	1925
T8	38662	512	718	804	1001	1082	1231	1438	1606
T7	36541	675	1004	1192	1483	1562	1778	2077	2319
T6B	33238	1078	1599	1871	2328	2465	2806	3275	3656
T6A	31960	1091	1619	1890	2351	2479	2821	3294	3677
T6	30997	1291	1965	2363	2940	3119	3551	4146	4627
T5	26003	1620	2484	3037	3778	4073	4636	5413	6041
T4A	22969	1739	2718	3340	4155	4494	5116	5973	6666
T4	21757	1823	2793	3507	4362	4777	5438	6349	7086
T3	16258	2095	3060	3907	4861	5333	6070	7087	7910
T2	13656	2576	3681	4534	5640	6496	7395	8633	9636
T1A	9809	2589	3735	4524	5628	6489	7386	8623	9625
T1	4256	2599	3774	4545	5654	6545	7450	8697	9708
R18	3162	3162	562	861	1064	1324	1396	1590	1857
R19	2554	2554	545	821	1109	1379	1525	1736	2028
R20	1693	1693	545	841	1013	1260	1333	1518	1773

Note: Plan D12 consists of one storage area on Baeder Run: Highland West.

Table 5.10
Plan D12 Frequency Water Surface Elevations at Economic Index Stations

Economic Index Station	WSEL (ft-NAVD88)							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany								
X-4731	75.87	77.11	77.77	78.59	79.22	79.83	80.66	81.34
X-8872	89.99	91.35	92.11	92.98	93.54	94.03	94.68	95.19
X-12076	104.30	105.53	106.35	107.27	107.95	108.62	109.42	109.99
X-15556	115.05	115.77	116.17	116.84	117.32	117.88	118.58	119.07
X-18967	128.92	130.50	131.26	132.05	132.39	132.93	133.63	134.13
X-21416	141.17	144.29	145.17	146.36	146.73	147.33	148.00	148.48
X-23275	149.66	151.17	152.37	154.26	154.49	154.86	155.35	155.70
X-26368	178.13	181.16	182.09	182.92	183.15	183.67	184.29	184.74
X-30700	197.52	199.07	199.79	200.73	201.01	201.61	202.37	202.85
X-34003	211.71	214.46	215.81	217.97	218.68	220.23	220.87	221.23
X-36541	220.65	221.75	222.26	223.13	223.37	225.09	225.64	226.17
X-39344	243.68	244.69	245.26	245.97	246.44	246.97	247.53	247.97
Rock Creek								
X-1572	186.19	187.07	189.47	193.47	194.37	195.36	196.34	197.04

Note: Plan D12 consists of one storage area on Baeder Run: Highland West.

**Table 5.11
Plan D15 Frequency Discharges at Flow Change Locations**

Location Label	X-section	Discharge (cfs)							
		2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany									
T10	40262	530	804	1059	1317	1476	1680	1963	2192
T9	39291	499	740	921	1146	1297	1476	1724	1925
T8	38662	512	718	804	1001	1082	1231	1438	1606
T7	36541	675	1004	1192	1483	1562	1778	2077	2319
T6B	33238	1079	1622	1910	2376	2514	2861	3343	3732
T6A	31960	1092	1641	1928	2399	2522	2871	3354	3745
T6	30997	1289	1995	2413	3001	3179	3619	4227	4720
T5	26003	1662	2513	2934	3650	3800	4325	5165	5865
T4A	22969	1792	2724	3195	3975	4177	4755	5678	6448
T4	21757	1830	2756	3313	4121	4410	5020	5995	6807
T3	16258	2057	2967	3641	4529	4923	5604	6692	7599
T2	13656	2489	3632	4168	5184	5947	6770	8084	9180
T1A	9809	2511	3685	4202	5227	6004	6834	8160	9267
T1	4256	2528	3725	4231	5263	6064	6903	8243	9360
R18	3162	395	533	545	679	713	732	876	995
R19	2554	421	573	595	741	787	821	956	1086
R20	1693	410	567	587	730	774	805	989	1123

Note: Plan D15 consists of one storage area on Rock Creek: Washington Lane.

**Table 5.12
Plan D15 Frequency Water Surface Elevations at Economic Index Stations**

Economic Index Station	WSEL (ft-NAVD88)							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany								
X-4731	75.78	77.06	77.52	78.31	78.89	79.47	80.35	81.11
X-8872	89.88	91.30	91.82	92.68	93.24	93.74	94.45	95.01
X-12076	104.18	105.48	106.01	106.91	107.52	108.16	109.08	109.73
X-15556	115.03	115.72	116.04	116.56	116.96	117.53	118.30	118.87
X-18967	128.93	130.45	131.06	131.84	132.09	132.59	133.35	133.95
X-21416	141.19	144.27	144.71	146.08	146.40	146.97	147.75	148.30
X-23275	149.73	151.18	152.08	153.82	154.28	154.66	155.19	155.60
X-26368	178.12	181.28	182.18	183.02	183.23	183.73	184.37	184.84
X-30700	197.51	199.14	199.87	200.83	201.09	201.70	202.48	202.93
X-34003	211.72	214.56	216.03	218.19	218.94	220.32	220.94	221.30
X-36541	220.65	221.75	222.29	223.14	223.40	225.09	225.64	226.17
X-39344	243.68	244.69	245.26	245.97	246.44	246.97	247.53	247.97
Rock Creek								
X-1572	185.58	186.27	186.33	186.76	186.88	186.92	187.48	189.00

Note: Plan D15 consists of one storage area on Rock Creek: Washington Lane.

**Table 5.13
Plan D27 Frequency Discharges at Flow Change Locations**

Location Label	X-section	Discharge (cfs)							
		2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany									
T10	40262	282	415	464	578	679	773	902	1006
T9	39291	283	414	463	576	632	720	840	937
T8	38662	399	555	593	737	777	885	1033	1152
T7	36541	583	835	939	1168	1210	1377	1608	1794
T6B	33238	951	1337	1503	1866	1901	2164	2626	2994
T6A	31960	964	1355	1529	1902	1941	2209	2681	3057
T6	30997	1160	1707	1974	2456	2591	2949	3579	4080
T5	26003	1521	2277	2613	3251	3387	3856	4660	5299
T4A	22969	1652	2496	2927	3641	3802	4328	5231	5949
T4	21757	1734	2558	3030	3769	4073	4636	5603	6371
T3	16258	1979	2816	3386	4213	4611	5248	6343	7213
T2	13656	2468	3625	4026	5009	5722	6513	7872	8952
T1A	9809	2462	3678	4084	5081	5799	6601	7978	9072
T1	4256	2479	3718	4127	5135	5869	6680	8074	9181
R18	3162	3162	395	533	545	679	713	732	876
R19	2554	2554	421	573	595	741	787	821	956
R20	1693	1693	410	567	587	730	774	805	989

Note: Plan D27 consists of:

- Five storage areas on the Upper Tookany: Doe Lane, West Waverly, Church Rd, Limekiln, Grove Park.
- Three storage areas on Baeder Run: Highland West, Highland East, Baeder Rd.
- One storage area on Rock Creek: Washington Lane.

**Table 5.14
Plan D27 Frequency Water Surface Elevations at Economic Index Stations**

Economic Index Station	WSEL (ft-NAVD88)							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany								
X-4731	75.71	77.05	77.44	78.22	78.75	79.32	80.23	80.99
X-8872	89.82	91.29	91.71	92.57	93.11	93.61	94.35	94.91
X-12076	104.15	105.47	105.87	106.76	107.34	107.96	108.94	109.60
X-15556	114.96	115.65	115.92	116.35	116.72	117.28	118.11	118.69
X-18967	128.76	130.14	130.83	131.52	131.80	132.27	133.05	133.64
X-21416	140.98	142.59	144.46	145.60	146.02	146.64	147.46	148.01
X-23275	149.53	150.71	151.51	152.96	154.06	154.38	154.94	155.34
X-26368	177.50	180.03	181.19	182.24	182.44	182.95	183.70	184.23
X-30700	197.18	198.51	199.09	199.94	200.17	200.74	201.65	202.28
X-34003	211.25	212.77	214.05	215.78	215.98	217.41	219.55	220.54
X-36541	220.31	221.19	221.52	222.19	222.35	222.89	223.62	225.12
X-39344	242.45	243.27	243.53	244.08	244.27	244.62	245.07	245.41
Rock Creek								
X-1572	185.58	186.27	186.33	186.76	186.88	186.92	187.48	188.70

Note: Plan D27 consists of:

- Five storage areas on the Upper Tookany: Doe Lane, West Waverly, Church Rd, Limekiln, Grove Park.
- Three storage areas on Baeder Run: Highland West, Highland East, Baeder Rd.
- One storage area on Rock Creek: Washington Lane.

**Table 5.15
Plan D30 Frequency Discharges at Flow Change Locations**

Location Label	X-section	Discharge (cfs)							
		2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany									
T10	40262	389	665	813	1011	1109	1262	1473	1643
T9	39291	482	710	813	1012	1192	1357	1584	1766
T8	38662	485	702	760	945	1036	1179	1377	1535
T7	36541	646	981	1126	1401	1482	1687	1970	2197
T6B	33238	1037	1574	1842	2292	2428	2764	3311	3762
T6A	31960	1053	1595	1864	2319	2444	2782	3332	3786
T6	30997	1255	1927	2302	2864	3044	3464	4150	4715
T5	26003	1606	2460	2863	3562	3716	4230	5068	5757
T4A	22969	1738	2671	3122	3884	4100	4667	5591	6351
T4	21757	1807	2711	3236	4025	4340	4940	5918	6723
T3	16258	2035	2929	3565	4435	4856	5528	6622	7523
T2	13656	2469	3629	4095	5094	5893	6707	8035	9128
T1A	9809	2492	3682	4138	5148	5951	6774	8115	9219
T1	4256	2508	3722	4171	5189	6016	6847	8203	9319
R18	3162	3162	3162	395	533	545	679	713	732
R19	2554	2554	2554	421	573	595	741	787	821
R20	1693	1693	1693	410	567	587	730	774	805

Note: Plan D30 consists of:

- Three storage areas on the Upper Tookany: Doe Lane, West Waverly, Grove Park.
- One storage area on Baeder Run: Highland West.
- One storage area on Rock Creek: Washington Lane.

**Table 5.16
Plan D30 Frequency Water Surface Elevations at Economic Index Stations**

Economic Index Station	WSEL (ft-NAVD88)							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
Tookany								
X-4731	75.75	77.06	77.48	78.26	78.86	79.43	80.32	81.08
X-8872	89.86	91.29	91.76	92.62	93.21	93.71	94.43	94.99
X-12076	104.16	105.48	105.94	106.83	107.47	108.11	109.04	109.71
X-15556	115.01	115.70	116.00	116.50	116.91	117.48	118.26	118.83
X-18967	128.89	130.38	130.96	131.76	132.02	132.52	133.29	133.90
X-21416	141.14	144.24	144.64	145.97	146.33	146.90	147.70	148.25
X-23275	149.65	151.09	151.95	153.28	153.65	154.59	155.14	155.55
X-26368	177.96	180.99	181.95	182.83	183.06	183.56	184.29	184.83
X-30700	197.43	198.99	199.68	200.60	200.90	201.48	202.37	202.93
X-34003	211.56	214.35	215.65	217.78	218.48	220.14	220.90	221.32
X-36541	220.54	221.67	222.18	222.96	223.16	224.00	225.44	225.88
X-39344	243.73	244.70	245.05	245.75	246.40	246.89	247.50	247.91
Rock Creek								
X-1572	185.58	186.27	186.33	186.76	186.88	186.92	187.48	188.97

Note: Plan D30 consists of:

- Three storage areas on the Upper Tookany: Doe Lane, West Waverly, Grove Park.
- One storage area on Baeder Run: Highland West.
- One storage area on Rock Creek: Washington Lane.

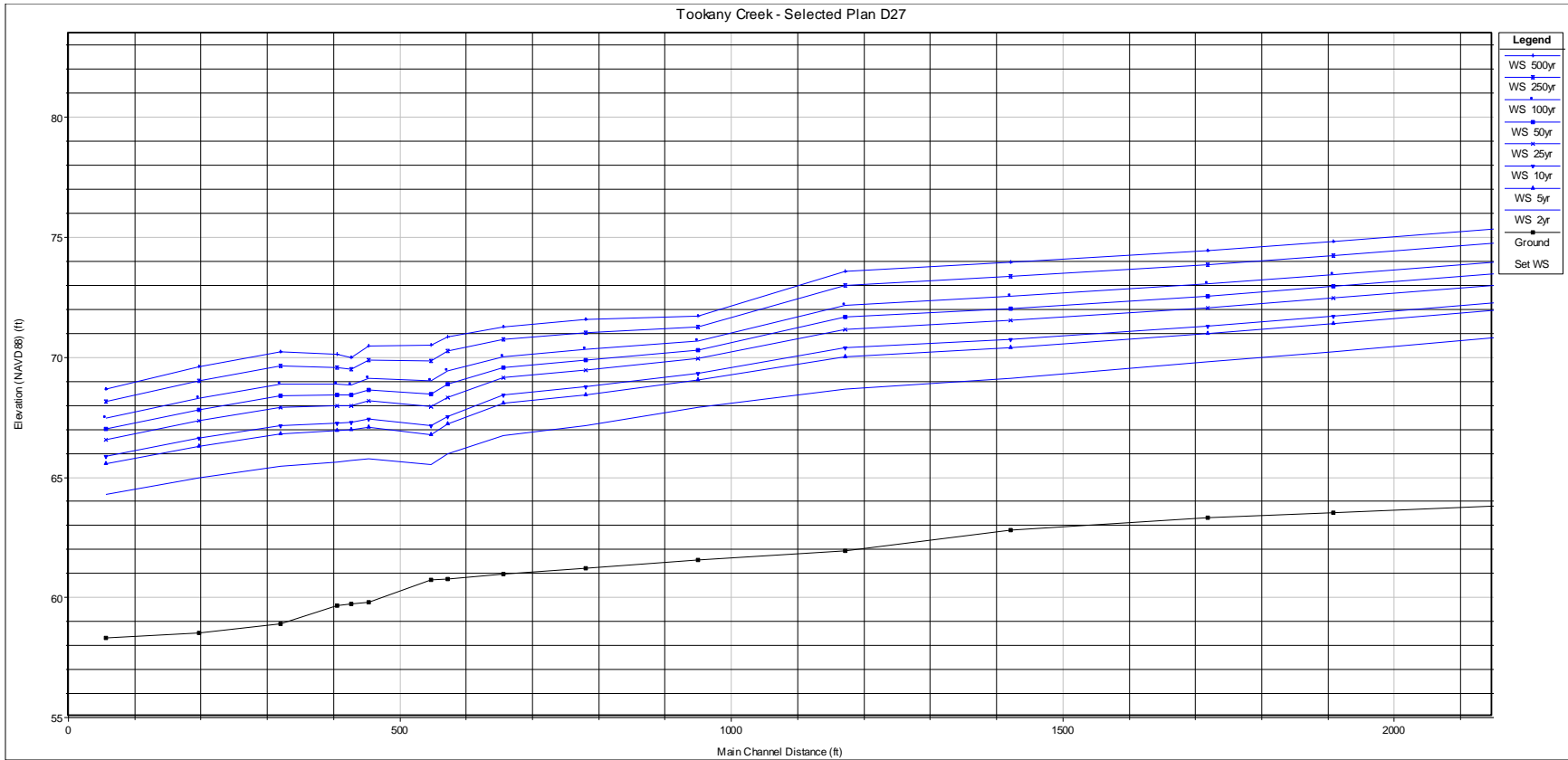


Figure 5.2-Part 1, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

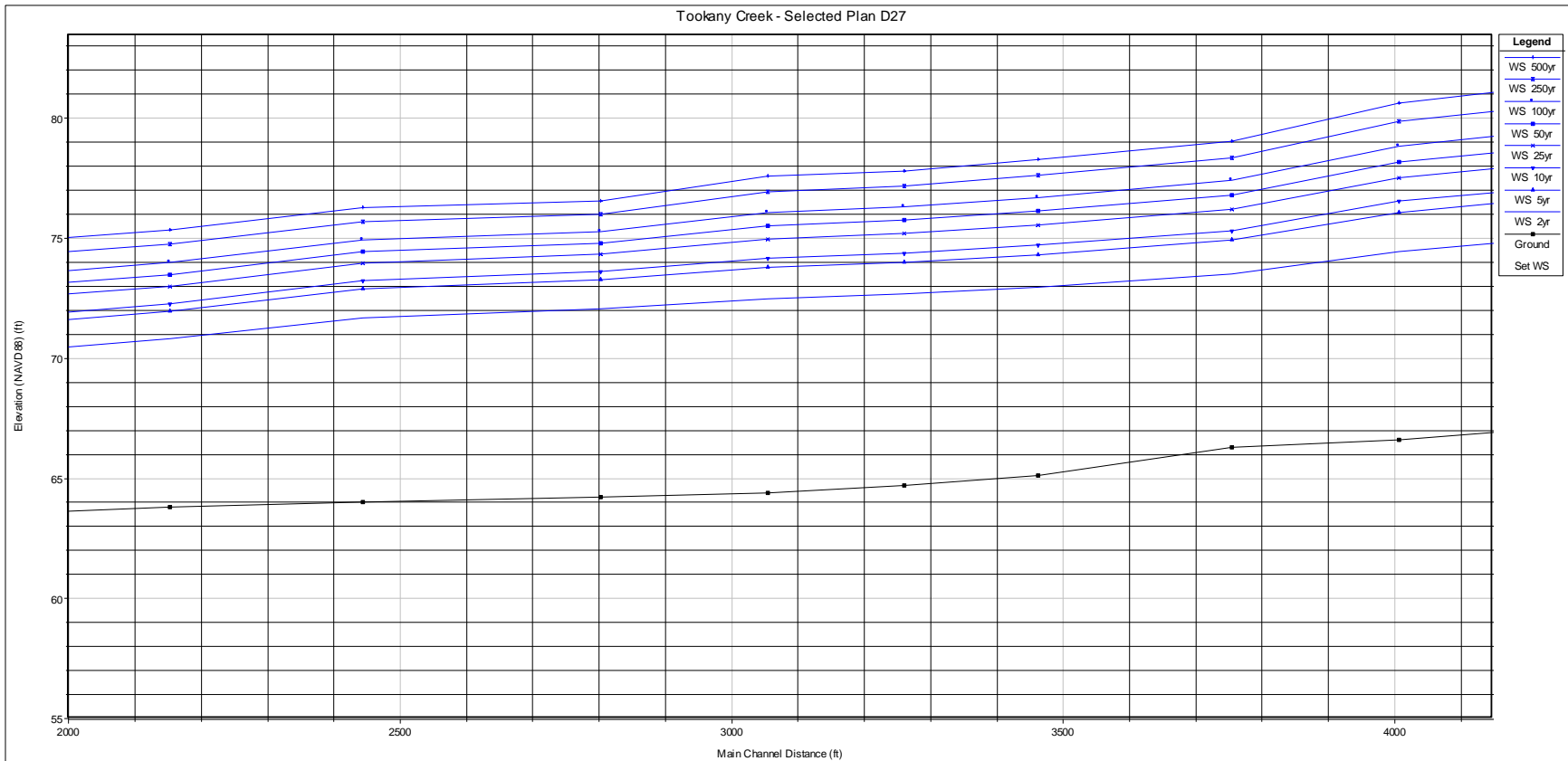


Figure 5.2-Part 2, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

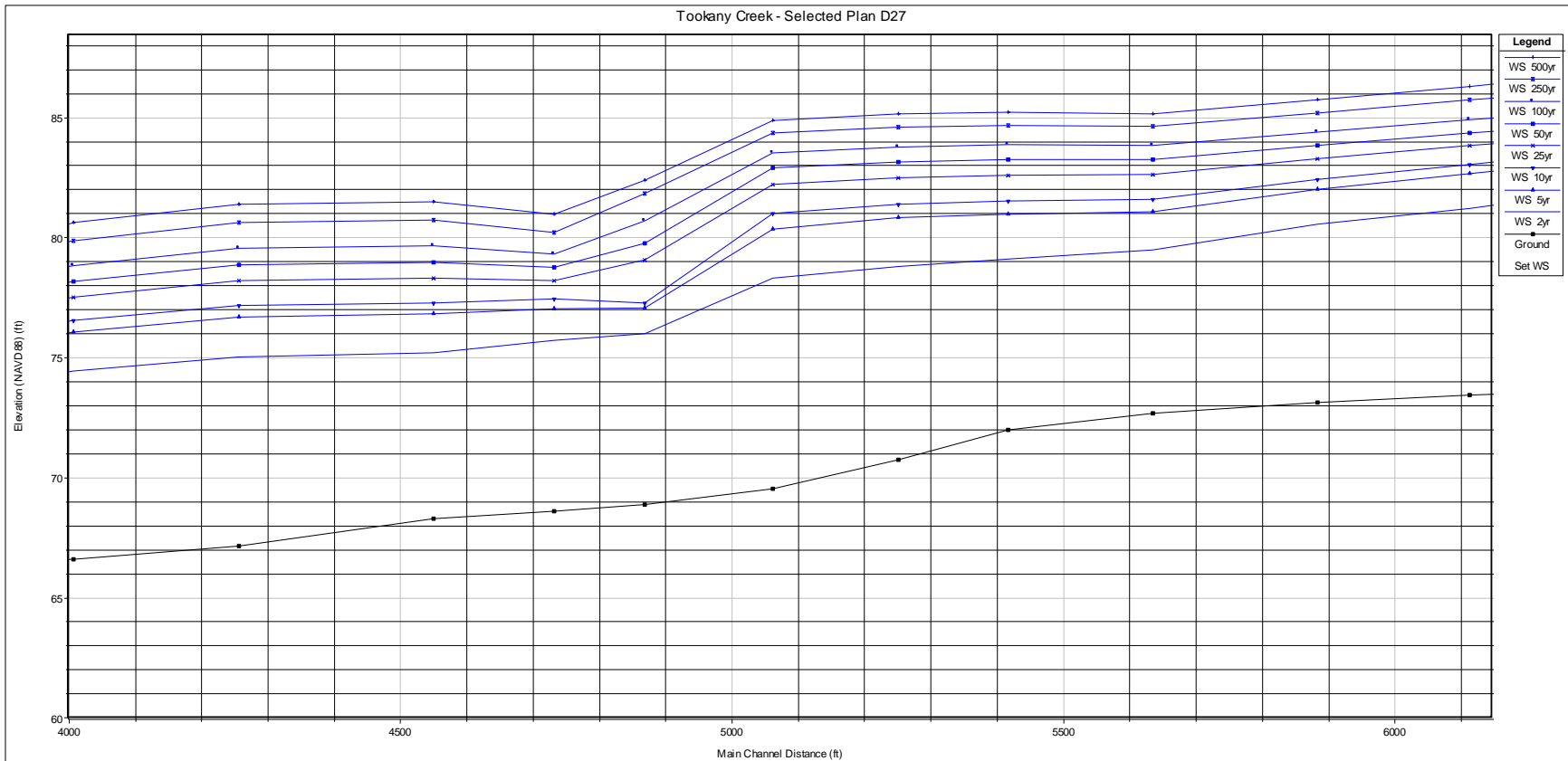


Figure 5.2-Part 3, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

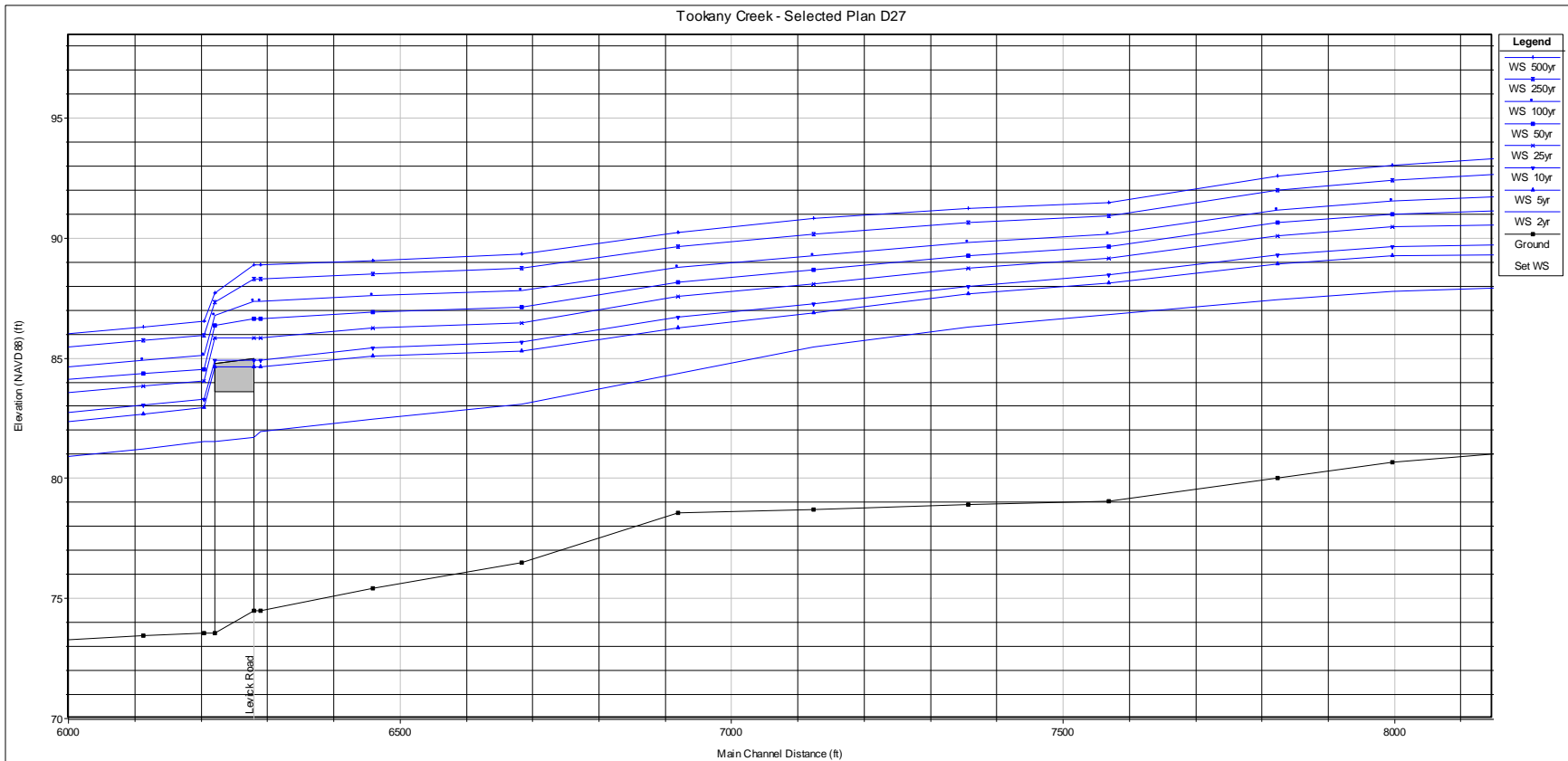


Figure 5.2-Part 4, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

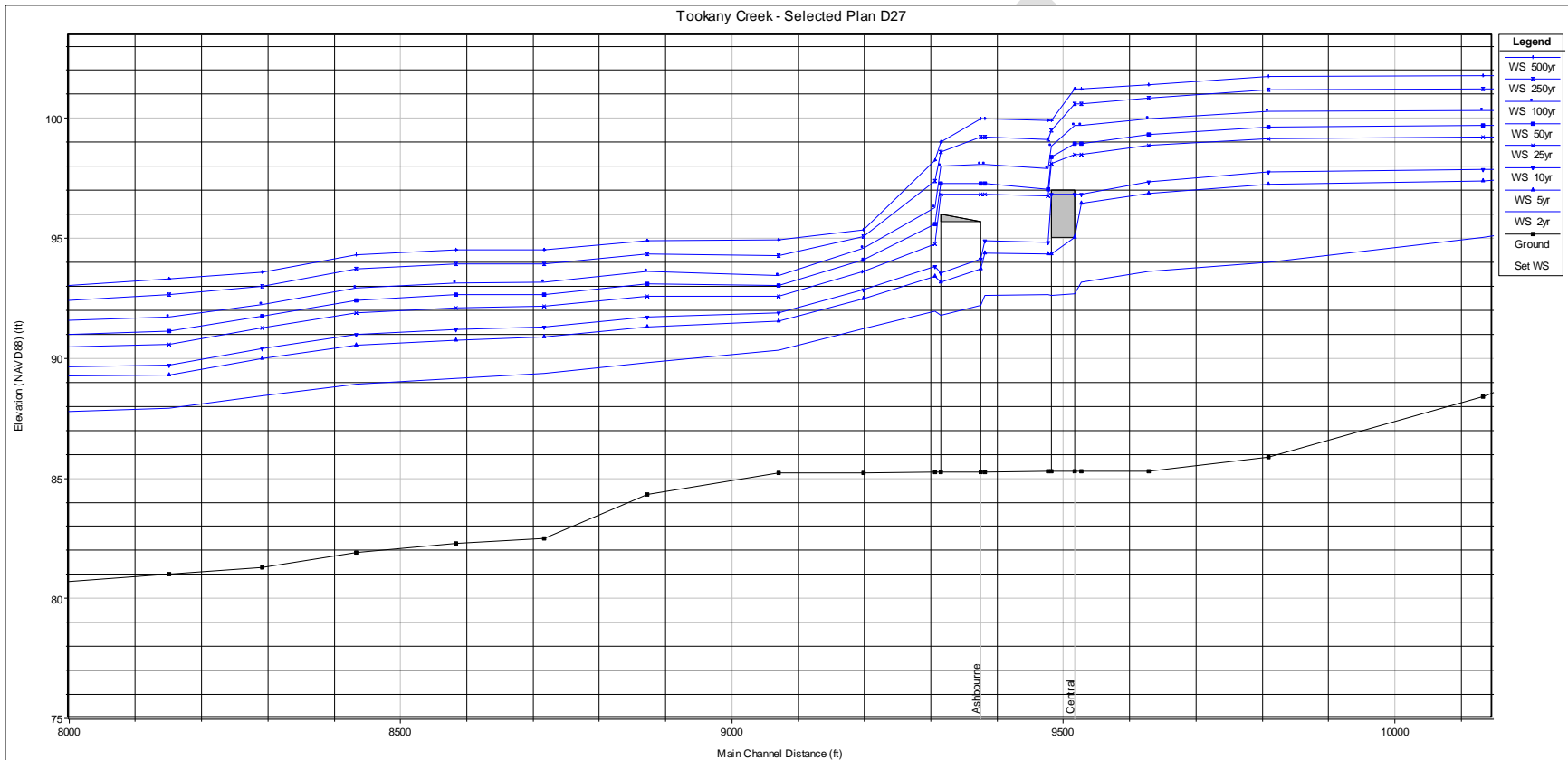


Figure 5.2-Part 5, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

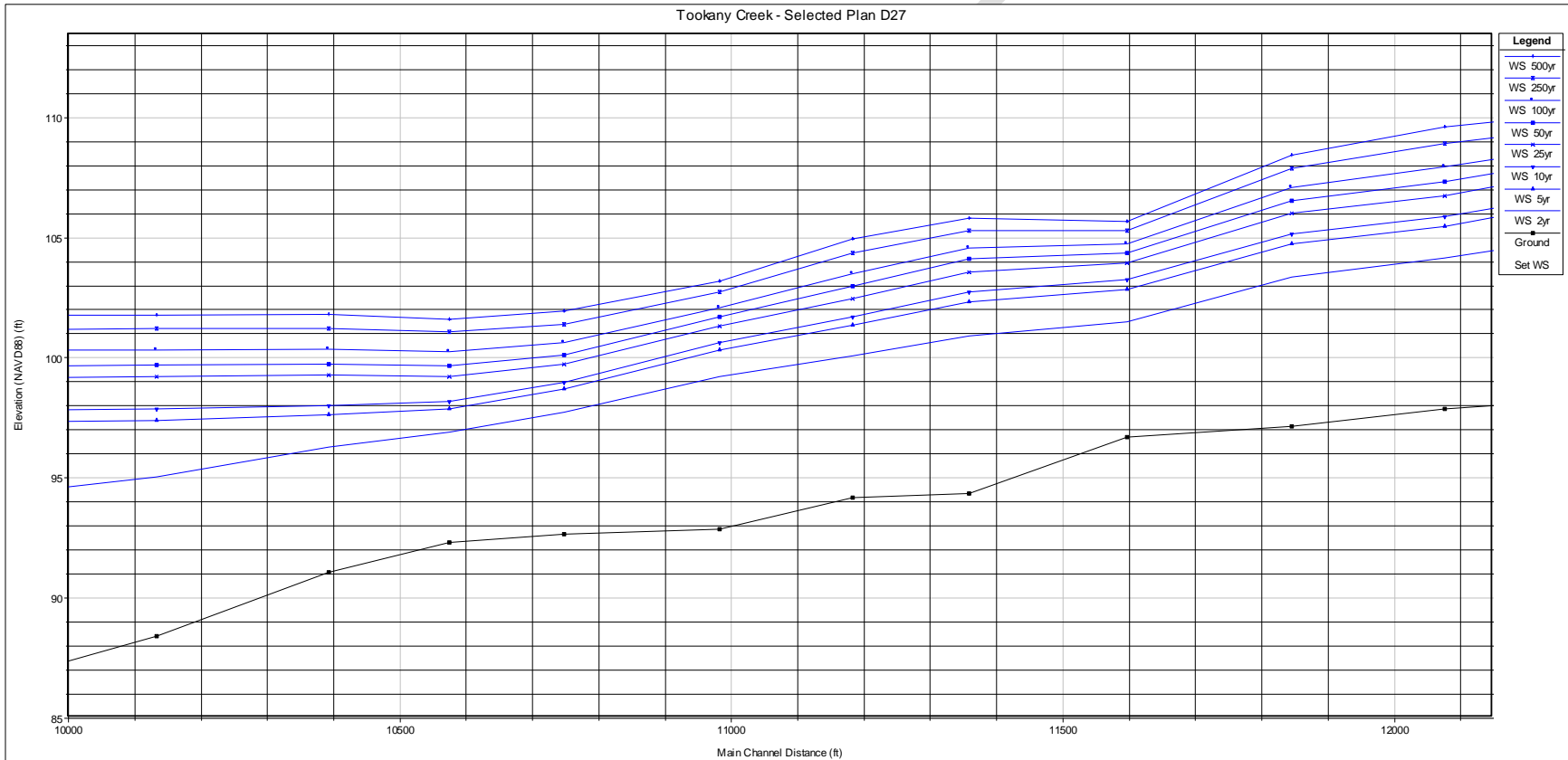


Figure 5.2-Part 6, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

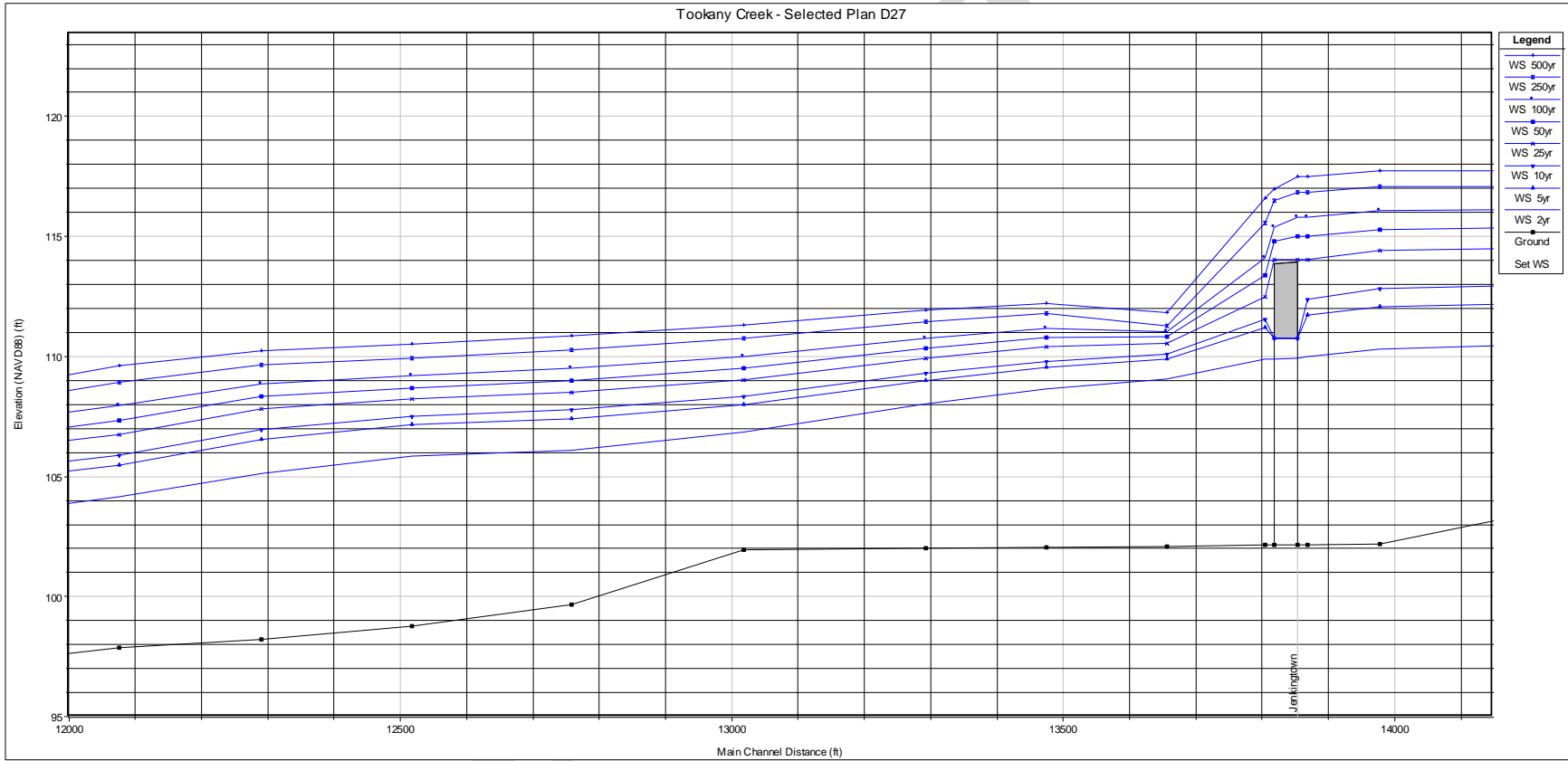


Figure 5.2-Part 7, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

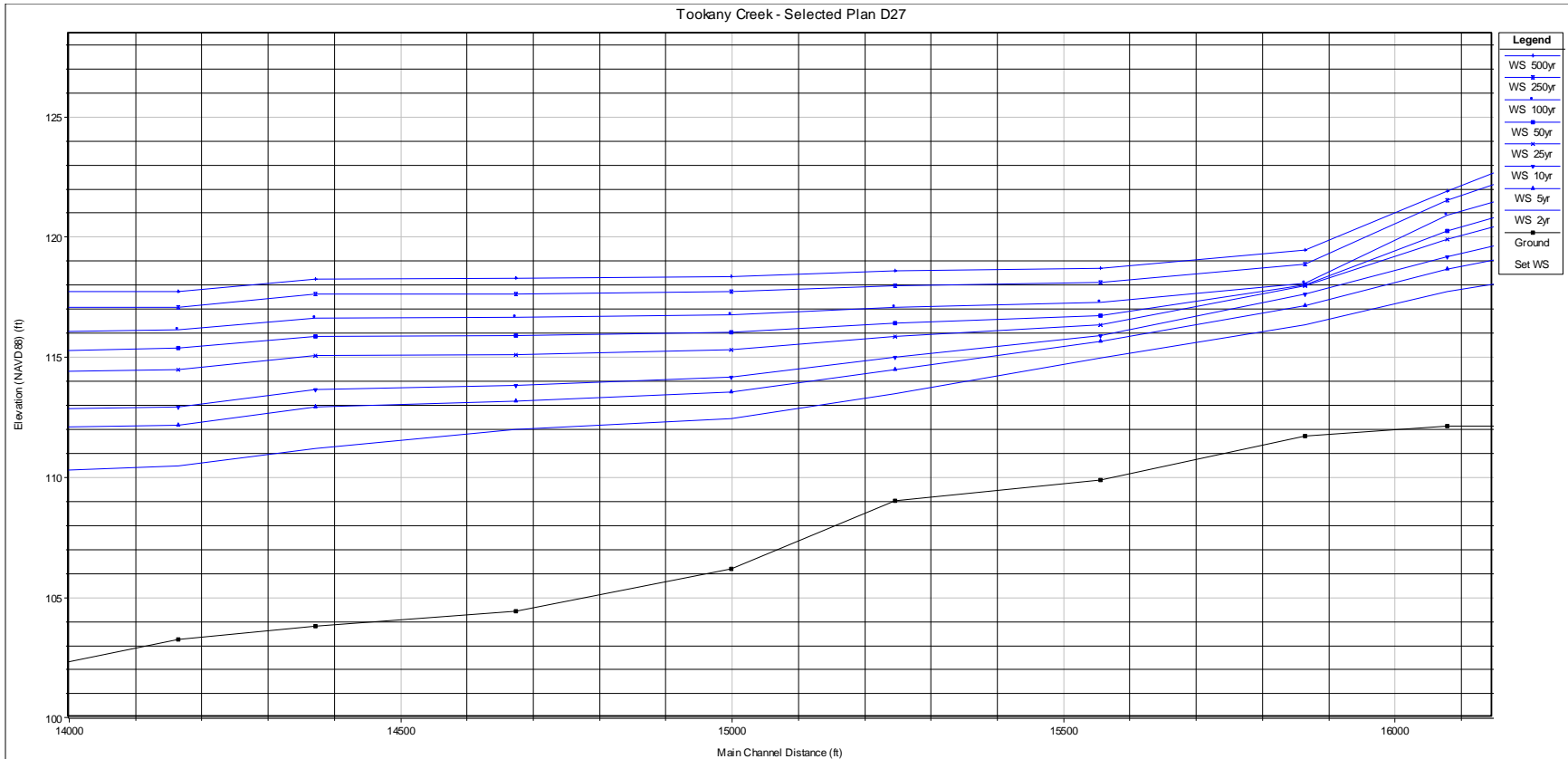


Figure 5.2-Part 8, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

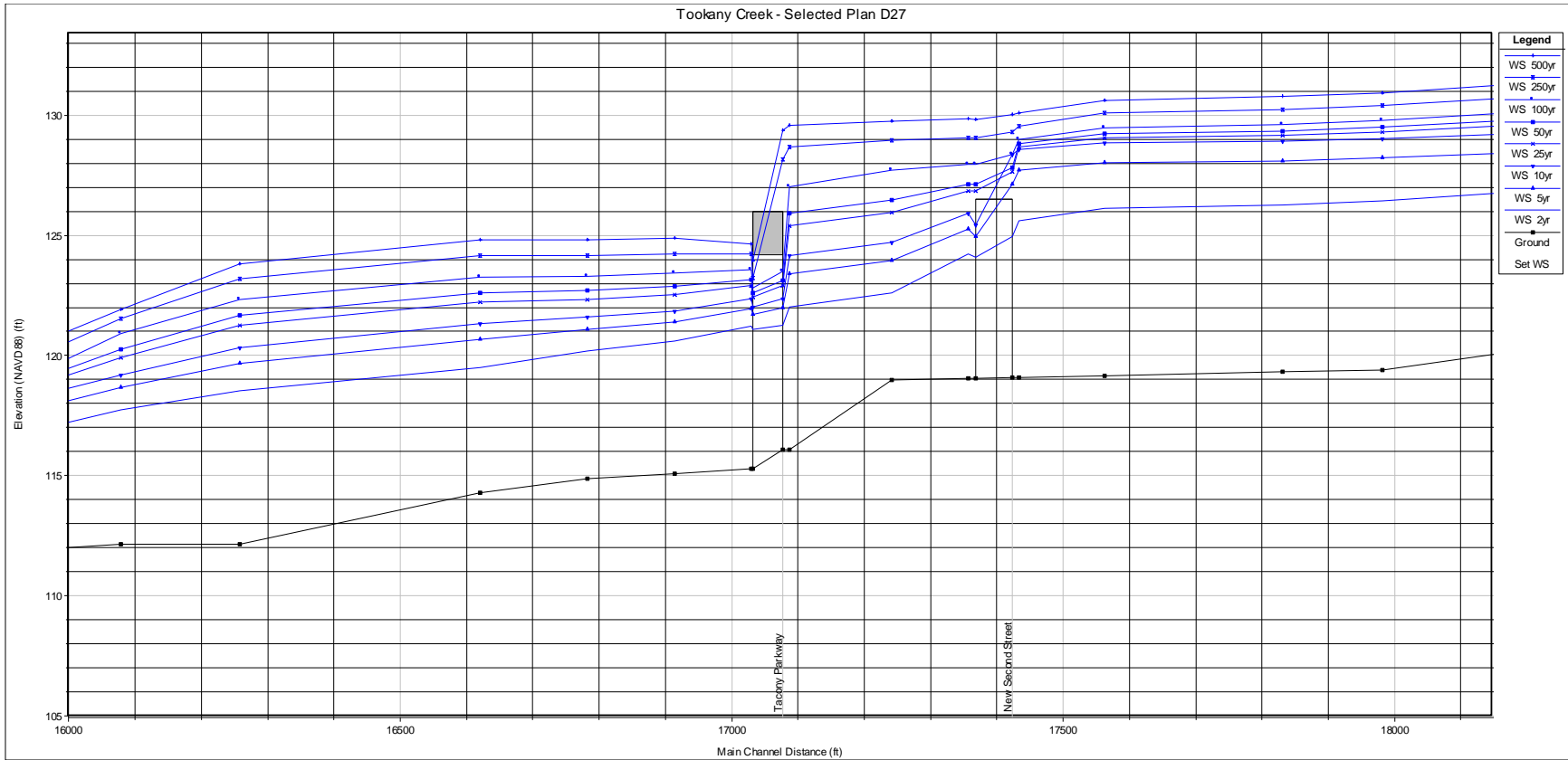


Figure 5.2-Part 9, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

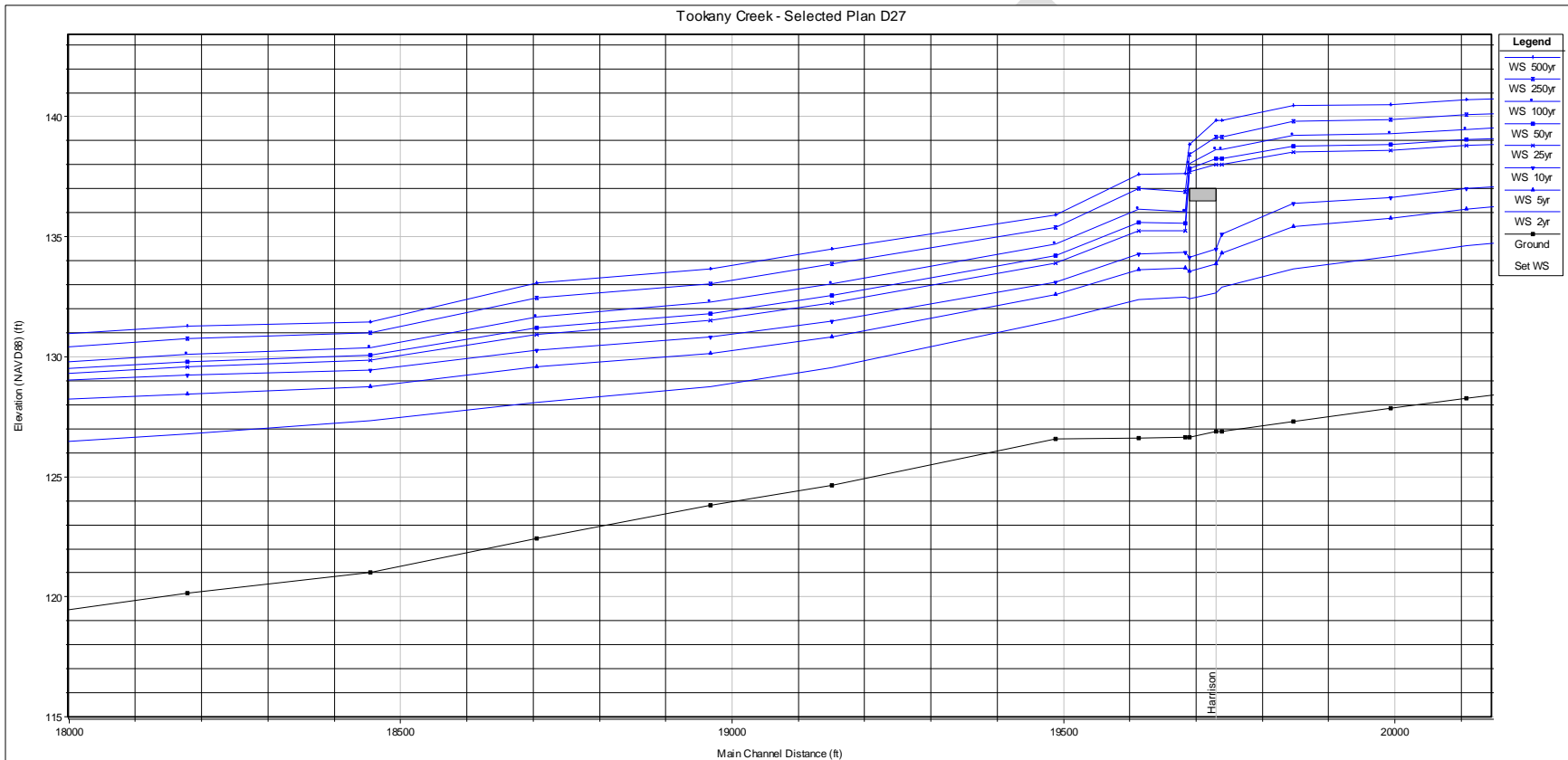


Figure 5.2-Part 10, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

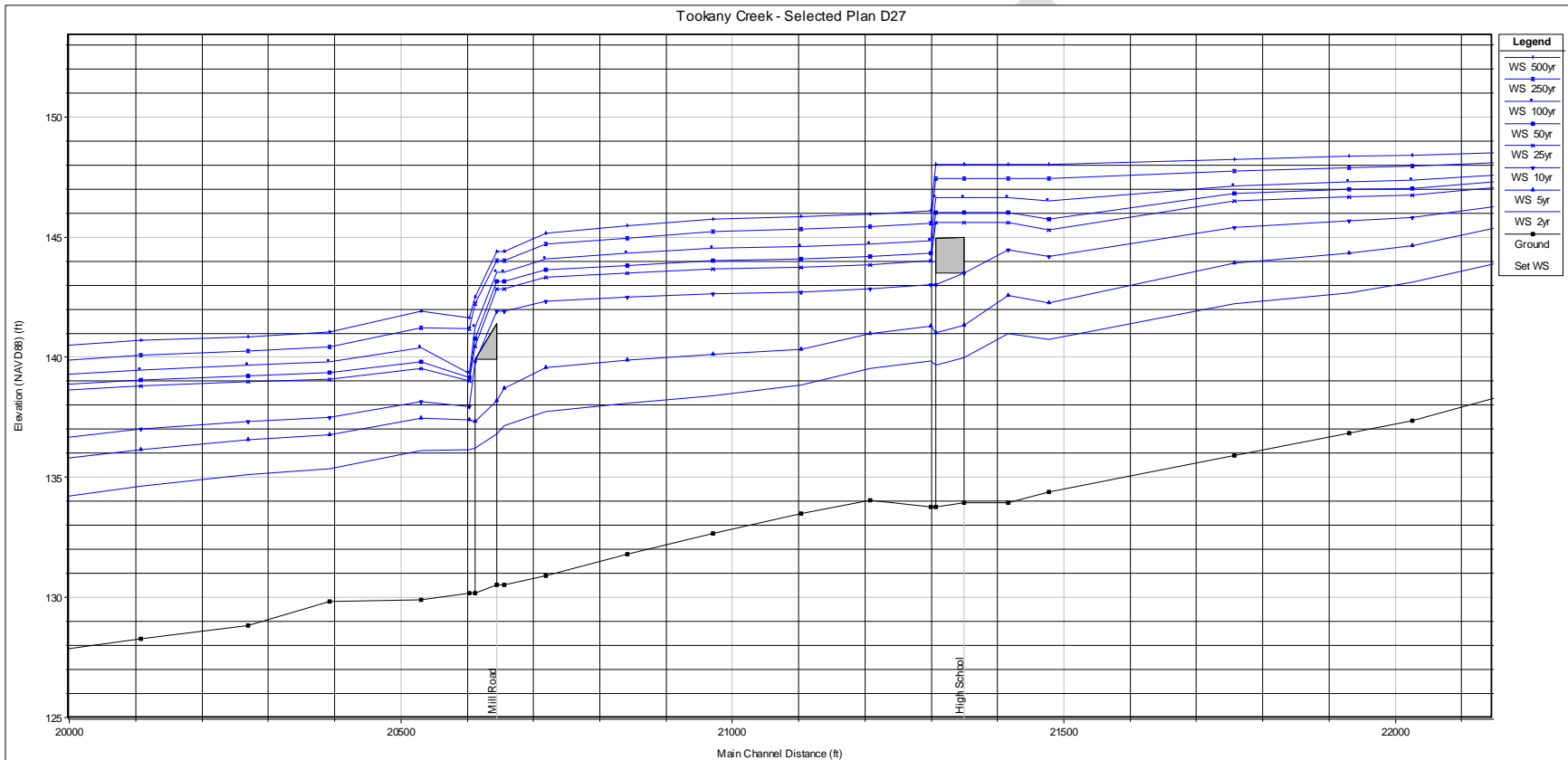


Figure 5.2-Part 11, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

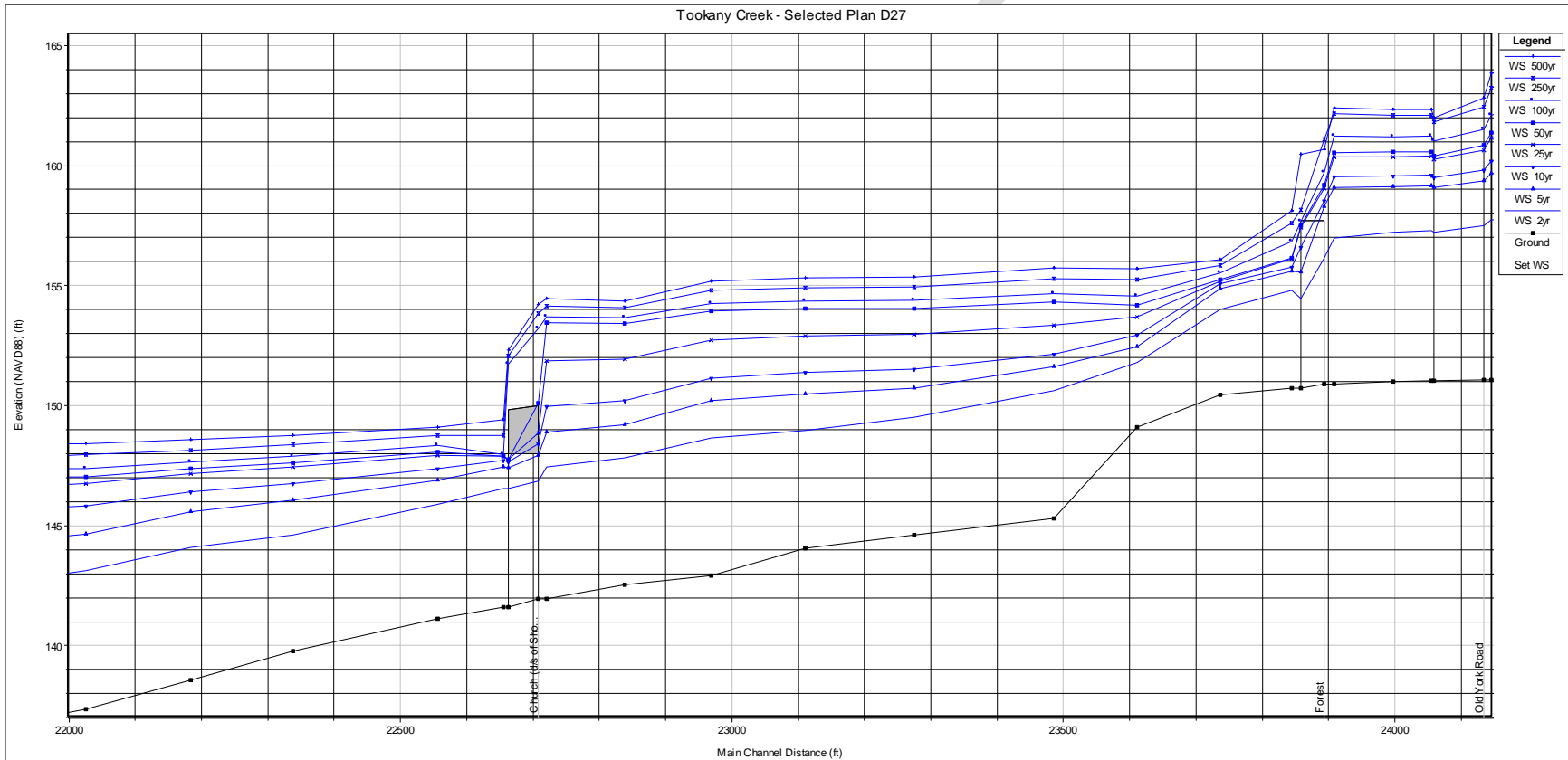


Figure 5.2-Part 12, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

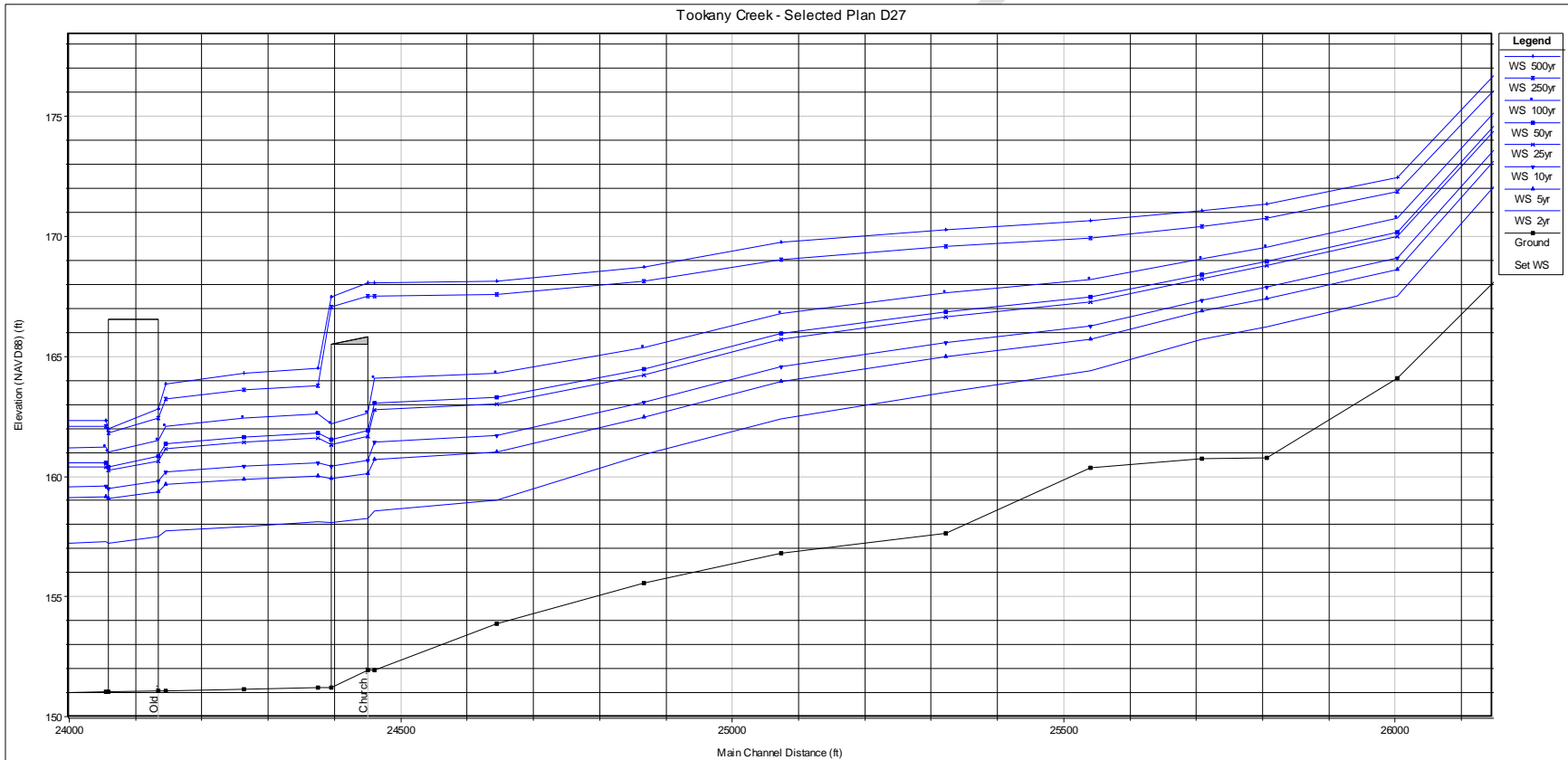


Figure 5.2-Part 13, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

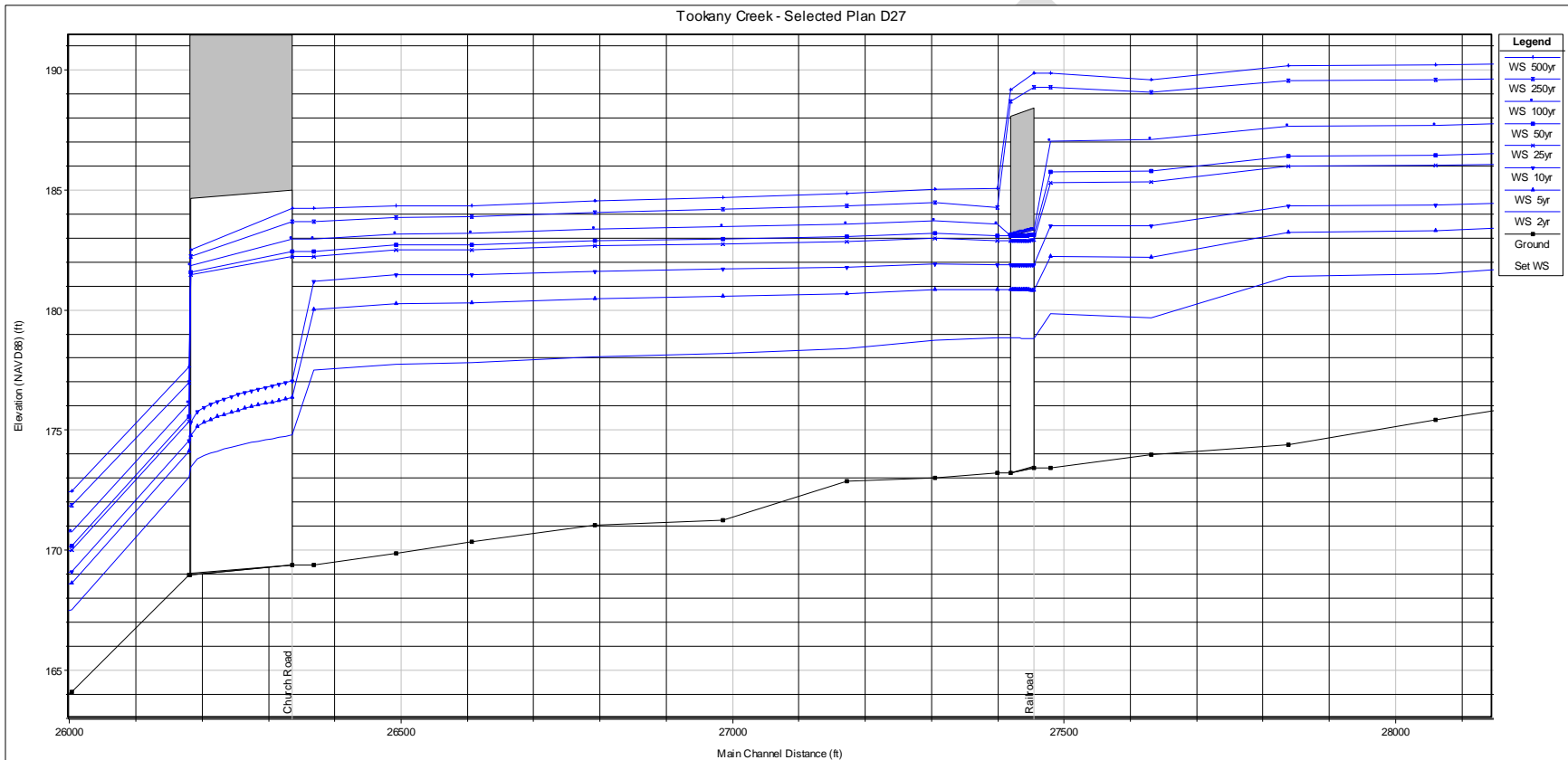


Figure 5.2-Part 14, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

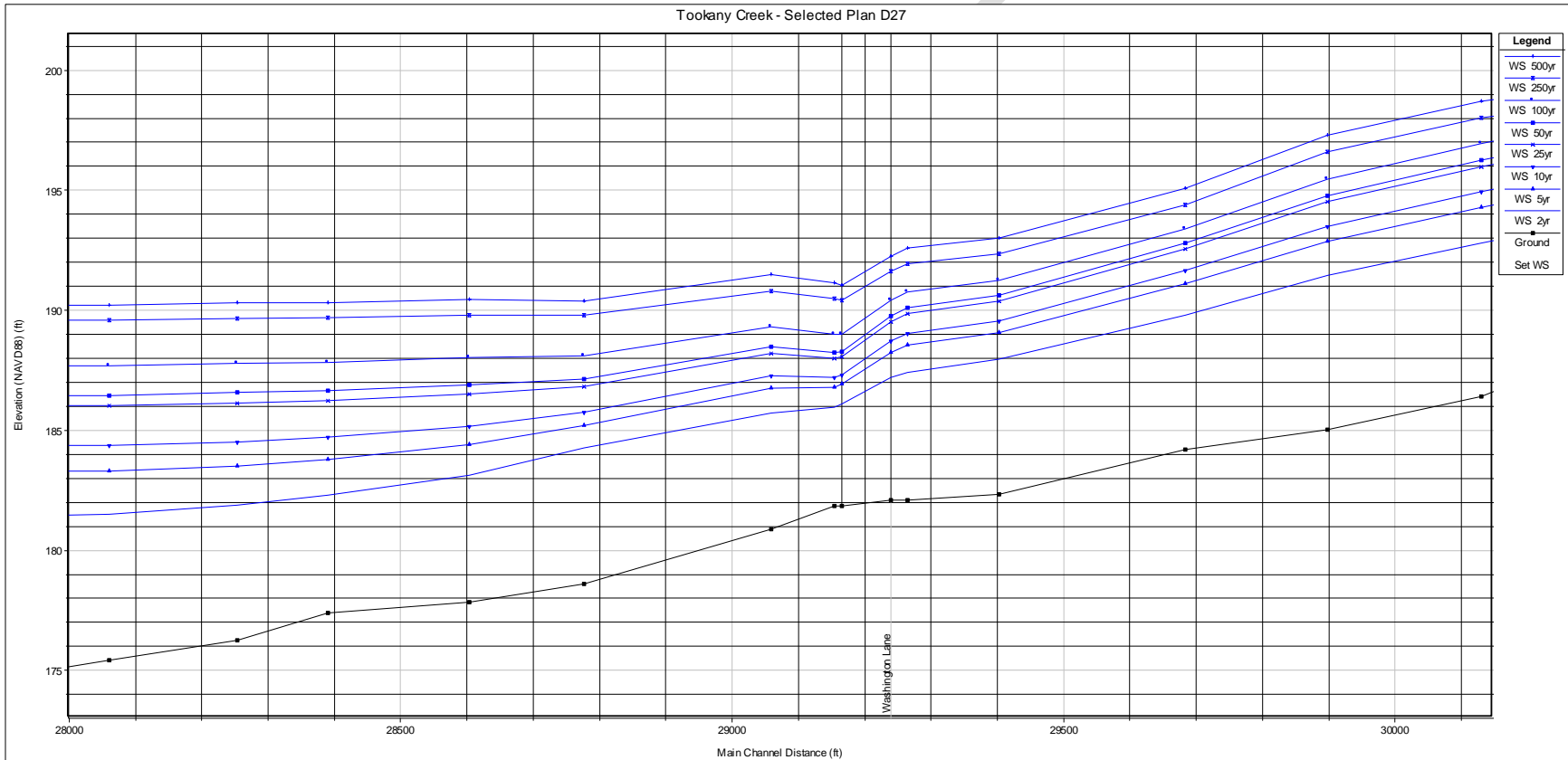


Figure 5.2-Part 15, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

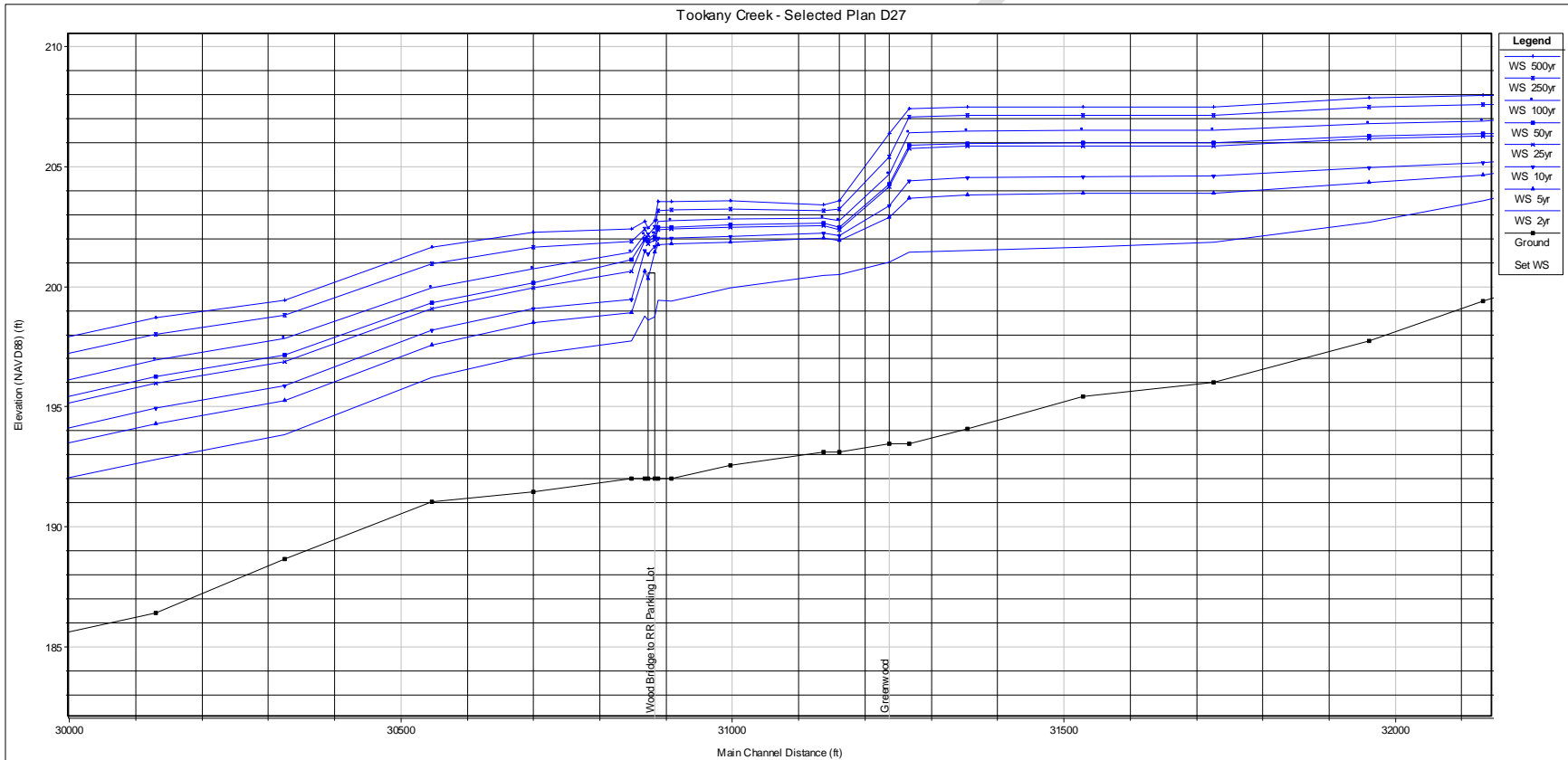


Figure 5.2-Part 16, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

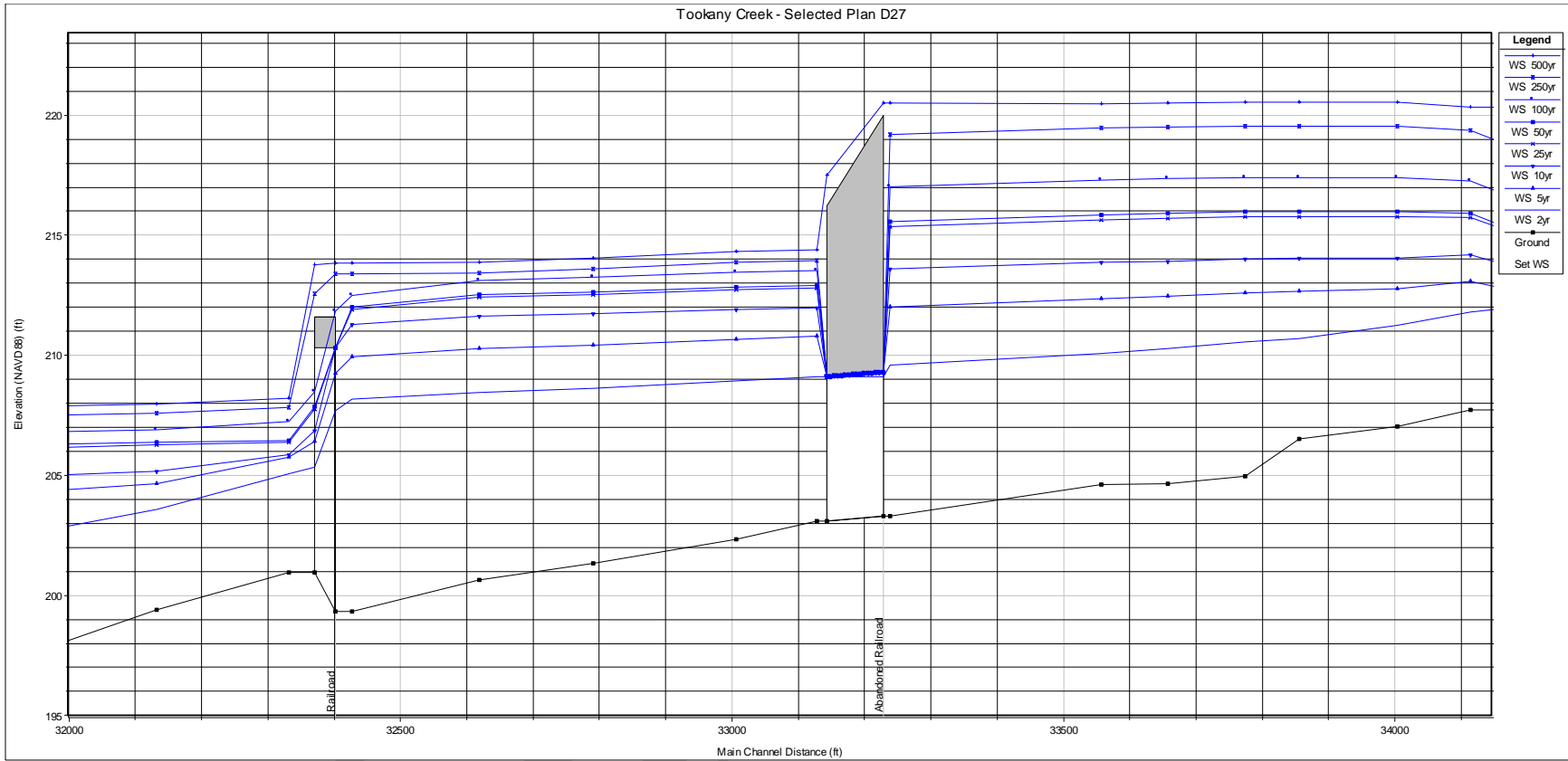


Figure 5.2-Part 17, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

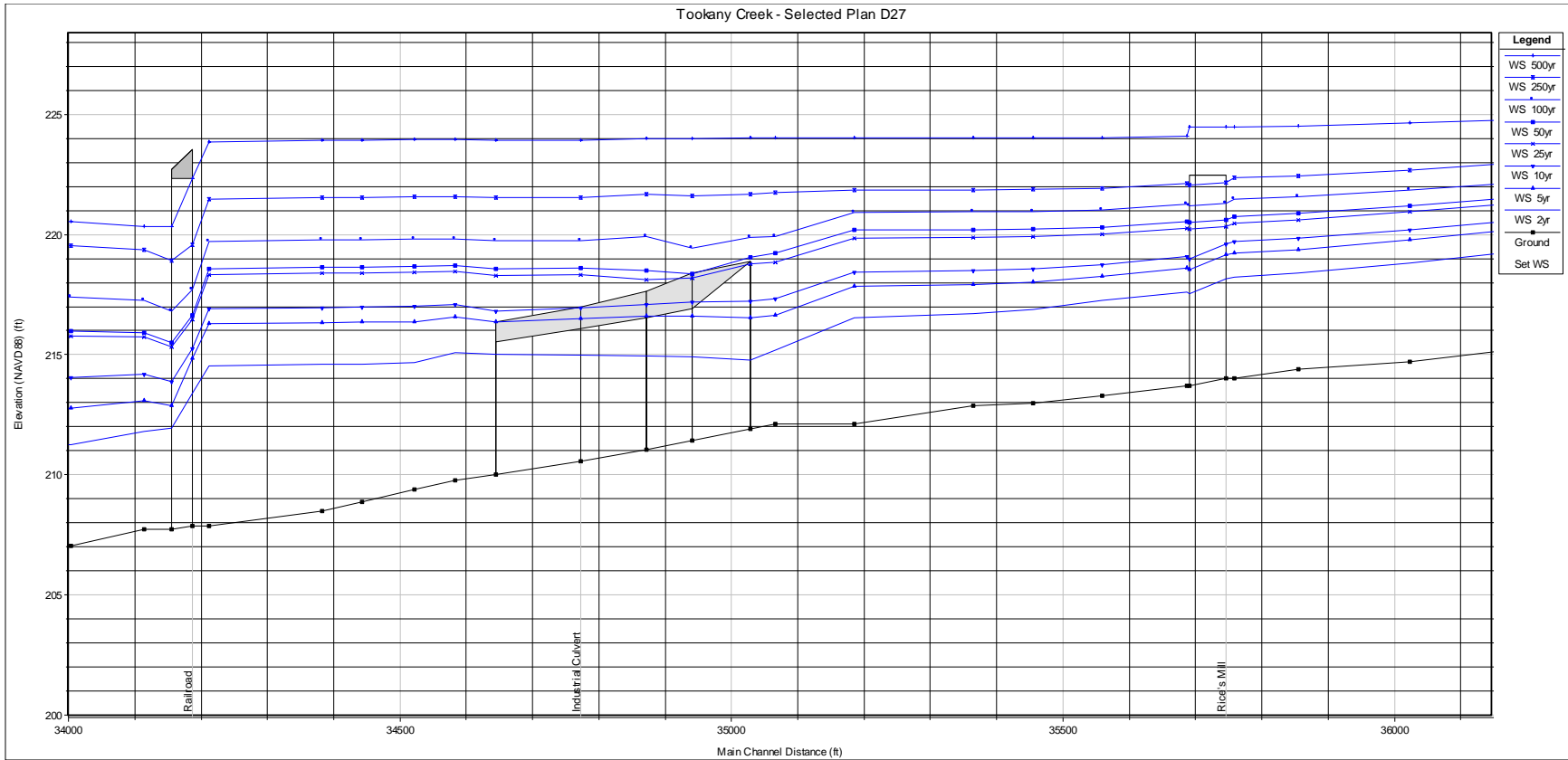


Figure 5.2-Part 18, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

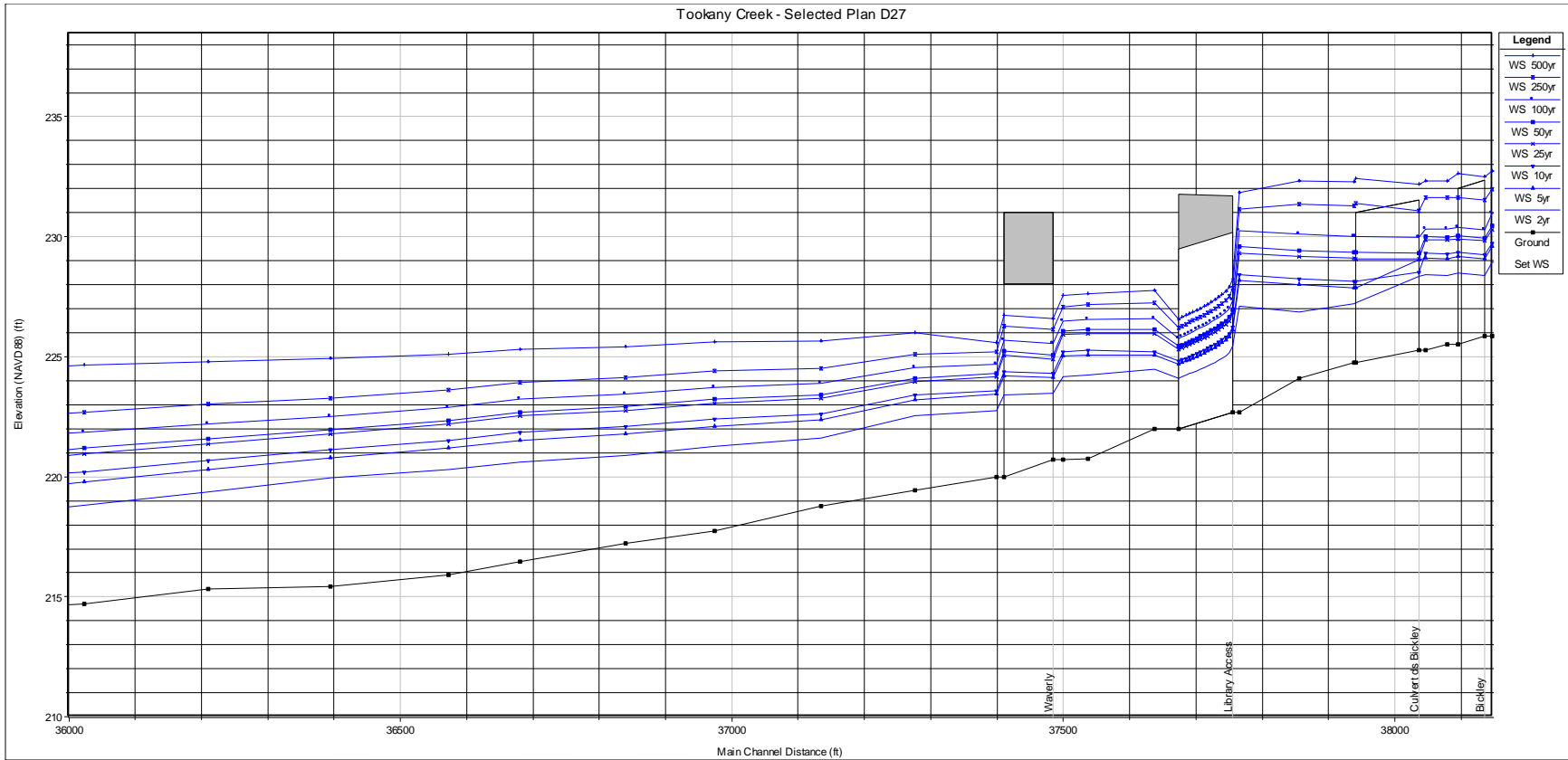


Figure 5.2-Part 19, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

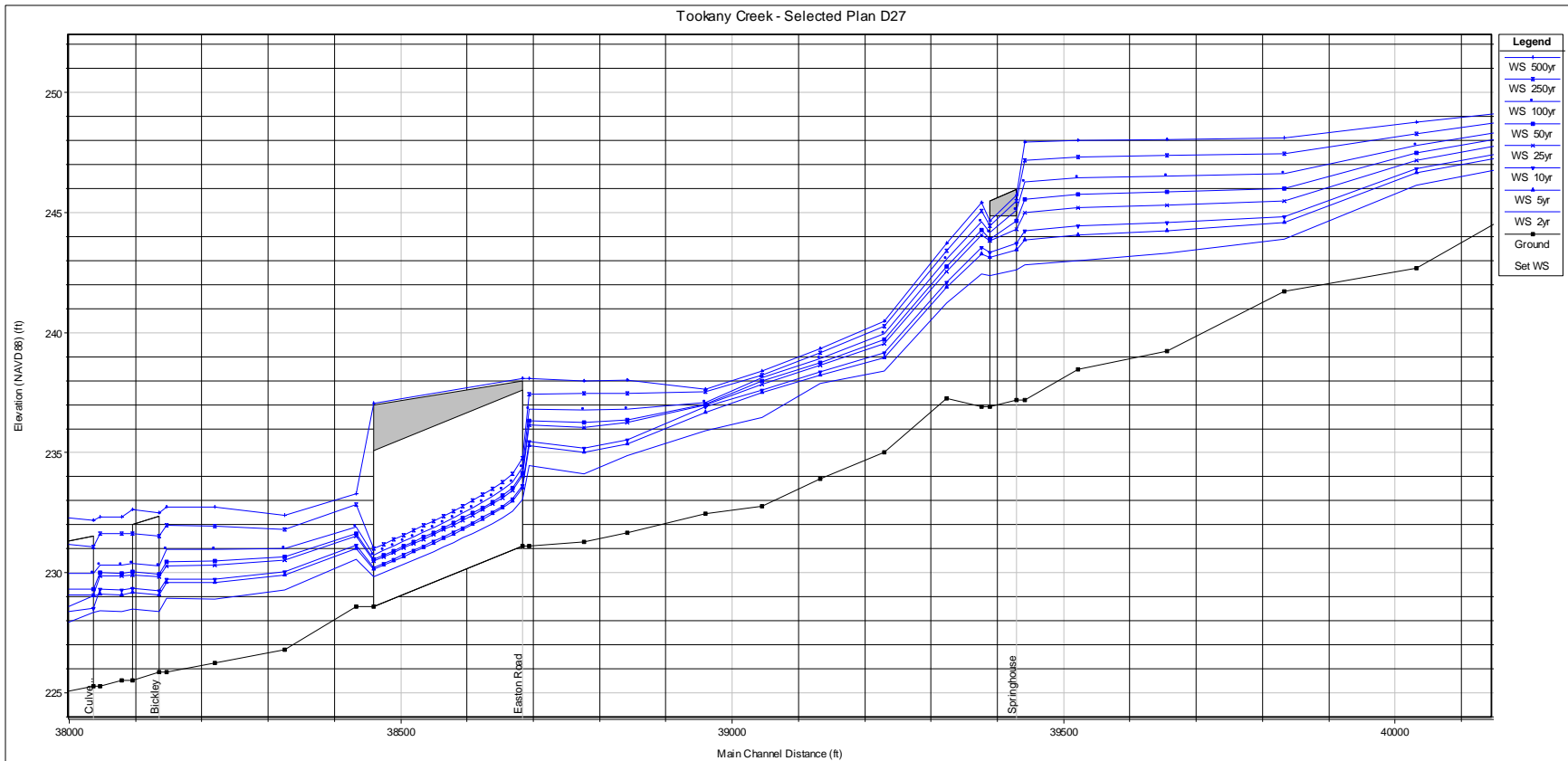


Figure 5.2-Part 20, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

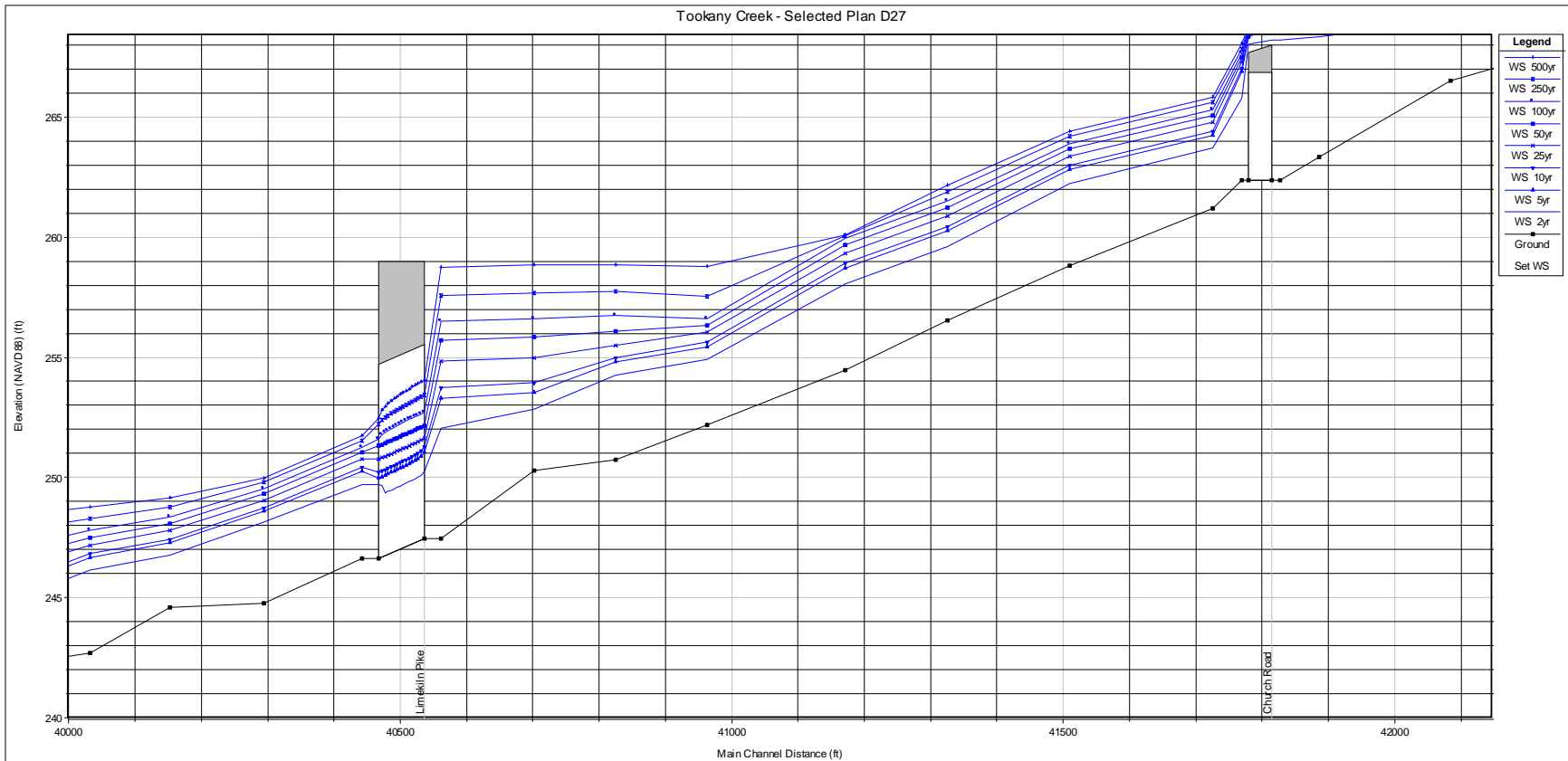


Figure 5.2-Part 21, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

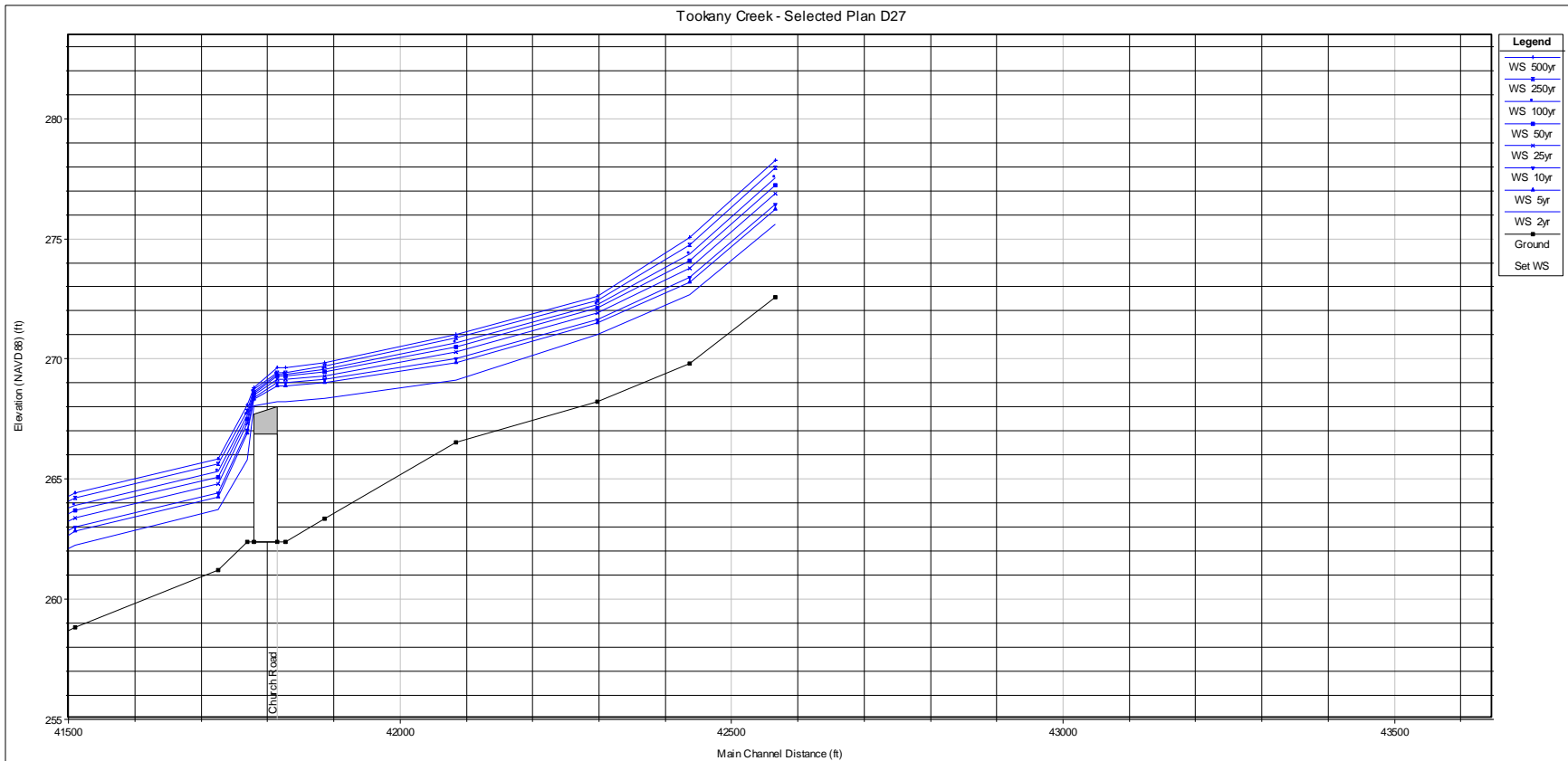


Figure 5.2-Part 22, Tookany Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

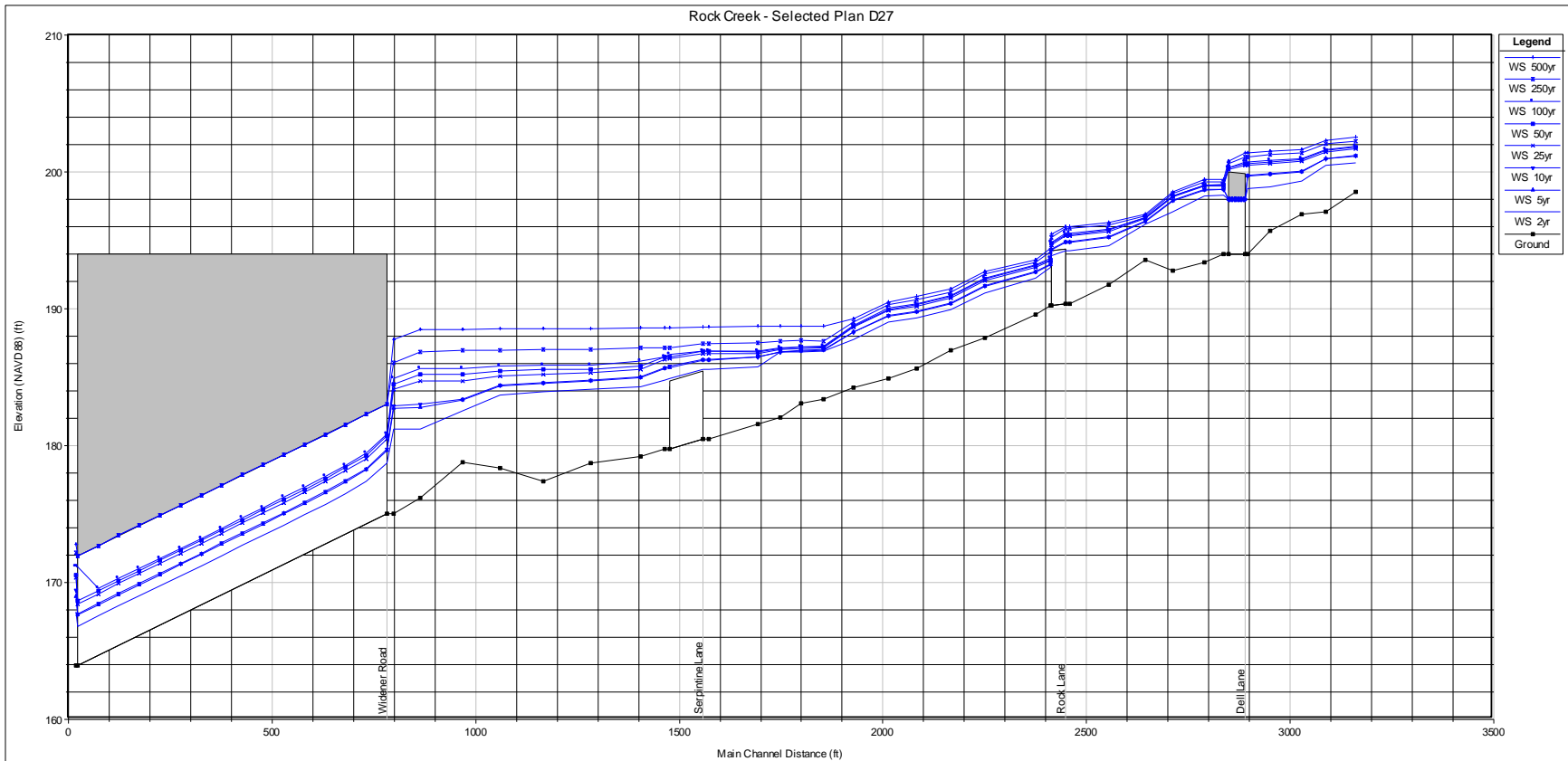


Figure 5.3, Rock Creek – Tentatively Selected Plan D27 Frequency Water Surface Elevation Profiles

LIMEKILN PIKE to SPRINGHOUSE LANE



EVENT	X-40262				X-39490			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	530	248.92	-248	-0.76	530	244.8	-248	-1.79
5yr	804	249.61	-389	-1.01	804	246.66	-389	-2.58
10yr	1059	250.09	-595	-1.35	1059	248.43	-595	-3.99
25yr	1317	250.49	-739	-1.44	1317	248.75	-739	-3.53
50yr	1476	250.71	-797	-1.4	1476	248.94	-797	-3.17
100yr	1680	250.98	-907	-1.44	1680	249.16	-907	-2.7
250yr	1963	251.31	-1061	-1.51	1963	249.43	-1061	-2.11
500yr	2192	251.55	-1186	-1.57	2192	249.65	-1186	-1.63

Figure 5.4-Part 1, Flow and WSEL Reductions for Tookany Crk between Limekiln Pike and Springhouse Lane

SPRINGHOUSE LANE to EASTON ROAD



EVENT	X-39291				X-38744			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	499	242.26	-216	-1.04	499	234.96	-216	-0.83
5yr	740	243.12	-326	-1.23	740	235.94	-326	-0.91
10yr	921	243.66	-458	-1.55	921	236.25	-458	-1.05
25yr	1146	244.26	-570	-1.7	1146	237.2	-570	-1.14
50yr	1297	244.62	-665	-1.86	1297	237.54	-665	-1.29
100yr	1476	244.98	-756	-1.92	1476	238.05	-756	-1.26
250yr	1724	245.63	-884	-2.2	1724	238.35	-884	-0.89
500yr	1925	246	-988	-2.29	1925	238.54	-988	-0.54

Figure 5.4-Part 2, Flow and WSEL Reductions for Tookany Crk between Springhouse Lane and Easton Road

EASTON ROAD to BICKLEY ROAD



X-38188					
EVENT	WithOut Project		PLAN 27		
	FLOW	WSEL	Delta	Delta	
	(cfs)	(ft-NAVD88)	(cfs)	(Feet)	
2yr	512	229.37	-113	-0.45	
5yr	718	230.16	-163	-0.55	
10yr	804	230.6	-211	-0.86	
25yr	1001	231.93	-264	-1.62	
50yr	1082	232.65	-305	-2.17	
100yr	1231	233.37	-346	-2.38	
250yr	1438	234.38	-405	-2.44	
500yr	1606	234.83	-454	-2.1	

Figure 5.4-Part 3, Flow and WSEL Reductions for Tookany Crk between Easton Road and Bickley Rd

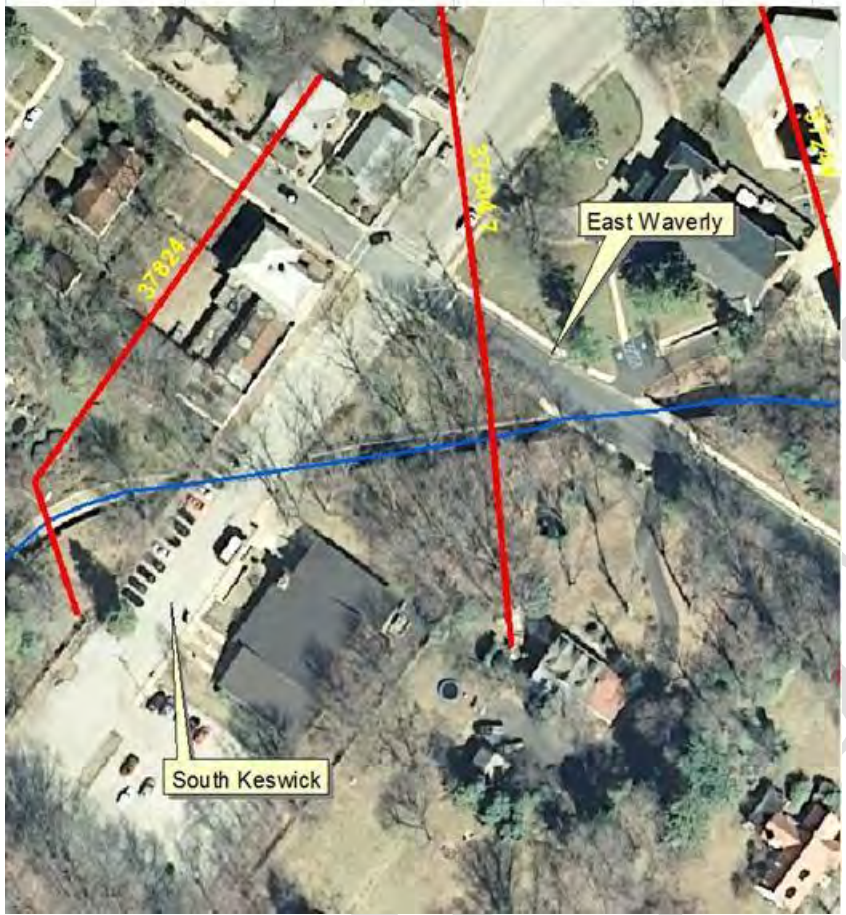
BICKLEY ROAD to SOUTH KESWICK



X-37824				
EVENT	Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	512	227.71	-113	-0.85
5yr	718	229.06	-163	-1.05
10yr	804	229.59	-211	-1.33
25yr	1001	230.97	-264	-1.79
50yr	1082	231.82	-305	-2.4
100yr	1231	232.82	-346	-2.72
250yr	1438	233.9	-405	-2.54
500yr	1606	234.41	-454	-2.09

Figure 5.4-Part 4, Flow and WSEL Reductions for Tookany Crk between Bickley Rd and S Keswick Ave

SOUTH KESWICK to EAST WAVERLY



X-37505				
EVENT	Without Project		PLAN 27	
	FLOW	WSEL	Delta	Delta
	(cfs)	(ft-NAVD88)	(cfs)	(Feet)
2yr	512	224.86	-113	-0.61
5yr	718	225.89	-163	-0.81
10yr	804	226.23	-211	-0.95
25yr	1001	227.03	-264	-1.05
50yr	1082	227.35	-305	-1.23
100yr	1231	227.92	-346	-1.36
250yr	1438	228.79	-405	-1.63
500yr	1606	230.19	-454	-2.55

Figure 5.4-Part 5, Flow and WSEL Reductions for Tookany Crk between S Keswick Ave and E Waverly

EAST WAVERLY to RICE'S MILL



X-37244

X-35823

EVENT	PLAN 27				PLAN 27			
	Without Project		Delta	Delta	Without Project		Delta	Delta
	FLOW	WSEL	FLOW	WSEL	FLOW	WSEL	FLOW	WSEL
	(cfs)	(ft-NAVD88)	(cfs)	(Feet)	(cfs)	(ft-NAVD88)	(cfs)	(Feet)
2yr	512	223.01	-113	-0.47	675	218.74	-92	-0.35
5yr	718	223.81	-163	-0.59	1004	220.17	-169	-0.79
10yr	804	224.17	-211	-0.77	1192	220.79	-253	-0.95
25yr	1001	224.87	-264	-0.9	1483	221.81	-315	-1.2
50yr	1082	225.11	-305	-0.99	1562	222.15	-352	-1.27
100yr	1231	226.05	-346	-1.51	1778	224.51	-401	-2.94
250yr	1438	226.56	-405	-1.45	2077	225.12	-469	-2.66
500yr	1606	226.98	-454	-0.99	2319	225.75	-525	-1.22

Figure 5.4-Part 6, Flow and WSEL Reductions for Tookany Crk between E Waverly and Rice's Mill

RICE'S MILL to GLENSIDE



EVENT	X-35527				X-35153			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	675	217.6	-92	-0.34	675	216.98	-92	-0.44
5yr	1004	219.12	-169	-0.87	1004	218.87	-169	-1.03
10yr	1192	220.22	-253	-1.47	1192	220.09	-253	-1.65
25yr	1483	221.23	-315	-1.22	1483	221.14	-315	-1.29
50yr	1562	221.58	-352	-1.27	1562	221.51	-352	-1.33
100yr	1778	224	-401	-2.97	1778	223.99	-401	-3.06
250yr	2077	224.75	-469	-2.83	2077	224.74	-469	-2.87
500yr	2319	225.61	-525	-1.57	2319	225.6	-525	-1.57

Figure 5.4-Part 7, Flow and WSEL Reductions for Tookany Crk between Rice's Mill and Glenside

GLENSIDE to RR



EVENT	X-34904				X-34383			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	675	215.54	-92	-0.63	675	215.26	-92	-0.67
5yr	1004	217.54	-169	-0.95	1004	217.37	-169	-1.03
10yr	1192	218.32	-253	-1.14	1192	218.58	-253	-1.62
25yr	1483	220.44	-315	-2.24	1483	220.47	-315	-2.06
50yr	1562	221.13	-352	-2.77	1562	221.08	-352	-2.43
100yr	1778	223.95	-401	-4.52	1778	223.89	-401	-4.12
250yr	2077	224.7	-469	-3.09	2077	224.64	-469	-3.09
500yr	2319	225.56	-525	-1.58	2319	225.5	-525	-1.57

Figure 5.4-Part 8, Flow and WSEL Reductions for Tookany Crk between Glenside and RR

RR to ABANDONED RR



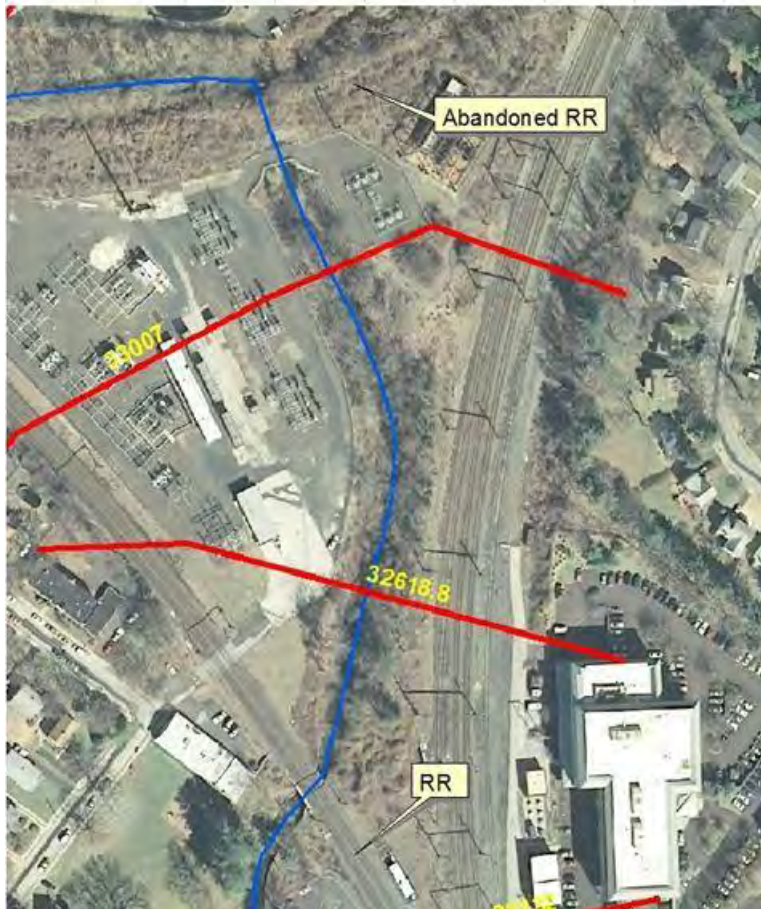
X-34004

X-33557

EVENT	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW	WSEL	Delta	Delta	FLOW	WSEL	Delta	Delta
	(cfs)	(ft-NAVD88)	(cfs)	(Feet)	(cfs)	(ft-NAVD88)	(cfs)	(Feet)
2yr	675	211.72	-92	-0.47	675	210.8	-92	-0.73
5yr	1004	214.56	-169	-1.79	1004	214.39	-169	-2.04
10yr	1192	216.03	-253	-1.98	1192	215.9	-253	-2.04
25yr	1483	218.19	-315	-2.41	1483	218.1	-315	-2.45
50yr	1562	218.94	-352	-2.96	1562	218.86	-352	-3.01
100yr	1778	220.32	-401	-2.91	1778	220.25	-401	-2.94
250yr	2077	220.94	-469	-1.39	2077	220.85	-469	-1.37
500yr	2319	221.3	-525	-0.76	2319	221.21	-525	-0.74

Figure 5.4-Part 9, Flow and WSEL Reductions for Tookany Crk between RR and Abandoned RR

ABANDONED RR to RR



EVENT	X-33007				X-32619			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1079	209.52	-128	-0.59	1079	209.09	-128	-0.64
5yr	1622	212.14	-285	-1.47	1622	211.85	-285	-1.55
10yr	1910	212.85	-407	-0.95	1910	212.54	-407	-0.91
25yr	2376	213.47	-510	-0.74	2376	213.06	-510	-0.64
50yr	2514	213.7	-613	-0.87	2514	213.27	-613	-0.76
100yr	2861	214.16	-697	-0.7	2861	213.7	-697	-0.58
250yr	3343	214.69	-717	-0.82	3343	214.23	-717	-0.8
500yr	3732	215.04	-738	-0.71	3732	214.56	-738	-0.69

Figure 5.4-Part 10, Flow and WSEL Reductions for Tookany Crk between Abandoned RR and RR

RR to GREENWOOD AVE



EVENT	X-32132				X-31355			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1079	203.85	-128	-0.28	1092	202.12	-128	-0.61
5yr	1622	205.45	-285	-0.81	1641	204.9	-286	-1.07
10yr	1910	206.31	-407	-1.15	1928	205.88	-399	-1.32
25yr	2376	207.17	-510	-0.90	2399	206.73	-497	-0.89
50yr	2514	207.35	-613	-0.96	2522	206.91	-581	-0.94
100yr	2861	207.77	-697	-0.86	2871	207.3	-662	-0.82
250yr	3343	208.22	-717	-0.64	3354	207.69	-673	-0.55
500yr	3732	208.55	-738	-0.59	3745	207.98	-688	-0.51

Figure 5.4-Part 11, Flow and WSEL Reductions for Tookany Crk between RR and Greenwood Ave

GREENWOOD AVE to WASHINGTON LANE



EVENT	X-30997				X-29402			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1289	200.44	-129	-0.48	1289	188.25	-129	-0.29
5yr	1995	202.12	-288	-0.25	1995	189.59	-288	-0.52
10yr	2413	202.44	-439	-0.33	2413	190.31	-439	-0.75
25yr	3001	202.85	-545	-0.38	3001	191.32	-545	-0.94
50yr	3179	202.98	-588	-0.41	3179	191.66	-588	-1.05
100yr	3619	203.27	-670	-0.45	3619	192.39	-670	-1.16
250yr	4227	203.69	-648	-0.45	4227	193.17	-648	-0.83
500yr	4720	204.02	-640	-0.43	4720	193.71	-640	-0.72

Figure 5.4-Part 12, Flow and WSEL Reductions for Tookany Crk between Greenwood Ave and Washington Lane

WASHINGTON LANE to CHURCH ROAD



EVENT	X-29059				X-27838			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1289	185.98	-129	-0.28	1289	181.81	-129	-0.4
5yr	1995	187.3	-288	-0.54	1995	184.42	-288	-1.18
10yr	2413	188.12	-439	-0.86	2413	185.85	-439	-1.53
25yr	3001	189.43	-545	-1.23	3001	187.86	-545	-1.88
50yr	3179	189.9	-588	-1.42	3179	188.51	-588	-2.09
100yr	3619	190.85	-670	-1.55	3619	189.62	-670	-1.95
250yr	4227	191.65	-648	-0.86	4227	190.32	-648	-0.76
500yr	4720	192.16	-640	-0.68	4720	190.68	-640	-0.5

EVENT	X-27305				X-26492			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1289	179.23	-129	-0.48	1289	178.36	-129	-0.63
5yr	1995	182	-288	-1.14	1995	181.55	-288	-1.27
10yr	2413	182.91	-439	-0.99	2413	182.44	-439	-0.99
25yr	3001	183.78	-545	-0.8	3001	183.24	-545	-0.73
50yr	3179	184	-588	-0.81	3179	183.44	-588	-0.73
100yr	3619	184.52	-670	-0.81	3619	183.9	-670	-0.72
250yr	4227	185.17	-648	-0.69	4227	184.46	-648	-0.6
500yr	4720	185.69	-640	-0.67	4720	184.91	-640	-0.58

Figure 5.4-Part 13, Flow and WSEL Reductions for Tookany Crk between Washington Lane and Church Road

CHURCH ROAD to OLD YORK ROAD



X-26003

X-24645

X-24264

EVENT	PLAN 27				PLAN 27				PLAN 27			
	Without Project		Delta	Delta	Without Project		Delta	Delta	Without Project		Delta	Delta
	FLOW	WSEL	FLOW	WSEL	FLOW	WSEL	FLOW	WSEL	FLOW	WSEL	FLOW	WSEL
	(cfs)	(ft-NAVD88)	(cfs)	(Feet)	(cfs)	(ft-NAVD88)	(cfs)	(Feet)	(cfs)	(ft-NAVD88)	(cfs)	(Feet)
2yr	1615	167.64	-94	-0.13	1615	169.28	-94	-0.26	1615	158.18	-94	-0.27
5yr	2516	168.97	-239	-0.36	2516	161.51	-239	-0.49	2516	160.26	-239	-0.39
10yr	3088	169.77	-475	-0.66	3088	162.68	-475	-0.97	3088	161.18	-475	-0.76
25yr	3842	170.76	-591	-0.77	3842	164.24	-591	-1.23	3842	162.34	-591	-0.9
50yr	4136	171.13	-749	-0.96	4136	164.86	-749	-1.56	4136	162.8	-749	-1.15
100yr	4708	171.91	-852	-1.13	4708	167.63	-852	-3.32	4708	163.68	-852	-1.26
250yr	5500	172.6	-840	-0.73	5500	168.33	-840	-0.73	5500	164.56	-840	-0.94
500yr	6141	172.99	-842	-0.55	6141	168.84	-842	-0.69	6141	165.44	-842	-1.14

Figure 5.4-Part 14, Flow and WSEL Reductions for Tookany Crk between Church Road and Old York Road

OLD YORK ROAD to CHURCH ROAD



EVENT	X-23736				X-22838			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1615	154.13	-94	-0.11	1746	147.99	-94	-0.17
5yr	2516	155.02	-239	-0.15	2754	149.89	-258	-0.67
10yr	3088	155.17	-475	-0.10	3391	151.34	-464	-1.13
25yr	3842	155.54	-591	-0.37	4218	153.6	-577	-1.68
50yr	4136	155.67	-749	-0.43	4556	153.76	-754	-0.33
100yr	4708	155.86	-852	-0.33	5186	154.05	-858	-0.39
250yr	5500	156.17	-840	-0.32	6059	154.4	-828	-0.33
500yr	6141	156.51	-842	-0.42	6765	154.65	-816	-0.29

Figure 5.4-Part 15, Flow and WSEL Reductions for Tookany Crk between Old York Road and Church Rd

CHURCH ROAD to HIGH SCHOOL ROAD



EVENT	X-22556				X-21478			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1746	146.02	-94	-0.13	1826	140.94	-92	-0.19
5yr	2754	147.2	-258	-0.31	2822	144.07	-264	-1.8
10yr	3391	147.75	-464	-0.38	3560	144.96	-530	-0.76
25yr	4218	148.26	-577	-0.33	4429	146.27	-660	-0.97
50yr	4556	148.43	-754	-0.37	4837	146.7	-764	-0.94
100yr	5186	148.73	-858	-0.41	5506	147.35	-870	-0.83
250yr	6059	149.15	-828	-0.39	6432	148.06	-829	-0.63
500yr	6765	149.49	-816	-0.38	7182	148.55	-811	-0.54

Figure 5.4-Part 16, Flow and WSEL Reductions for Tookany Crk between Church Rd and High School Rd

HIGH SCHOOL ROAD to MILL ROAD



EVENT	X-21208				X-20720			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1826	139.71	-92	-0.18	1826	137.95	-92	-0.21
5yr	2822	142.51	-264	-1.54	2822	142.01	-264	-2.46
10yr	3560	143.6	-530	-0.76	3560	143.09	-530	-0.75
25yr	4429	144.55	-660	-0.69	4429	143.96	-660	-0.63
50yr	4837	144.82	-764	-0.61	4837	144.15	-764	-0.5
100yr	5506	145.35	-870	-0.63	5506	144.64	-870	-0.55
250yr	6432	145.99	-829	-0.57	6432	145.22	-829	-0.52
500yr	7182	146.45	-811	-0.51	7182	145.64	-811	-0.47

Figure 5.4-Part 17, Flow and WSEL Reductions for Tookany Crk between High School Rd and Mill Rd

MILL ROAD to HARRISON AVE



EVENT	X-20530				X-19847			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1826	136.28	-92	-0.16	1826	133.87	-92	-0.19
5yr	2822	137.84	-264	-0.38	2822	135.96	-264	-0.55
10yr	3560	139.34	-530	-1.21	3560	138.39	-530	-1.99
25yr	4429	140.19	-660	-0.66	4429	139.06	-660	-0.52
50yr	4837	140.58	-764	-0.76	4837	139.36	-764	-0.58
100yr	5506	141.13	-870	-0.74	5506	139.72	-870	-0.51
250yr	6432	141.98	-829	-0.77	6432	140.5	-829	-0.69
500yr	7182	142.54	-811	-0.64	7182	141.01	-811	-0.56

Figure 5.4-Part 18, Flow and WSEL Reductions for Tookany Crk between Mill Rd and Harrison Ave

HARRISON AVE to NEW SECOND ST



EVENT	X-19613				X-17562			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1826	132.54	-92	-0.15	1826	126.33	-92	-0.21
5yr	2822	133.99	-264	-0.36	2822	128.53	-264	-0.5
10yr	3560	134.99	-530	-0.69	3560	128.89	-530	-0.04
25yr	4429	135.94	-660	-0.71	4429	129.4	-660	-0.35
50yr	4837	136.32	-764	-0.74	4837	129.6	-764	-0.36
100yr	5506	136.92	-870	-0.78	5506	130.05	-870	-0.56
250yr	6432	137.65	-829	-0.65	6432	130.68	-829	-0.59
500yr	7182	138.2	-811	-0.6	7182	130.98	-811	-0.35

Figure 5.4-Part 19, Flow and WSEL Reductions for Tookany Crk between Harrison and New Second St

NEW SECOND ST to TOOKANY CREEK PKWY



X-17241

EVENT	Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	1826	122.77	-92	-0.16
5yr	2822	124.39	-264	-0.42
10yr	3560	125.6	-530	-0.88
25yr	4429	127.34	-660	-1.38
50yr	4837	128.07	-764	-1.58
100yr	5506	128.91	-870	-1.19
250yr	6432	129.83	-829	-0.88
500yr	7182	130.04	-811	-0.28

Figure 5.4-Part 20, Flow and WSEL Reductions for Tookany Crk between New Second St and Tookany Creek Parkway

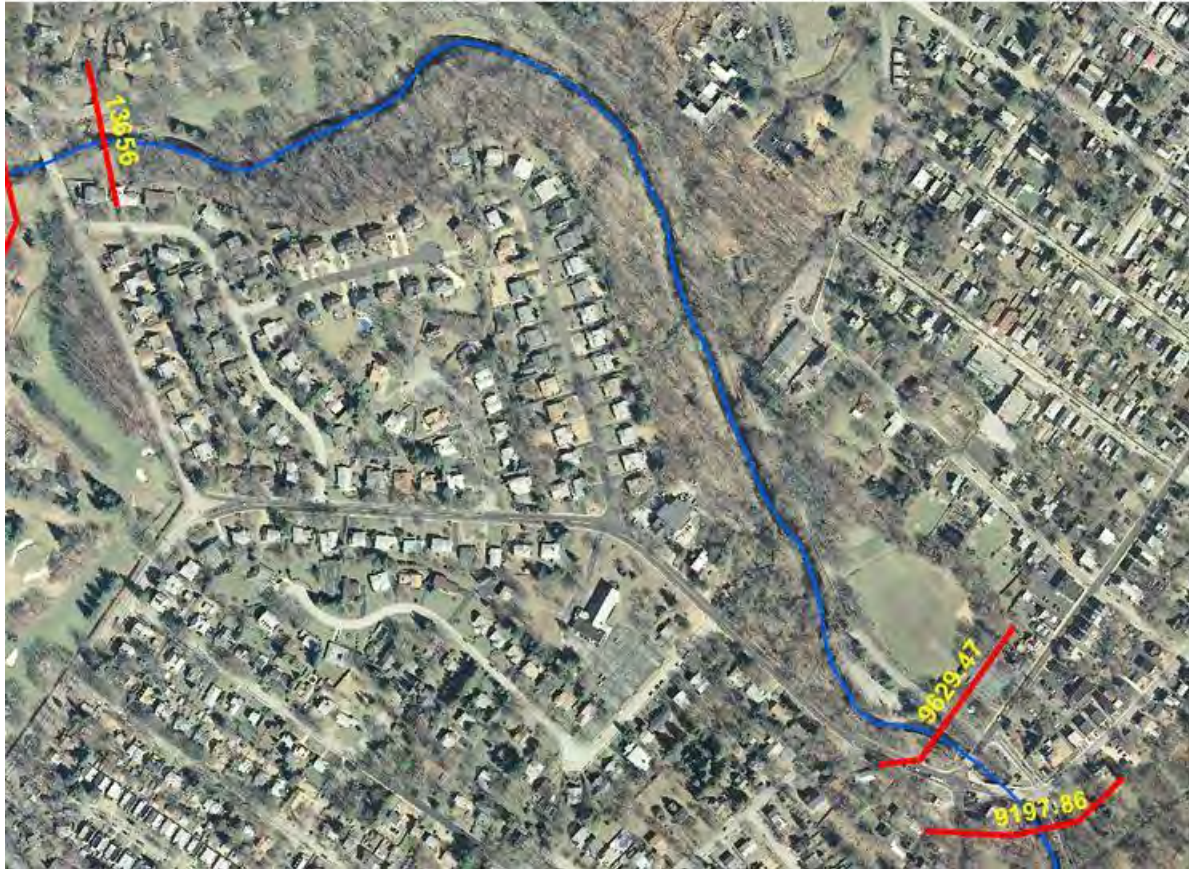
TOOKANY CREEK PKWY to JENKINTOWN RD



EVENT	X-16914				X-13977			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW	WSEL	FLOW	Delta	FLOW	WSEL	Delta	Delta
	(cfs)	(ft-NAVD88)	(cfs)	(Feet)	(cfs)	(ft-NAVD88)	(cfs)	(Feet)
2yr	1826	120.71	-92	-0.10	2097	110.44	-118	-0.15
5yr	2822	121.61	-264	-0.23	3086	112.24	-270	-0.16
10yr	3560	122.31	-530	-0.48	3961	113.85	-575	-1.01
25yr	4429	123.15	-660	-0.61	4928	115.44	-715	-1.03
50yr	4837	123.55	-764	-0.68	5390	116.14	-779	-0.87
100yr	5506	124.06	-870	-0.64	6135	116.82	-887	-0.75
250yr	6432	124.84	-829	-0.61	7167	117.62	-824	-0.55
500yr	7182	125.45	-811	-0.58	8002	118.15	-789	-0.43

Figure 5.4-Part 21, Flow and WSEL Reductions for Tookany Crk between Tookany Creek Parkway and Jenkintown Road

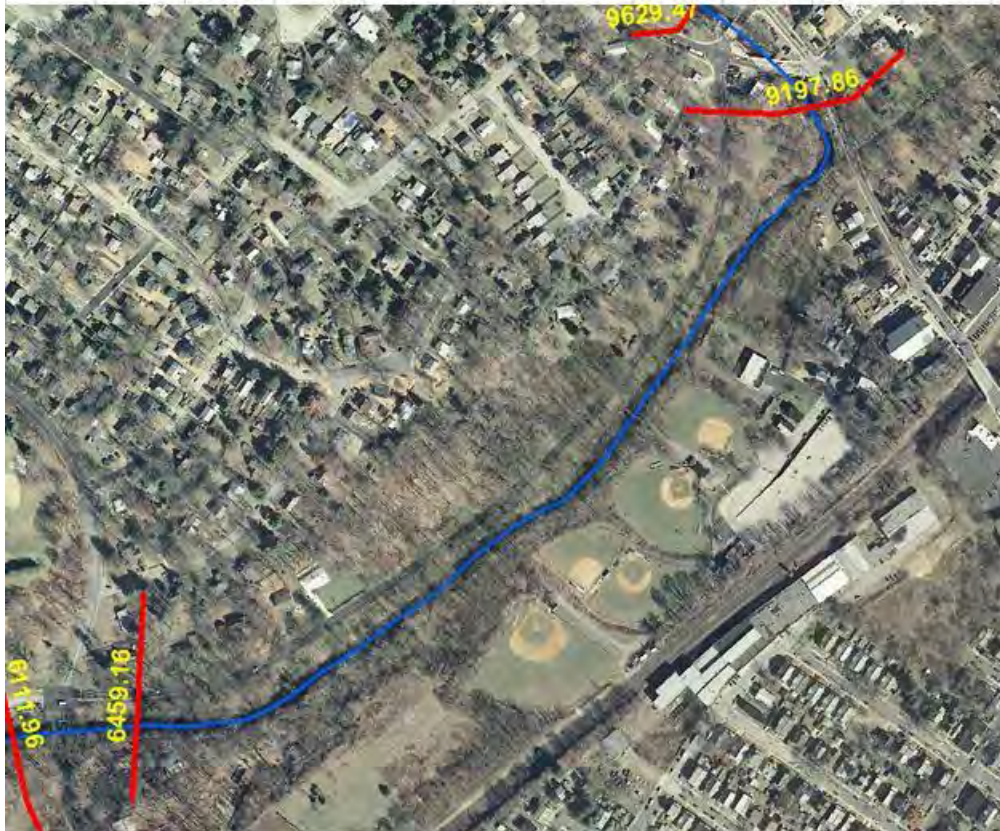
JENKINTOWN RD to CENTRAL AVE



EVENT	X-13656				X-9629			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	2568	109.15	-100	-0.08	2580	93.83	-118	-0.21
5yr	3666	109.91	-41	-0.03	3720	96.92	-42	-0.05
10yr	4589	110.38	-563	-0.27	4571	98.49	-487	-1.14
25yr	5708	110.82	-699	-0.25	5687	99.24	-606	-0.38
50yr	6539	111.03	-817	-0.21	6529	99.92	-730	-0.61
100yr	7443	111.18	-930	-0.16	7432	100.53	-831	-0.56
250yr	8695	111.63	-823	-0.36	8683	101.21	-705	-0.36
500yr	9709	112.28	-757	-0.46	9695	101.69	-623	-0.28

Figure 5.4-Part 22, Flow and WSEL Reductions for Tookany Crk between Jenkintown Rd and Central Ave

ASHBOURNE RD to ASHMEAD RD



X-9198

X-6459

EVENT	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW	WSEL	Delta	Delta	FLOW	WSEL	Delta	Delta
	(cfs)	(ft-NAVD88)	(cfs)	(Feet)	(cfs)	(ft-NAVD88)	(cfs)	(Feet)
2yr	2580	91.37	-118	-0.14	2580	82.65	-118	-0.2
5yr	3720	92.54	-42	-0.04	3720	85.11	-42	-0.04
10yr	4571	93.25	-487	-0.4	4571	85.69	-487	-0.24
25yr	5687	94.03	-606	-0.41	5687	86.82	-606	-0.56
50yr	6529	94.55	-730	-0.44	6529	87.55	-730	-0.63
100yr	7432	94.9	-831	-0.31	7432	88.17	-831	-0.57
250yr	8683	95.27	-705	-0.2	8683	88.89	-705	-0.39
500yr	9695	95.44	-623	-0.1	9695	89.37	-623	-0.29

Figure 5.4-Part 23, Flow and WSEL Reductions for Tookany Crk between Ashbourne Rd and Ashmead Rd

ASHMEAD RD to PHILADELPHIA BDY



EVENT	X-6112				X-2443			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW	WSEL	Delta	Delta	FLOW	WSEL	Delta	Delta
	(cfs)	(ft-NAVD88)	(cfs)	(Feet)	(cfs)	(ft-NAVD88)	(cfs)	(Feet)
2yr	2580	81.41	-118	-0.17	2590	71.8	-111	-0.12
5yr	3720	82.71	-42	-0.04	3760	72.92	-42	-0.03
10yr	4571	83.45	-487	-0.41	4590	73.57	-463	-0.35
25yr	5687	84.3	-606	-0.45	5710	74.33	-575	-0.38
50yr	6529	84.87	-730	-0.49	6580	74.86	-711	-0.43
100yr	7432	85.42	-831	-0.51	7490	75.38	-810	-0.46
250yr	8683	86.1	-705	-0.37	8750	76.05	-676	-0.35
500yr	9695	86.58	-623	-0.28	9770	76.56	-589	-0.29

Figure 5.4-Part 24, Flow and WSEL Reductions for Tookany Crk between Ashmead Rd and Philadelphia Bdy

UPSTREAM LIMIT to DELL LANE



EVENT	X-3162				X-2951			
	WithOut Project		PLAN 27		WithOut Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	562	201.28	-167	-0.6	562	199.99	-167	-1.11
5yr	861	202.22	-328	-1.04	861	201.21	-328	-1.41
10yr	1064	202.67	-519	-1.45	1064	201.66	-519	-1.78
25yr	1324	203.15	-645	-1.47	1324	202.12	-645	-1.5
50yr	1396	203.26	-683	-1.47	1396	202.21	-683	-1.46
100yr	1590	203.55	-858	-1.7	1590	202.47	-858	-1.65
250yr	1857	203.87	-981	-1.62	1857	202.75	-981	-1.5
500yr	2073	204.08	-1078	-1.56	2073	202.95	-1078	-1.43

Figure 5.5-Part 1, Flow and WSEL Reductions for Rock Crk between Upstream Limit and Dell Lane

DELL LANE to ROCK LANE



EVENT	X-2789				X-2554			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	562	198.74	-167	-0.49	545	195.11	-124	-0.48
5yr	861	199.24	-328	-0.56	821	195.82	-248	-0.63
10yr	1064	199.52	-519	-0.82	1109	196.35	-514	-1.09
25yr	1324	199.84	-645	-0.89	1379	196.71	-638	-1.07
50yr	1396	199.91	-683	-0.91	1525	196.9	-738	-1.16
100yr	1590	200.13	-858	-1.09	1736	197.17	-915	-1.35
250yr	1857	200.39	-981	-1.13	2028	197.59	-1072	-1.47
500yr	2073	200.58	-1078	-1.14	2265	197.89	-1179	-1.57

Figure 5.5-Part 2, Flow and WSEL Reductions for Rock Crk between Dell Lane and Rock Lane

ROCK LANE to SERPENTINE LANE



EVENT	X-2374				X-1693			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	545	192.62	-124	-0.37	545	186.44	-135	-0.68
5yr	821	193.18	-248	-0.50	841	187.07	-274	-0.61
10yr	1109	193.58	-514	-0.84	1013	189.47	-426	-2.99
25yr	1379	194.08	-638	-1.02	1260	193.47	-530	-6.74
50yr	1525	194.76	-738	-1.63	1333	194.37	-559	-7.5
100yr	1736	195.66	-915	-2.48	1518	195.39	-713	-8.48
250yr	2028	196.53	-1072	-3.16	1773	196.31	-784	-8.82
500yr	2265	197.23	-1179	-3.68	1980	197.04	-857	-8.34

Figure 5.5-Part 3, Flow and WSEL Reductions for Rock Crk between Rock Lane and Serpentine Lane

SERPENTINE LANE to WIDENER ROAD



EVENT	X-1405				X-864			
	Without Project		PLAN 27		Without Project		PLAN 27	
	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)	FLOW (cfs)	WSEL (ft-NAVD88)	Delta FLOW (cfs)	Delta WSEL (Feet)
2yr	545	184.89	-135	-0.57	545	182.57	-135	-1.34
5yr	841	186.64	-274	-1.67	841	186.34	-274	-3.54
10yr	1013	189.41	-426	-4.36	1013	189.35	-426	-6.35
25yr	1260	193.45	-530	-7.86	1260	193.43	-530	-8.7
50yr	1333	194.35	-559	-8.52	1333	194.33	-559	-9.14
100yr	1518	195.36	-713	-9.19	1518	195.32	-713	-9.71
250yr	1773	196.3	-784	-9.15	1773	196.28	-784	-9.4
500yr	1980	196.99	-857	-8.4	1980	196.97	-857	-8.5

Figure 5.5-Part 4, Flow and WSEL Reductions for Rock Crk between Serpentine Lane and Widener Road

The frequency discharges of Plan D27 were run in the “low” and “high” versions of the hydraulic model and the frequency standard deviations at the Economic Index stations are provided in Table 5.17. Since the “low” and “high” hydraulic parameters of the HEC-RAS models for Without Project and Plan D27 are the same, differences in the frequency standard deviations between Plan D27 and Without Project are solely a function of discharge differences.

Table 5.17								
Tookany and Rock Creeks - Plan D27 Frequency Standard Deviations at the Economic Index Stations								
Tookany Creek Plan D27 Standard Deviations								
Index Station	Events							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
4731	0.26	0.2975	0.31	0.3375	0.37	0.4	0.4475	0.4775
8872	0.245	0.25	0.25	0.24	0.2325	0.225	0.2525	0.28
12076	0.2225	0.2525	0.26	0.2625	0.25	0.2375	0.2125	0.2025
15557	0.1175	0.1525	0.15	0.225	0.25	0.2175	0.18	0.18
18967	0.225	0.265	0.24	0.265	0.265	0.29	0.315	0.35
21416	0.18	0.5	0	0.0775	0.07	0.0425	0.07	0.07
23275	0.1775	0.2675	0.42	0.4225	0.1375	0.1475	0.1525	0.1575
26368	0	0	0	0	0	0	0	0
30700	0.1825	0.2325	0.24	0.245	0.2525	0.255	0.2325	0.205
34004	0.195	0.3725	0.15	0.15	0.15	0.15	0.11	0.0425
36541	0.1825	0.2075	0.23	0.2325	0.235	0.25	0.315	0.3875
39344	0.0675	0.08	0.0825	0.0875	0.095	0.1025	0.1075	0.1125
Rock Creek Plan D27 Standard Deviations								
Index Station	Events							
	2yr	5yr	10yr	25yr	50yr	100yr	250yr	500yr
1525	0.05	0.04	0.0375	0.04	0.0325	0.015	0.215	1.035