Hydraulic Report
(Final)

Haggerty Road over
Tributary (Smith Drain) to Willow Creek
CS 82292 – JN 115177

July 3, 2013

Owner:

MDOT
Michigan Department of Transportation

Prepared For:

CDM Smith

Prepared By:

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SUMMARY

This hydraulic analysis was conducted to examine the backwater effect of the proposed structure which carries Haggerty Road over a Tributary (Smith Drain) to Willow Creek in Wayne County. The existing structure is scheduled to be replaced in conjunction with the road work that will be required for the Preferred Alternative selected for M-153 (Ford Road). This analysis found an improvement with the proposed conditions as compared with existing conditions for the 1 percent (100 year) flood event.

PROJECT DATA

STRUCTURE NUMBER:	NA	
CONTROL SECTION:	NA	
JOB NUMBER:	115177	
STREAM:	Unnamed (Smith Drain) Tributary to Willow Creek	
TOWNSHIP:	Canton Township	
COUNTY:	Wayne	
SECTION:	13	
TOWN AND RANGE:	Town 2 South, Range 8 East	
DRAINAGE AREA:	0.47 square miles	
DISCHARGE:	10-year (10% chance flow)	95 cfs
	50-year (2% chance flow)	130 cfs
	100-year (1% chance flow)	145 cfs
	500-year (0.2% chance flow)	185 cfs

METHOD OF ANALYSIS

The U.S. Army Corps of Engineers HEC-RAS computer program, version 4.1.0, was used to determine the water surface profile elevations for the 50 and 100 year storm discharges for existing and proposed conditions.

Because the drainage area for the tributary (Smith Drain) is less than 2 square miles, peak flows for the watershed area were determined utilizing the design rainfall, soil type, land use, and runoff curve number (RCN). The RCN is a representative average or composite of the culvert's watershed. The watershed area for the culvert was determined using United States Geological Survey contour maps in conjunction with the drainage area of 0.59 square miles for the tributary (Smith Drain) at I-275 provided by the Michigan Department of Environmental Quality. After determining the watershed area, soil type and land usage maps were used to determine the effect these characteristics have on the design rainfall. The hydrologic soil group map and report for this area was provided by the United States Department of Agriculture Natural Resource Conservation Service Web Soil Survey web site located at the following address:

http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Flow paths within the watershed were determined which were used to establish the most hydraulically distant point within the watershed. All of the above data was then used to determine the time of concentration and ultimately the peak flow of the entire watershed. Maps showing the watershed and flow paths, soil series layout and report, and land use, as well as a summary of the SCS-92 Method Discharge are included in the Appendices.

Once the peak flow information was established, the existing culvert was analyzed using HEC-RAS to model site conditions for the existing culvert and to analyze the impact of the proposed culvert.

SCOPE OF STUDY

Smith Drain, a tributary to Willow Creek, flows from west to east under Haggerty Road via a single corrugated metal pipe culvert. Haggerty Road consists of a five lane road with curb and gutter on each side. The crossing is approximately 1/8 mile south of M-153 (Ford Road). The existing structure is an 11-foot span (hydraulic width) by 8-foot rise culvert with a total length (hydraulic length) of 149 feet. The upstream and downstream ends of the culvert are both mitered to follow the roadway sideslope. Storm sewer outlets are located inside of the pipe.

The existing culvert shows areas of deflection of the metal pipe, along with corrosion, at locations under the roadway. Replacement of the culvert in conjunction with any road work on Haggerty Road for the M-153 project that will impact the culvert is recommended.

The proposed structure consists of a single span precast three-sided concrete culvert, with a 16-foot span and a 7-foot rise. The hydraulic length of structure is 184 feet. The proposed low chord of the structure will be approximate elevation 670.28. This elevation is approximately 1.3 feet lower than the top of the existing culvert but the overall available flow area is increased due to the longer span length. The hydraulic analysis results indicate that a decrease in the backwater elevation will occur because of the new structure.

The existing channel for the tributary is in general 3 to 6 feet in width at the bottom, 5 to 8 feet wide at the top (bank to bank) and less than 1.0 feet deep at normal flow. The channel is relatively straight with well-defined banks upstream and downstream of the crossing.

The reach studied begins approximately 285 feet downstream of the existing structure and ends approximately 285 feet upstream.

GEOMETRY OF THE MODEL

River cross sections were obtained by field survey by SSI at locations as recommended by MDOT and HH Engineering after an initial field visit. Survey data was recorded using a data collector. A baseline was established on the channel bank and referenced to the road centerline. All cross sections were tied to the baseline. Elevations are given in North American Vertical Datum of 1988 (NAVD 88).

MANNING'S ROUGHNESS COEFFICIENTS

Alan Halbeisen, P.E. and David Strockis, P.E. of HH Engineering (HHE) performed inspection of the site on December 12, 2012 to gather information on site conditions prior to running HEC-RAS. Manning's roughness coefficients ("n" values) are based on values given in Table 4-1 of the MDOT Drainage Manual. The overbanks within the study reach have medium brush and trees along the banks. The recommended "n" values for the channel are 0.04 downstream of the existing structure and 0.04 upstream. The recommended "n" value for the overbanks is 0.10 from the edge of channel to the top of banks and a value of 0.06 beyond the top of bank for the upstream cross sections and a value of 0.10 for the entire overbanks of cross sections downstream of the existing bridge.

The proposed condition was modeled using the same values as the existing condition.

EXPANSION AND CONTRACTION COEFFICIENTS

Based on the stream geometry, expansion and contraction coefficients of 0.3 and 0.1 respectively were used. At the culvert, expansion and contraction coefficients of 0.5 and 0.3 were used.

STARTING WATER SURFACE ELEVATION

The starting water surface elevation was calculated using the slope area method for the normal flow. The energy slope was estimated using the average slope of the water surface in a 275 foot reach of the stream downstream of the crossing. The slope used was 0.000327.

FINDINGS

The analysis performed indicates an improved condition with the proposed conditions for the 1 percent (100 year) storm condition. The attached summary table describes this improvement.

APPENDICES

SUMMARY TABLE
LOCATION MAP AND MAP OF CROSS SECTIONS
SECTION LOCATIONS
STREAM PROFILE & CROSS SECTIONS
HYDRAULIC CALCULATIONS
PHOTOGRAPHS
COMPUTER INPUT AND OUTPUT

SUMMARY TABLE

TRIBUTARY (SMITH DRAIN) TO WILLOW CREEK

100-YEAR FLOOD FREQUENCY: EXISTING VS. PROPOSED CONDITIONS
ELEVATIONS ARE IN NAVD88.

SEC NO	VELOCITY IN CHANNEL (FPS)		TOP WIDTH (FT)		ENERGY GRADE (FT)		CHANGE IN ENERGY (FT)	COMPUTED WSEL (FT)		CHANGE IN WSEL (FT)
	EX	PROP	EX	PROP	EX	PROP		EX	PROP	
80	1.90	1.99	62.85	62.09	671.16	671.04	-0.12	671.14	671.02	-0.12
70	1.71	1.79	69.28	68.00	671.11	670.99	-0.12	671.09	670.97	-0.12
60	1.47	1.53	64.24	63.11	671.10	670.98	-0.12	671.09	670.96	-0.13
50	2.98	2.42	56.78	56.18	671.08	670.96	-0.12	670.94	670.89	-0.05
BRIDGE										
40	3.40	2.57	31.19	31.33	670.98	670.91	-0.07	670.80	670.83	0.03
30	2.33	2.33	28.60	28.60	670.90	670.90	0.00	670.82	670.82	0.00
20	2.99	2.99	28.84	28.84	670.87	670.87	0.00	670.77	670.77	0.00
10	2.04	2.04	30.24	30.24	670.77	670.77	0.00	670.71	670.71	0.00

LOCATION MAP
AND
MAP OF CROSS SECTIONS

Haggerty Road over
Tributary (Smith Drain) to Willow Creek
CS 82292 – JN 115177

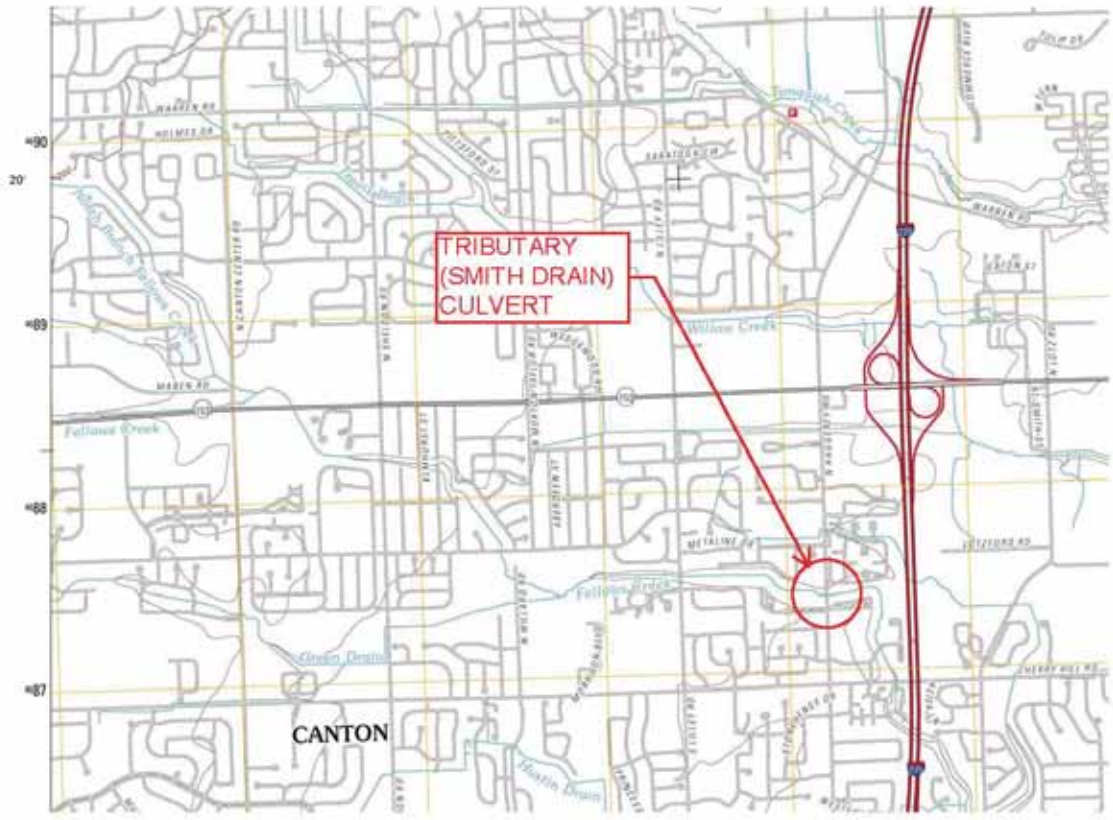


Figure 1 - Vicinity Map

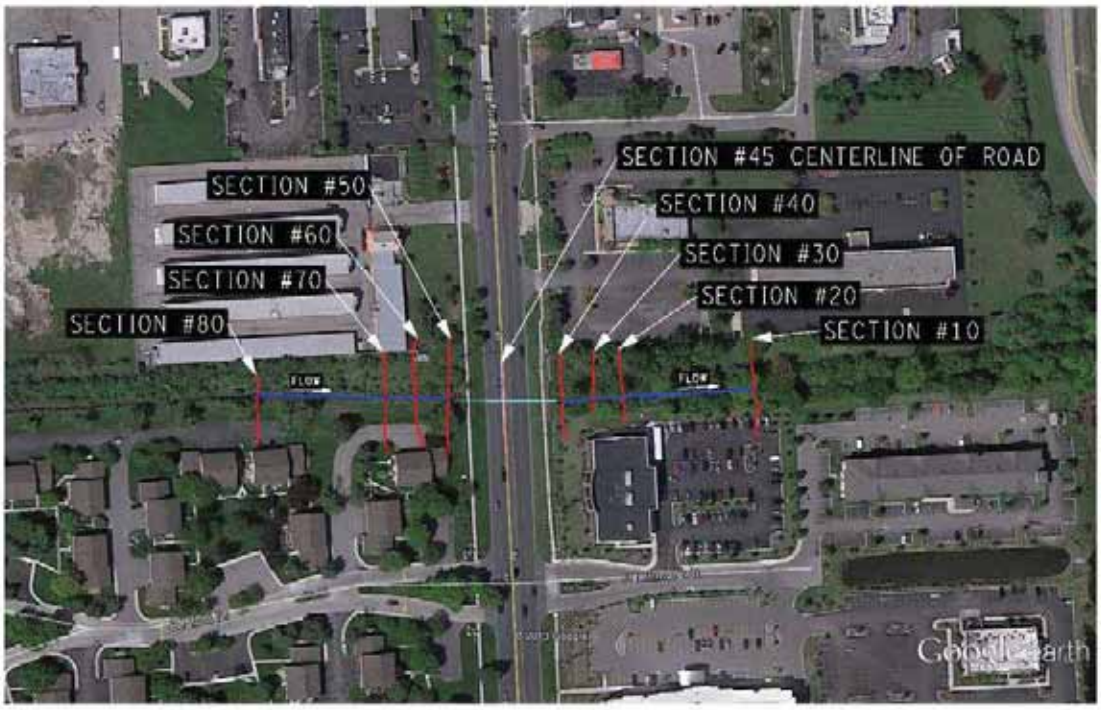
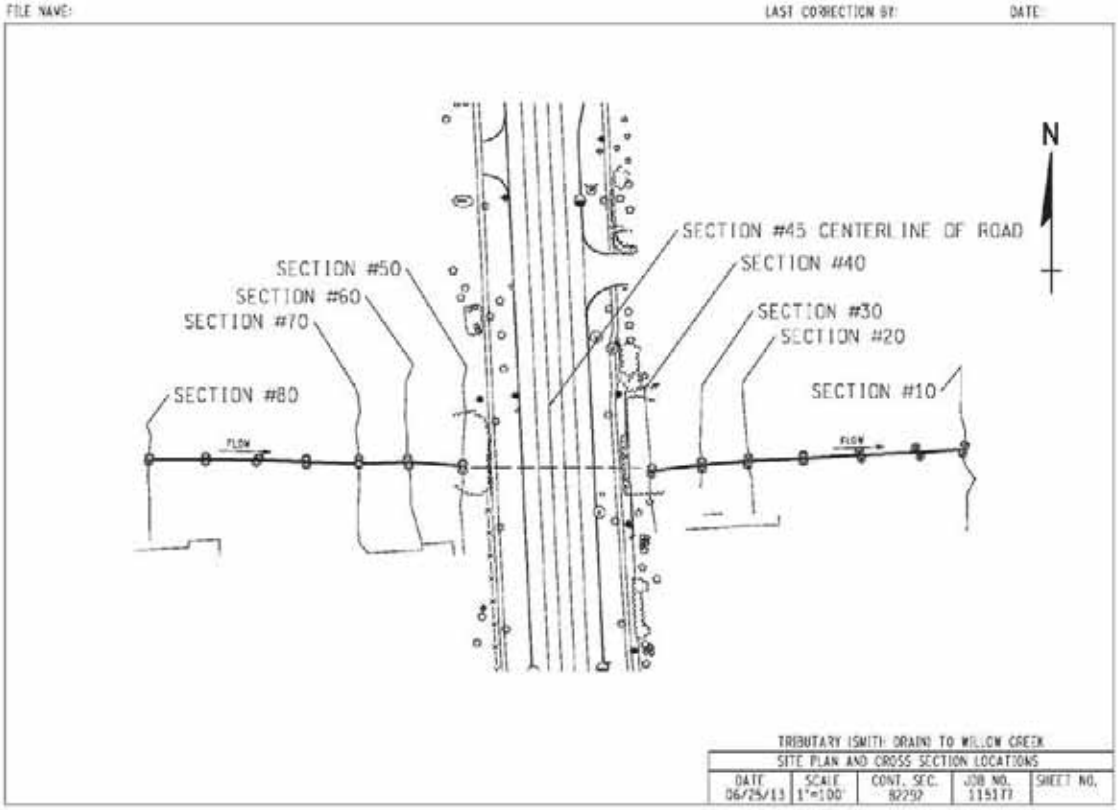


Figure 2 - Aerial Photo Showing Approximate Cross-Section Locations



STREAM PROFILE
& CROSS SECTIONS

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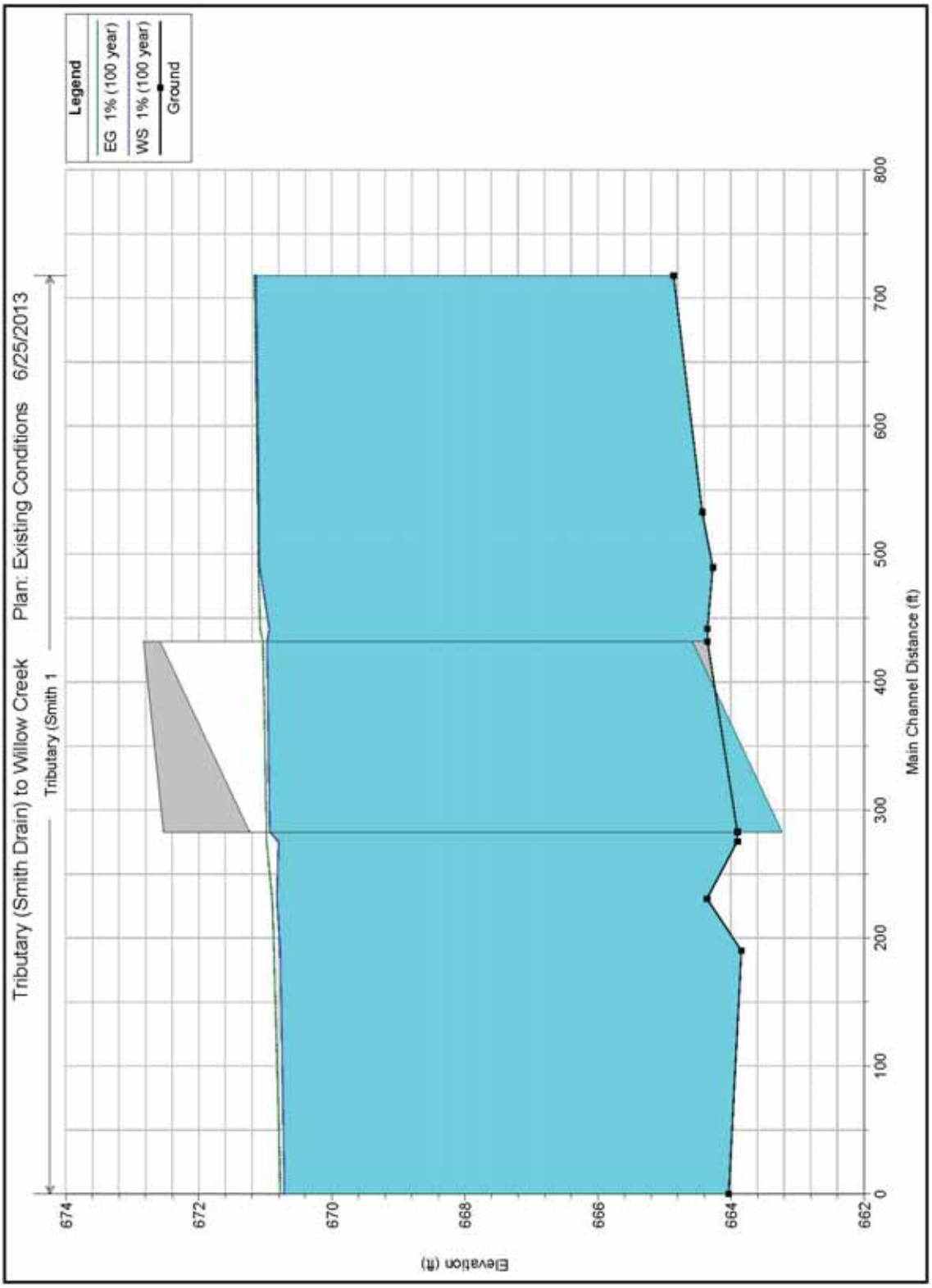
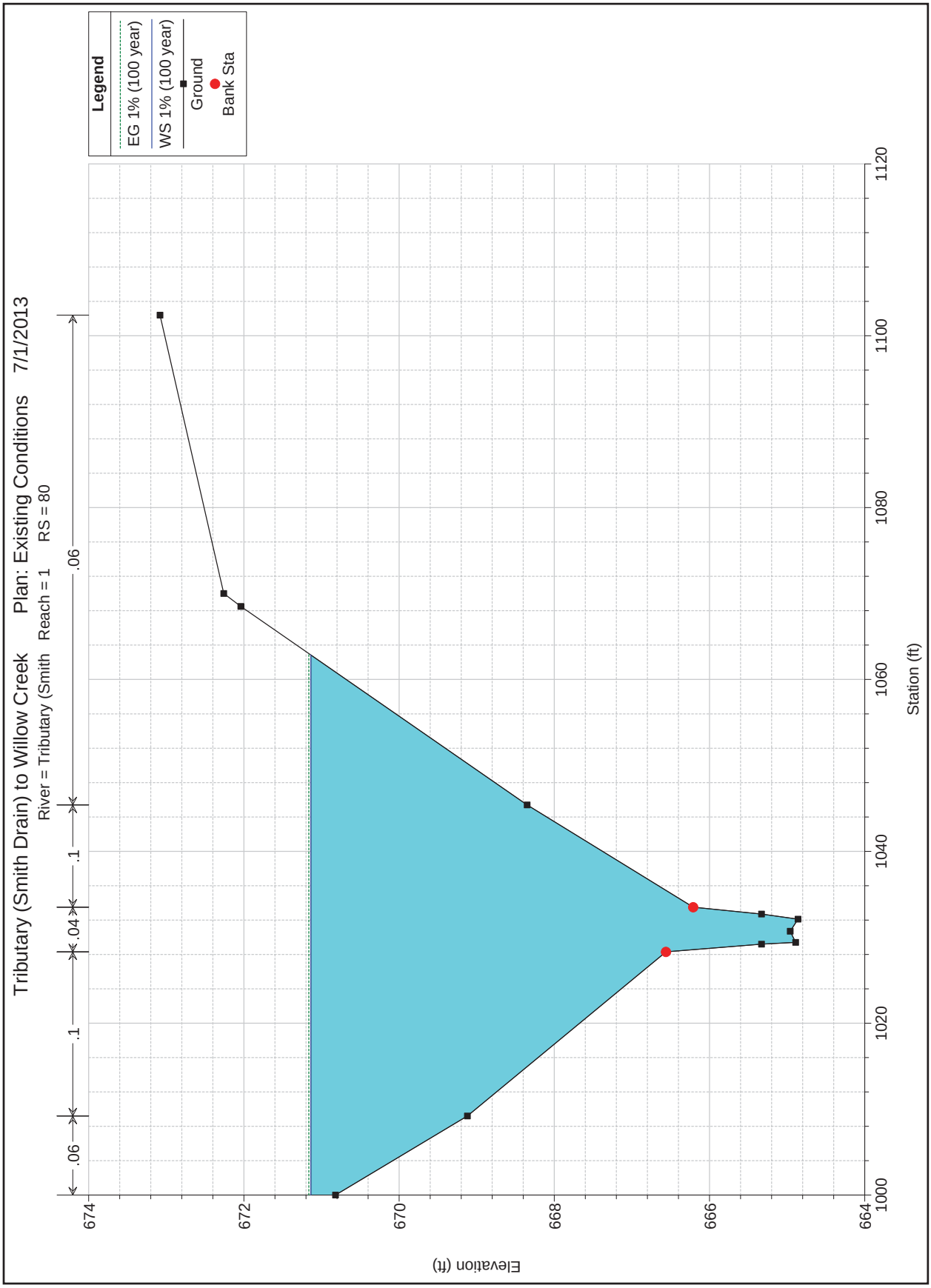

Tributary (Smith Drain) to Willow Creek Plan: Existing Conditions 6/25/2013
Tributary (Smith 1
Legend
EG 1% (100 year)
WS 1% (100 year)
Ground
Elevation (ft)
Main Channel Distance (ft)
674
672
670
668
666
664
662
0
100
200
300
400
500
600
700
800



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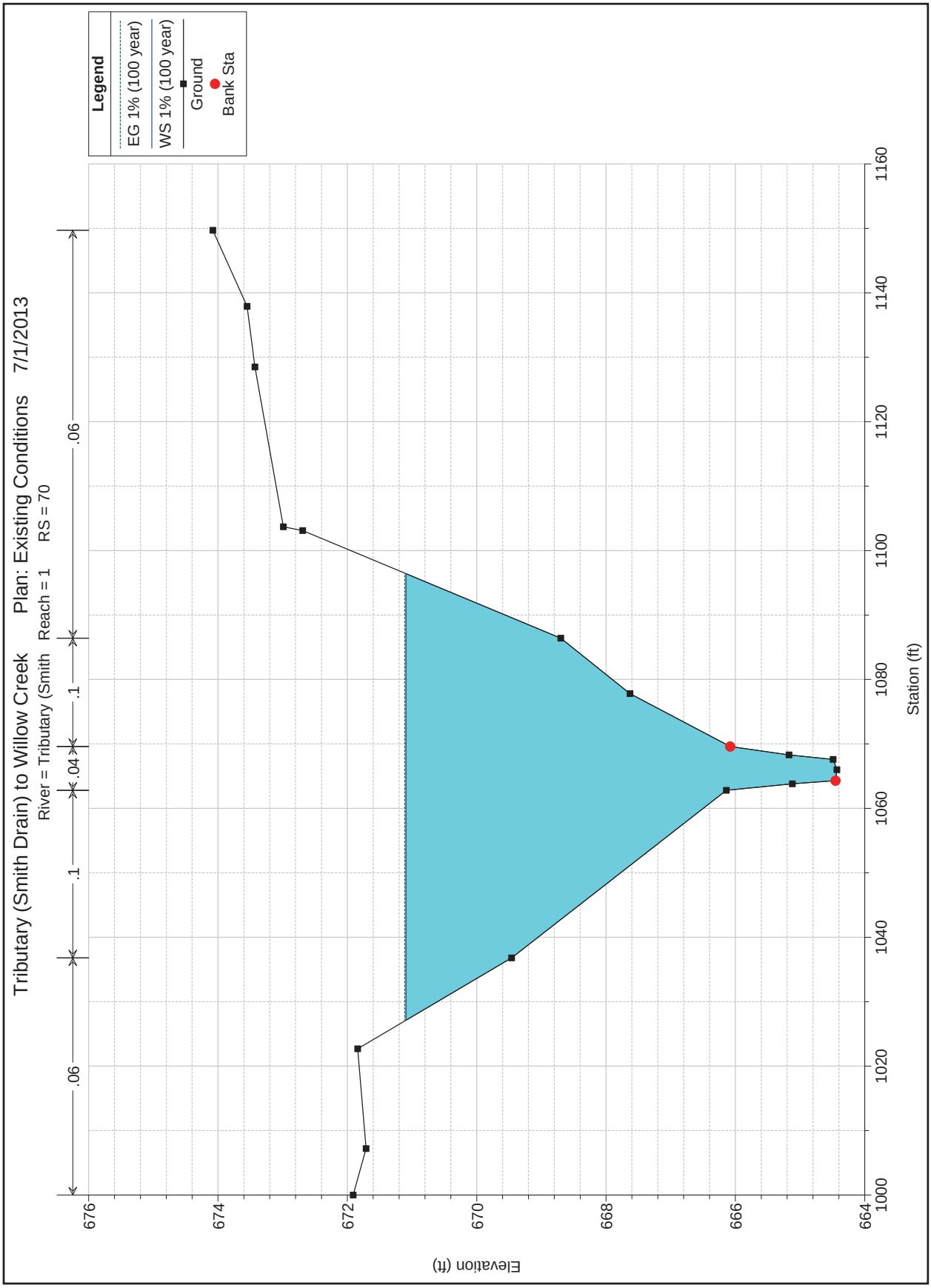

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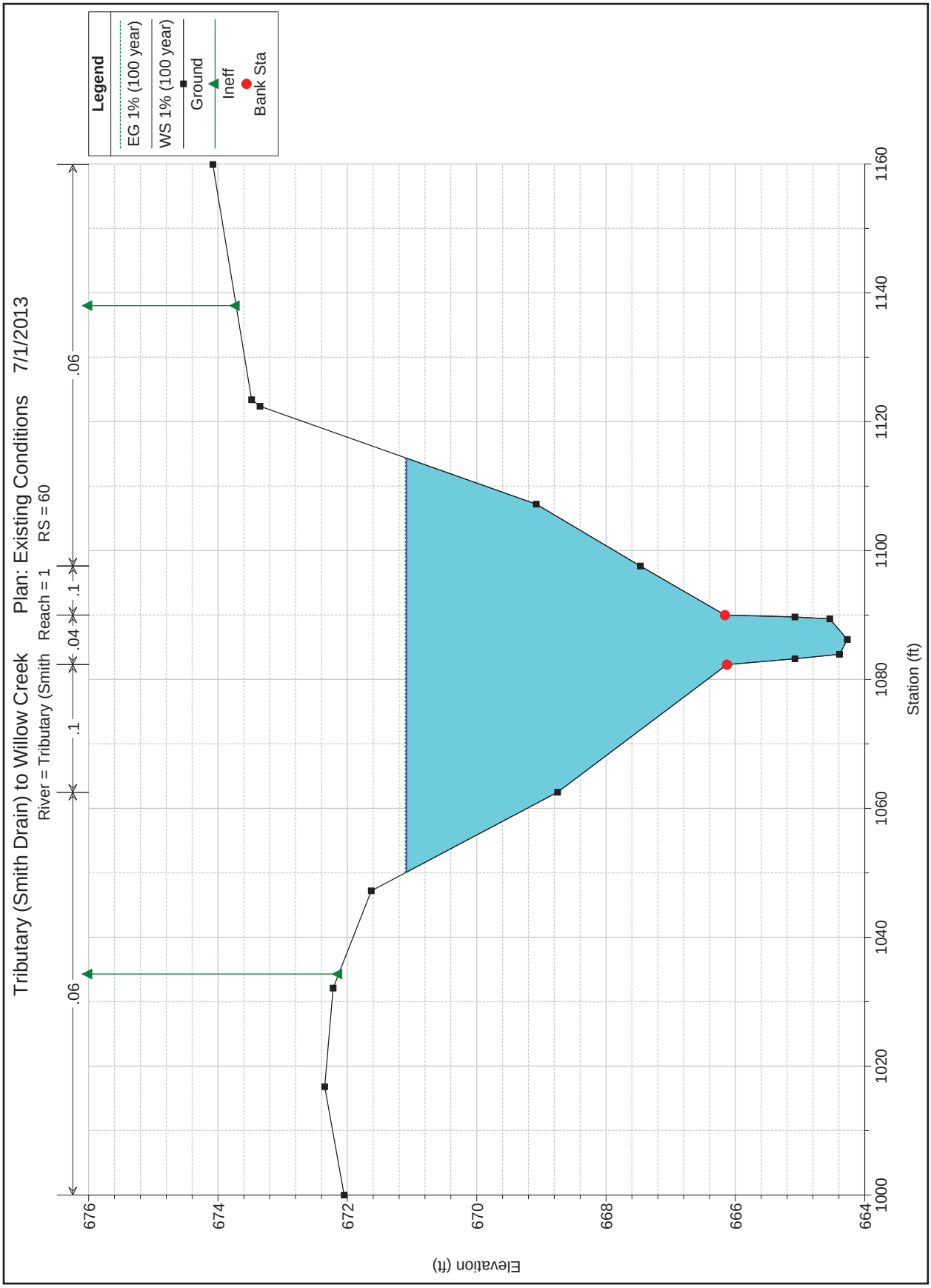

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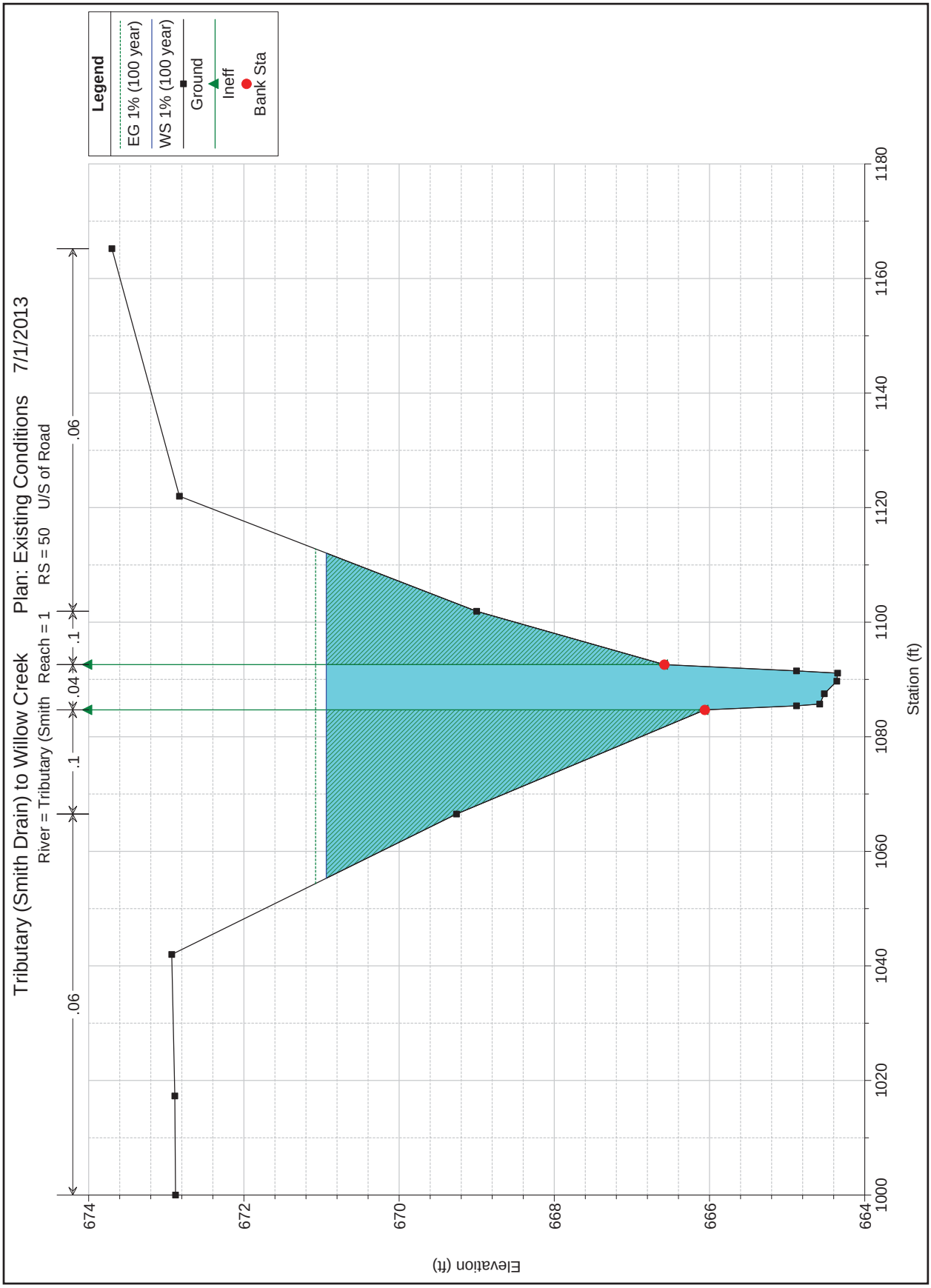

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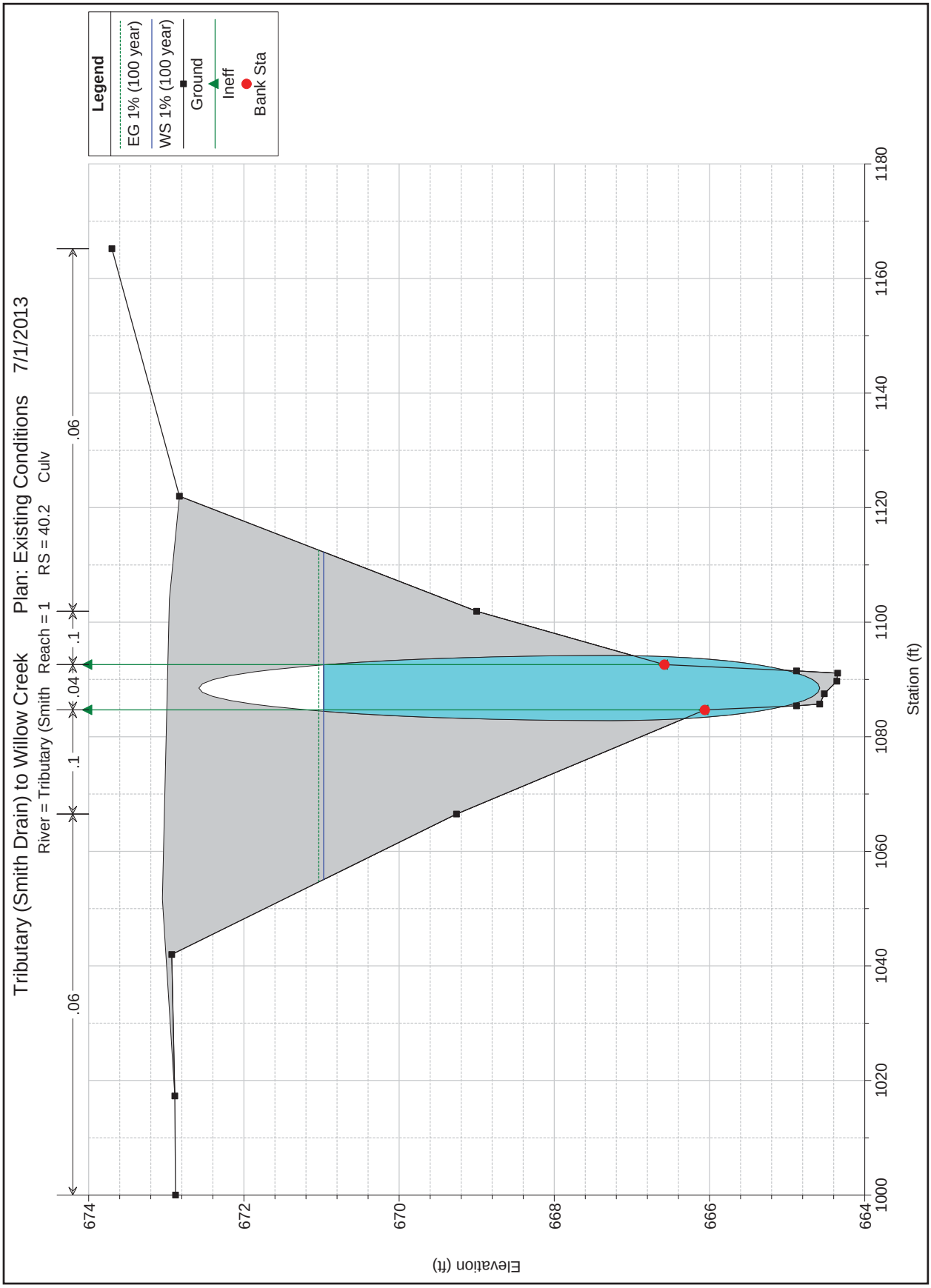

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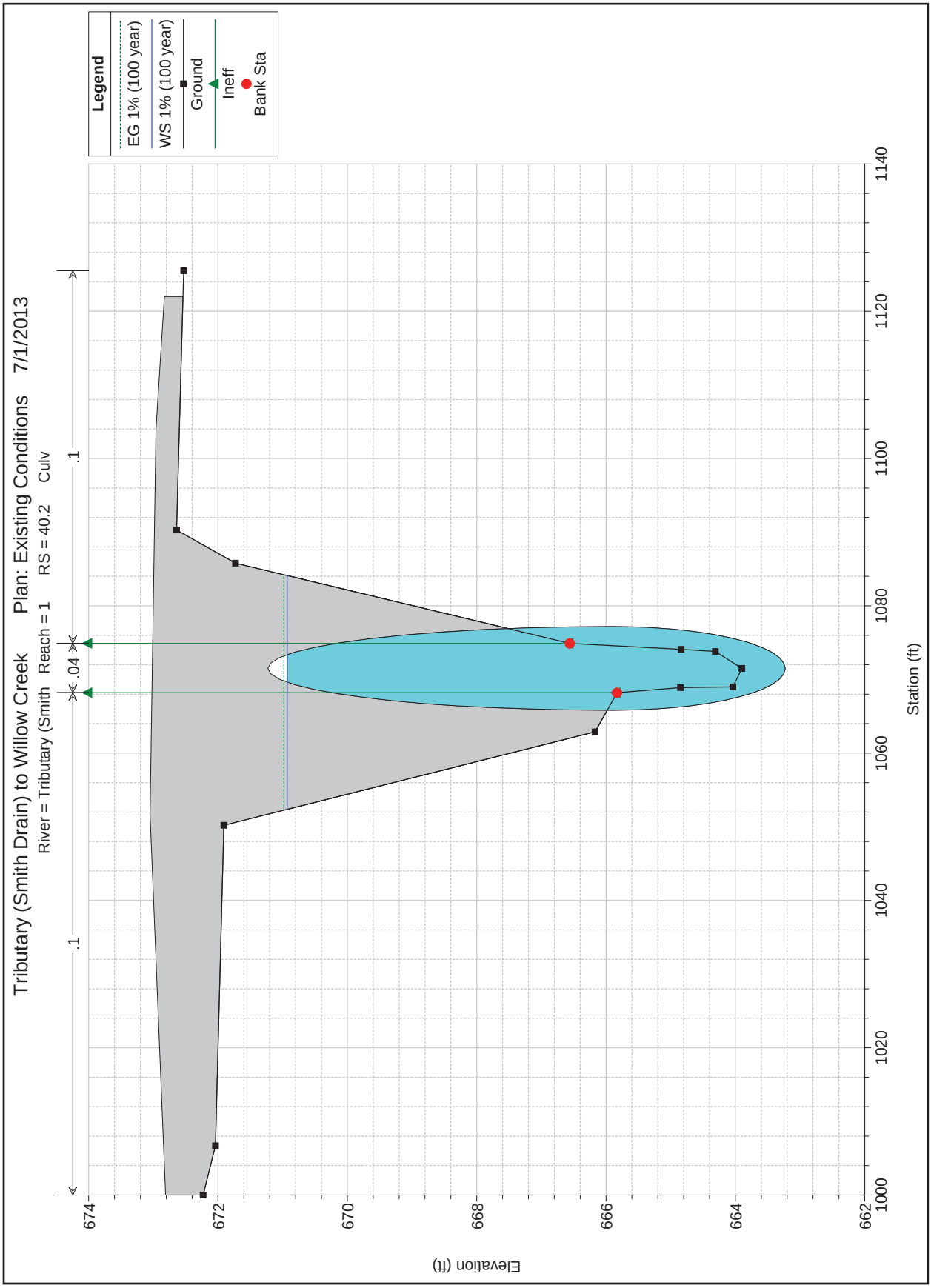

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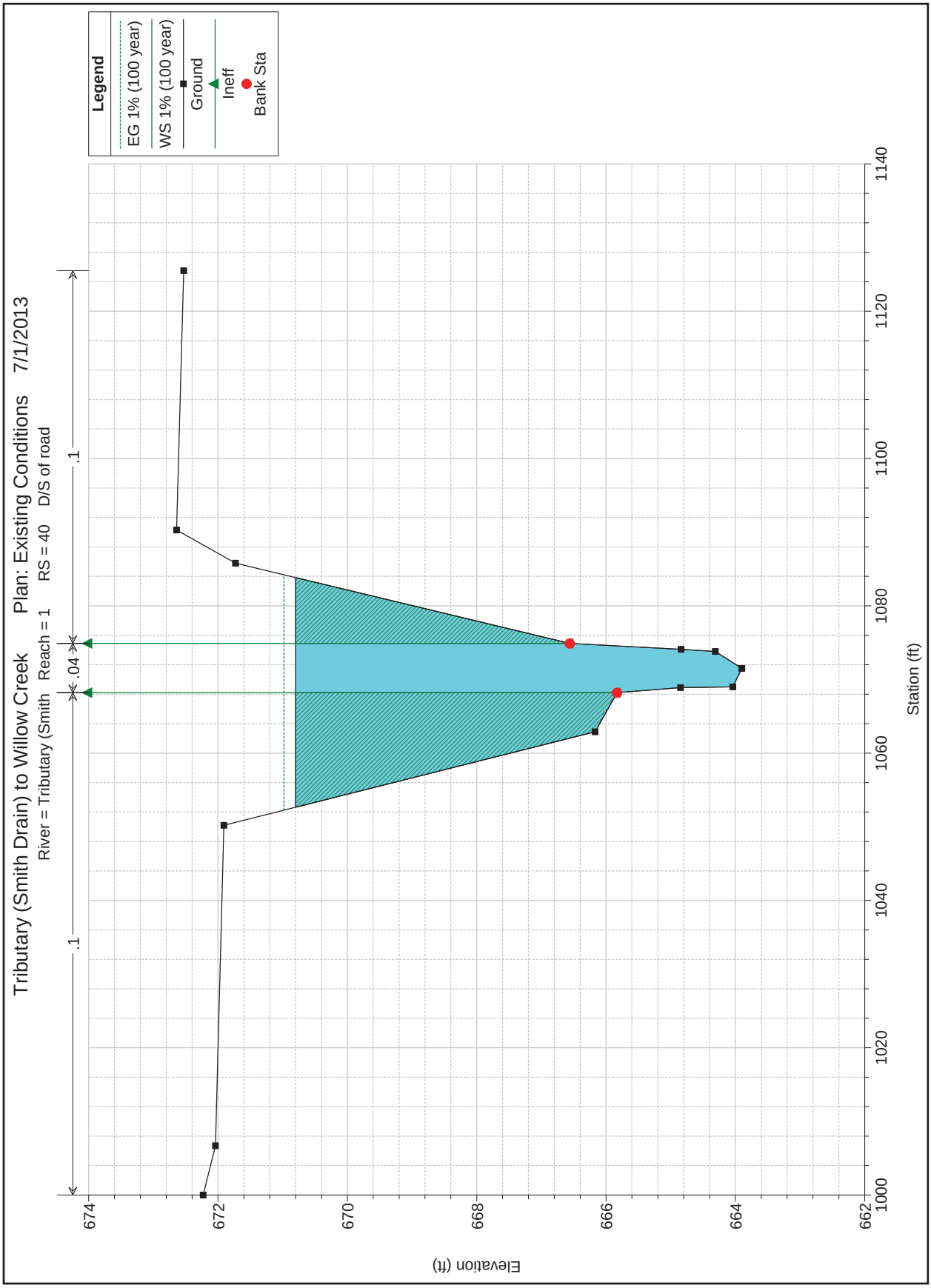

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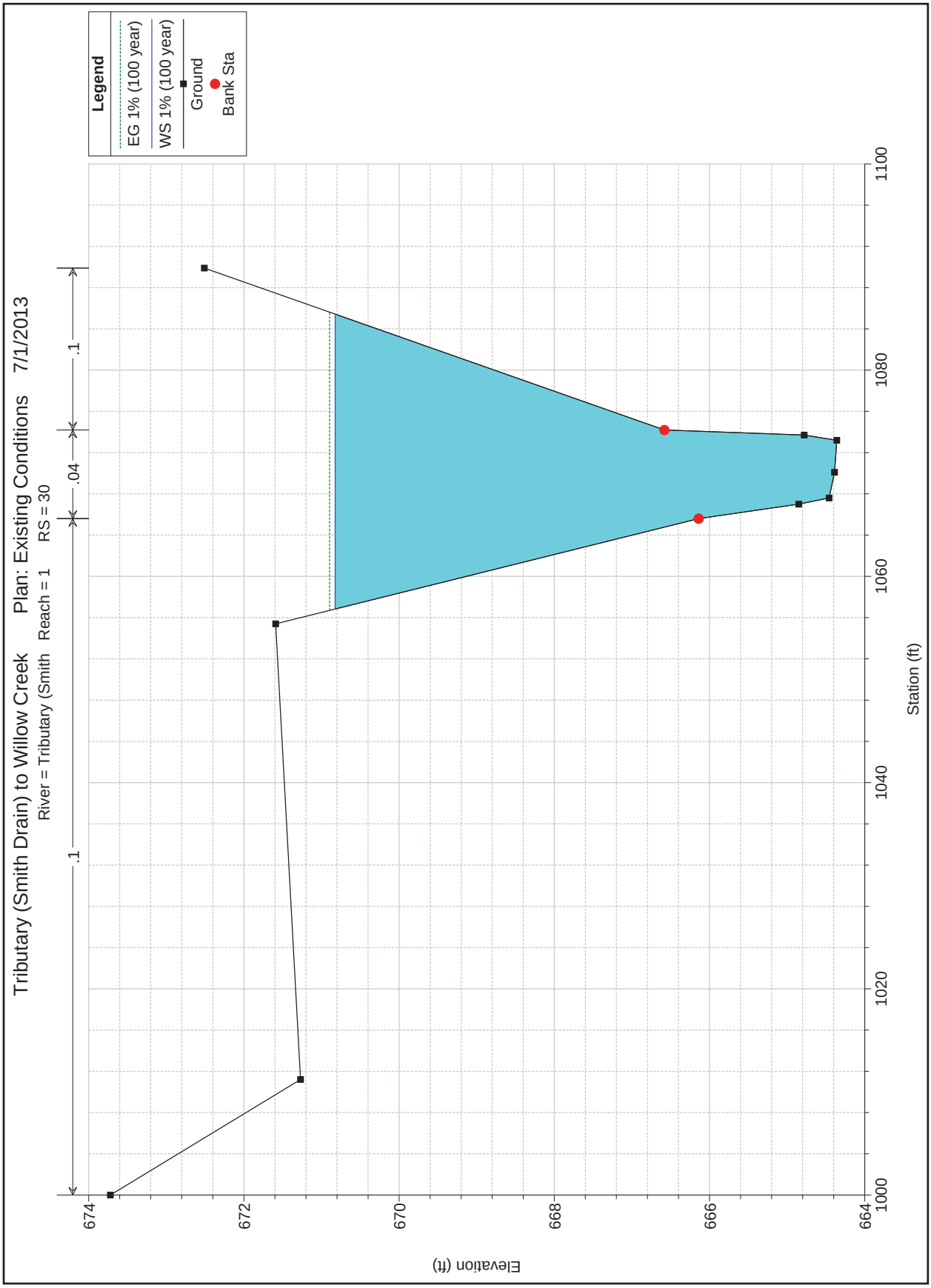

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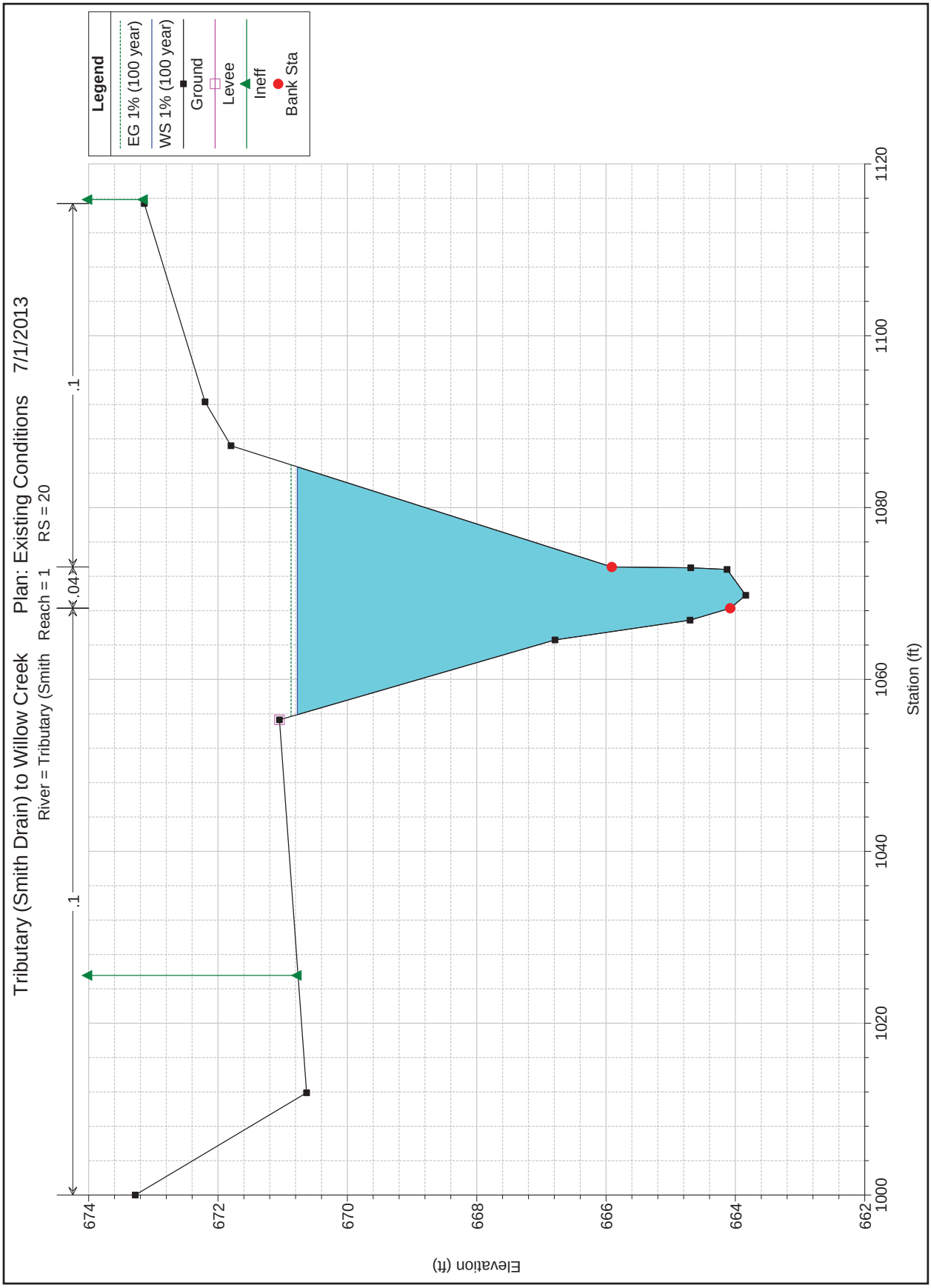

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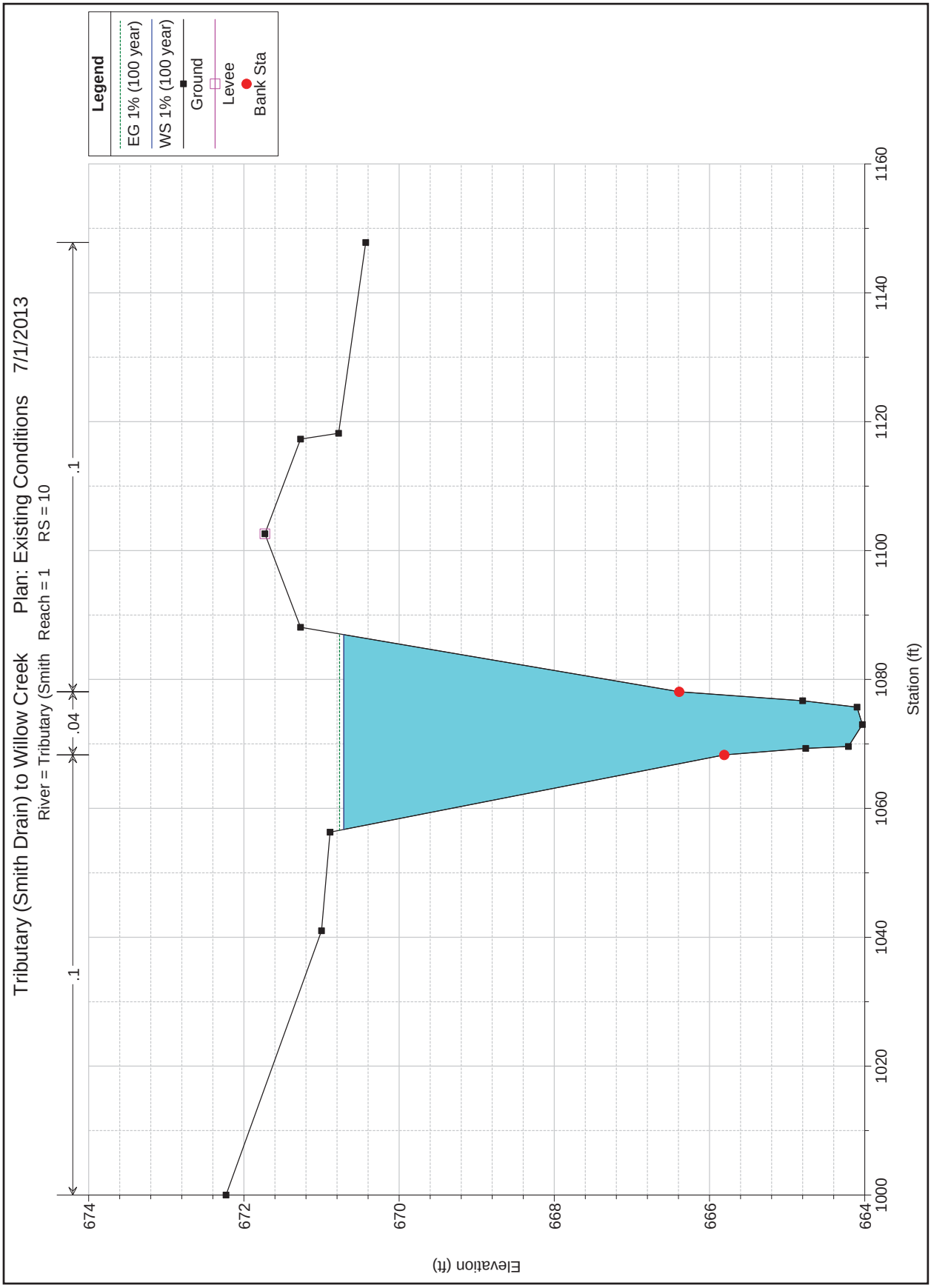

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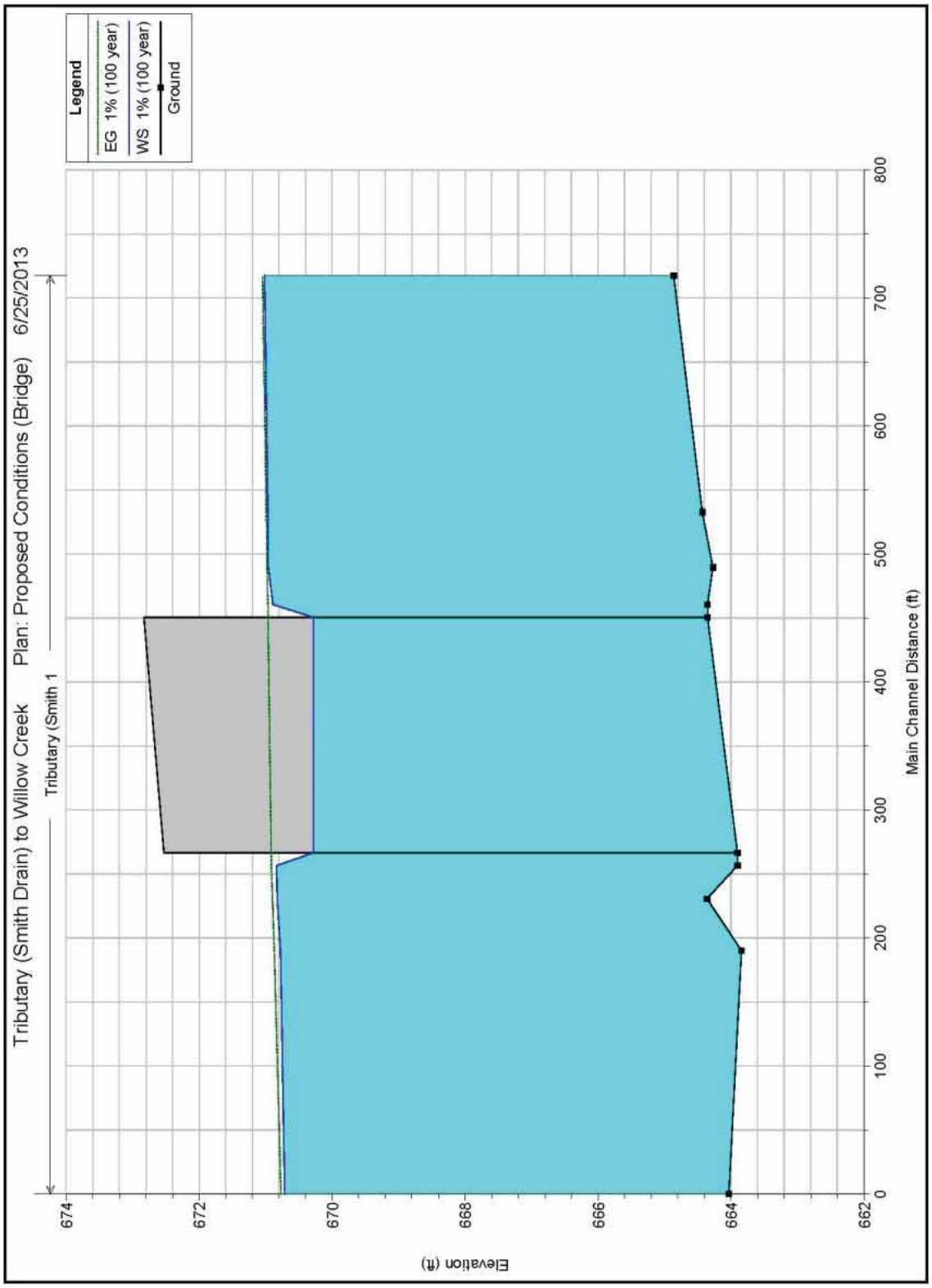
Tributary (Smith Drain) to Willow Creek Plan: Proposed Conditions (Bridge) 6/25/2013
Tributary (Smith 1
Legend
EG 1% (100 year)
WS 1% (100 year)
Ground
Elevation (ft)
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674
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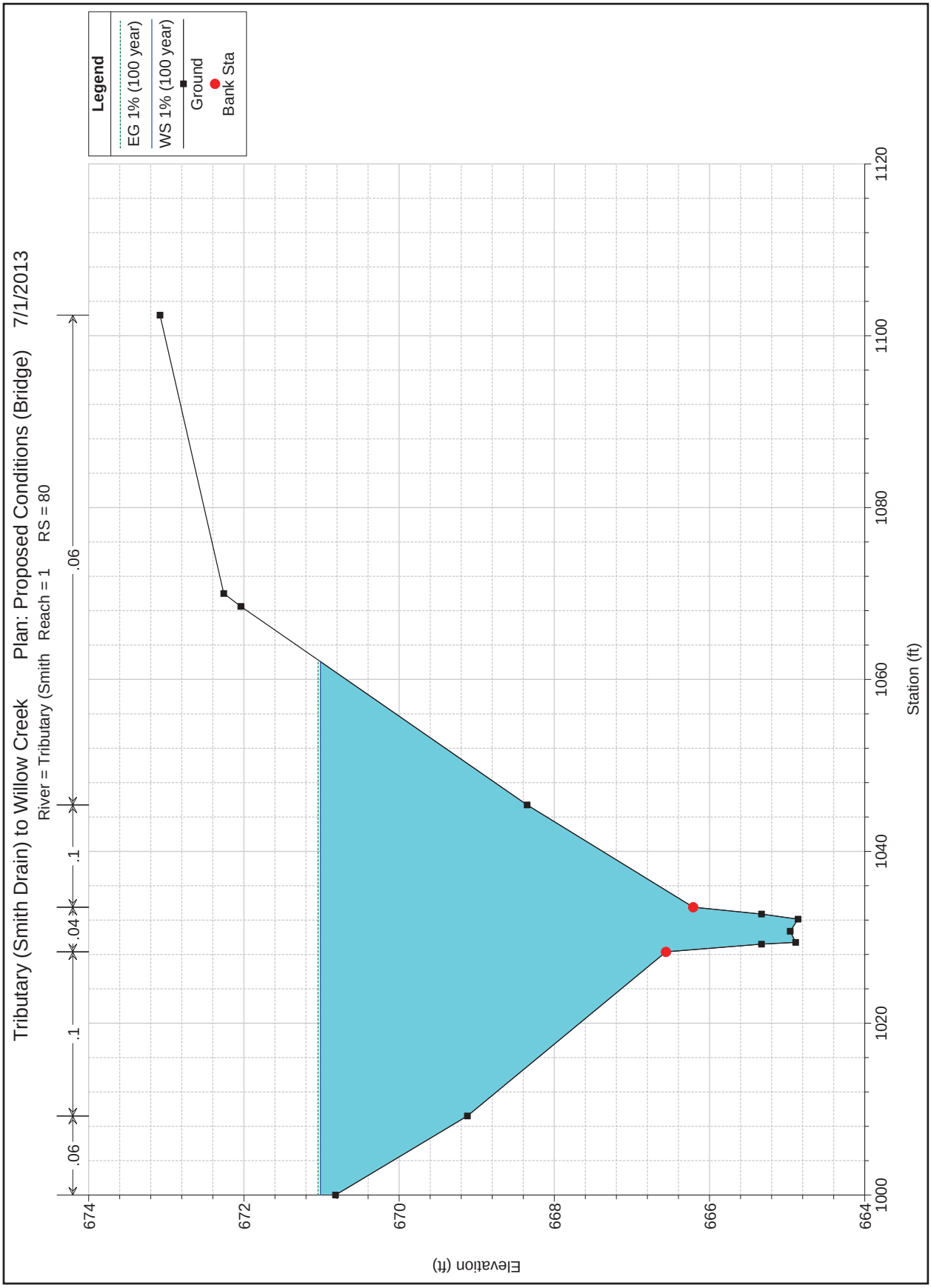

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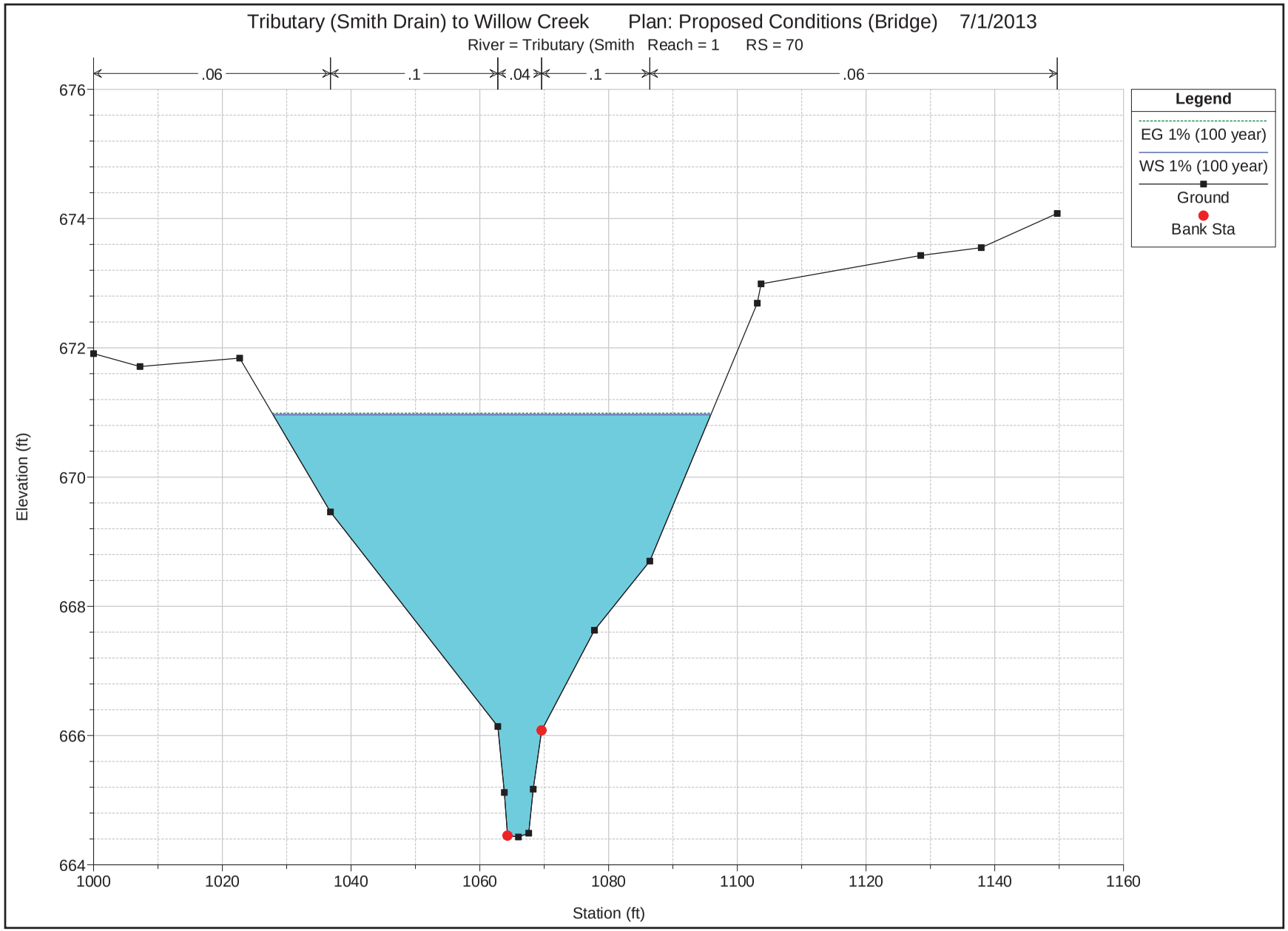

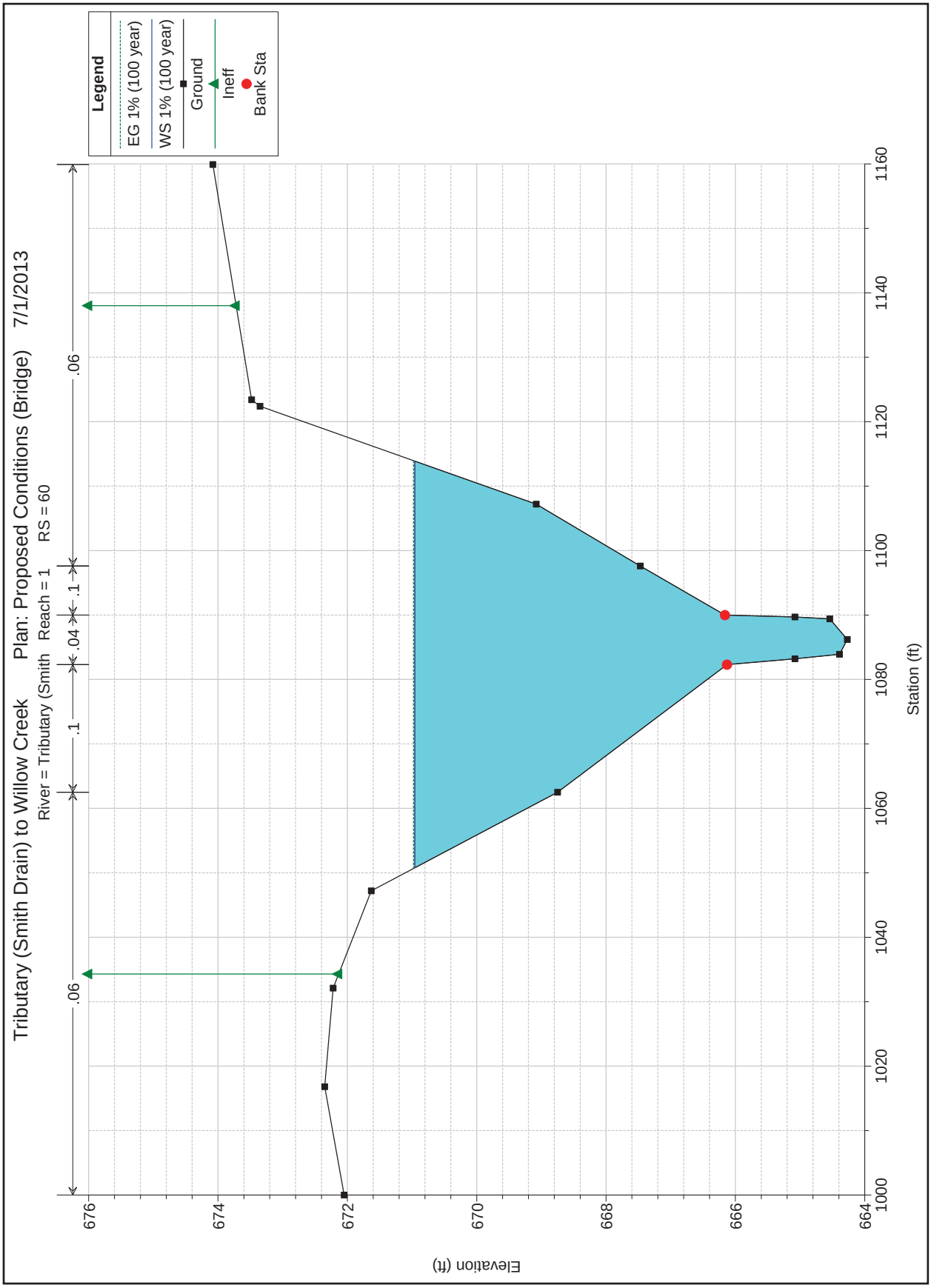

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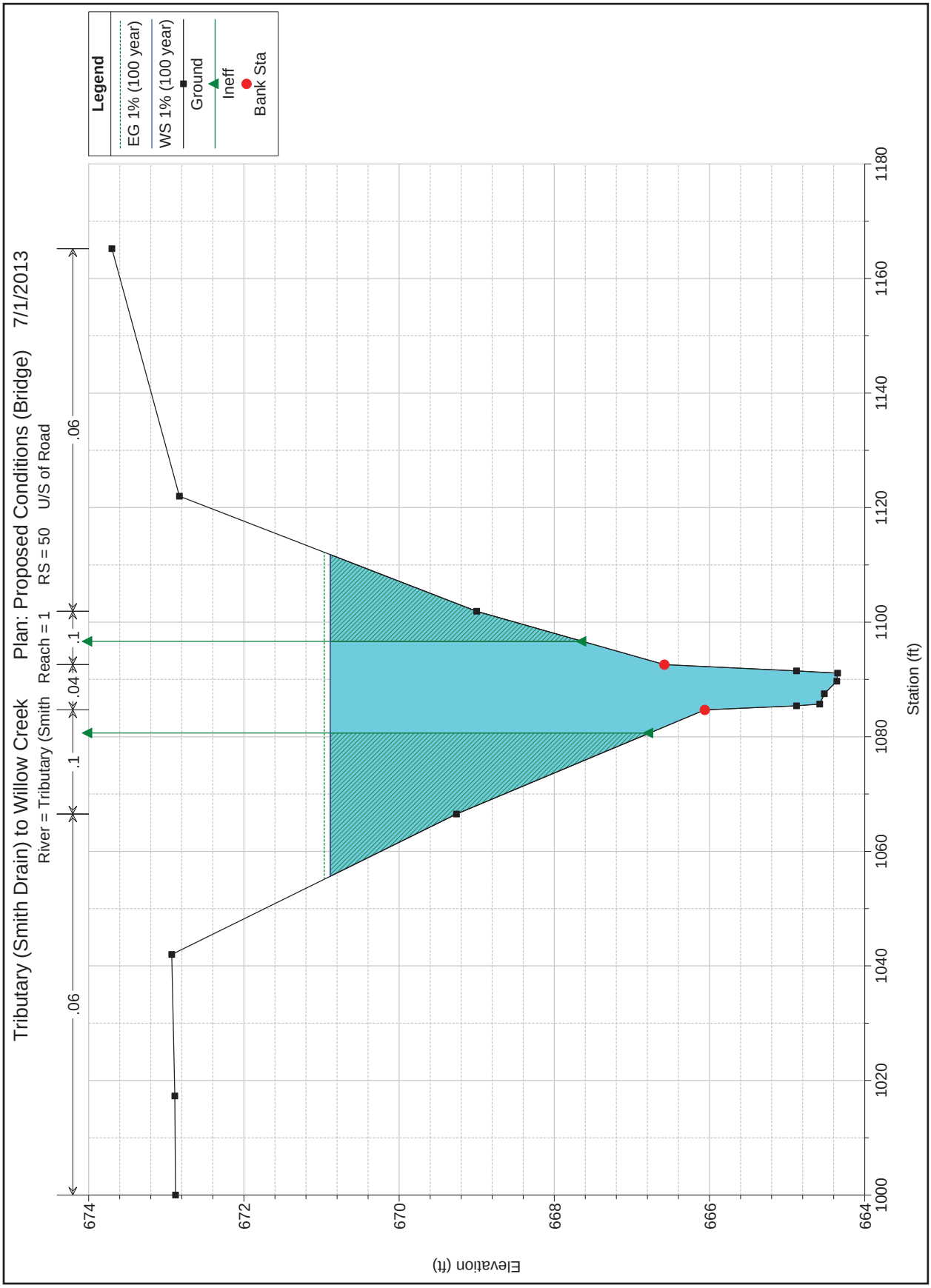

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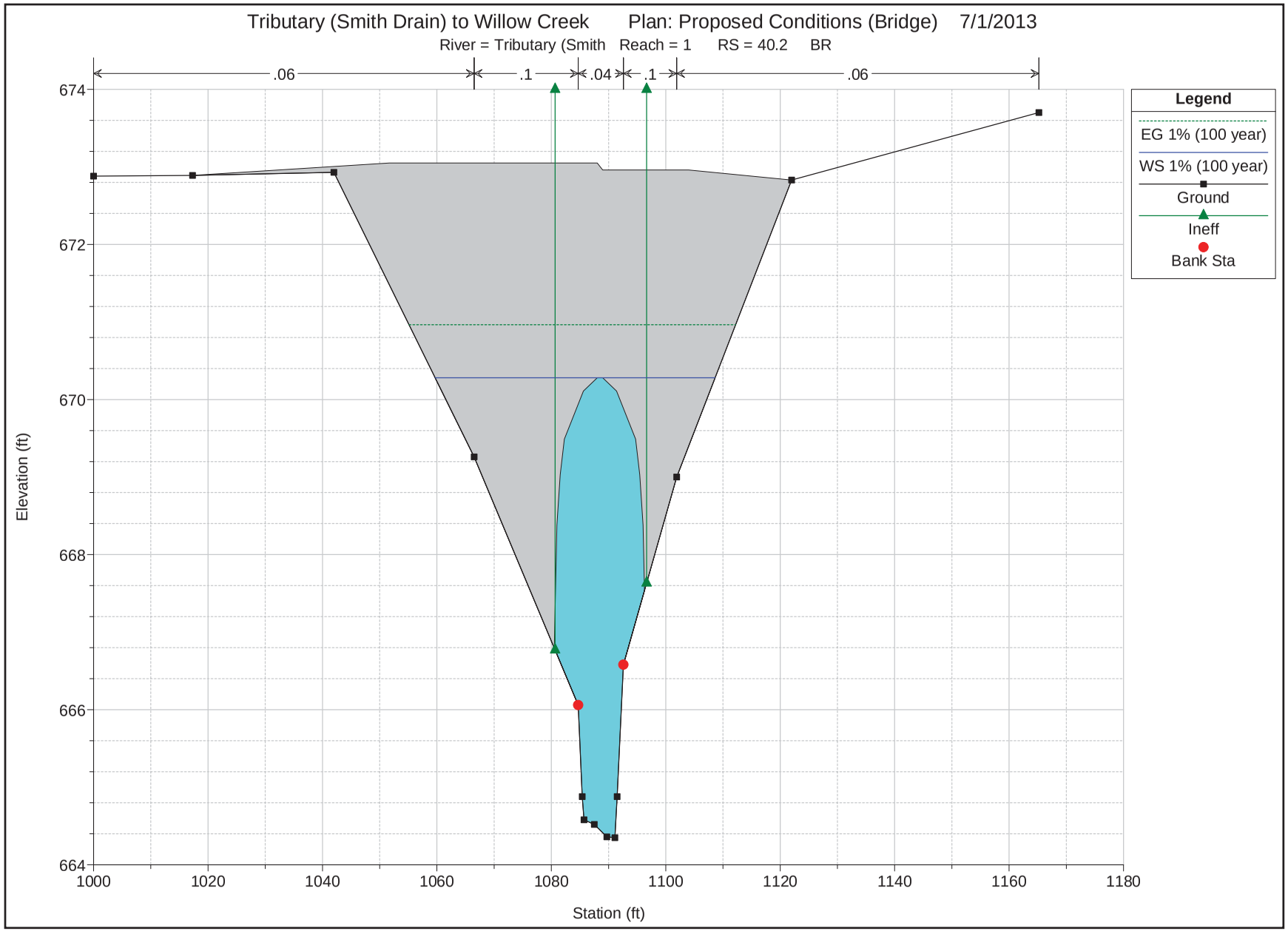

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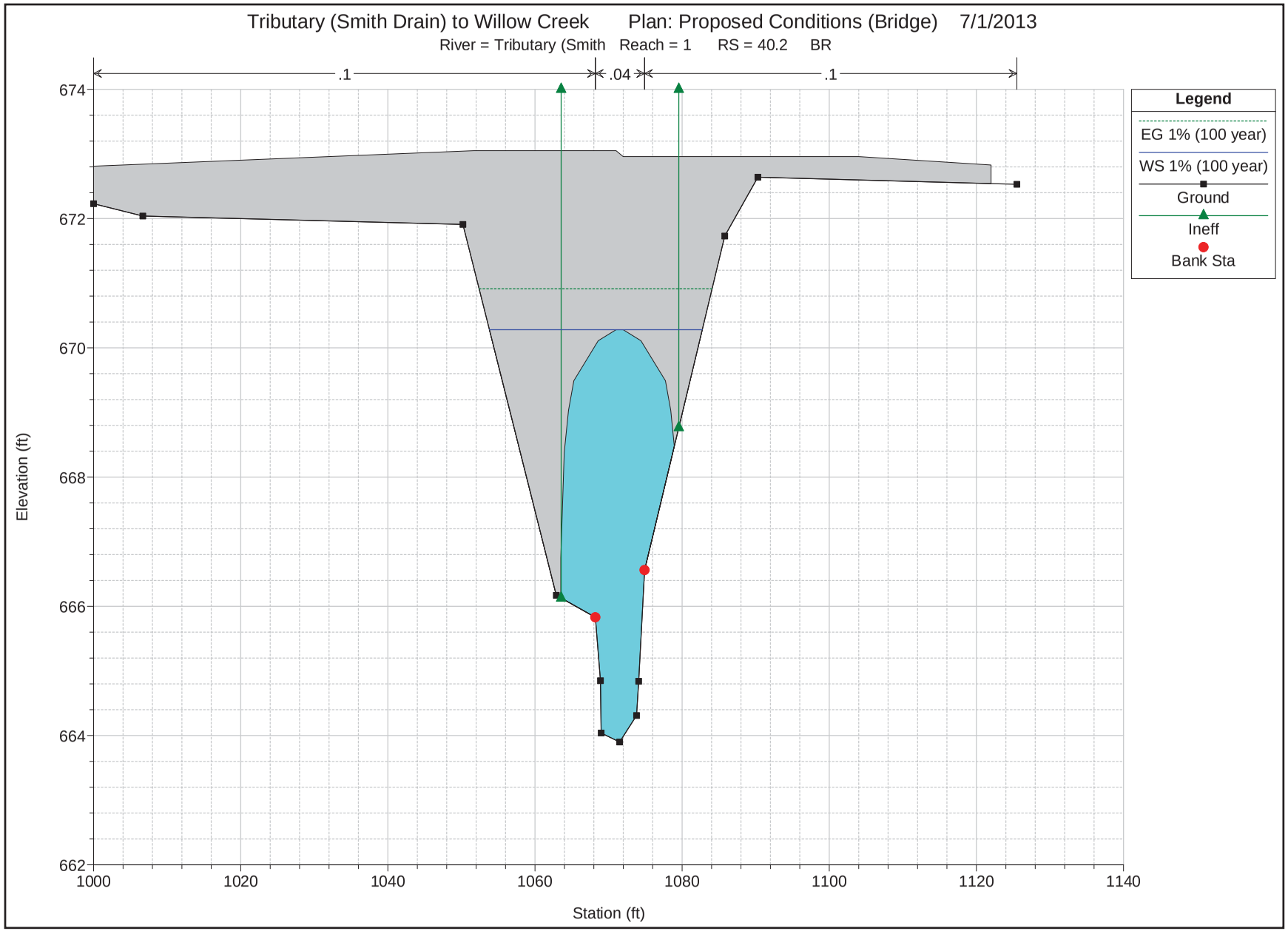

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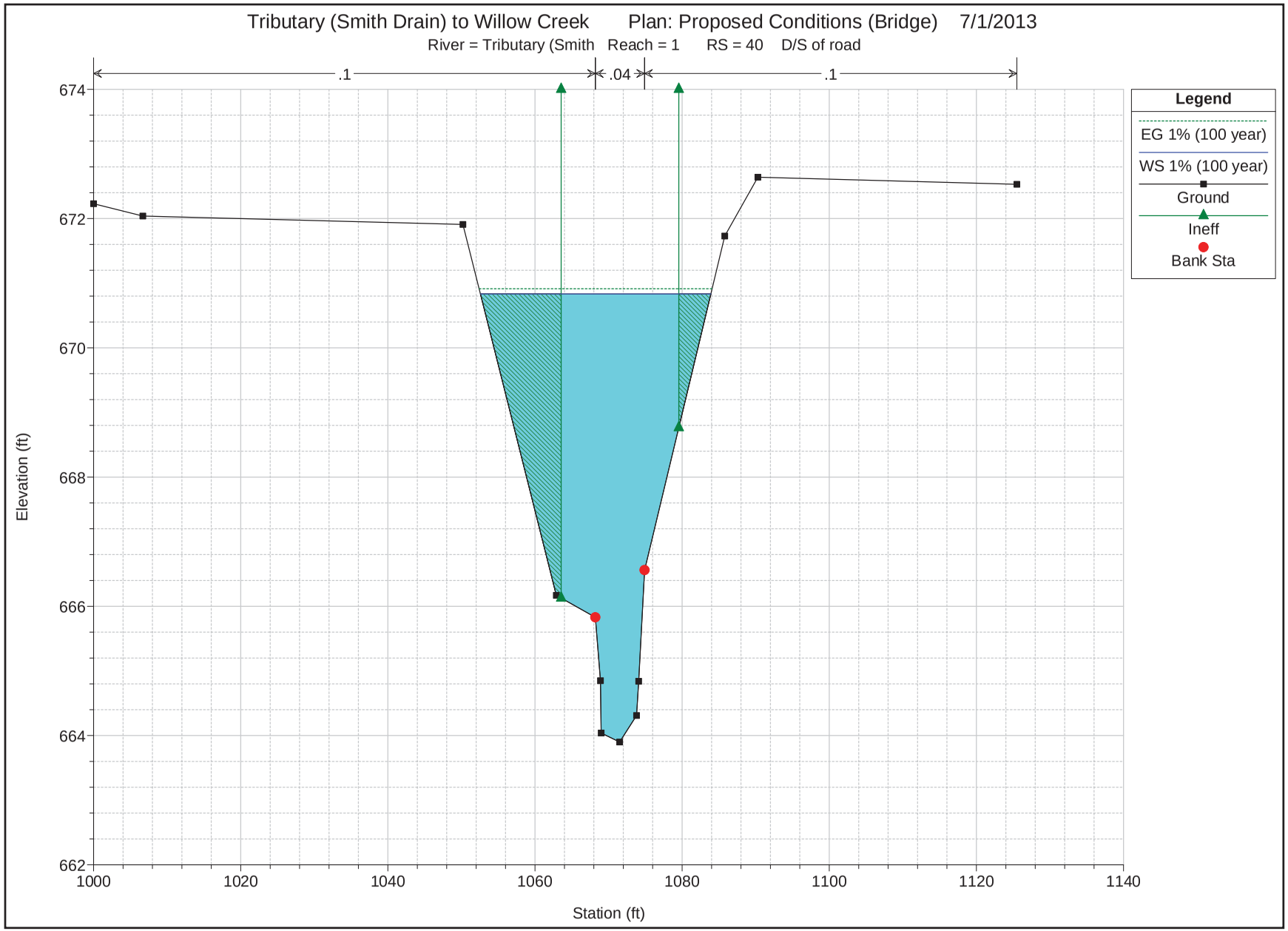

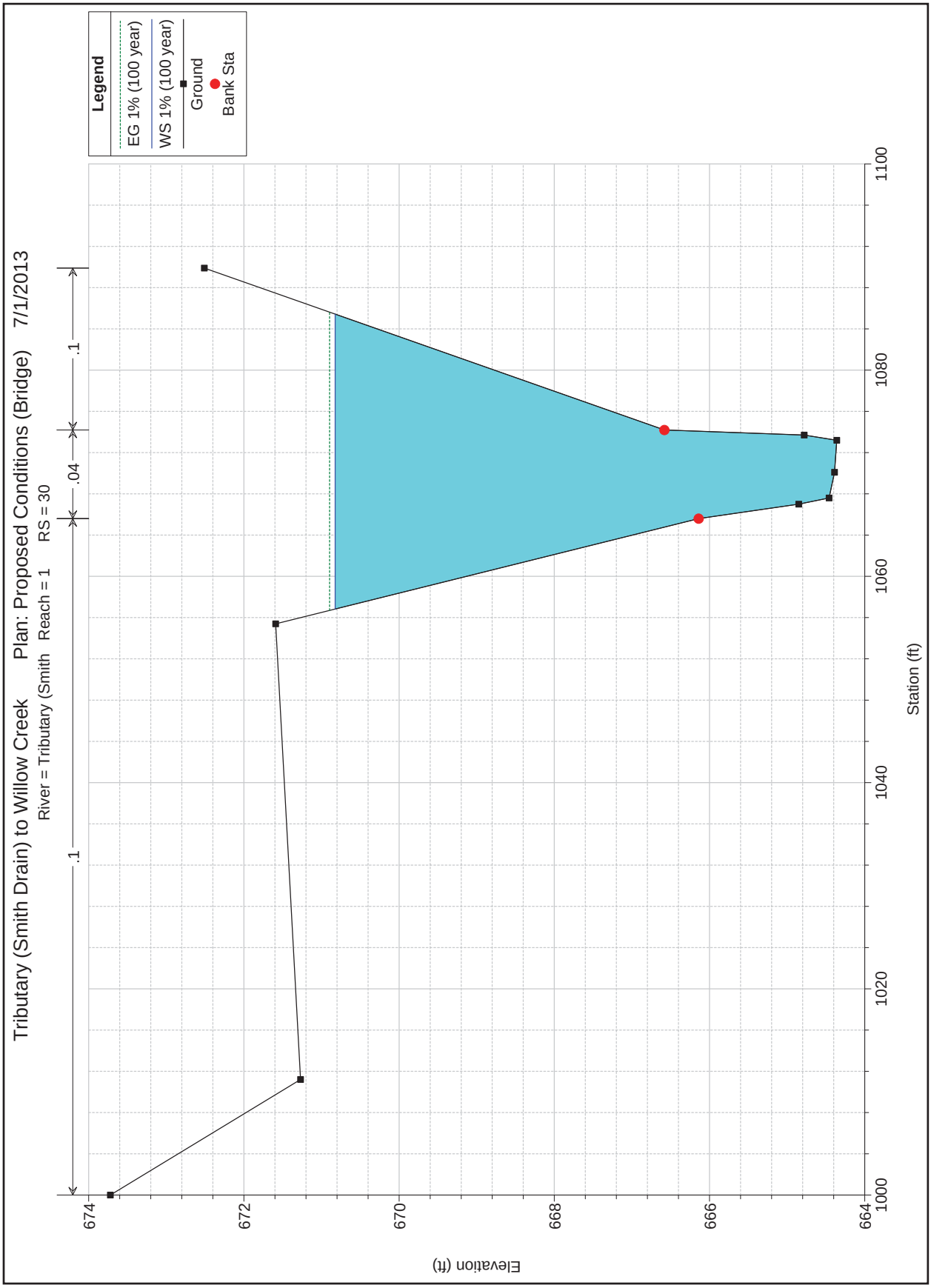

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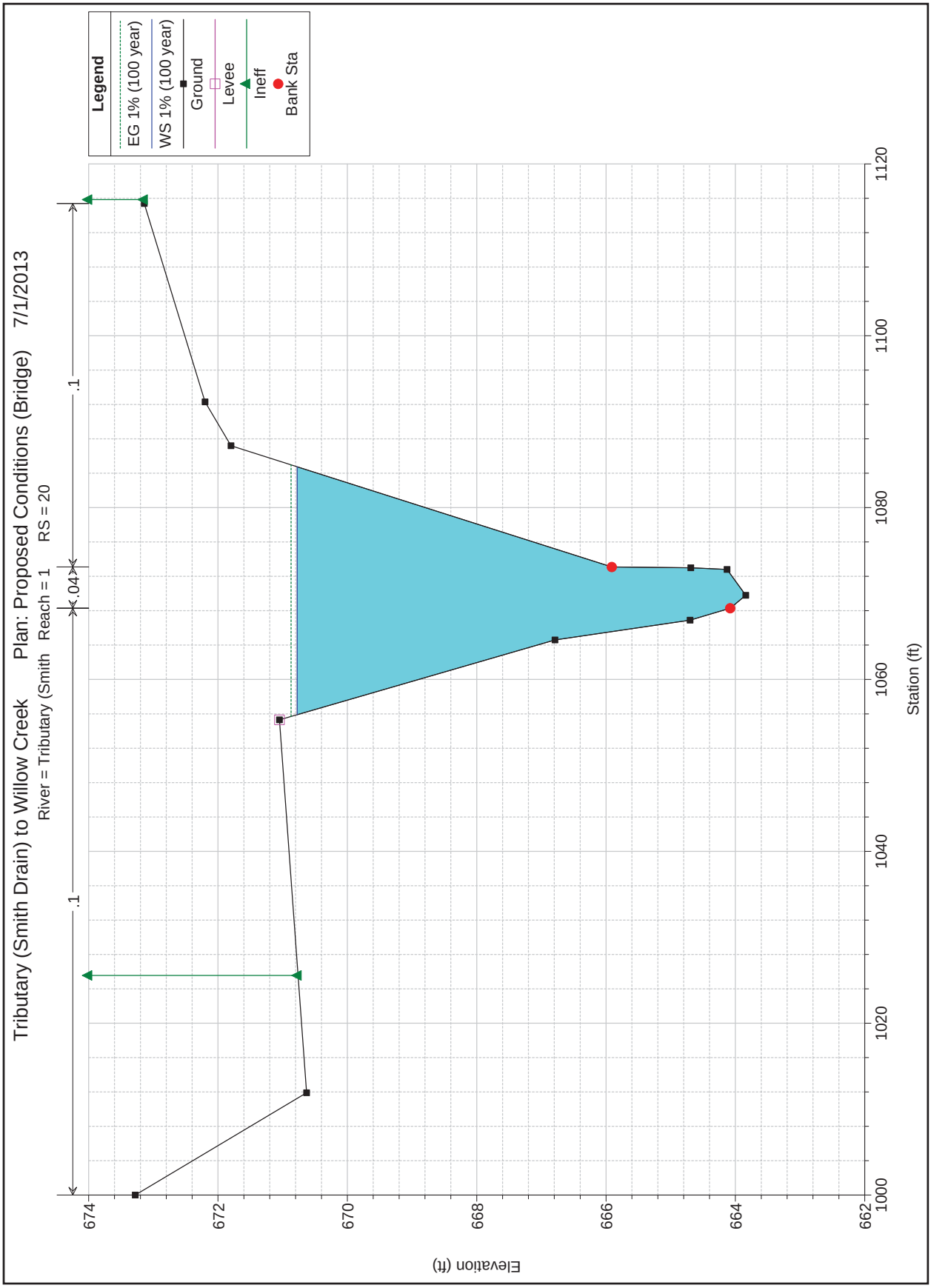

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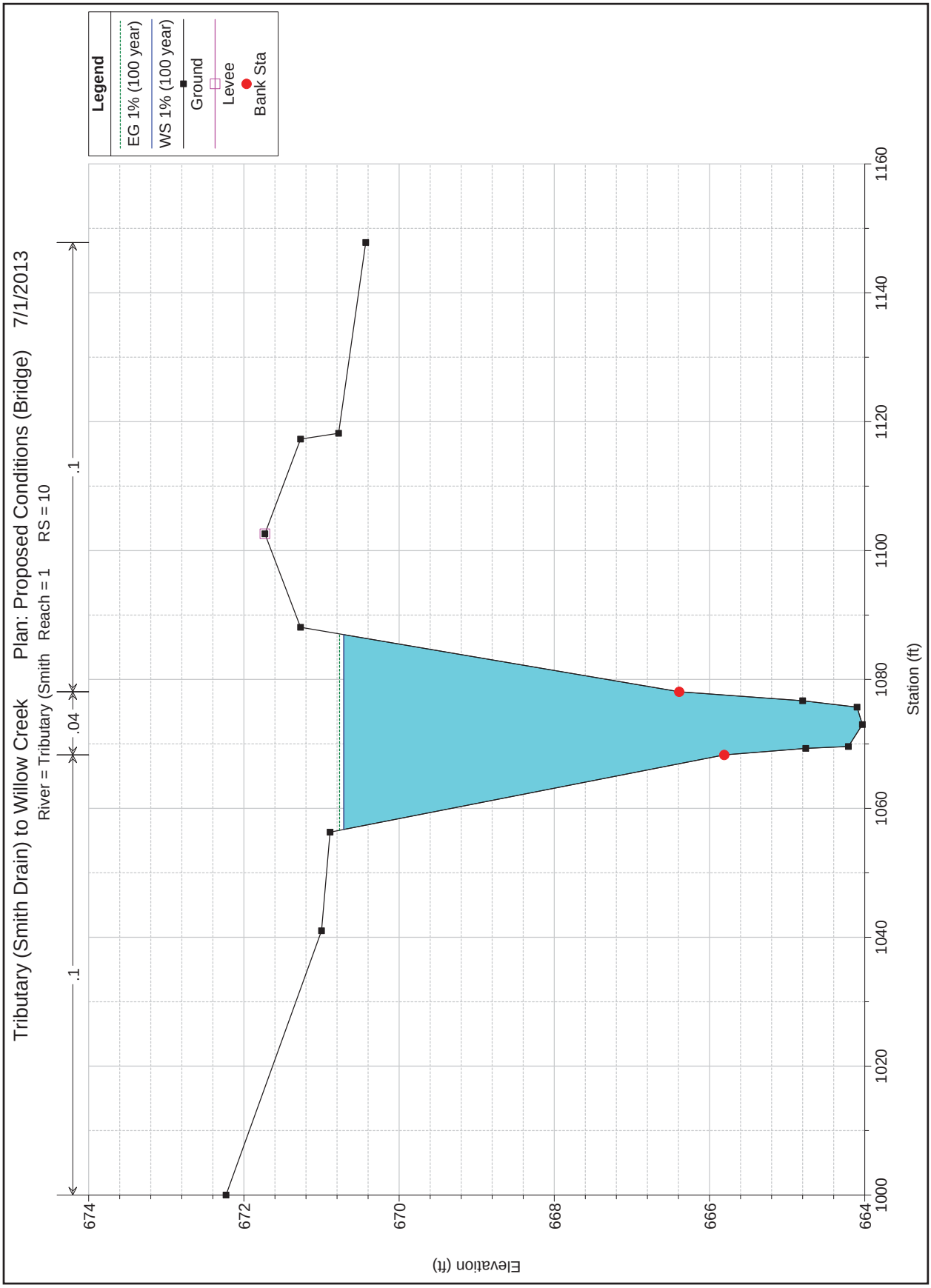

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HYDRAULIC CALCULATIONS
DISCHARGE ESTIMATES

Climate Zones & Rainfall Depths
Computing Flood Discharges for Small Ungaged Watersheds – pgs. 5-6
Runoff Curve Numbers - *Computing Flood Discharges for Small Ungaged Watersheds – pg. 9*
Watershed and Flowpaths
Soil Map
Hydrologic Soil Group Table
Land Use Map
Hydrologic Soil – Cover Complex Map
SCS-92 Method Discharge Calculations
Tributary (Smith Drain) to Willow Creek Watershed

through the soil and is controlled by the horizons. The hydrologic soil groups, as defined by NRCS soil scientists, are:

A. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

B. Soils having moderate infiltration rates when thoroughly wetted and consisting of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes the downward movement of water or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Figure 3.1 - Climatic Zones for Michigan

Table 3.1 - Rainfall depths corresponding to the climatic zones in Figure 3.1

Zone	Annual probability storm depth, 24-hour duration (rainfall in inches)					
	50%	20%	10%	4%	2%	1%
1	2.39	3.00	3.48	4.17	4.73	5.32
2	2.09	2.71	3.19	3.87	4.44	5.03
3	2.09	2.70	3.21	3.89	4.47	5.08
4	2.11	2.62	3.04	3.60	4.06	4.53
5	2.28	3.00	3.60	4.48	5.24	6.07
6	2.27	2.85	3.34	4.15	4.84	5.62
7	2.14	2.65	3.05	3.56	3.97	4.40
8	2.37	3.00	3.52	4.45	5.27	6.15
9	2.42	2.98	3.43	4.09	4.63	5.20
10	2.26	2.75	3.13	3.60	3.98	4.36

Table 3.2 - Ratios for areal adjustment of point rainfall

Area (mi^2)	Ratio
10	1.000
15	0.978
20	0.969
25	0.964
30	0.960
35	0.957
40	0.953

Appendix B tabulates the hydrologic soil group for many soil series as of March 1990, and is presented as an example only. See below for information on obtaining current soils data

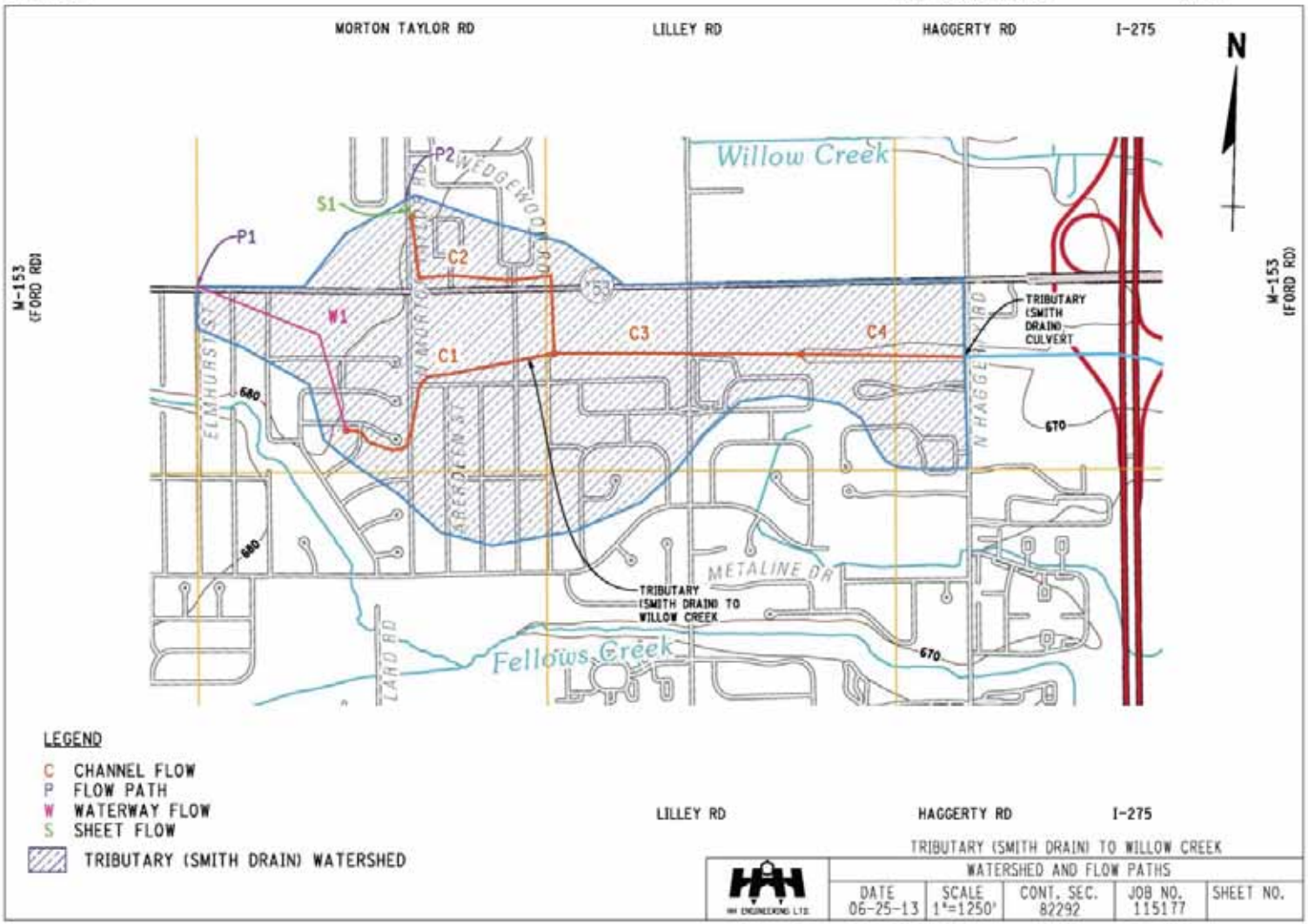
As shown in Appendix B, in some cases, several possible hydrologic soil groupings may be listed for a soil series. When this occurs, the first hydrologic group shown is the native or natural group under which the soil series is usually classified when its water intake characteristics have not been significantly changed by artificial drainage, land use, or other factors. The second group shown is the probable maximum improvement that can be made through artificial drainage and the maintenance or improvement of soil structure. For example, the Adrian soil series is classified as D/A. This means that the natural hydrologic soil group is D. If a field inspection shows that drains and tiles have been constructed to improve the drainage or a county drain has been installed nearby, then the hydrologic soil group may be lowered to A. In general, those soils having several possible classifications are those with relatively high water tables so that artificial drainage measurably improves their ability to absorb rainfall and thus reduce runoff.

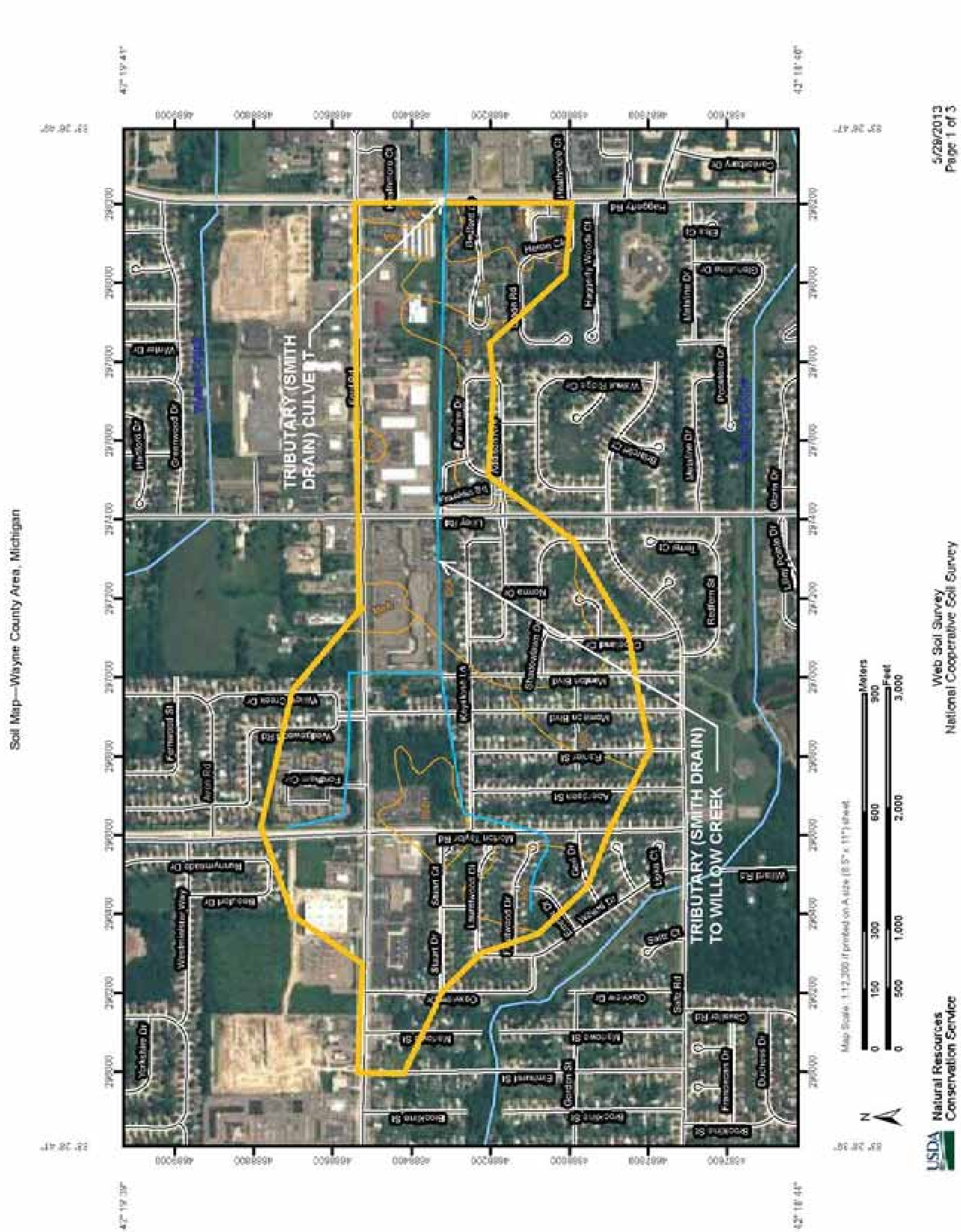
County soil surveys have been performed by the NRCS and were originally published in book form. Surveys published since 1970 show the soil type delineations superimposed on

Table 6.1 – Runoff curve numbers for hydrologic soil-cover complexes (AMC-II conditions)

Land use	Treatment or practice	Hydrologic condition	Hydrologic soil group			
			A	B	C	D
Fallow soil	Straight row		77	86	91	94
Row crops	Straight row	Poor	72	81	88	91
		Good	67	78	85	89
	Contoured	Poor	70	79	84	88
		Good	65	75	82	86
	Contoured and terraced	Poor	66	74	80	82
		Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	Contoured and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes or rotation meadow	Straight row	Poor	66	77	85	89
		Good	58	72	81	85
	Contoured	Poor	64	75	83	85
		Good	55	69	78	83
	Contoured and terraced	Poor	63	73	80	83
		Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
		Fair	30	59	75	83
		Good	30	35	70	79
Meadow			30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Residential	⅛ acre		77	85	90	92
	¼ acre		61	75	83	87
	1/3 acre		57	72	81	86
	½ acre		54	70	80	85
	1 acre		51	68	79	84
Open spaces (parks, golf courses, cemeteries, etc.)	Good condition: Grass cover > 75% of area		39	61	74	80
	Fair condition: Grass cover 50-75% of area		49	69	79	84
Commercial or business area (85% impervious)			89	92	94	95
Industrial district (72% impervious)			81	88	91	93
Farmsteads			59	74	82	86
Paved areas (roads, drive-ways, parking lots, roofs)			98	98	98	98
Water surfaces (lakes, ponds, reservoirs, etc.)			100	100	100	100
Swamp	At least 1/3 is open water		85	85	85	85
	Vegetated		78	78	78	78

Haggerty Road over
Tributary (Smith Drain) to Willow Creek
CS 82292 – JN 115177




Soil Map—Wayne County Area, Michigan
TRIBUTARY (SMITH DRAIN) CULVERT
TRIBUTARY (SMITH DRAIN) TO WILLOW CREEK
Haggerty Rd
Meters
Feet
Natural Resources
Conservation Service
Web Soil Survey
National Cooperative Soil Survey
5/28/2013
Page 1 of 3

Table—Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Wayne County Area, Michigan (MI602)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Ba	Belleville loamy fine sand	B/D	14.9	4.9%
BbB	Blount loam, 0 to 4 percent slopes	C	9.8	3.2%
BcA	Blount-Pewamo loams, 0 to 2 percent slopes	C	82.6	27.5%
Co	Corunna fine sandy loam	B/D	1.2	0.4%
KnA	Kibbie fine sandy loam, 0 to 3 percent slopes	B	0.4	0.1%
MeA	Metamora sandy loam, 0 to 3 percent slopes	B	16.5	5.5%
MfA	Metamora-Pewamo complex, 0 to 3 percent slopes	B	32.2	10.7%
Pe	Pewamo loam	C/D	128.2	42.6%
SeA	Selfridge loamy sand, 0 to 3 percent slopes	B	11.7	3.9%
TeA	Tedrow loamy fine sand, 0 to 2 percent slopes	B	2.5	0.8%
ThA	Thetford loamy sand, 0 to 2 percent slopes	A	0.9	0.3%
Totals for Area of Interest			300.9	100.0%

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Haggerty Road over
Tributary (Smith Drain) to Willow Creek
CS 82292 – JN 115177

FILE NAME:

LAST CORRECTION BY:

DATE:

MORTON TAYLOR RD

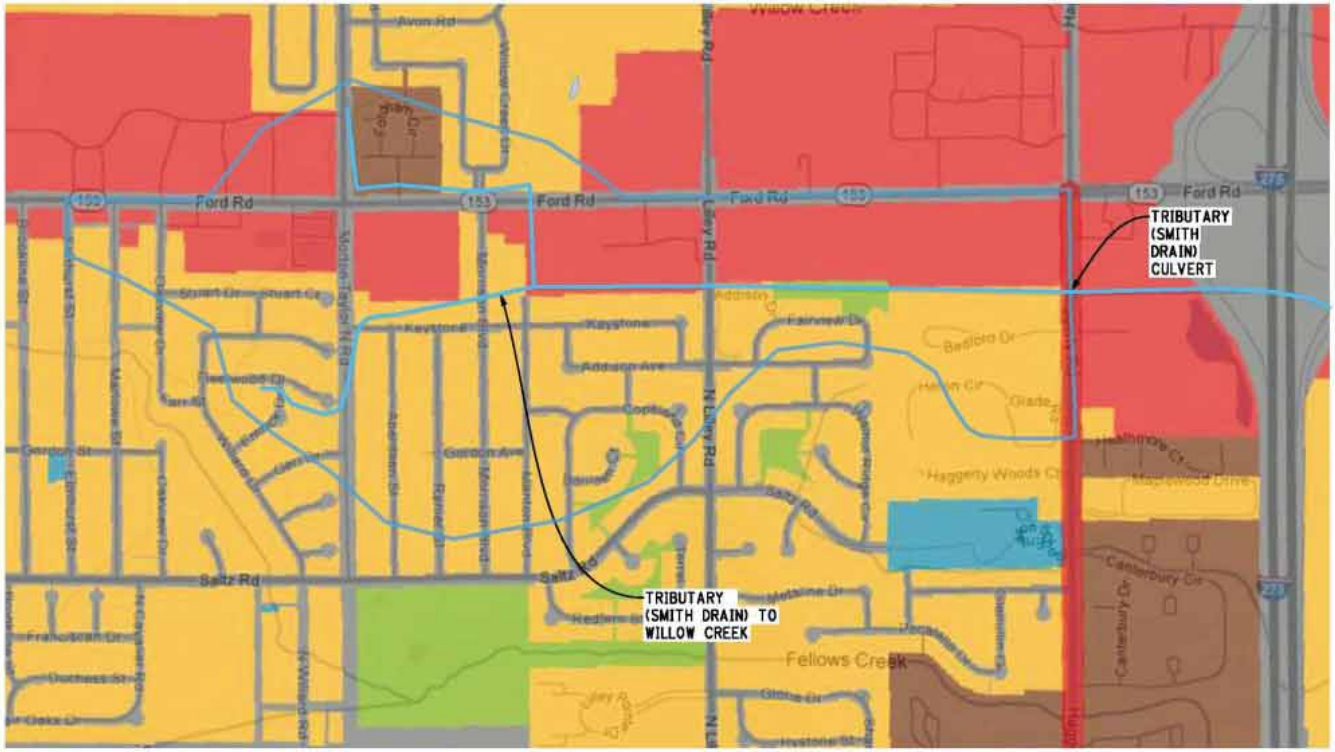
LILLEY RD

HAGGERTY RD

I-275

N

M-153
(FORD RD)



M-153
(FORD RD)

LEGEND

- Agricultural
- Single-family residential
- Multiple-family residential
- Commercial
- Industrial
- Government / Institutional
- Park, recreation, and open space
- Airport
- Transportation, communication, and utility
- Water

LILLEY RD

HAGGERTY RD

I-275

TRIBUTARY (SMITH DRAIN) TO WILLOW CREEK

HH ENGINEERING LTD.

LAND USE MAP

DATE	SCALE	CONT. SEC.	JOB NO.	SHEET NO.
06-25-13	1"=1250'	82292	115177	

Haggerty Road over
Tributary (Smith Drain) to Willow Creek
CS 82292 – JN 115177

FILE NAME:

LAST CORRECTION BY:

DATE:

MORTON TAYLOR RD

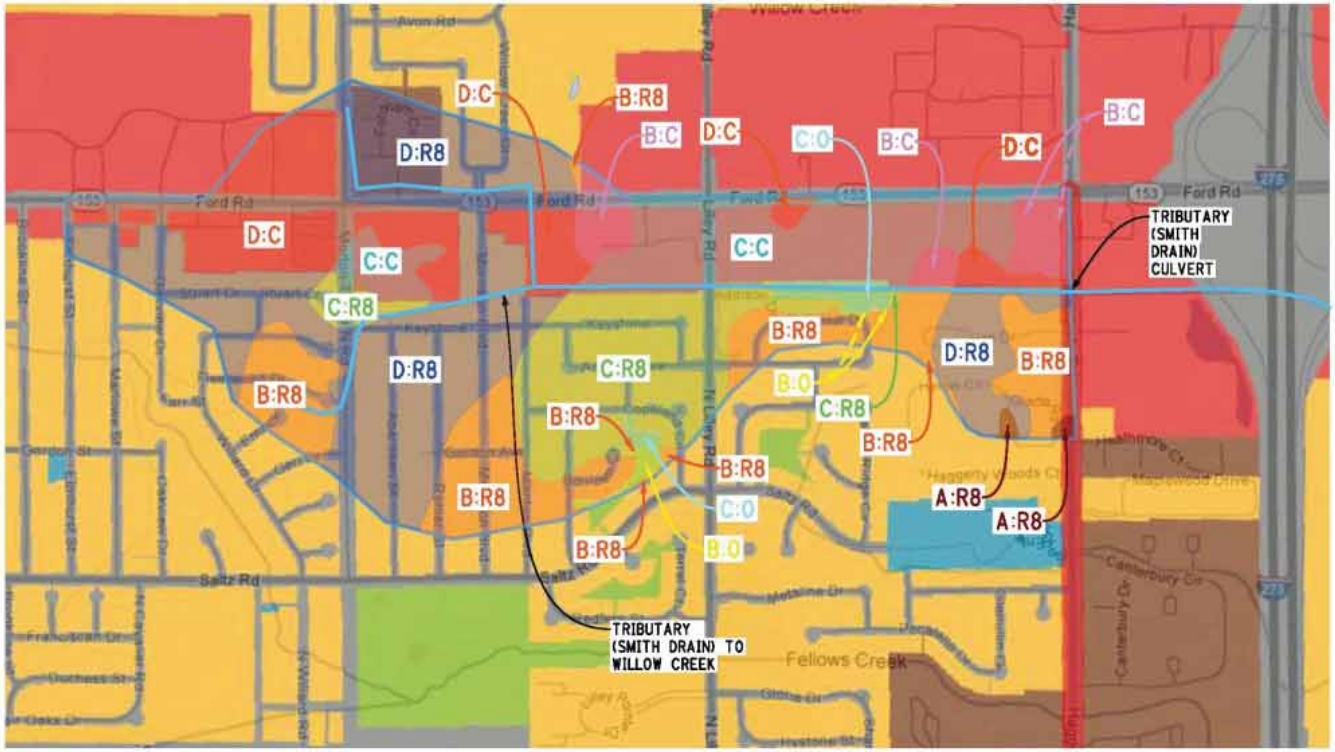
LILLEY RD

HAGGERTY RD

I-275

N

M-153
(FORD RD)



M-153
(FORD RD)

SOIL SERIES/DESCRIPTION		HYDRAULIC SOIL GROUP MAP SYMBOL
Ba	Belleville loamy fine sand	D
BbB	Blount loam, 0 to 4 percent slopes	C
BcA	Blount-Pewamo loams, 0 to 2 percent slopes	C
Co	Corunna fine sandy loam	D
KnA	Kibbie fine sandy loam, 0 to 3 percent slopes	B
MeA	Metamora sandy loam, 0 to 3 percent slopes	B
MfA	Metaora-Pewamo complex, 0 to 3 percent slopes	B
Pe	Pewamo loam	D
SeA	Selfridge loamy sand, 0 to 3 percent slopes	B
TeA	Tedrow loamy fine sand, 0 to 2 percent slopes	B
ThA	Thetford loamy sand, 0 to 2 percent slopes	A

MAP SYMBOL	LAND USE
R8	Residential: 1/8 acre
C	Commercial or business area
O	Open spaces: good condition

LILLEY RD

HAGGERTY RD

I-275

TRIBUTARY (SMITH DRAIN) TO WILLOW CREEK

HYDROLOGICAL SOIL - COVER COMPLEX MAP

HH ENGINEERING LTD.

DATE	SCALE	CONT. SEC.	JOB NO.	SHEET NO.
06-25-13	1"=1250'	82292	115177	

Haggerty Road over
Tributary (Smith Drain) to Willow Creek
CS 82292 – JN 115177

SCS-92 Method Discharge Calculations:

Description	
Watercourse	Tributary to Willow Creek
Drainage Area	0.47 sq. mile
Cont Drainage Area	**0.47** sq. mile
Basin Number	31
Basin Name	Rouge
Quad	0
Section	13
Town/Range	2S / 8E
Latitude	83°26'35.72"W
Longitude	#REF!
County	Wayne
Township	Canton
Location	South of M-153
Job Number	115379
By	TEP
Date	May-31-2013

Time of Concentration

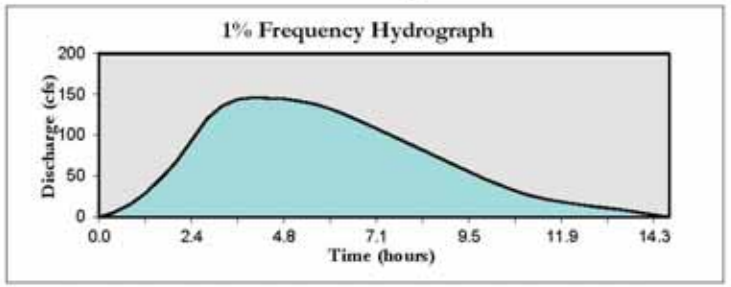
Flow Type	Length feet	U/S Elev feet	D/S Elev feet	Slope %	Velocity ft/s	Tc hours
Sm Trib	1530	670.00	664.58	0.354	1.250	0.34
Sm Trib	2320	675.50	670.00	0.237	1.022	0.63
Sm Trib	2525	679.50	675.50	0.158	0.836	0.84
Waterway	2170	682.50	679.50	0.138	0.446	1.35
Sm Trib						
Sm Trib						
Sm Trib						
Sm Trib						
Sm Trib						
Sm Trib						
Sm Trib						
Sm Trib						
Sm Trib						
Total	8545			0.210	0.862	**3.16**

* Portions of the Time of Concentration that were cut off to evaluate alternate travel routes

Curve Number

Soils Group	%	Land Use Type	%	CN
A	0.3	res 1/8	100	77
B	21	res 1/8	78.3	85
		commercial	19.5	92
		open good	2.3	61
C	30.8	res 1/8	48.9	90
		commercial	46.7	94
		open good	4.3	74
D	47.9	res 1/8	68.4	92
		commercial	31.6	95

Discharge Frequency	10%	4%	2%	1%	0.50%	0.20%
Adj Rainfall (inch)	3.13		3.98	4.36		
Avg Runoff (inch)	2.18		2.98	3.35		
Comp Curve Number	90.8		90.8	**90.8**		
Discharge (cfs)	95	115	130	146	161	183
Volume (Acre-ft)	55	66	75	84	93	105
Ponding: throughout	0	0	0	0	0	0
Ponding: upper reaches	0	0	0	0	0	0
Ponding: design point	0	0	0	0	0	0
Ponding Adjustment	1.00	1.00	1.00	1.00	1.00	1.00
Adjusted Flow (cfs)	**95**	**115**	**130**	**146**	**161**	**183**



Unit Hydrograph Peak (cfs/sq. mile-in) 92.87

PHOTOGRAPHS

Haggerty Road over (Smith Drain) Tributary to Willow Creek
Canton Township, Section 13, T 02 S, R 08 E, Wayne County

3592 Looking West inside pipe

3593 Looking West inside pipe

Haggerty Road over (Smith Drain) Tributary to Willow Creek
Canton Township, Section 13, T 02 S, R 08 E, Wayne County

3594 Looking East (downstream)

3595 East end of pipe

Haggerty Road over (Smith Drain) Tributary to Willow Creek
Canton Township, Section 13, T 02 S, R 08 E, Wayne County

3596 Looking South, East end

3597 Looking West across Haggerty Road

Haggerty Road over (Smith Drain) Tributary to Willow Creek
Canton Township, Section 13, T 02 S, R 08 E, Wayne County

3598 Looking West (upstream)

3599 West end of pipe