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F.Y.I.
Already reviewed + approved.

E-17/D000

BEAR CANYON ARROYO TRAIL – CITY WIDE ON-CALL ENGINEERING SERVICES FOR TRANSPORTATION, A/E JOB # 7516.01
BEAR CANYON ARROYO STRUCTURAL AND HYDRAULIC ANALYSIS

I, Craig W. Hoover, hereby certify that I am a Registered Professional Engineer, registered in the state of New Mexico, and that the following report was prepared under my direction and is true and correct to the best of my knowledge and belief.

Craig W. Hoover, P.E.
NMPE No. 11848

I, Sean M. Melville, hereby certify that I am a Registered Professional Engineer, registered in the state of New Mexico, and that the following report was prepared under my direction and is true and correct to the best of my knowledge and belief.

Sean M. Melville, P.E.
NMPE No. 17400

Rec 11 June 2012

Bohannan Huston

Engineering
Spatial Data
Advanced Technologies

Courtyard I
7500 Jefferson St. NE
Albuquerque, NM
87109-4335
www.bhinc.com
voice: 505.823.1000
facsimile: 505.798.7988
toll free: 800.877.5332

MEMORANDUM

TO: Juan Carlos Samuel, Department of Municipal Development, Transportation Division, City of Albuquerque
Jerry Lovato, AMAFCA

FROM: Craig W. Hoover, P.E.
Sean M. Melville, P.E.

DATE: June 29, 2011

RE: BEAR CANYON ARROYO TRAIL – CITY WIDE ON-CALL ENGINEERING SERVICES FOR TRANSPORTATION, A/E JOB # 7516.01 - BEAR CANYON ARROYO STRUCTURAL AND HYDRAULIC ANALYSIS

INTRODUCTION

In December 2010 Gannett Fleming West Inc. completed preliminary Hydraulic Calculations with respect to the Bear Canyon Arroyo as part of the Bear Canyon Arroyo Trail Extension Wyoming to I-25 project. Three channel options were considered through the use of simple Manning's Equation calculations using typical channel sections for each option. Based on the analysis, the City selected Option 3 which would incorporate the new trail by narrowing the channel with the construction of a vertical wall on the south side of the channel.

Recently, the City contracted with Bohannan Huston Inc. (BHI) to further the detail of the analysis of the trail and then design the trail from Brentwood Lane to the Arroyo Del Oso Golf Course. Specifically with respect to the existing channel, the City has contracted BHI to confirm the selection of Option 3 and verify the hydraulic calculations by completing a more detailed hydraulic analysis using HEC-RAS to establish the water surface profile for the channel reach immediately upstream of Seagull Street. In addition, BHI was tasked with evaluating the Structural ramifications with any proposed modifications to the channel to accommodate the trail.

This memo is written to summarize and present BHI's structural and hydraulic analysis for the Bear Canyon Arroyo upstream of Seagull Street as a result of the proposed trail. Figure 1 shows the project location.

STRUCTURAL ANALYSIS OF CHANNEL OPTIONS

Two channel modification options to accommodate the proposed Bear Canyon Arroyo Trail were evaluated and compared for structural feasibility. The first option was a vertical wall channel modification generally based on the preliminary hydraulic calculations completed by Gannett Fleming West Inc. The second option was a trail notch into the side of the existing channel. The analysis evaluated both concepts for construction and permanent impacts to adjacent properties and the existing channel, constructability, construction costs, and trail/channel functionality.

Upon evaluation of both options, both options are structurally feasible. However, through further review of each option's constructability and functionality, the vertical wall channel modification option appears to be the most feasible option. The excavation, removal and construction of this option closely follow conventional construction practices, while the notched channel option requires special attention to neat excavation and an increased level of effort in casting and finishing of the notch wall. This practice of notching into channel walls has proven to require a costly chemical grout injection procedure prior to excavation of the notch in order to ensure stable soil slopes, making it more costly than the vertical wall channel option.

The vertical wall channel modification option provides the required trail functionality without having major vertical grade changes and maintains the necessary channel capacity and function, as will be demonstrated in the Hydraulic Analysis section. It would also provide a quicker and less complex construction sequence to complete than a channel notch option. As a result, this option would have a considerably lower construction cost than a notch option. For both options, there would be construction easement and access needs.

This recommended option would include construction activities including, but not limited to: temporary storm water management and protection during construction, concrete channel demolition and removal, minor excavation for wall footing, cast-in-place concrete

cantilever retaining wall, steel railing, structural backfill and compaction earthwork, asphalt paving and trail striping/signage.

HYDRAULIC ANALYSIS

Given the preliminary calculations completed by Gannett Fleming West Inc. and our Structural Evaluation indicating a vertical walled channel section is the preferred structural option, we have completed a detailed hydraulic assessment of this option. A description of the option and the results of the hydraulic analysis are provided as follows:

VERTICAL WALLED CHANNEL OPTION

In the subject reach, upstream of Seagull Street, the Bear Canyon Arroyo has an 11-ft bottom width and 2 to 1 side slopes. The average slope of this reach is at 1.2%. The total lined depth of the channel is 7 ft. The total lined width is 39 ft. To accommodate a new pedestrian trail in this reach within the existing channel right-of-way, the channel must be narrowed. A vertical walled section along the south side of the arroyo from Seagull Street upstream 400' is proposed to accommodate the trail within the existing right-of-way. The Bear Canyon Arroyo currently passes under Seagull Street through two 14 ft W x 10 ft H box culverts. Currently the channel transitions from a trapezoidal section to a vertical walled section at the upstream end of the box culverts over a length of approximately 200'. The proposed vertical wall section on the south side of the arroyo will easily transition to this section at Seagull Street and will not alter the north side of the channel at or upstream of Seagull Street. Figure 2 shows a plan view of extent of the channel modifications associated with the preferred option while Figure 3 shows a typical section of the proposed vertical wall option. Based on the City Development Process Manual (DPM) the freeboard should be at least $0.7(2.0+0.025Vd^{1/3})$ everywhere in the channel. The new vertical wall section on the south side will be designed to be at the same elevation as the existing top of channel in order to provide this freeboard.

HEC-RAS MODEL RESULTS

In order to determine the hydraulic impacts of narrowing the channel with a vertical walled section to accommodate the proposed bike trail, a proposed conditions model was

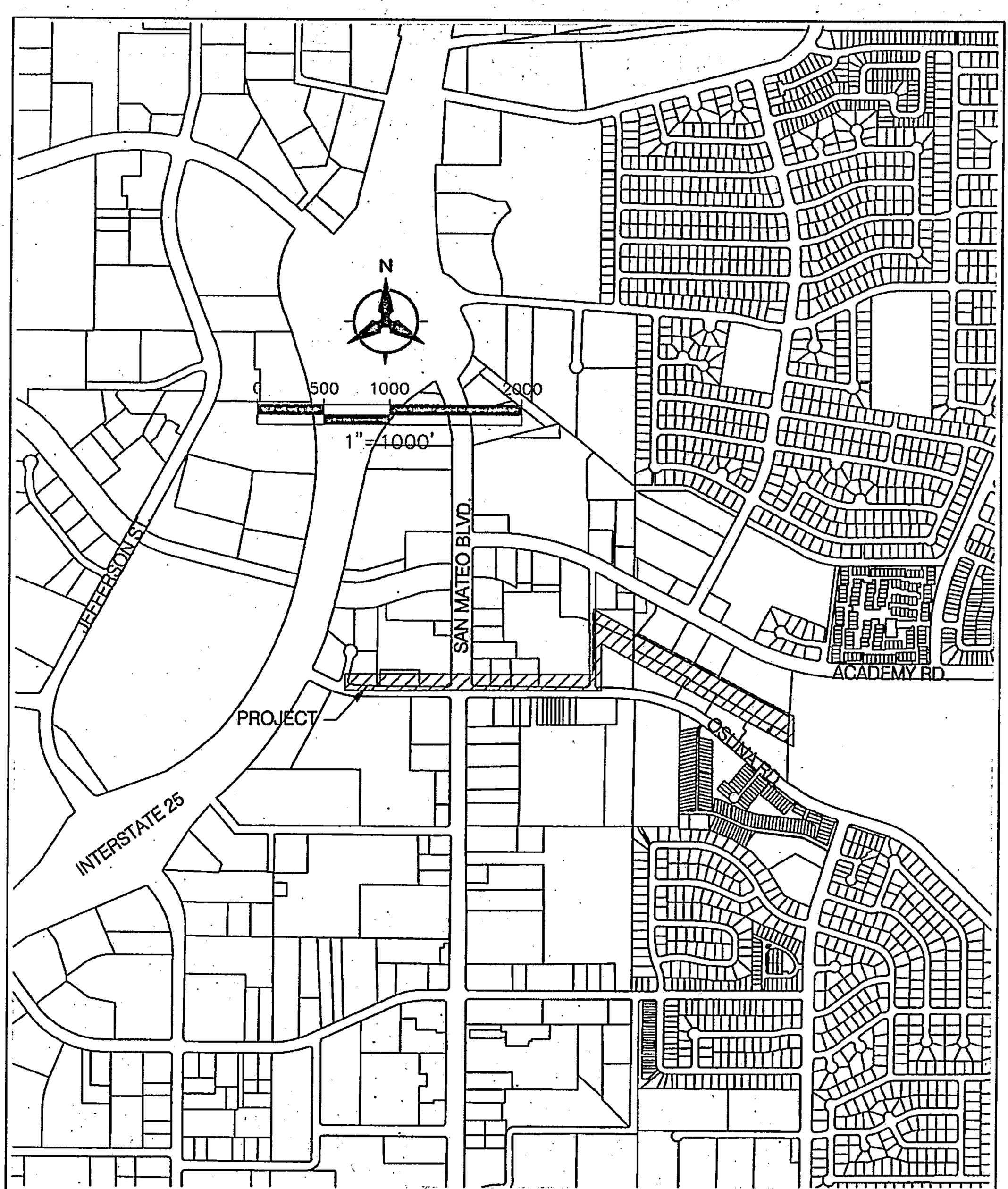
developed. Channel data including the box culverts at Seagull Street were determined from field survey information obtained by BHI as part of this project. As shown in Figure 4, the model extends approximately 1,500 ft upstream and approximately 200 ft downstream of Seagull Street. For this analysis, a 100-year flow rate of 1,900 cfs was provided by the City. A Manning's n of 0.013 was used for the concrete channel, based on the City DPM and in agreement with the preliminary channel hydraulic analysis that was completed by Gannett Fleming West, Inc. The model was run in the mixed flow regime.

Based on the HEC-RAS model the 100-year water surface is fully contained within the proposed vertical walled channel section. The water surface remains supercritical for the entire reach and does not contact the top of the box culvert. The minimum freeboard was met in all cross sections.

CONCLUSION

The preferred channel improvements option does not significantly impact the hydraulics of the Bear Canyon Arroyo. The 100-year water surface is fully contained within the proposed channel and the City DPM criterion for freeboard is met in all cross sections. The proposed vertical walled channel option as described herein is a structurally and hydraulically feasible means for modifying the channel to accommodate the proposed Bear Canyon Arroyo Trail.

FIGURES



Bohannan Huston

FIGURE 1
VICINITY MAP

DRAWN BY:	R.E.B.	DATE:	06-24-11
CHECKED BY:	C.W.H.	PROJECT NO.	20120012

LEGEND

PROPOSED BIKE TRAIL

HEC-RAS CROSS SECTIONS

N

100 50 0 100

SCALE: 1"=100'

Bohannan Huston

FIGURE 4
HEC-RAS CROSS SECTIONS

DRAWN BY:	R.E.B.	DATE:	06-24-11
CHECKED BY:	C.W.H.	PROJECT NO.	20120012

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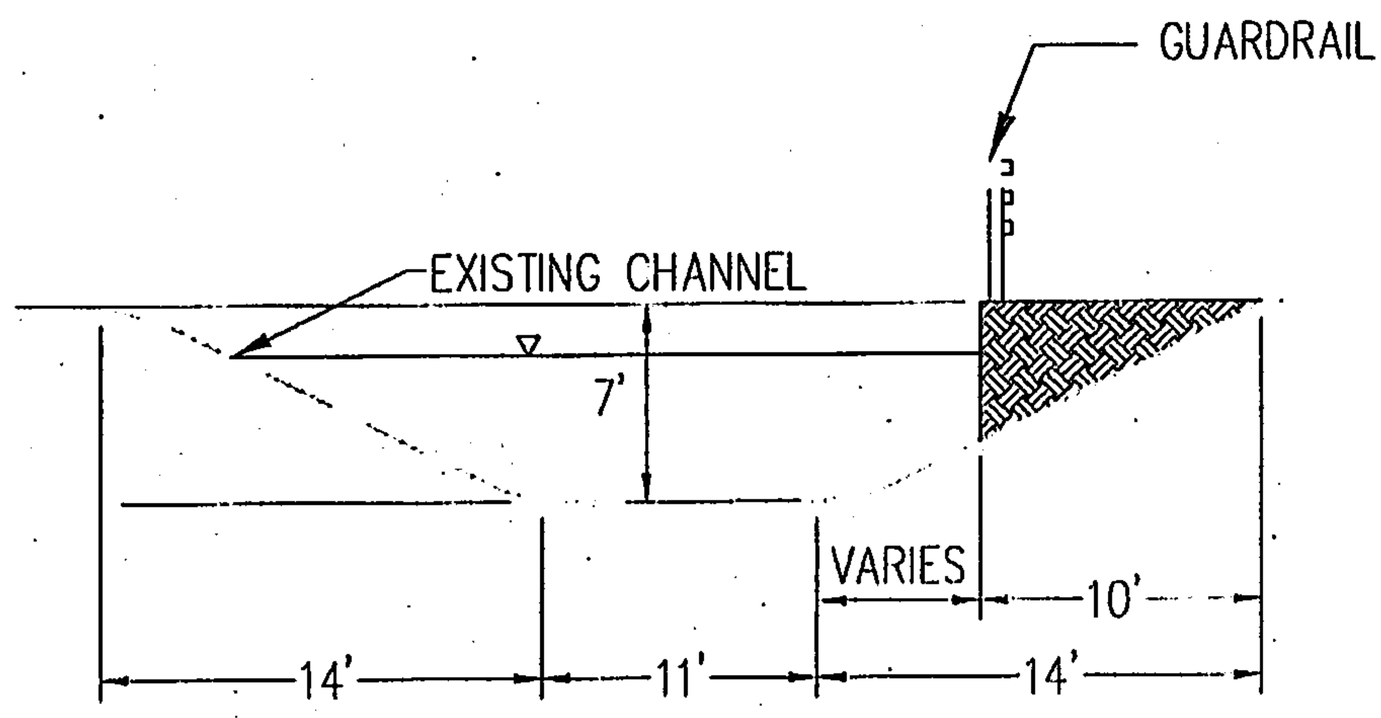
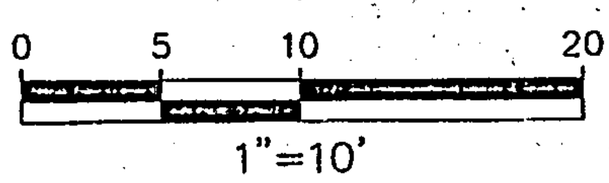
Tue, 28-Jun-2011 - 12:55pm, Plotted by: RELUM





Schlemmer Huston

FIGURE 3
PROPOSED TRAIL TYPICAL SECTION

DRAWN BY:	R.E.B.	DATE:	06–24–11
CHECKED BY:	C.W.H.	PROJECT NO.	20120012

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Jun 23, 2011 - 11:18am

LEGEND

PROPOSED BIKE TRAIL

N

40 20 0 40

SCALE: 1"=40'

Bohannan Huston

FIGURE 2
PROPOSED TRAIL PLAN VIEW

DRAWN BY	R.E.B.	DATE	06-24-11
CHECKED BY	C.W.H.	PROJECT NO.	20120012

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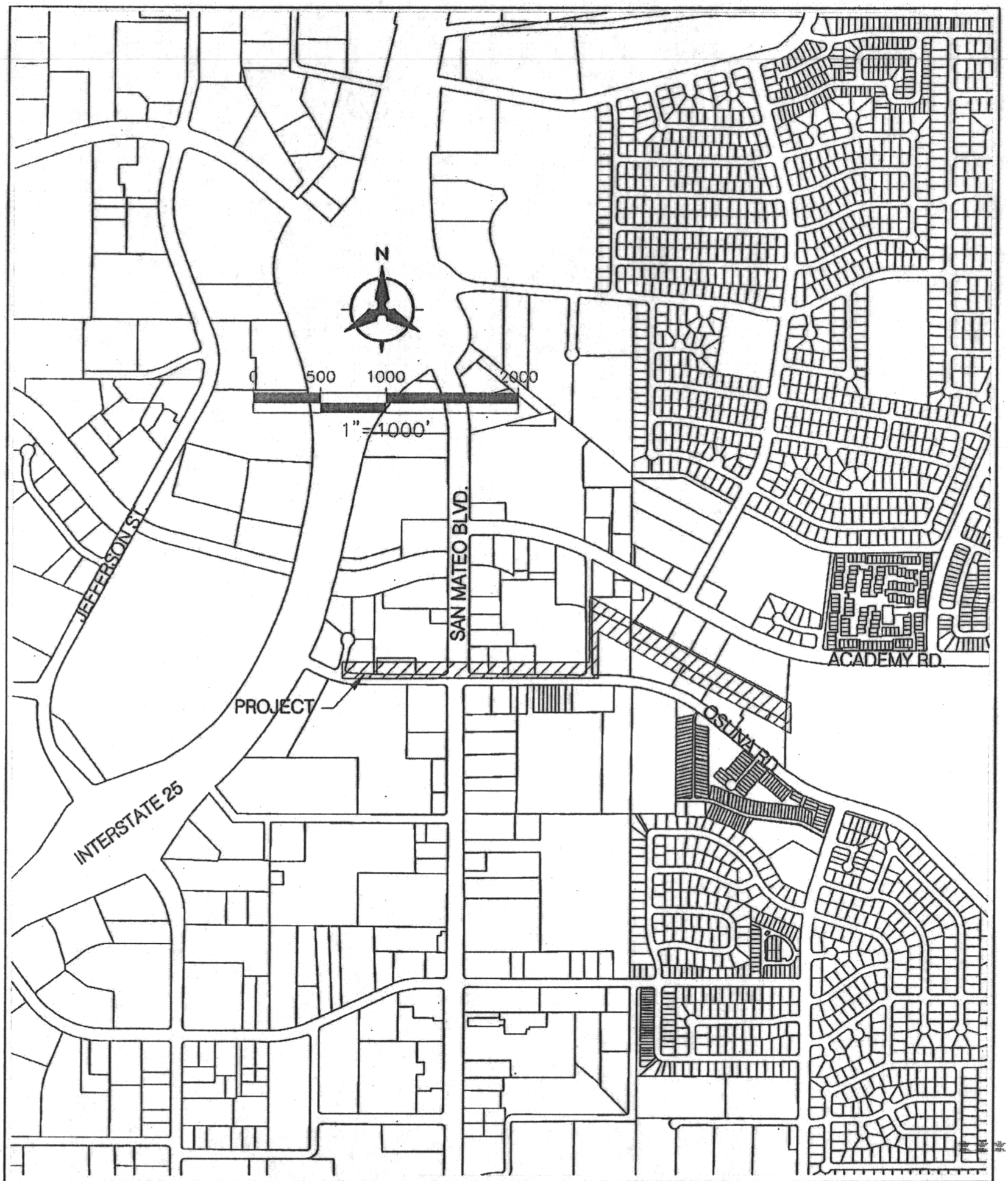
Thu, 23-Jun-2011 - 11:08am, Plotted by RBLUM



Bohannan Huston

FIGURE 1
VICINITY MAP

DRAWN BY:	R.E.B.	DATE:	06-24-11
CHECKED BY:	C.W.H.	PROJECT NO.	20120012

APPENDIX A

DRAINAGE ANALYSIS BY GANNETT FLEMING WEST

Gannett Fleming
Your Trusted Advisor Since 1915

GANNETT FLEMING WEST, INC.
Suite 7000
2155 Louisiana Boulevard, N.E.
Albuquerque, NM 87110-5429

Office: (505) 266-8468
Fax: (505) 881-2513
www.gannettfleming.com

December 28, 2010

Mr. Bradley Bingham, P.E., C.F.M.
City Hydrologist/City Flood Plain Manager
City of Albuquerque
P.O. Box 1293
Albuquerque, NM 87103

Re: Channel Hydraulics Calculations
Bear Canyon Arroyo Trail Extension-Wyoming to I-25
COA Project #7392-03

Dear Mr. Bingham,

During a 30% design review meeting of the above referenced project, GFW and Larkin Group, NM presented three options for construction of the Bear Canyon Arroyo Trail Extension adjacent to the stretch of concrete lined channel between the Arroyo Del Oso golf course and Seagull Street. In comparing these options, GFW performed a hydraulic analysis of the existing channel along with subsequent channel modifications associated with each option. The City selected Option 3 for design and Mr. Chuck Thompson, P.E., DMD Section Manager, requested that GFW share our hydraulic calculations with you.

Attached are three (3) 11x17 exhibits, which show the three options and are described as follows:

- Option 1-The channel would be crossed in two locations by prefabricated bridges. The north side of the channel would be modified to create a vertical wall for approximately 250'. This would allow for more room on the north side of the channel, adjacent to existing parking. This parking area encroaches on the COA drainage easement due to a development agreement. See Exhibit 1 of 3.

- Option 2-The channel would be replaced with a (2)-10x7 Concrete Box Culvert for approximately 500'. This would allow the trail lie on top of the CBC and provide ample room. See Exhibit 2 of 3.

- Option 3-The south side of the channel would be modified to create a vertical wall for approximately 700'. The trail would remain on the south side of the channel. See Exhibit 3 of 3.

A peak flow rate of 1,900 cfs was used as a target number for the channel modifications. This number was based on the capacity of the CBC, which was installed downstream as part of the development of the Texas Land and Cattle Co Restaurant. However, GFW and Larkin would like to verify the design flow rate that is to be used.

The following table summarizes our hydraulic analysis of the existing channel and each option. A detailed output report of each option is also attached. A depth of 6' was used, which would provide 1' of freeboard in the channel.

Channel Hydraulic Analysis Arroyo Del Oso Golf Course to Seagull Street		
Option	**Capacity (cfs)**	**Water Surface**
Existing	4,094.45	5217.08
Option 1	2,861.35	5217.08
Option 2	2,837.00	NA
Option 3	2,861.35	5217.08

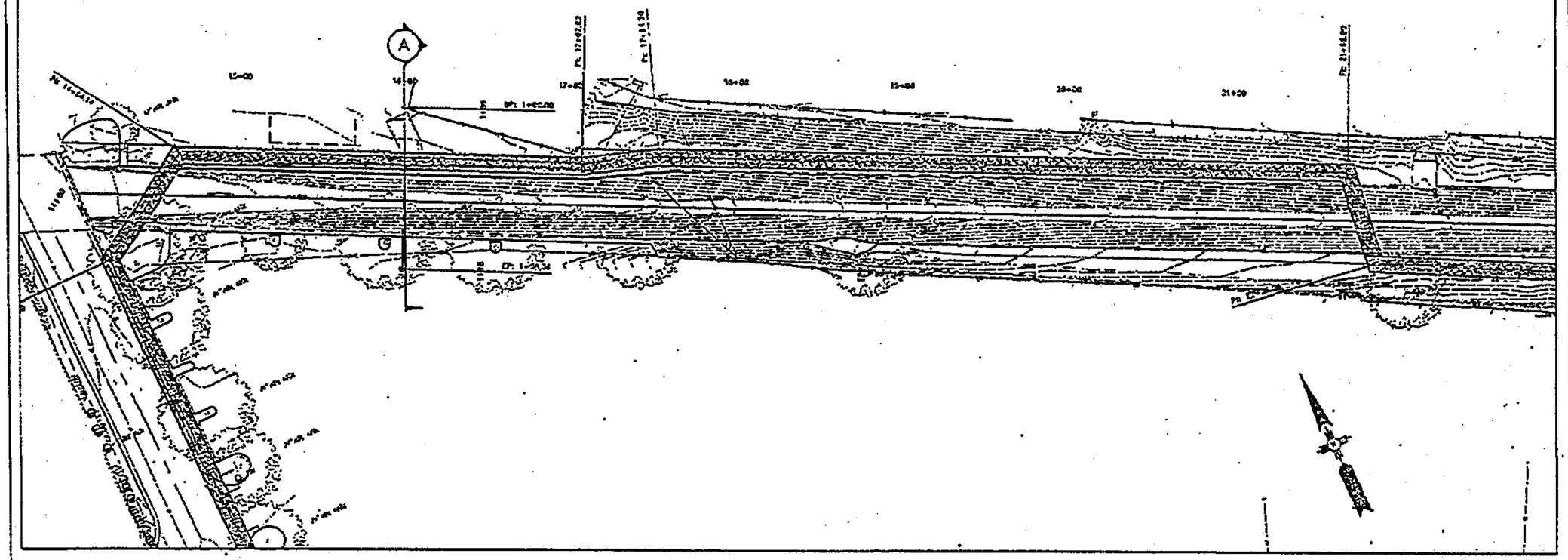
Please provide confirmation of our target capacity so that we may revise our hydraulic analysis, if necessary. If you have any questions or comments, please do not hesitate to call me at 265-8468.

Sincerely,
Gannett Fleming West, Inc.

Raymond J. Smith, P.E.
Project Manager

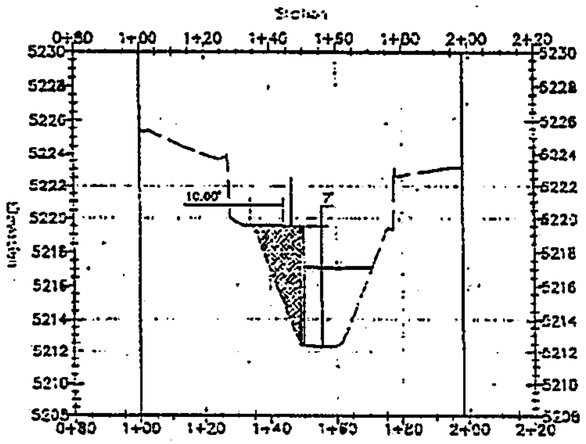
Attachments: (3) 11x17 Exhibits
Hydraulic Output Reports

Cc: Chuck Thompson, P.E., COA DMD
Roland Penttila, P.E., COA DMD Drainage Section
Ernest Armijo, P.E., Larkin Group NM, Inc.
Project File 52622



OPTION 1—PREFABRICATED BRIDGES

SCALE: 1"=30'



EXISTING SECTION (A)

SCALE: 1"=20' H
1"=2' V

Option 1 (Prefabricated Bridges)				
Item	Unit	Quantity	Unit Price	Amount
Prefabricated Bridge	EA	2	$100,000	$200,000
Reinforced Concrete Wall	CY	90	$600	$54,000
Borrow Material	CY	600	$12	$7,200
Demolish Existing Channel	CY	150	$80	$11,400
Handrail	LF	720	$24	$17,280
Contingencies (33%)				$60,000
Total				$349,880

*ESTIMATE ONLY CONSIDERS DIFFERENCES BETWEEN THE OPTIONS
DOES NOT INCLUDE TRAIL PAVING

CHANNEL HYDRAULICS:
EXISTING CAPACITY = 4234.43 CFS
PROPOSED FLOW RATE = 1915 CFS
PROPOSED CAPACITY = 2861.25
WATER SURFACE ELEVATION = 5217.26 FT

Gannett Fleming West, Inc.

AS BUILT INFORMATION

BENCH MARKS

ACS BM 11-113, PBS STANDARD BRASS DISK IN PIC
CENTER MEDIAN OF JACKSONVILLE RD. NE ON DIA
WEST MEDIAN OF THE ENTRANCE DRIVE NEW PAVILION BA.
THE STANDARD IS AN ALUMINUM DISK STAMPED 30 TOP OF
A CONCRETE MAINTENANCE BUILDING WITH THE GROUND
ELEVATION 5173.356, NAVD 1988 DATUM

AS BUILT INFORMATION

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE
1		

ENGINEER'S SEAL

NO.	DATE	REVISIONS	BY
1			
2			
3			

REMARKS

DESIGN

DESIGNED BY: TJC
DRAWN BY: TJC
CHECKED BY: TJC

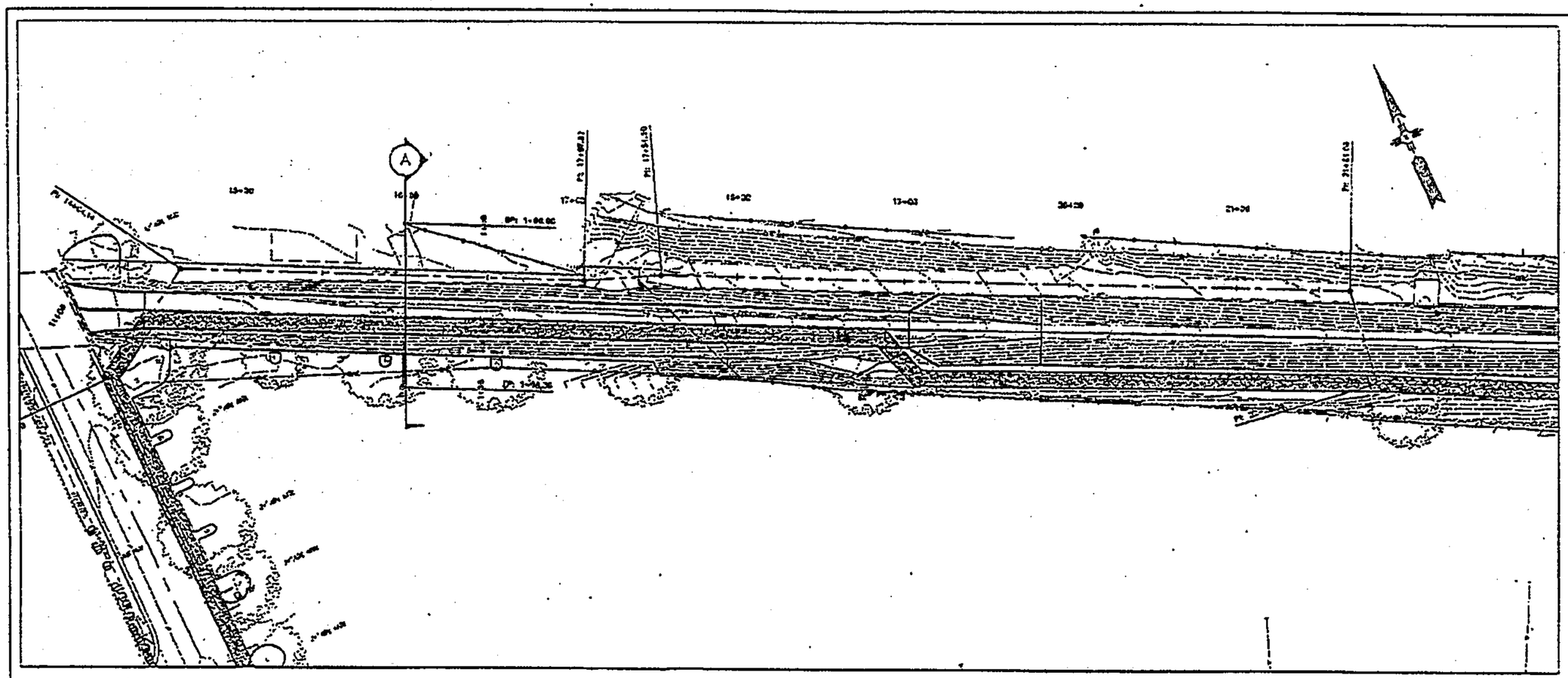
LARSON GROUP

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

BEAR CANYON ARROYO TRAIL
I-25 TO WYOMING
CHANNEL OPTION EXHIBITS

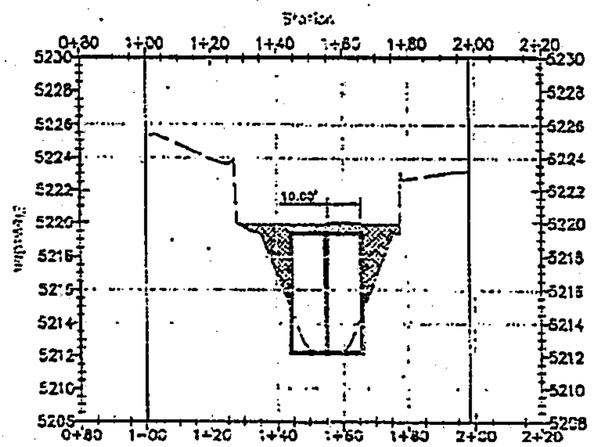
Design Review Committee | City Engineer Approval

PROJECT NO. 7392.03 | DRAWING NO. F-17,1215 | Sheet 1 of 3



OPTION 2–(2) 10'x7' CONCRETE BOX CULVERTS

SCALE: 1"=30'



PROPOSED SECTION (A)

SCALE: 1"=20' H
1"=2' V

Option 2 (Concrete Box Culvert)				
Item	Unit	Quantity	Unit Price	Amount
2-10x6 CBC, HEADWALL WINGWALLS AND TRANSITION WALLS	CY	1200	$600	$720,000
Demolish Existing Channel	CY	783	$50	$39,800
Borrow Material	CY	630	$12	$7,530
Contingencies (30%)				$214,000
Total				$980,345

*ESTIMATE ONLY CONSIDERS DIFFERENCES BETWEEN THE OPTIONS DOES NOT INCLUDE TRAIL PAVING

CHANNEL HYDRAULICS:
EXISTING CAPACITY = 4054.45 CFS
PROPOSED FLOW RATE = 1913 CFS
2-10'x7' CBC CAPACITY = 2327 CFS

Gannett Fleming West, Inc.

LARKIN GROUP

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

BEAR CANYON ARROYO TRAIL
I-25 TO WYOMING
CHANNEL OPTION EXHIBITS

Project No. 7392.03

Sheet 2 of 3

AS BUILT INFORMATION

BENCH MARKS

SURVEY INFORMATION

FIELD NOTES

OWNER'S SEAL

REVISIONS

REMARKS

DATE

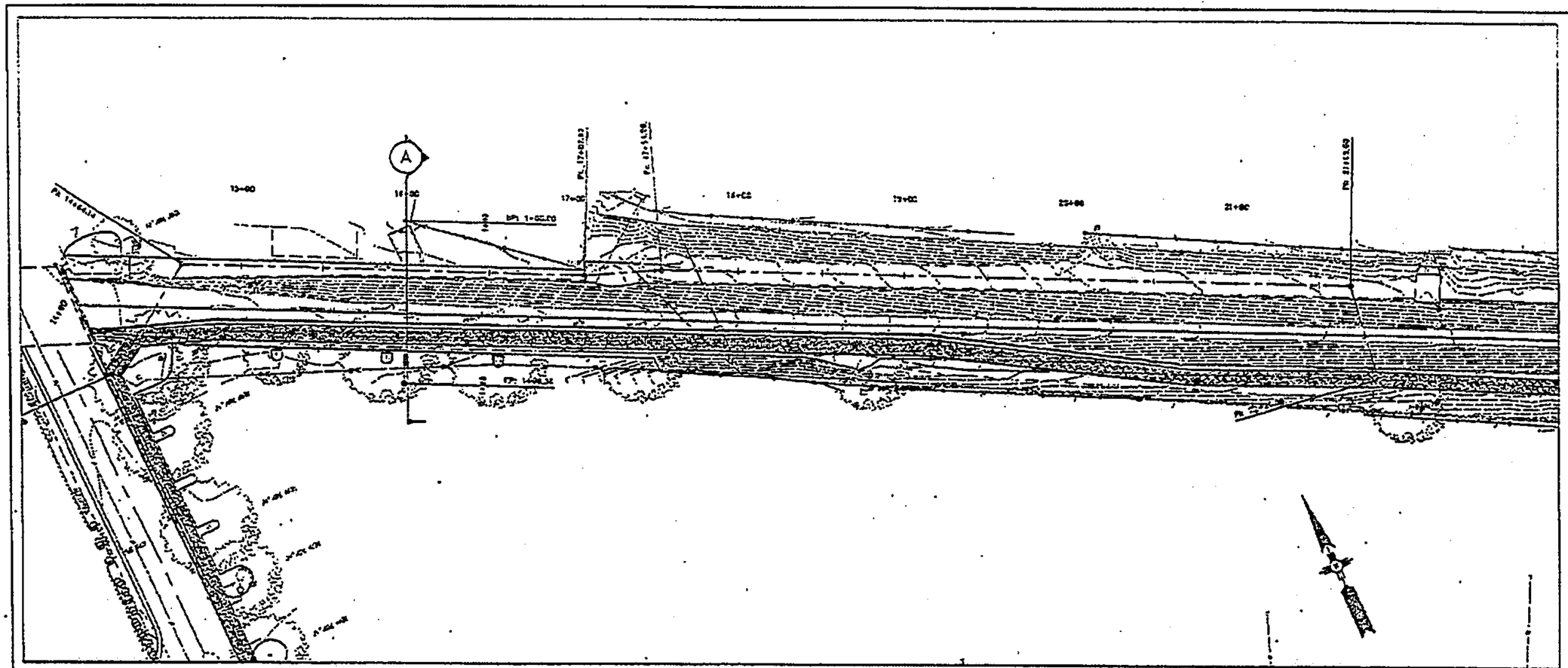
BY

NO.

DESIGNED BY

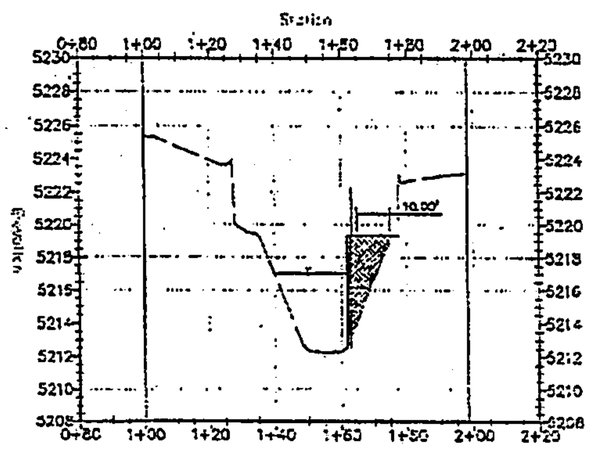
DRAWN BY

CHECKED BY



OPTION 3 – VERTICAL WALL

SCALE: 1"=20'



PROPOSED SECTION (A)

SCALE: 1"=20' H, 1"=5' V

Option 3 (Vertical Wall)				
Item	Unit	Quantity	Unit Price	Amount
Reinforced Concrete Wall	CY	170	$600	$102,000
Demolish Existing Channel	CY	300	$60	$18,000
Borrow Material	CY	3600	$12	$43,200
Handrail	LF	642	$24	$15,408
Contingencies (30%)				$50,600
Total				$229,200

*ESTIMATE ONLY CONSIDERS DIFFERENCES BETWEEN THE OPTIONS DOES NOT INCLUDE TRAIL PAVING

CHANNEL HYDRAULICS:
EXISTING CAPACITY = 4604.45 CFS
PROPOSED FLOW RATE = 1915 CFS
PROPOSED CAPACITY = 2661.35 CFS
WATER SURFACE ELEVATION = 5217.08

Gannett Fleming West, Inc.

AS BUILT INFORMATION

BENCH MARKS

SURVEY INFORMATION

FIELD NOTES

NO.	BY	DATE
1		

REVISIONS

NO.	DATE	REMARKS
1		

DESIGN

LARKIN GROUP

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

BEAR CANYON ARROYO TRAIL
I-25 TO WYOMING
CHANNEL OPTION EXHIBITS

Design Review Committee | City Engineer Approval

Project No. 7392.03 | Drawing No. F-17,164d19 | Sheet 3 of 3

Cross Section for Existing Channel

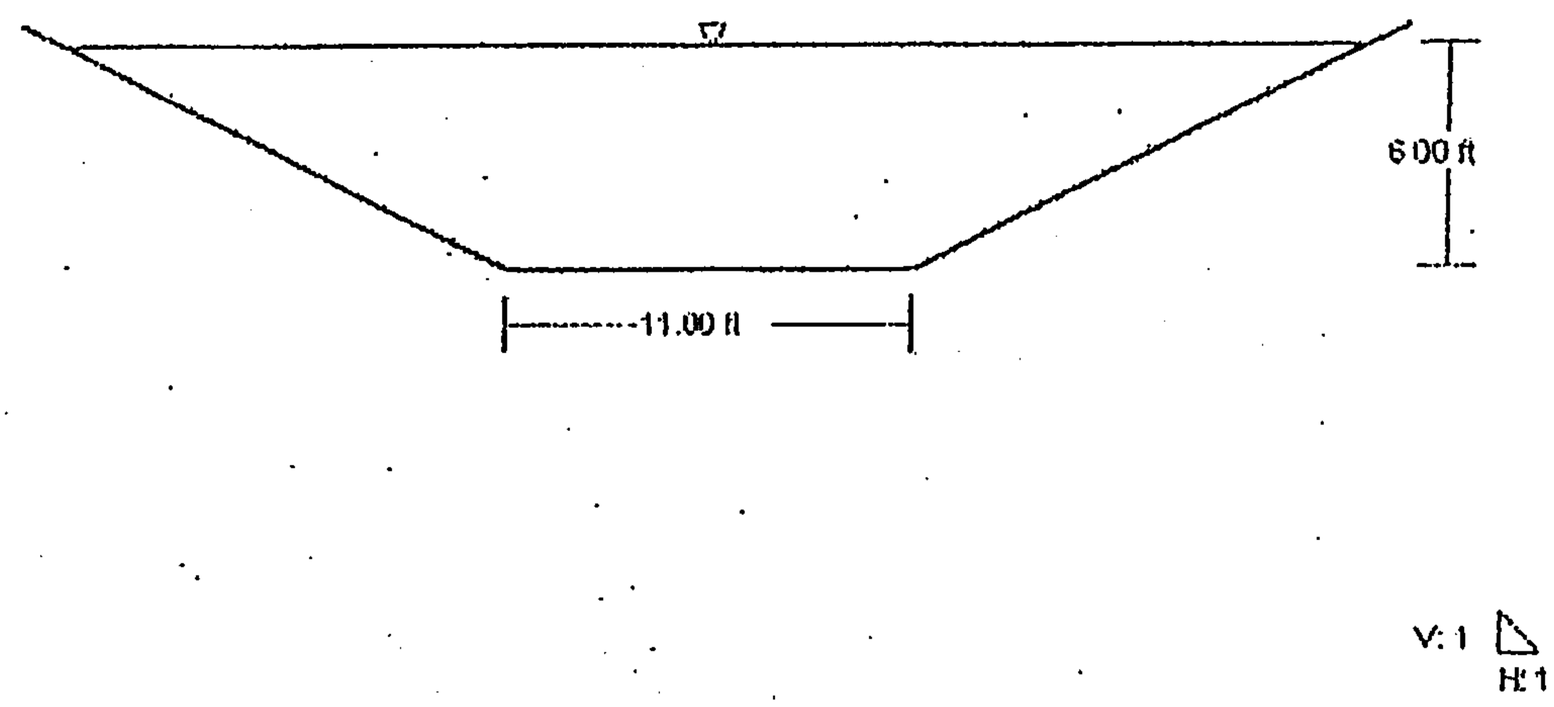
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.01200	ft/ft
Normal Depth	6.00	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	11.00	ft
Discharge	4094.45	ft^3/s

Cross Section Image



Worksheet for Box Pipe - 1

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.01200	ft/ft
Normal Depth	7.00	ft
Height	7.00	ft
Bottom Width	10.00	ft
Discharge	1418.47	ft³/s

Results

Flow Area	70.00	ft²
Wetted Perimeter	34.00	ft
Hydraulic Radius	2.06	ft
Top Width	10.00	ft
Critical Depth	8.55	ft
Percent Full	100.0	%
Critical Slope	0.00455	ft/ft
Velocity	20.26	ft/s
Velocity Head	6.38	ft
Specific Energy	13.38	ft
Froude Number	1.35	
Discharge Full	1418.47	ft³/s
Slope Full	0.01200	ft/ft
Flow Type	Supercritical	

GVF Input Data

Upstream Depth	7.00	ft
Length	500.00	ft
Number Of Steps	2	

GVF Output Data

Downstream Depth	7.00	ft
Profile Description	Uniform Flow	
Profile Headloss	6.00	ft
Average End Depth Over Rise	100.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	20.26	ft/s

Worksheet for Box Pipe - 1

GVF Output Data

Upstream Velocity	20.26	ft/s
Normal Depth	7.00	ft
Critical Depth	8.55	ft
Channel Slope	0.01200	ft/ft
Critical Slope	0.00455	ft/ft

Cross Section for Vertical Wall Channel

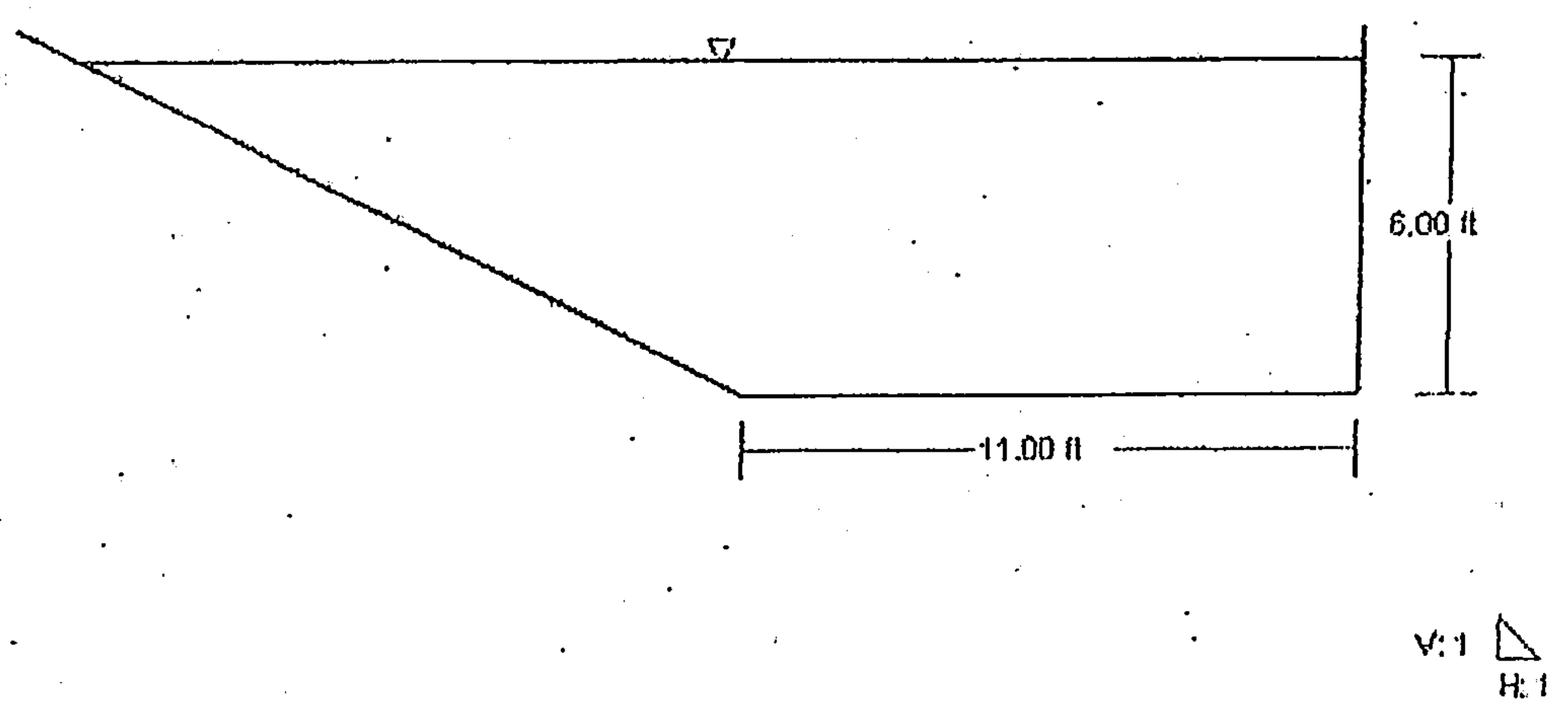
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.01200	ft/ft
Normal Depth	6.00	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	0.00	ft/ft (H:V)
Bottom Width	11.00	ft
Discharge	2861.35	ft^3/s

Cross Section Image

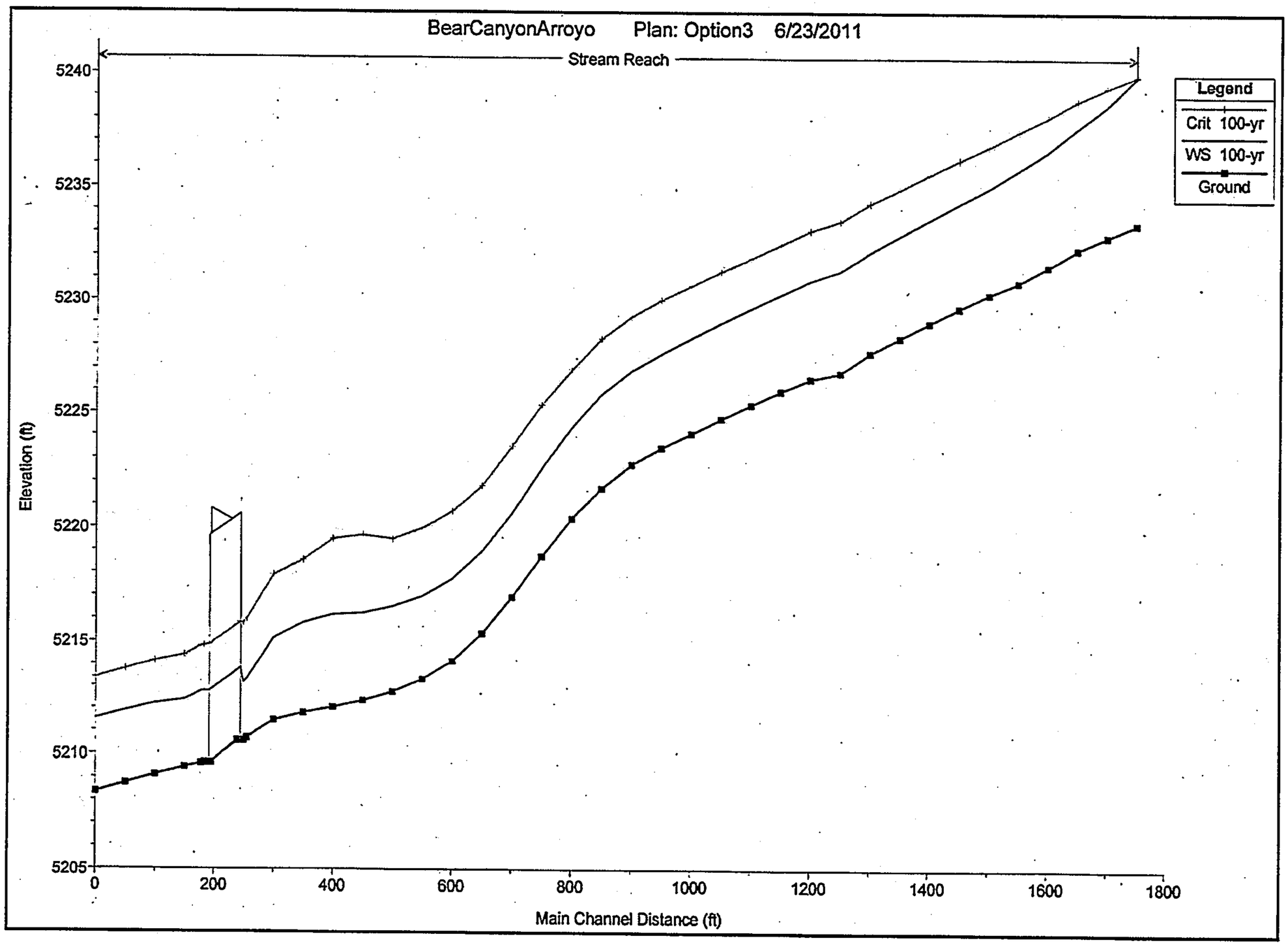


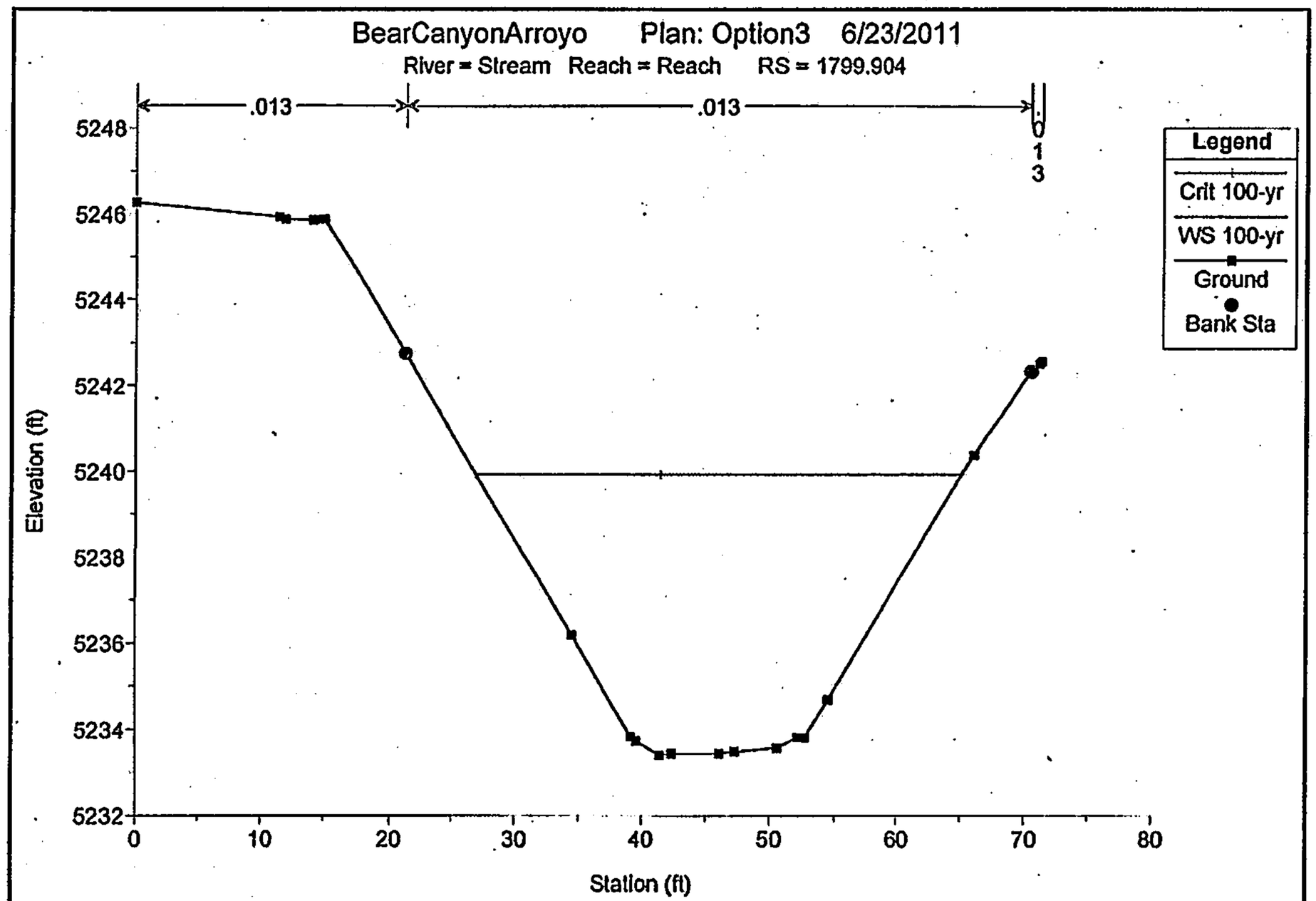
APPENDIX B

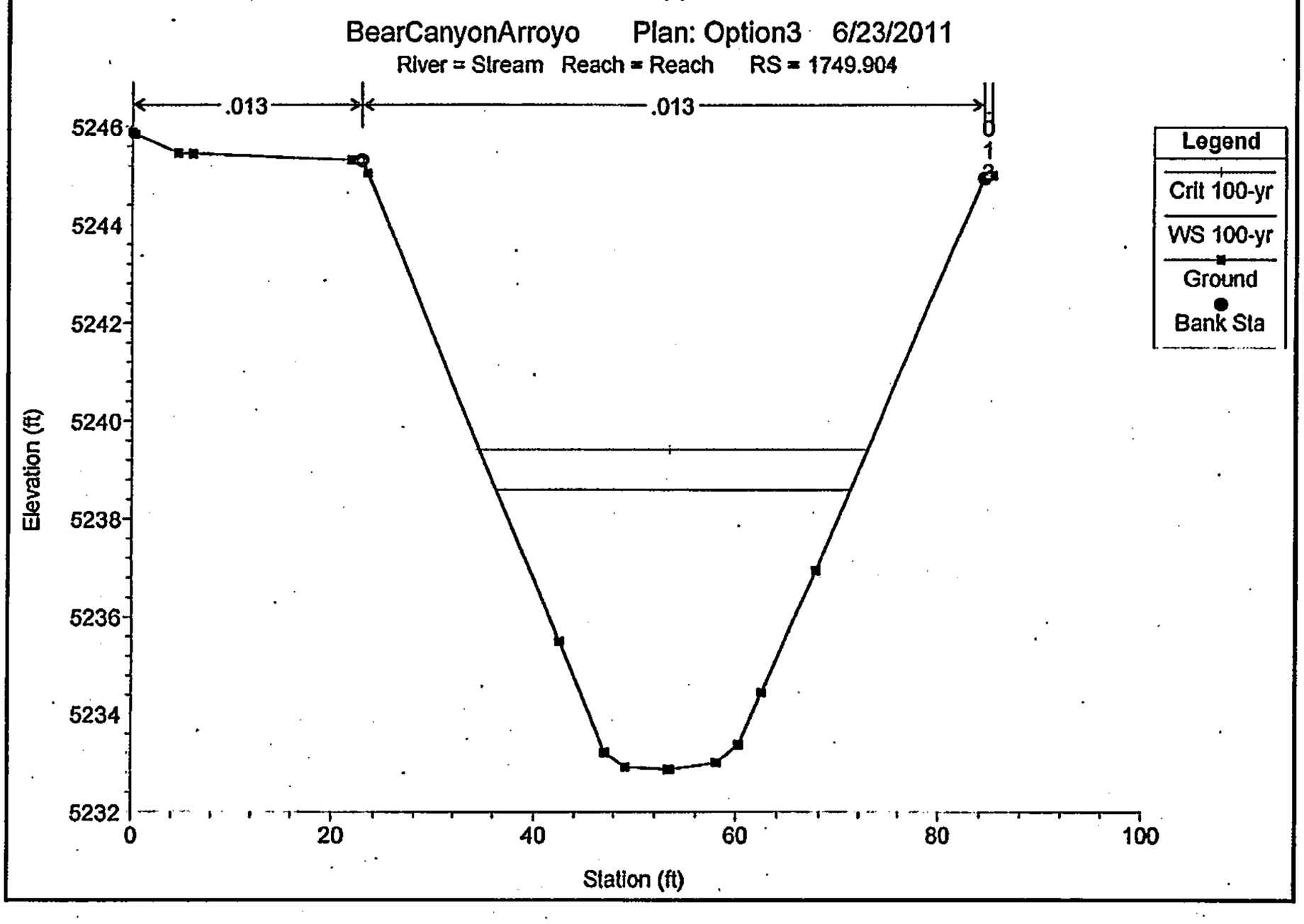
PROPOSED CONDITIONS MODEL

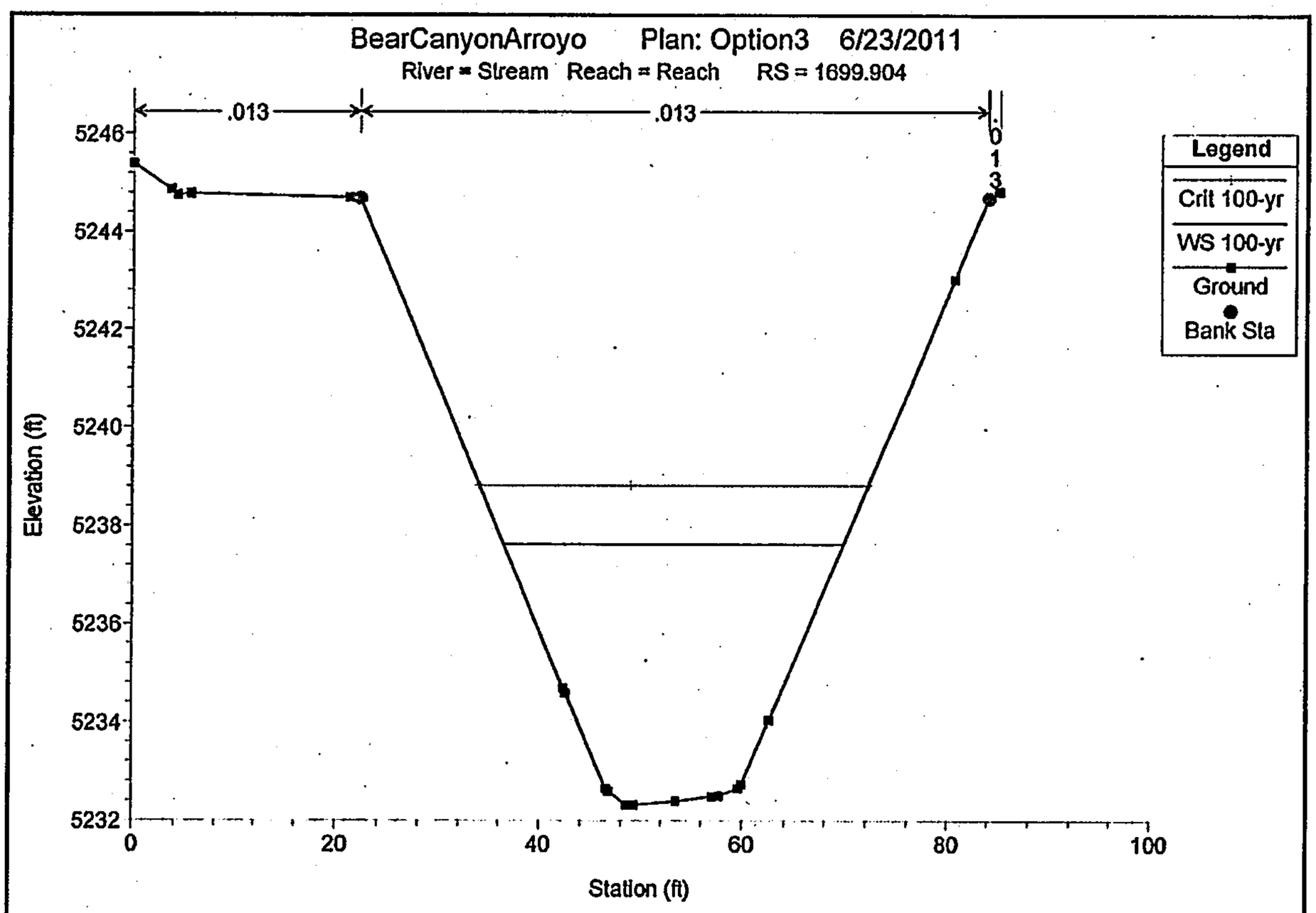
HEC-RAS Plan: Option3 River: Stream Reach: Reach Profile: 100-yr

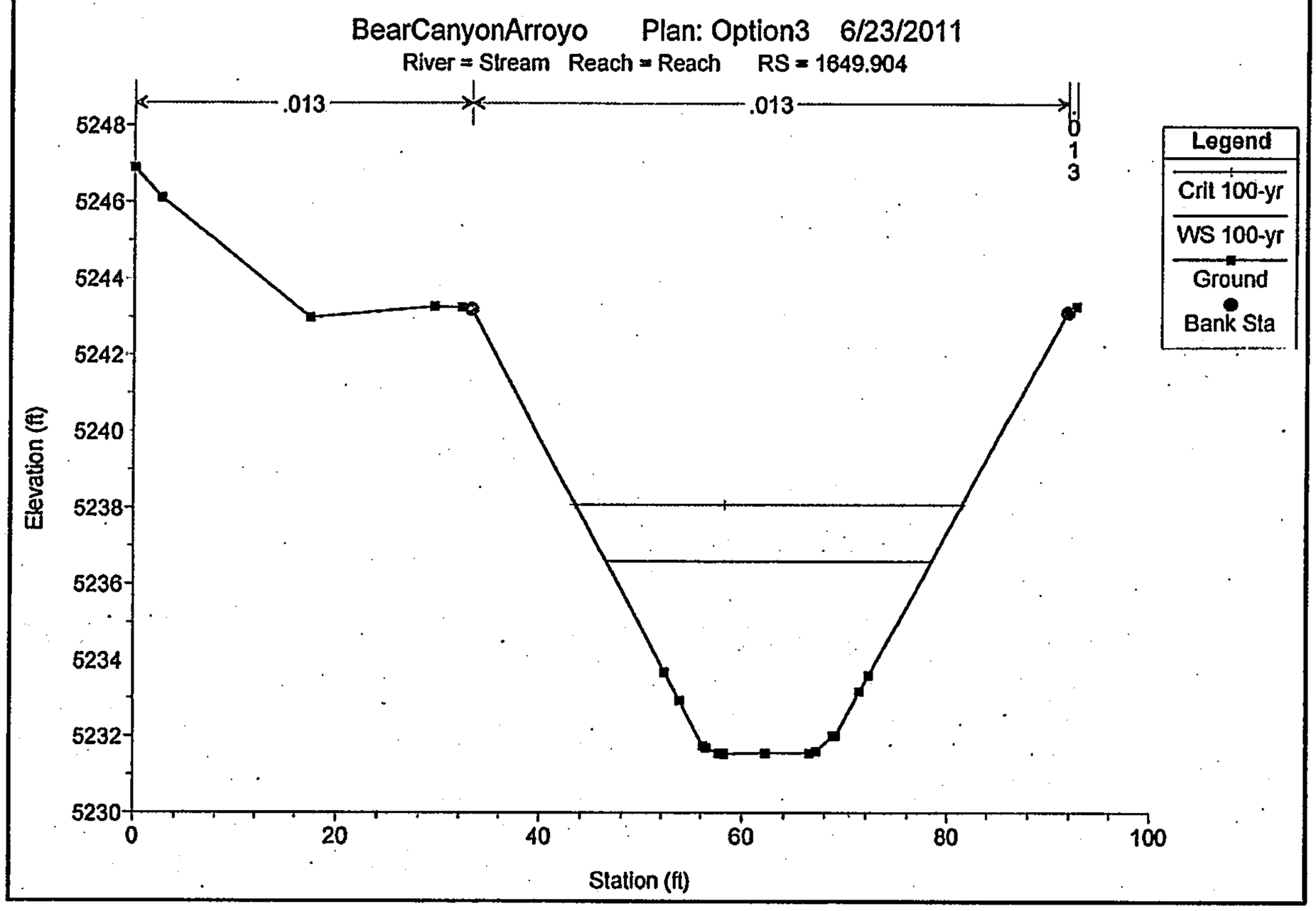
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	1799.904	100-yr	1900.00	5233.40	5239.93	5239.93	5242.07	0.001701	11.75	161.76	38.21	1.01
Reach	1749.904	100-yr	1900.00	5232.87	5238.60	5239.43	5241.84	0.002981	14.44	131.55	34.84	1.31
Reach	1699.904	100-yr	1900.00	5232.32	5237.63	5238.82	5241.60	0.003942	16.00	118.76	33.34	1.49
Reach	1649.904	100-yr	1900.00	5231.65	5236.60	5238.09	5241.30	0.004927	17.39	109.28	32.00	1.66
Reach	1599.904	100-yr	1900.00	5230.84	5235.80	5237.46	5240.99	0.005664	18.28	103.92	31.38	1.77
Reach	1549.904	100-yr	1900.00	5230.29	5235.00	5236.80	5240.65	0.006341	19.07	99.62	30.71	1.87
Reach	1499.904	100-yr	1900.00	5229.68	5234.32	5236.22	5240.29	0.006864	19.61	96.89	30.46	1.94
Reach	1449.904	100-yr	1900.00	5229.04	5233.60	5235.59	5239.90	0.007375	20.14	94.35	30.11	2.00
Reach	1399.904	100-yr	1900.00	5228.38	5232.89	5234.93	5239.48	0.007837	20.60	92.23	29.78	2.06
Reach	1349.904	100-yr	1900.00	5227.72	5232.19	5234.31	5239.05	0.008238	21.02	90.38	29.34	2.11
Reach	1299.904	100-yr	1900.00	5226.83	5231.35	5233.52	5238.59	0.008989	21.59	88.00	29.21	2.19
Reach	1249.904	100-yr	1900.00	5226.55	5230.91	5233.11	5238.14	0.008899	21.58	88.03	29.15	2.19
Reach	1199.904	100-yr	1900.00	5226.00	5230.27	5232.50	5237.67	0.009230	21.83	87.03	29.14	2.23
Reach	1149.904	100-yr	1900.00	5225.38	5229.65	5231.92	5237.19	0.009427	22.03	86.26	28.94	2.25
Reach	1099.904	100-yr	1900.00	5224.76	5229.02	5231.31	5236.69	0.009707	22.23	85.47	28.94	2.28
Reach	1049.904	100-yr	1900.00	5224.10	5228.35	5230.67	5236.19	0.009958	22.47	84.58	28.71	2.31
Reach	999.9047	100-yr	1900.00	5223.49	5227.66	5230.01	5235.66	0.010221	22.70	83.69	28.52	2.34
Reach	949.9047	100-yr	1900.00	5222.76	5226.90	5229.29	5235.12	0.010653	23.01	82.59	28.50	2.38
Reach	899.9047	100-yr	1900.00	5221.74	5225.65	5228.32	5234.52	0.011453	23.63	80.40	28.16	2.46
Reach	849.9047	100-yr	1900.00	5220.42	5224.36	5226.94	5233.83	0.013008	24.70	76.91	27.81	2.62
Reach	799.9047	100-yr	1900.00	5218.74	5222.60	5225.37	5233.04	0.014859	25.93	73.28	27.24	2.79
Reach	749.9047	100-yr	1900.00	5216.94	5220.65	5223.54	5232.14	0.016770	27.20	69.85	26.38	2.95
Reach	699.9047	100-yr	1900.00	5215.36	5218.96	5221.88	5231.19	0.018371	28.03	67.78	26.27	3.06
Reach	649.9047	100-yr	1900.00	5214.15	5217.75	5220.73	5230.23	0.018567	28.35	67.03	25.45	3.08
Reach	599.9047	100-yr	1900.00	5213.33	5216.97	5219.99	5229.29	0.017420	28.16	67.47	23.83	2.95
Reach	549.9047	100-yr	1900.00	5212.75	5216.54	5219.52	5228.28	0.016065	27.49	69.11	23.60	2.83
Reach	499.9047	100-yr	1900.00	5212.36	5216.25	5219.66	5227.31	0.014613	26.68	71.21	23.23	2.69
Reach	449.9036	100-yr	1900.00	5212.04	5216.19	5219.51	5226.36	0.012876	25.58	74.27	22.90	2.50
Reach	399.8936	100-yr	1900.00	5211.79	5215.83	5218.58	5225.61	0.012505	25.09	75.72	22.25	2.40
Reach	349.8835	100-yr	1900.00	5211.46	5215.17	5217.91	5224.97	0.012533	25.12	75.62	22.08	2.39
Reach	304.6771	100-yr	1900.00	5210.69	5213.34	5215.97	5224.19	0.018760	26.44	71.87	26.90	2.95
Reach	299.1824	100-yr	1900.00	5210.58	5213.18	5215.61	5224.06	0.019204	26.50	71.70	29.03	2.97
Reach	264		Culvert									
Reach	232.9862	100-yr	1900.00	5209.63	5212.78	5214.82	5219.69	0.010021	21.40	88.81	28.57	2.14
Reach	227.4931	100-yr	1900.00	5209.60	5212.75	5214.78	5219.63	0.009948	21.35	88.98	28.54	2.13
Reach	200.0054	100-yr	1900.00	5209.43	5212.39	5214.42	5219.54	0.010582	21.45	88.56	30.09	2.20
Reach	150.0000	100-yr	1900.00	5209.11	5212.21	5214.13	5218.90	0.009439	20.76	91.53	29.68	2.08
Reach	100.0000	100-yr	1900.00	5208.75	5211.87	5213.76	5218.39	0.009110	20.49	92.74	29.85	2.05
Reach	50.0000	100-yr	1900.00	5208.38	5211.54	5213.39	5217.89	0.008782	20.24	93.89	29.88	2.01

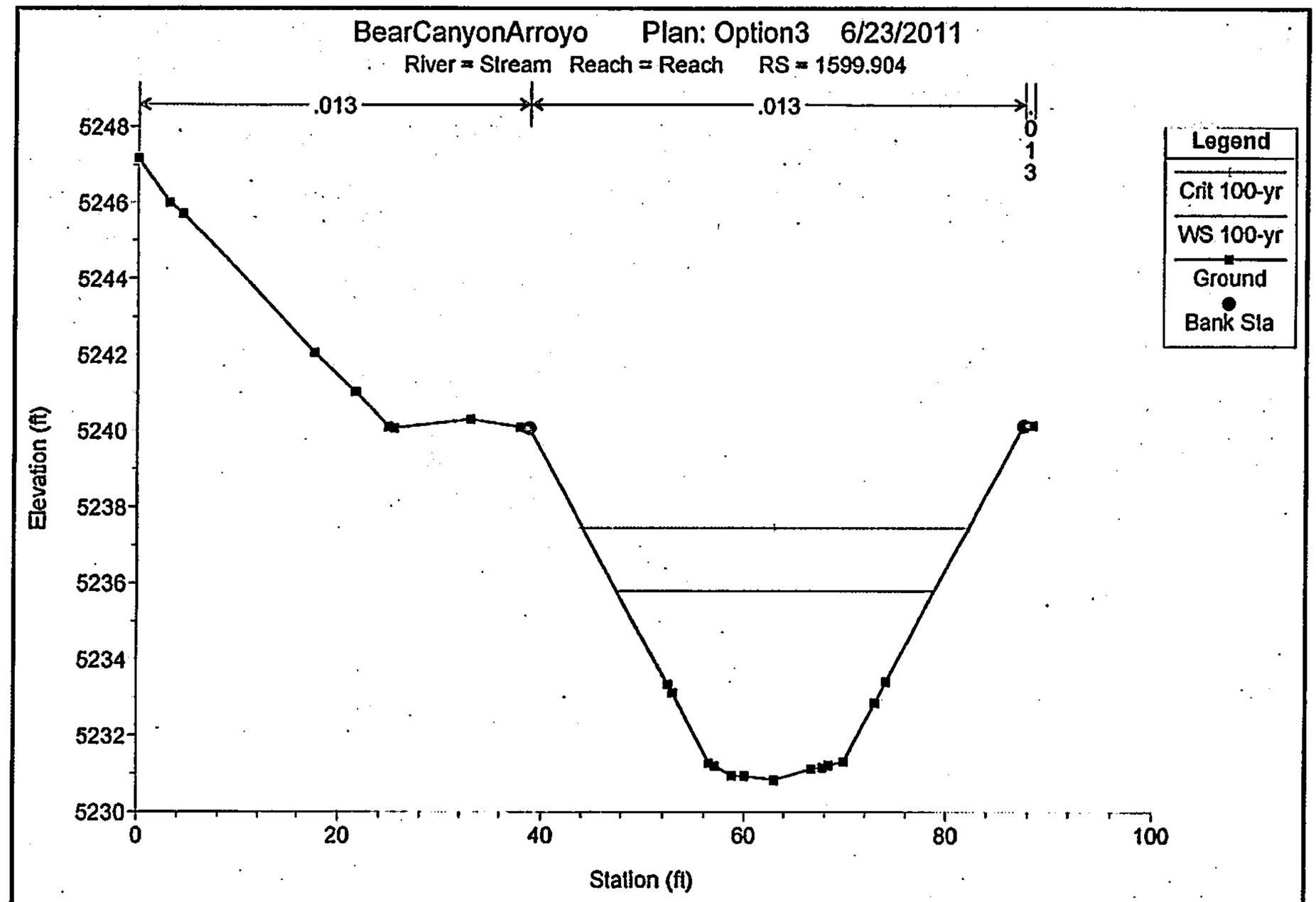

BearCanyonArroyo Plan: Option3 6/23/2011
Stream Reach
Legend
Crit 100-yr
WS 100-yr
Ground
Elevation (ft)
5240
5235
5230
5225
5220
5215
5210
5205
0
200
400
600
800
1000
1200
1400
1600
1800
Main Channel Distance (ft)

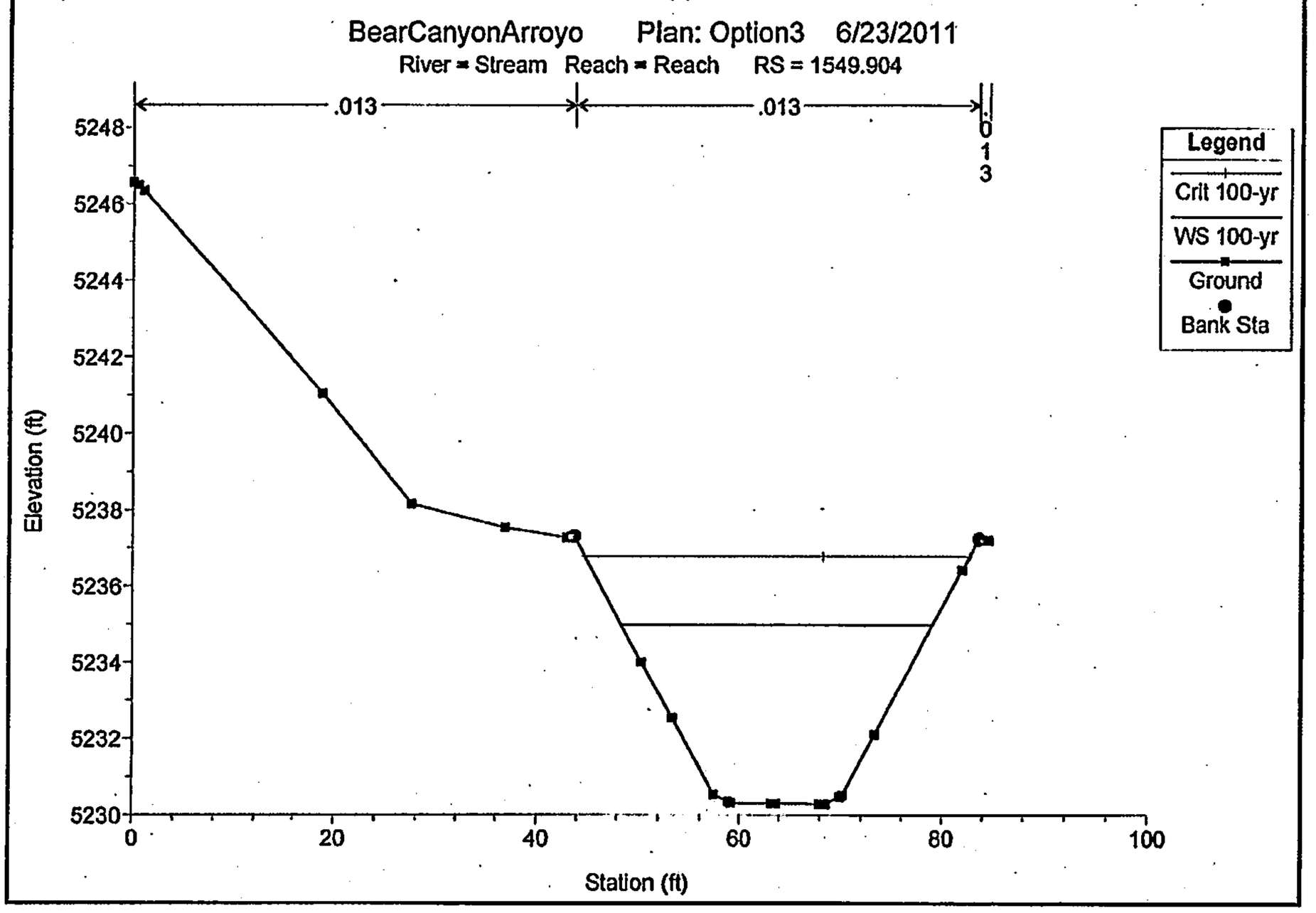

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1799.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5248
5246
5244
5242
5240
5238
5236
5234
5232
0
10
20
30
40
50
60
70
80
Station (ft)

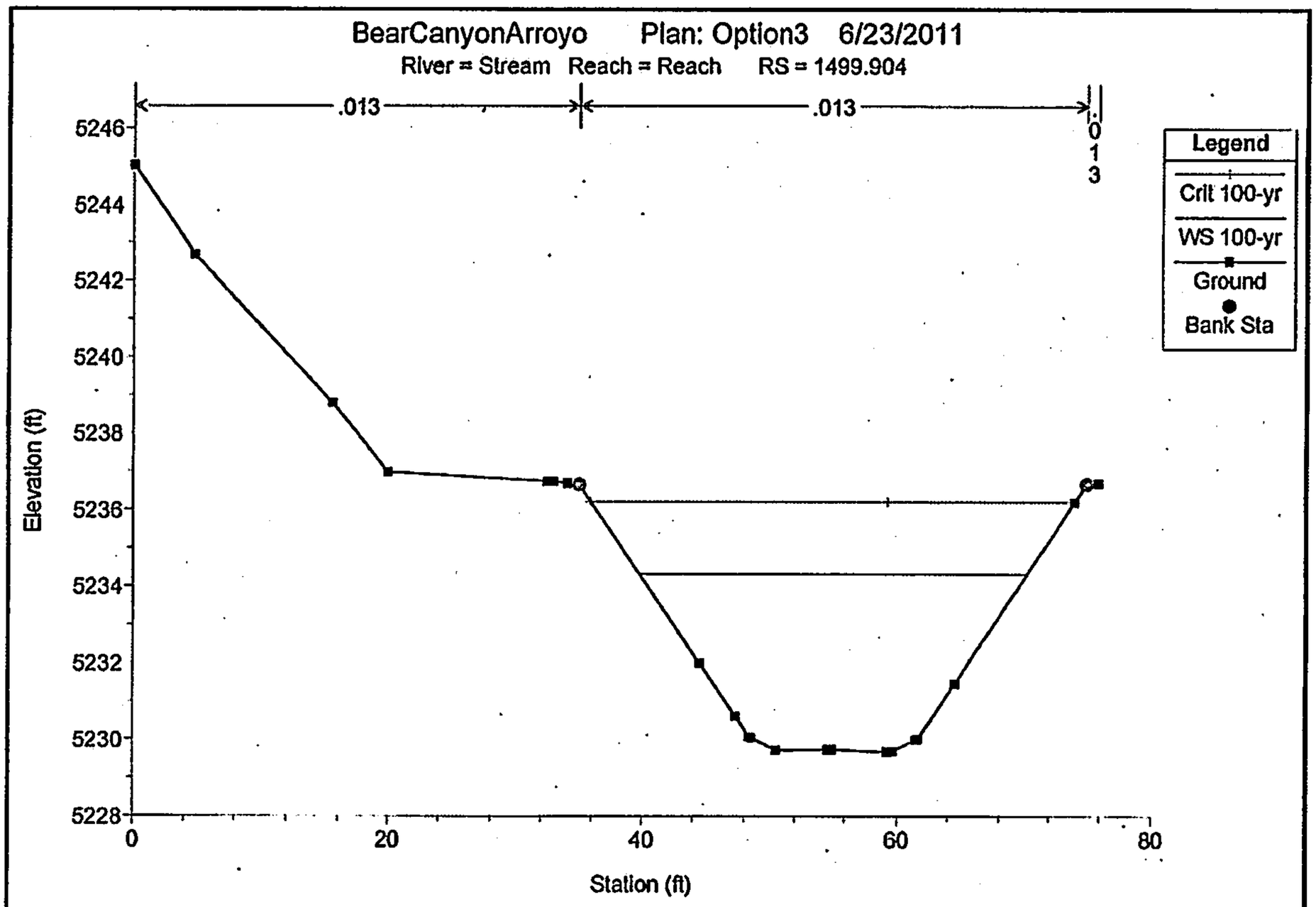

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1749.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5246
5244
5242
5240
5238
5236
5234
5232
0
20
40
60
80
100
Station (ft)

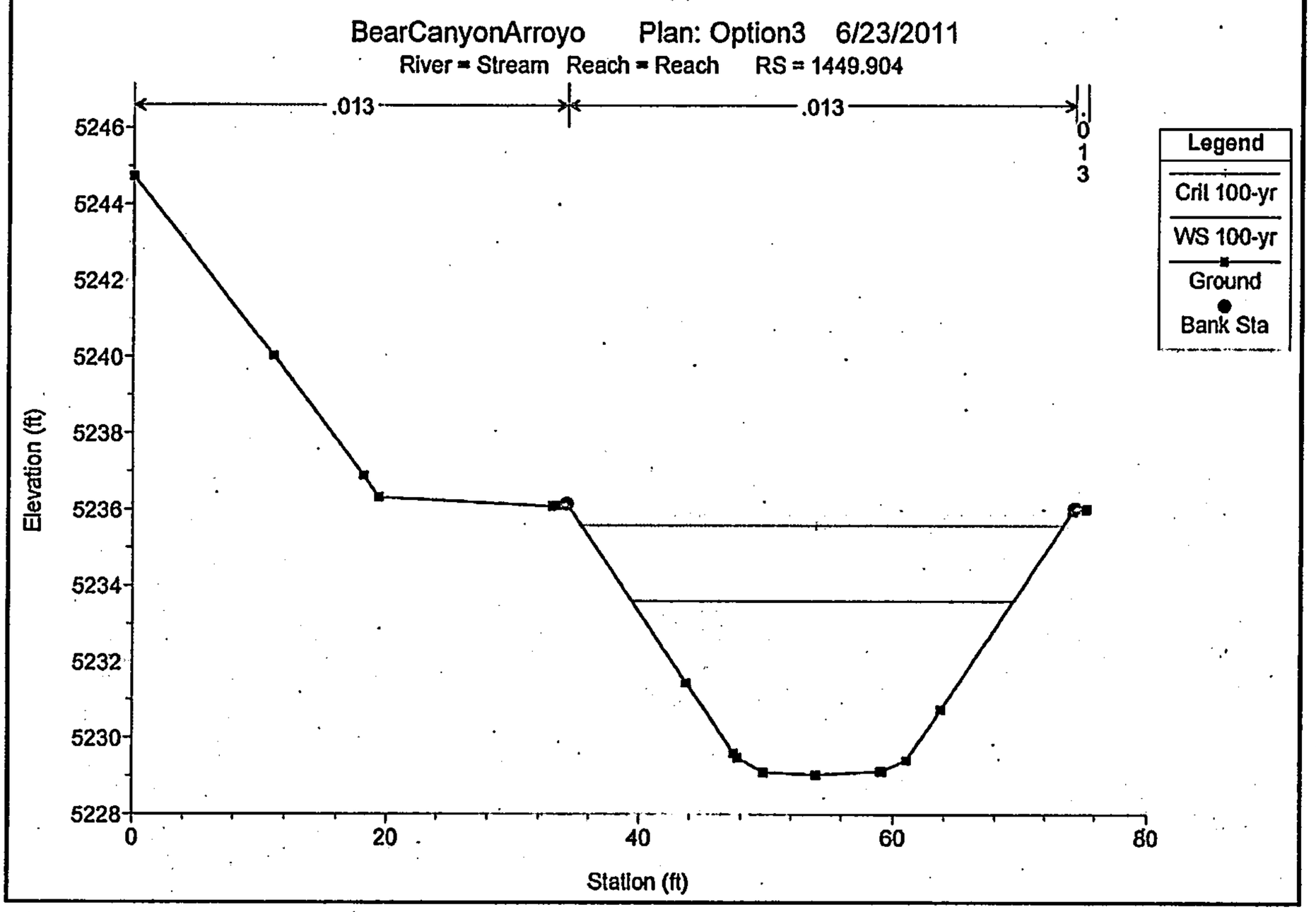

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1699.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5246
5244
5242
5240
5238
5236
5234
5232
0
20
40
60
80
100
Station (ft)

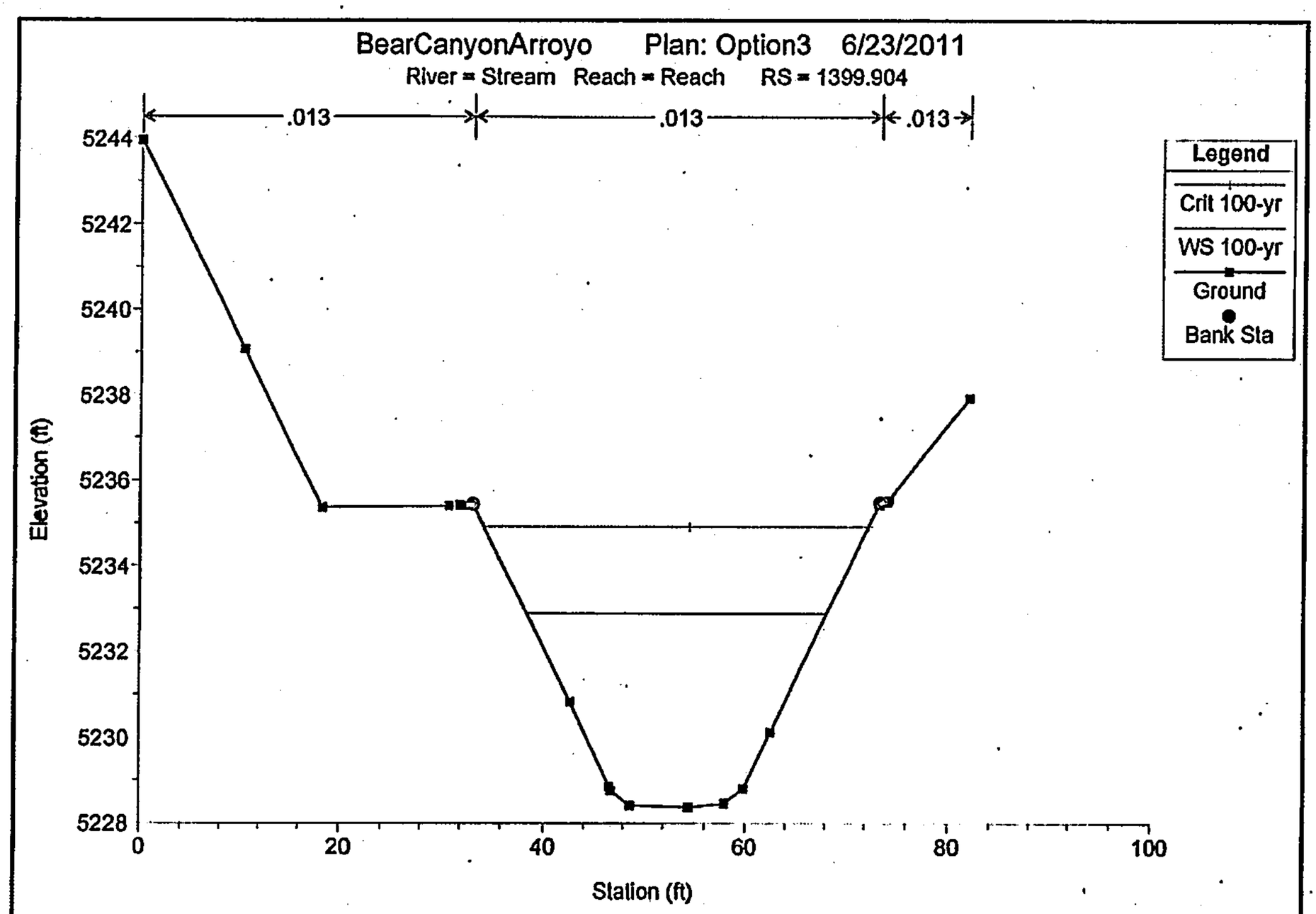

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1649.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5248
5246
5244
5242
5240
5238
5236
5234
5232
5230
0
20
40
60
80
100
Station (ft)

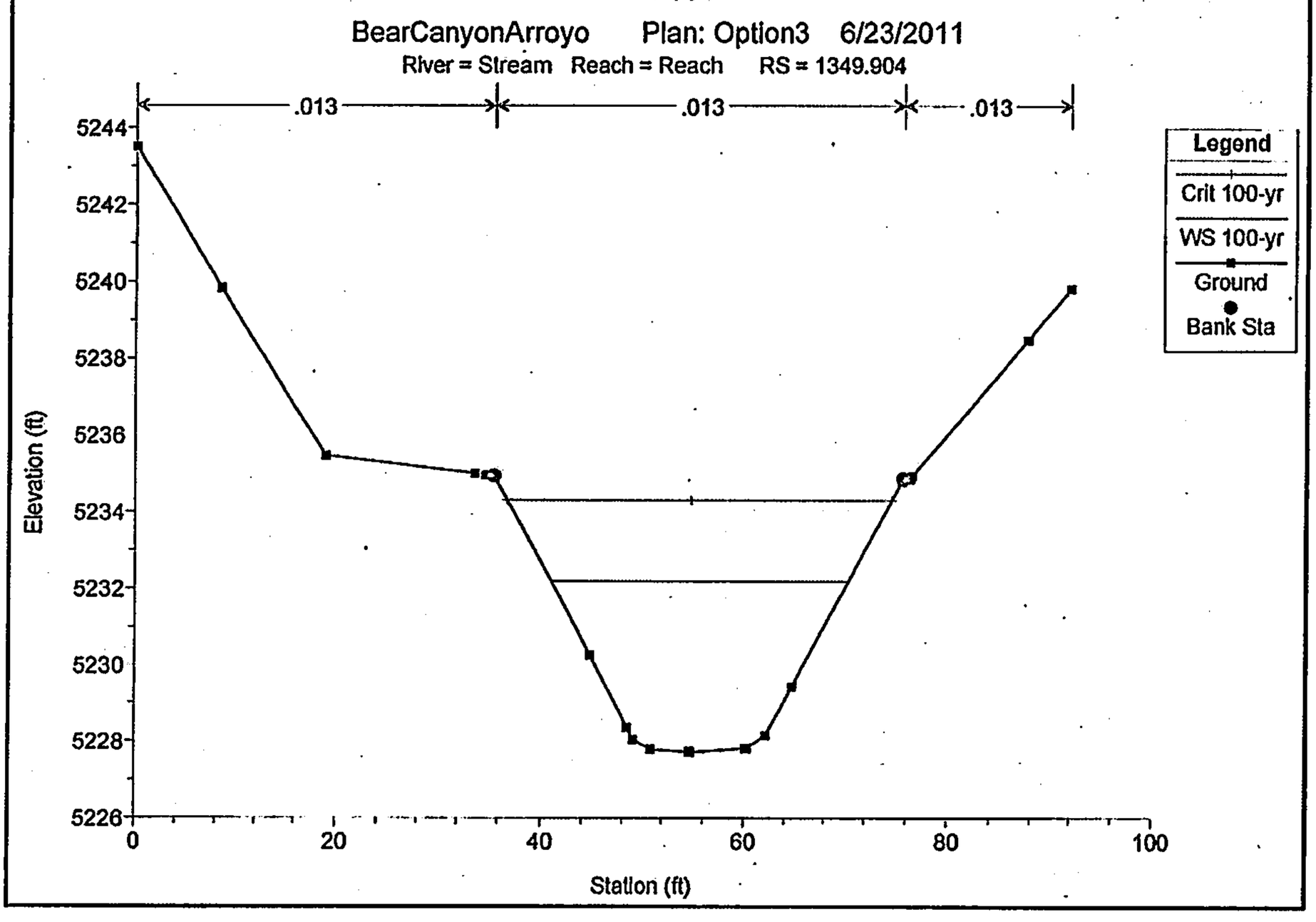

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1599.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5248
5246
5244
5242
5240
5238
5236
5234
5232
5230
0
20
40
60
80
100
Station (fl)

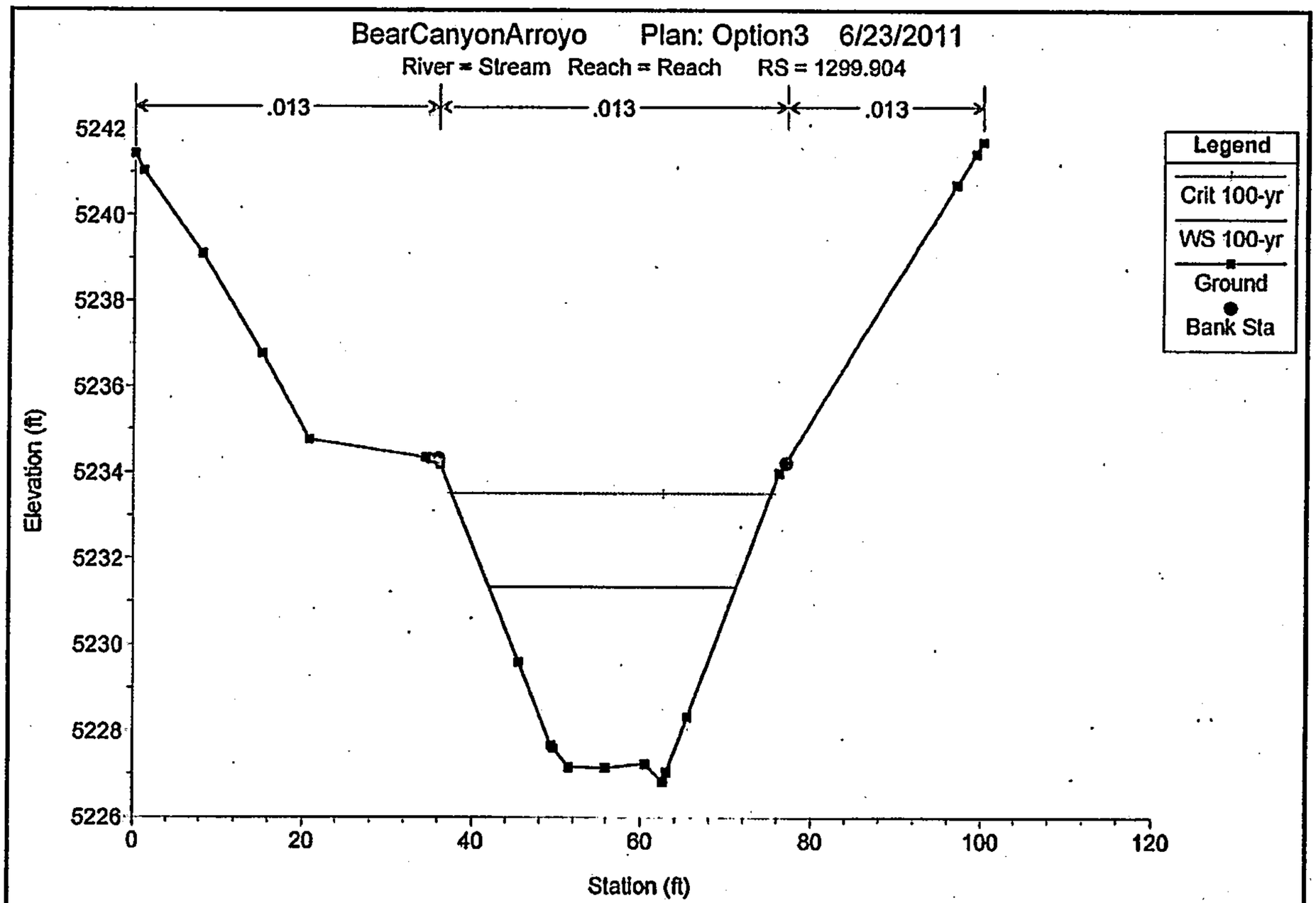

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1549.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5248
5246
5244
5242
5240
5238
5236
5234
5232
5230
0
20
40
60
80
100
Station (ft)

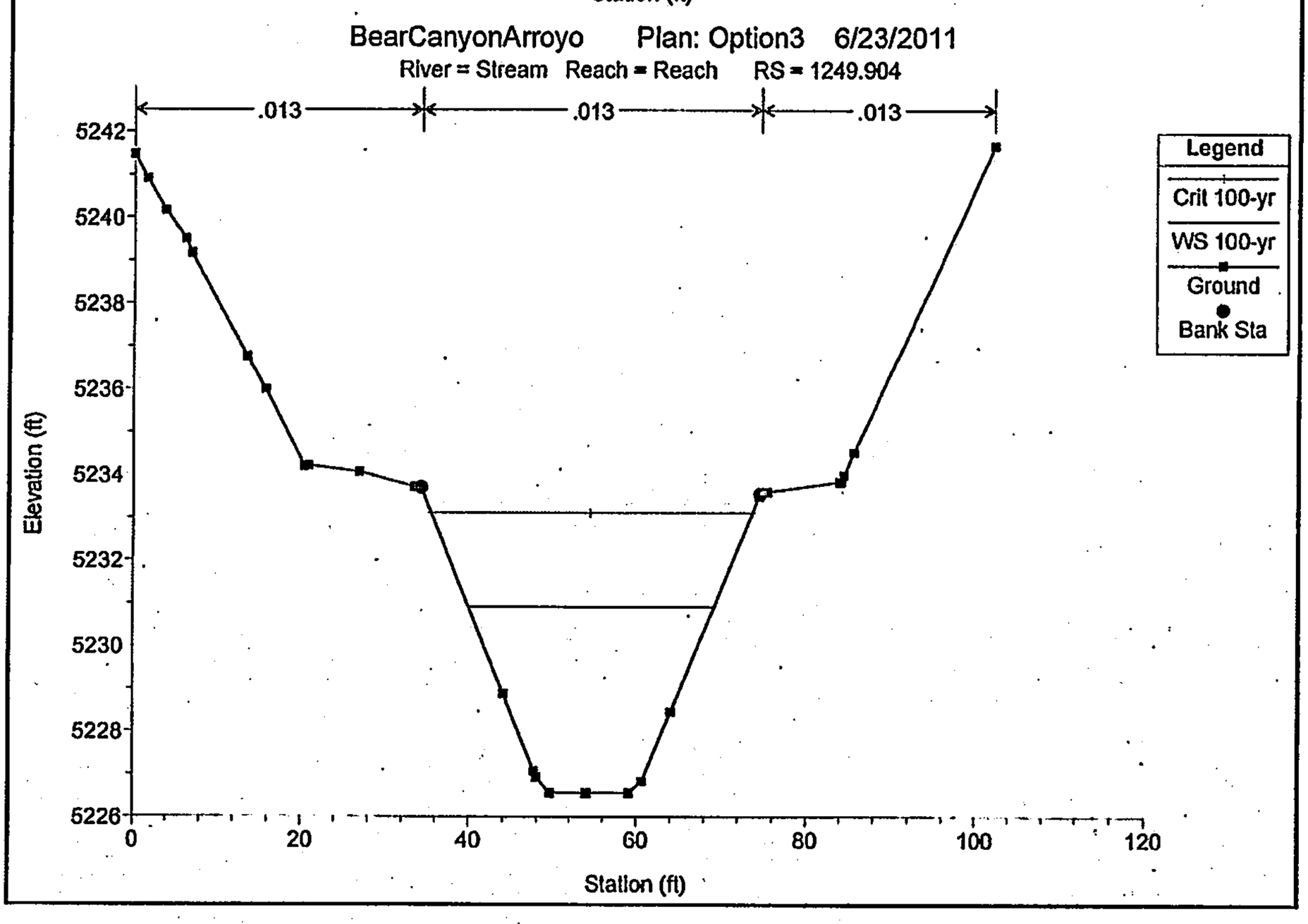

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1499.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5246
5244
5242
5240
5238
5236
5234
5232
5230
5228
0
20
40
60
80
Station (ft)

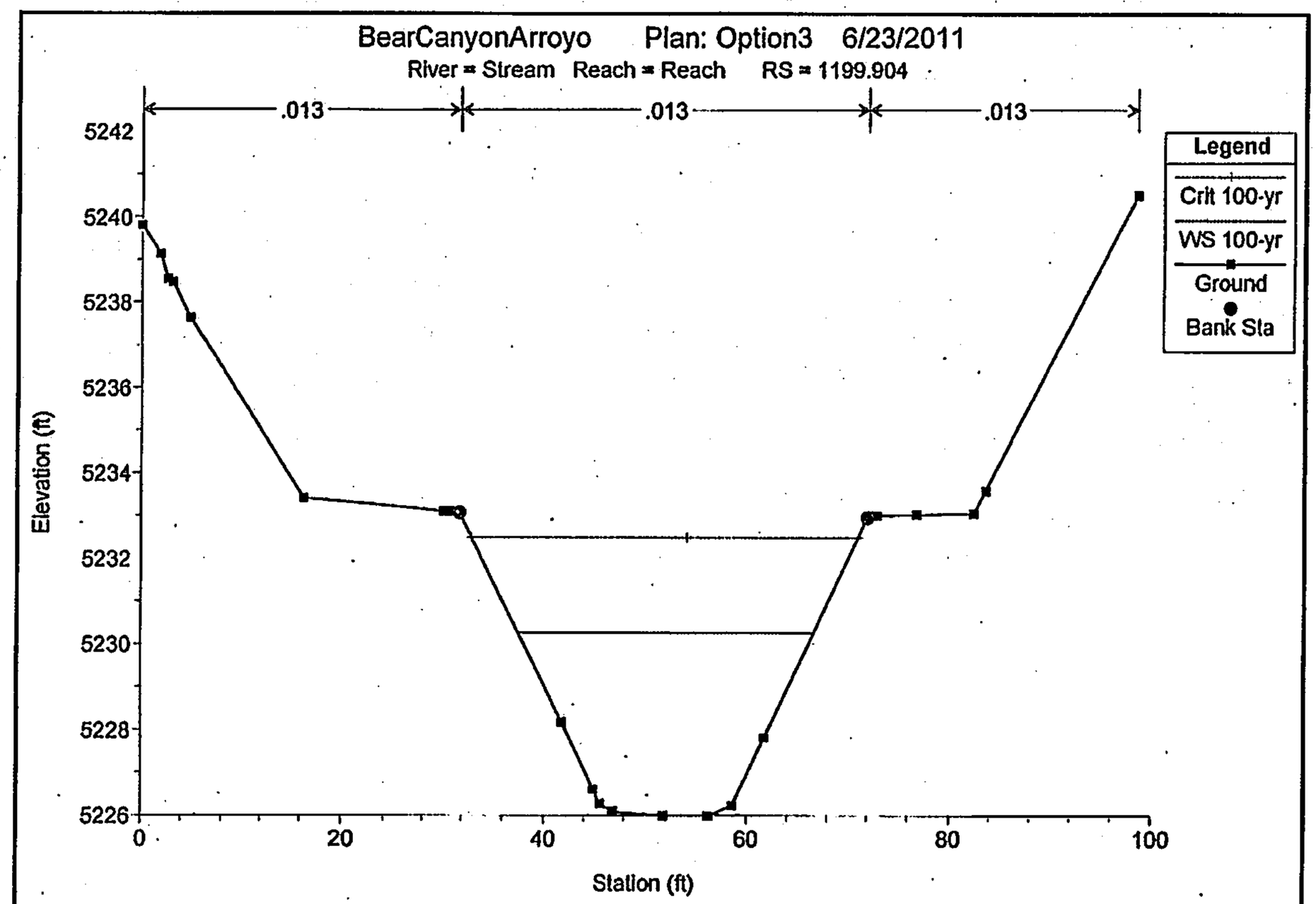

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1449.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5246
5244
5242
5240
5238
5236
5234
5232
5230
5228
0
20
40
60
80
Station (ft)

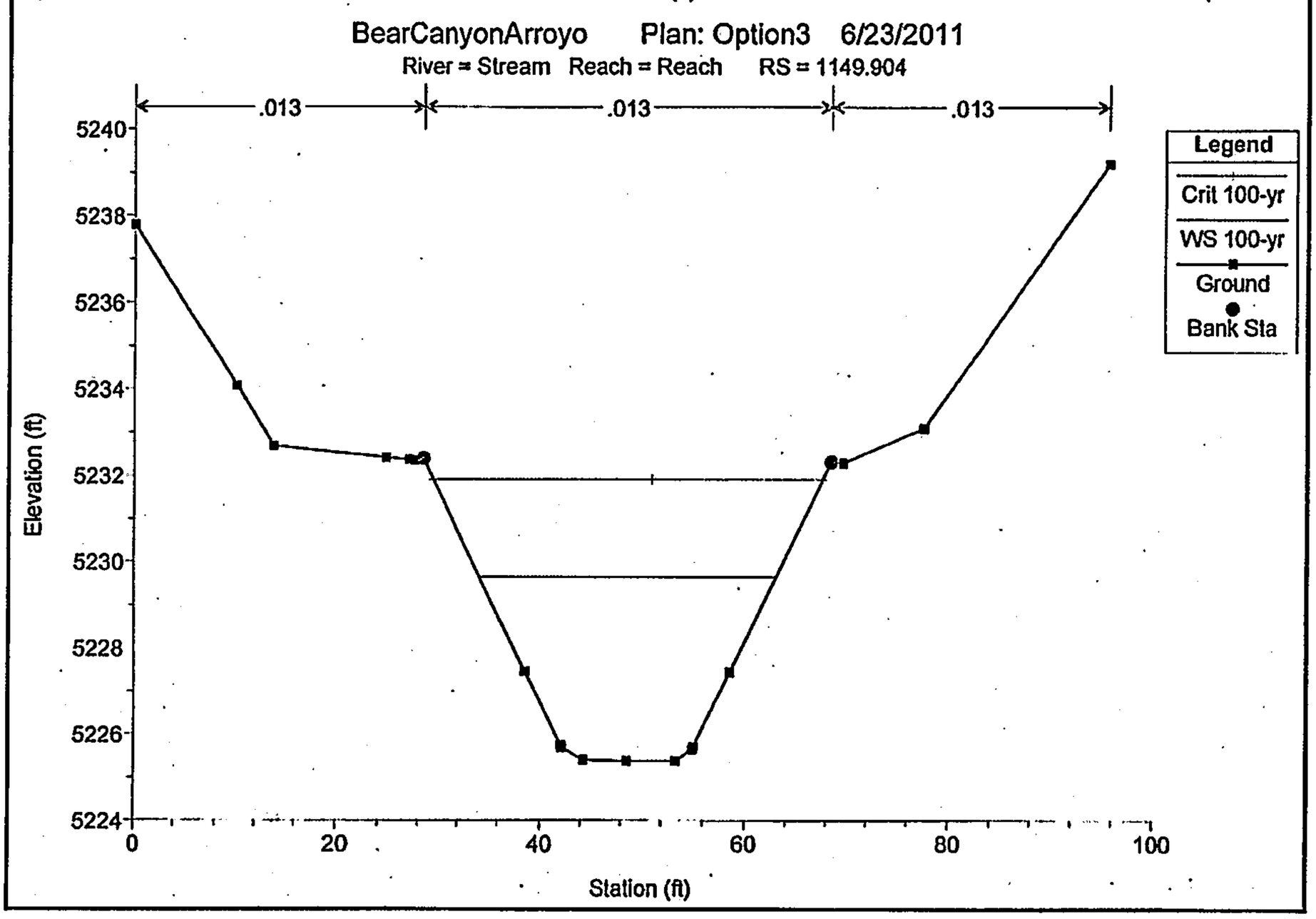

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1399.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5244
5242
5240
5238
5236
5234
5232
5230
5228
0
20
40
60
80
100
Station (ft)

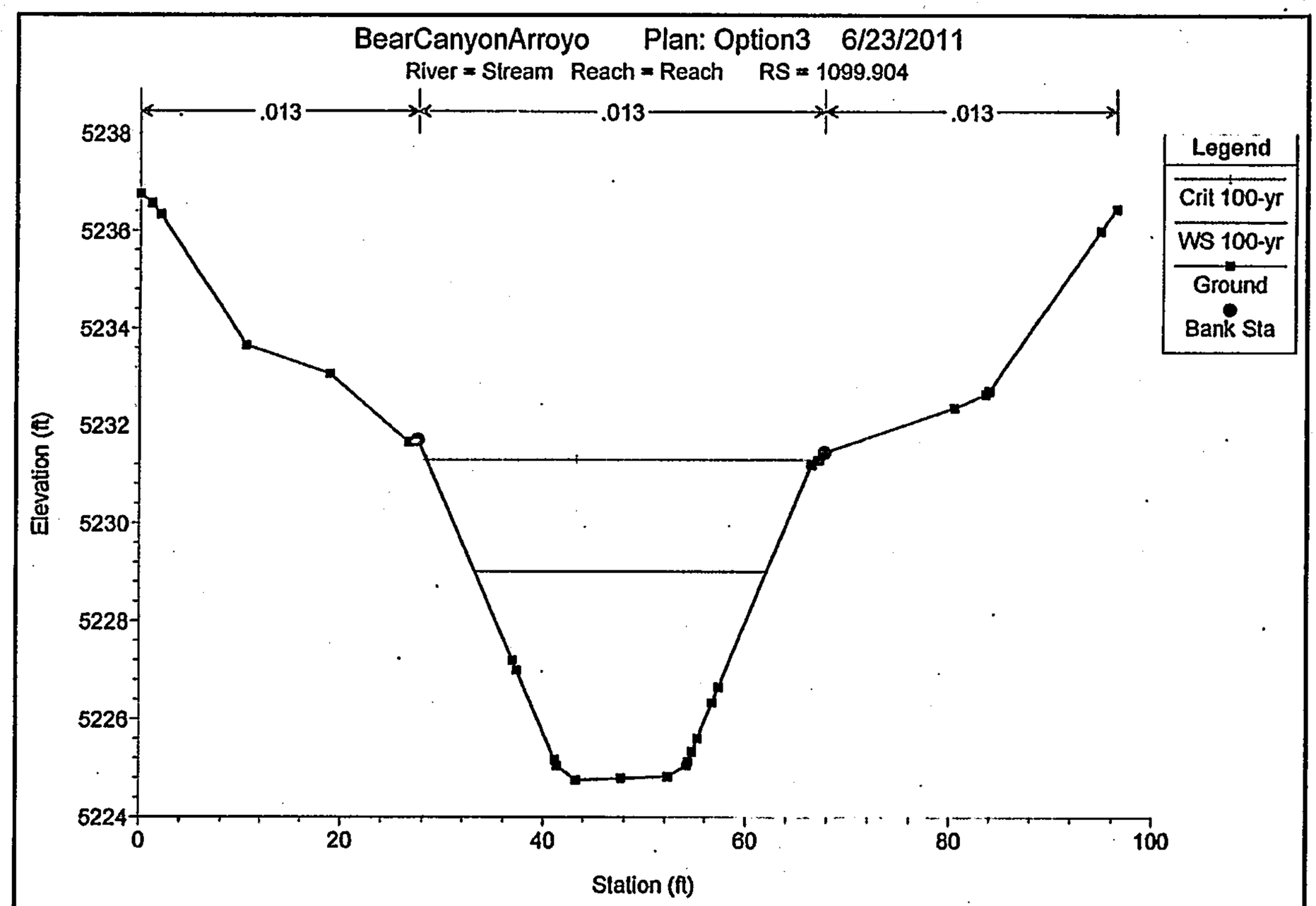

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1349.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5244
5242
5240
5238
5236
5234
5232
5230
5228
5226
0
20
40
60
80
100
Station (ft)

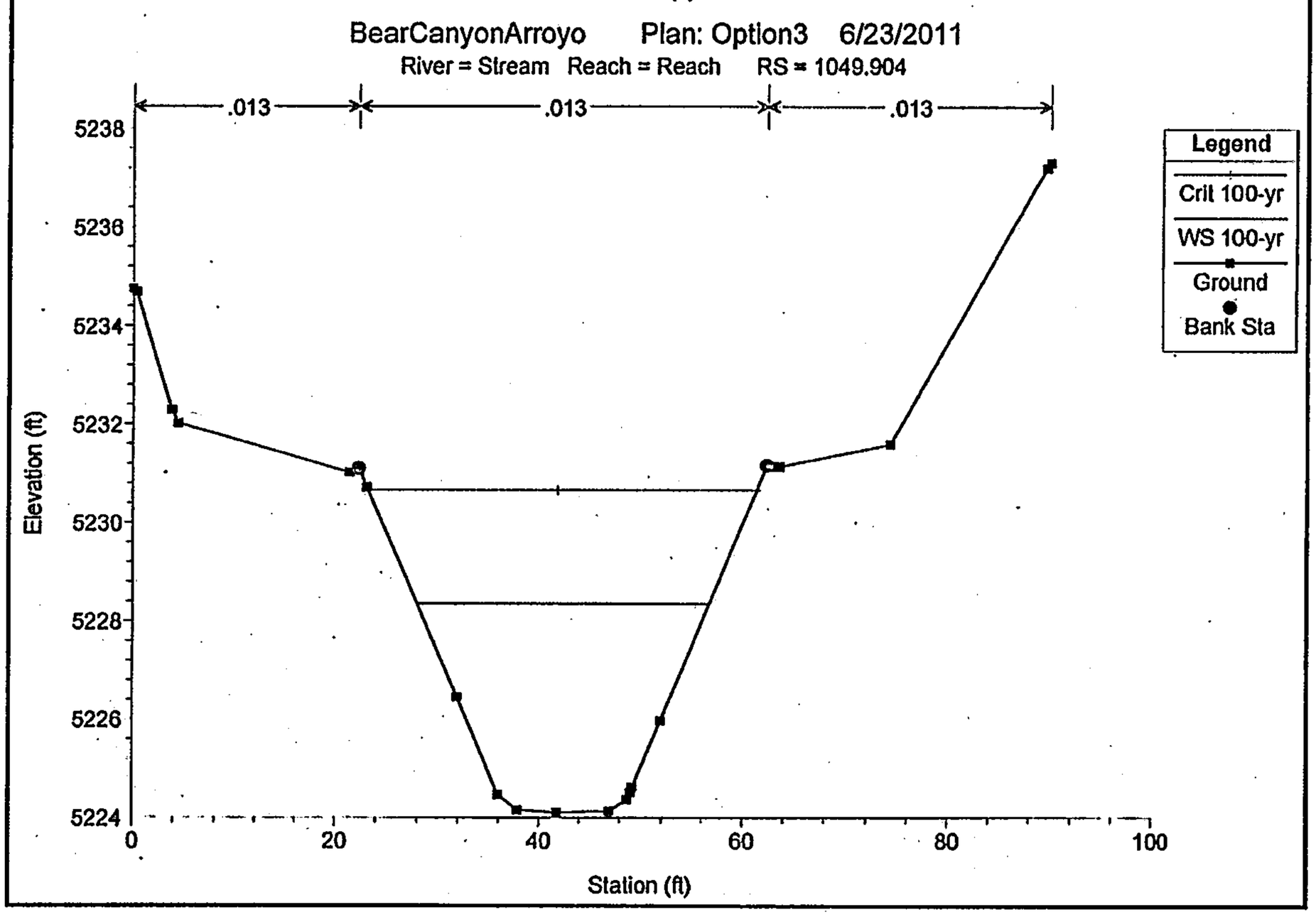

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1299.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5242
5240
5238
5236
5234
5232
5230
5228
5226
0
20
40
60
80
100
120
Station (ft)

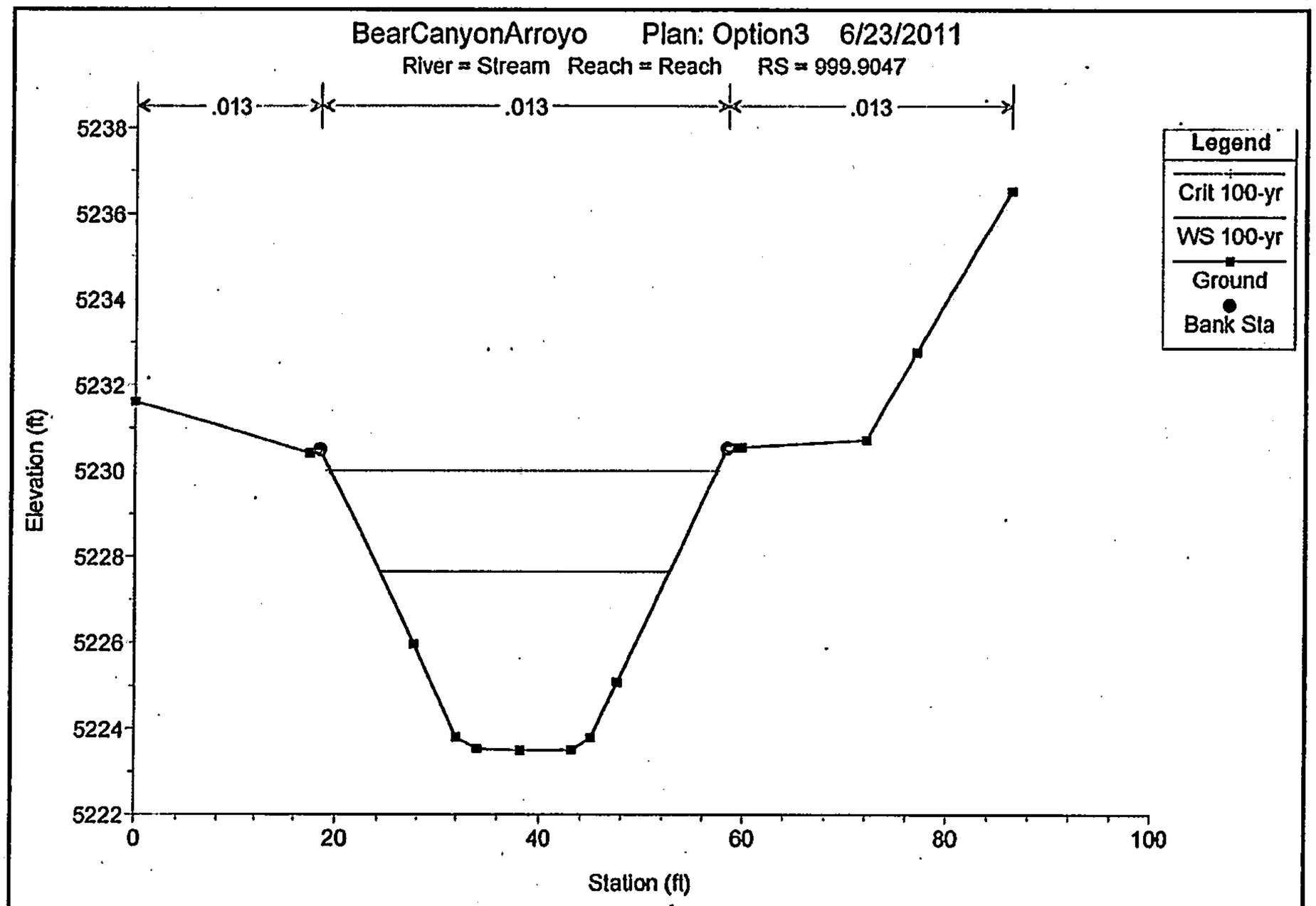

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1249.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5242
5240
5238
5236
5234
5232
5230
5228
5226
0
20
40
60
80
100
120
Station (ft)

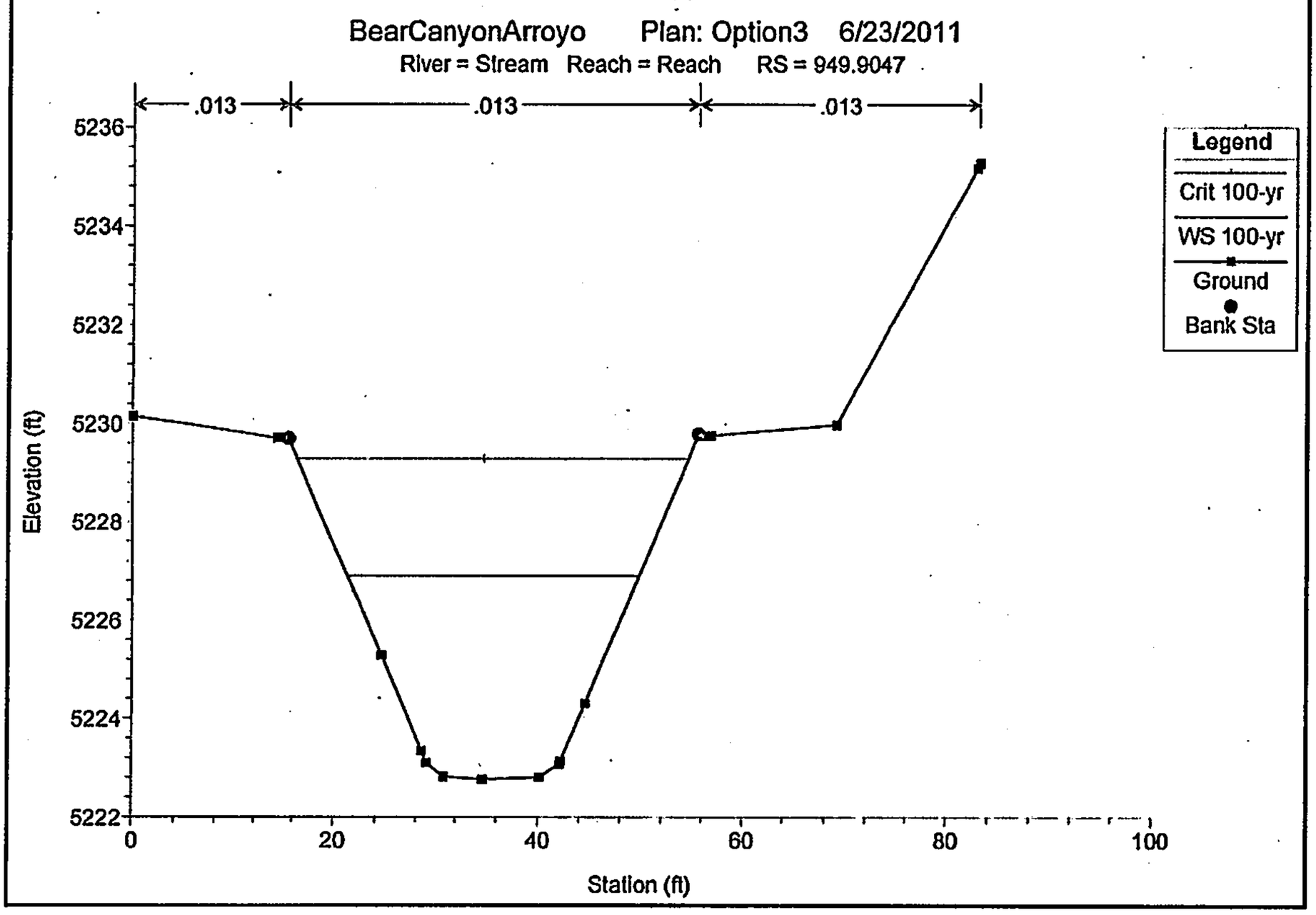

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1199.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5242
5240
5238
5236
5234
5232
5230
5228
5226
0
20
40
60
80
100
Station (ft)

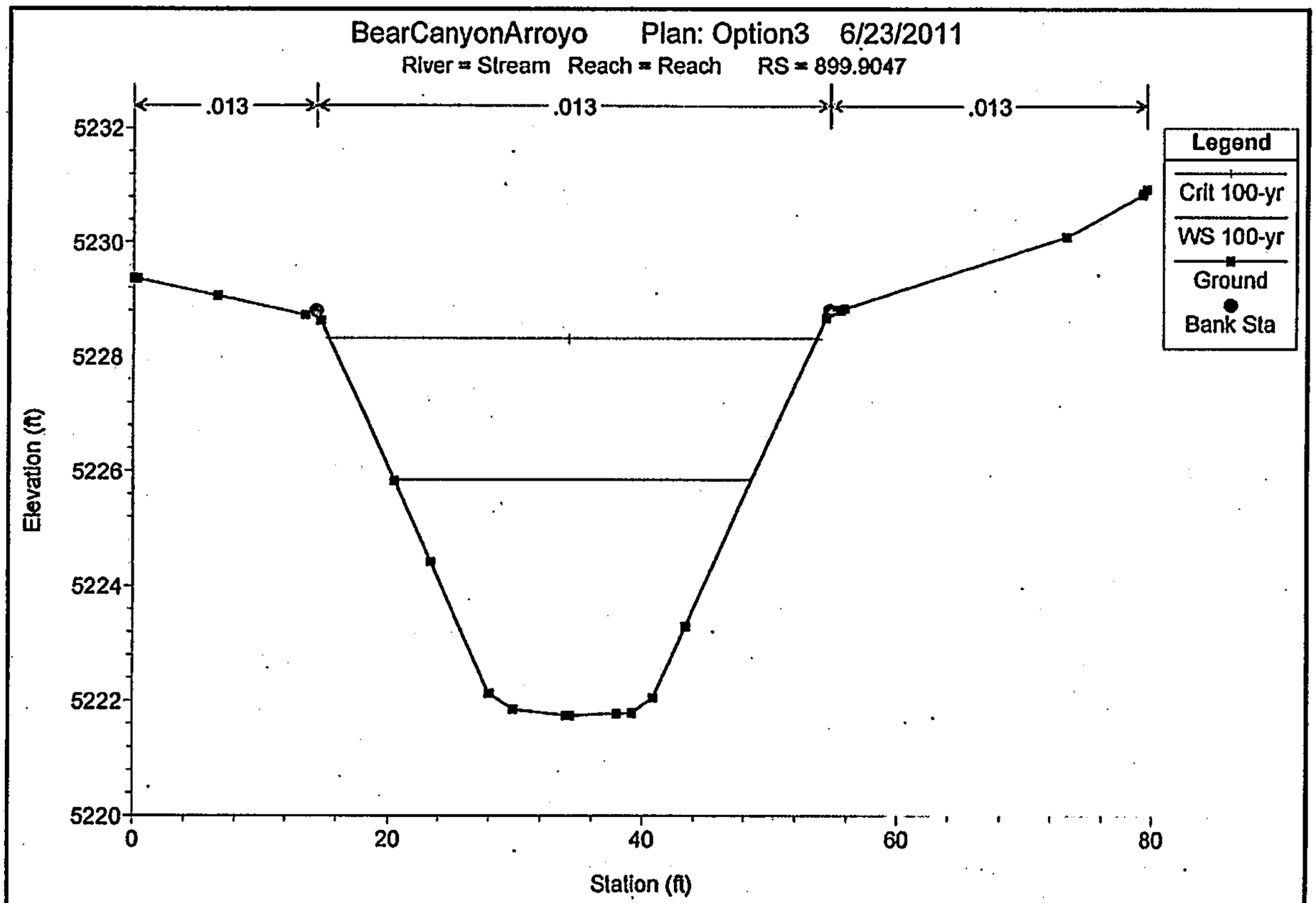

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1149.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5240
5238
5236
5234
5232
5230
5228
5226
5224
0
20
40
60
80
100
Station (ft)

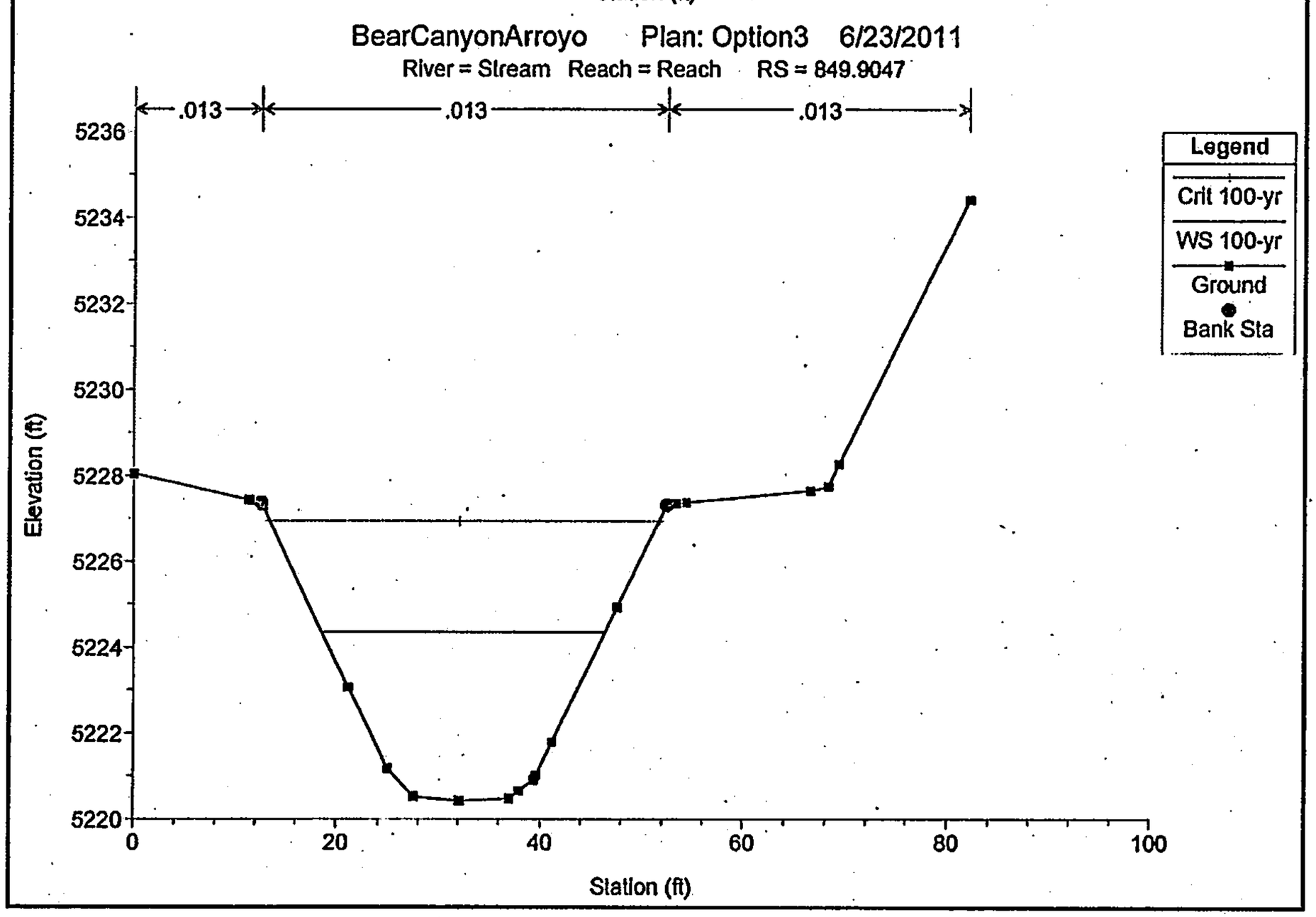

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1099.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5238
5236
5234
5232
5230
5228
5226
5224
0
20
40
60
80
100
Station (ft)

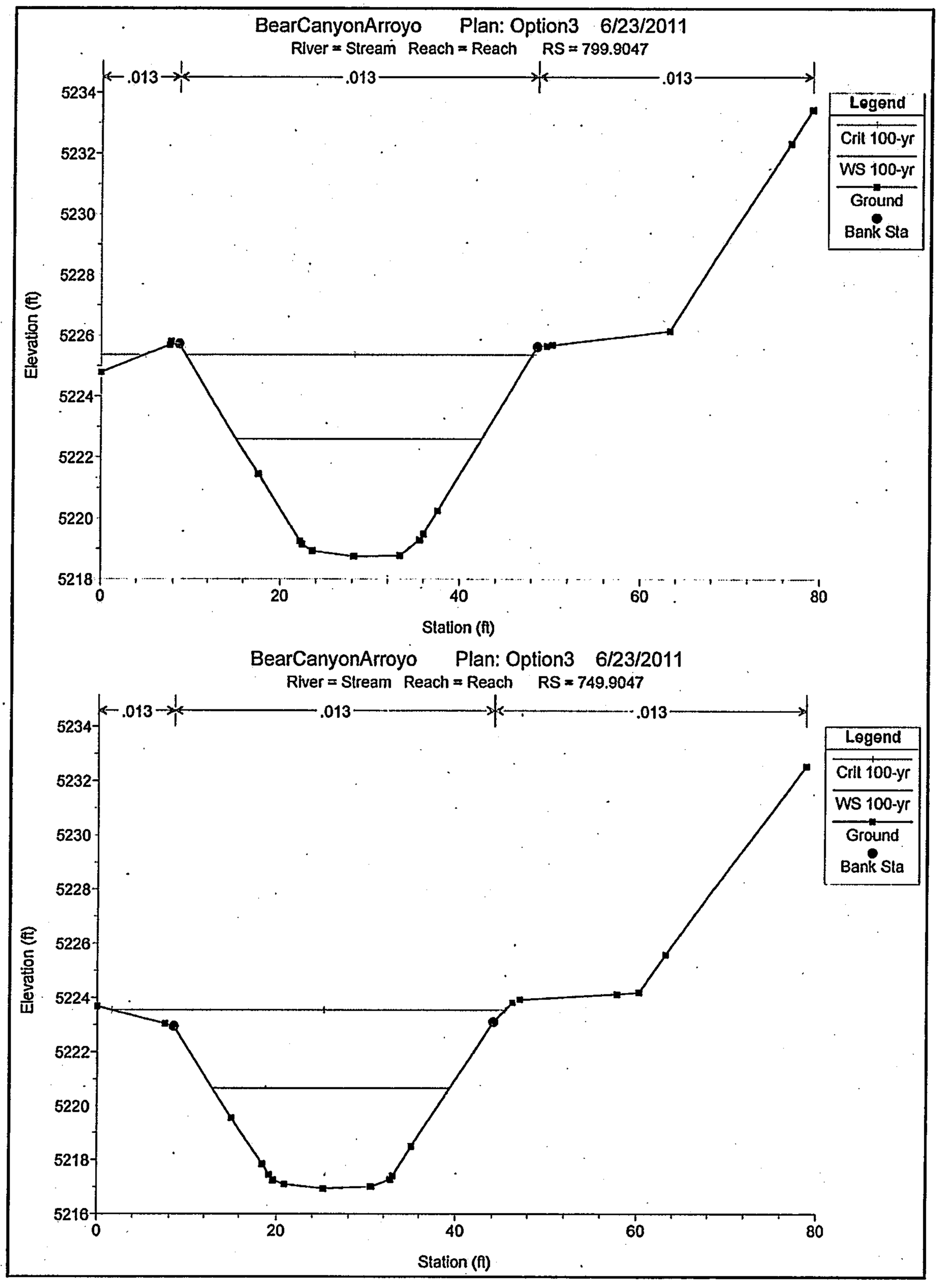

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 1049.904
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5238
5236
5234
5232
5230
5228
5226
5224
0
20
40
60
80
100
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 999.9047
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5238
5236
5234
5232
5230
5228
5226
5224
5222
0
20
40
60
80
100
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 949.9047
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5236
5234
5232
5230
5228
5226
5224
5222
0
20
40
60
80
100
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 899.9047
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5232
5230
5228
5226
5224
5222
5220
0
20
40
60
80
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 849.9047
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5236
5234
5232
5230
5228
5226
5224
5222
5220
0
20
40
60
80
100
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 799.9047
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5234
5232
5230
5228
5226
5224
5222
5220
5218
0
20
40
60
80
Station (ft)
BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 749.9047
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5234
5232
5230
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5226
5224
5222
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5218
5216
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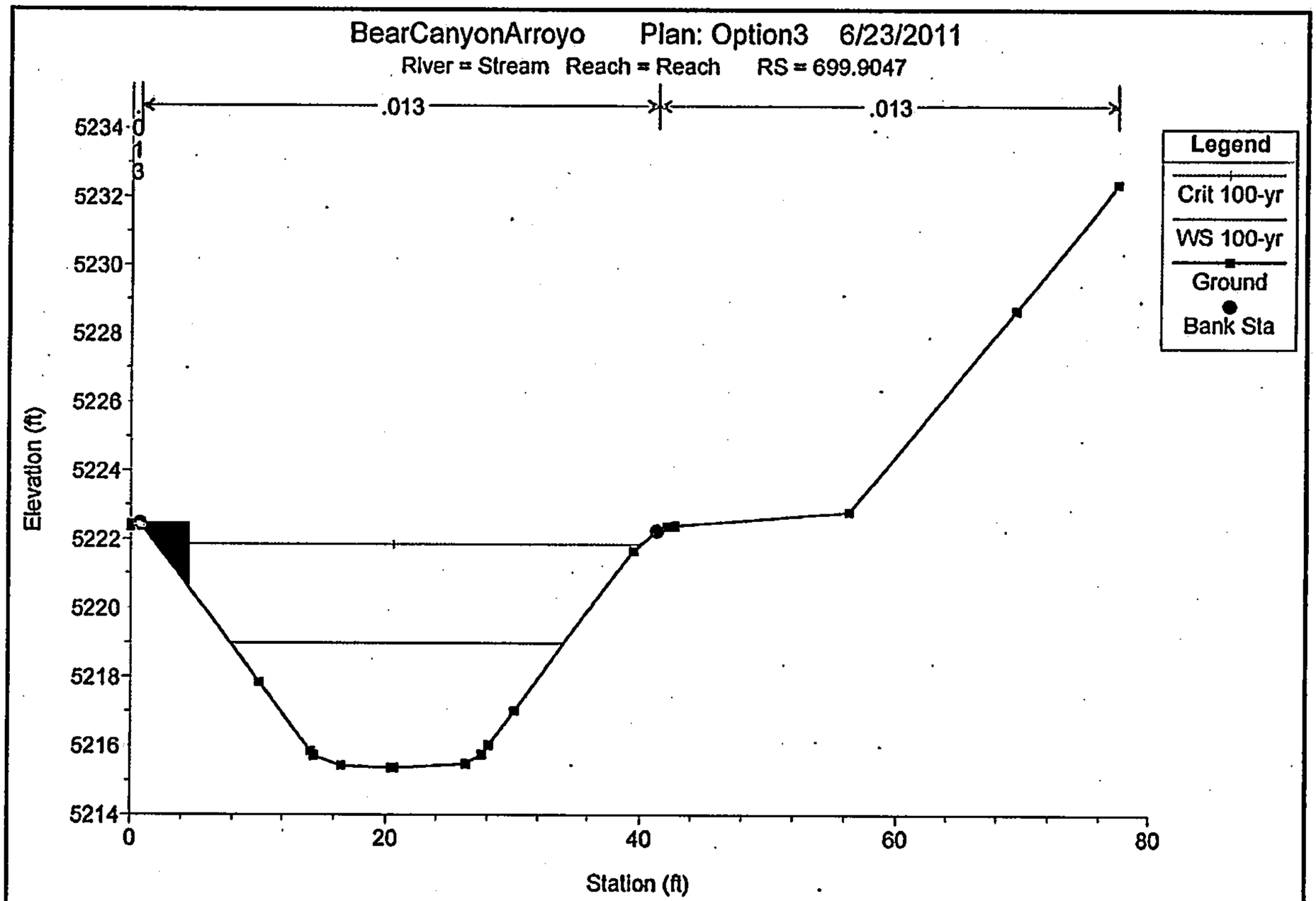
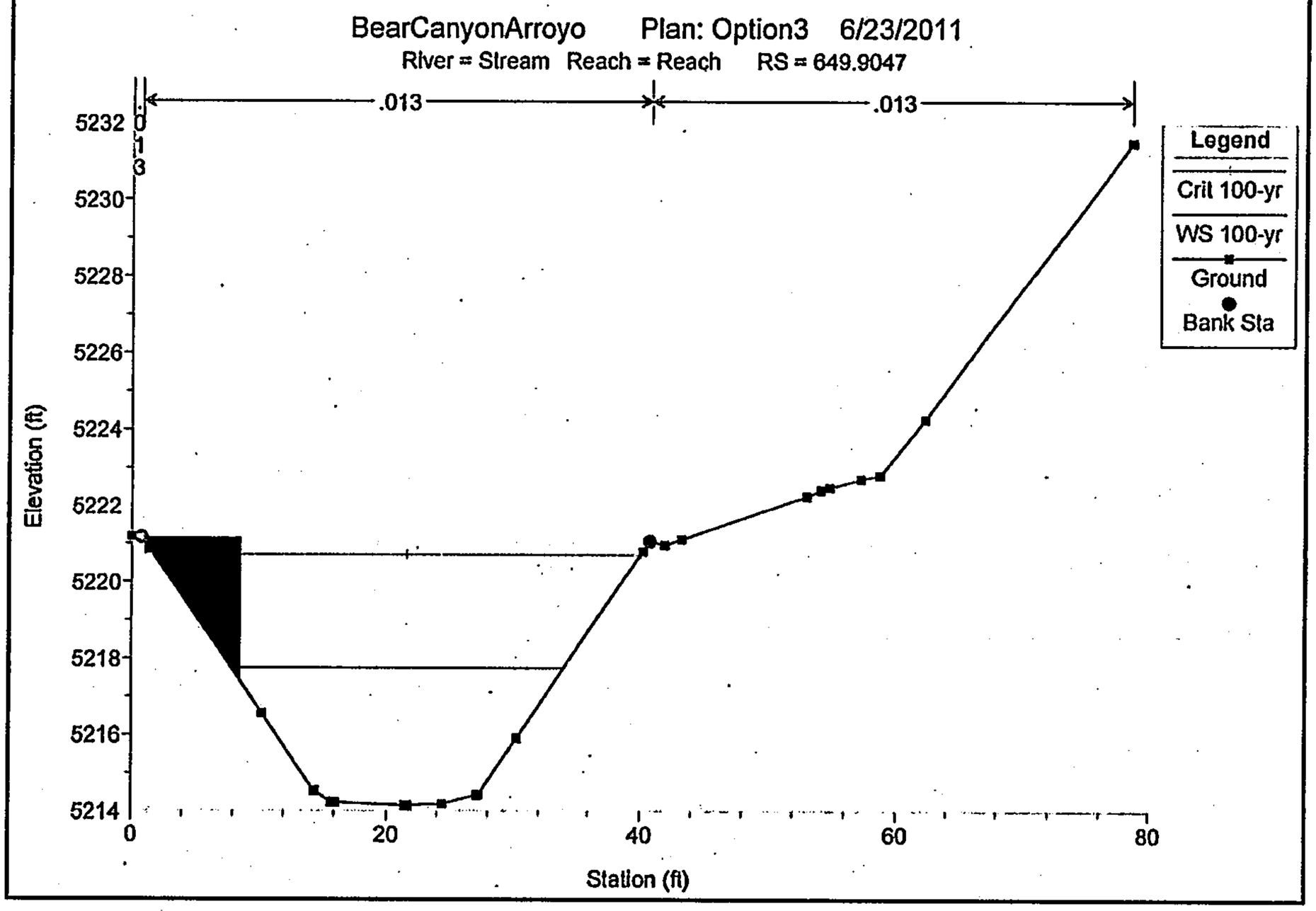
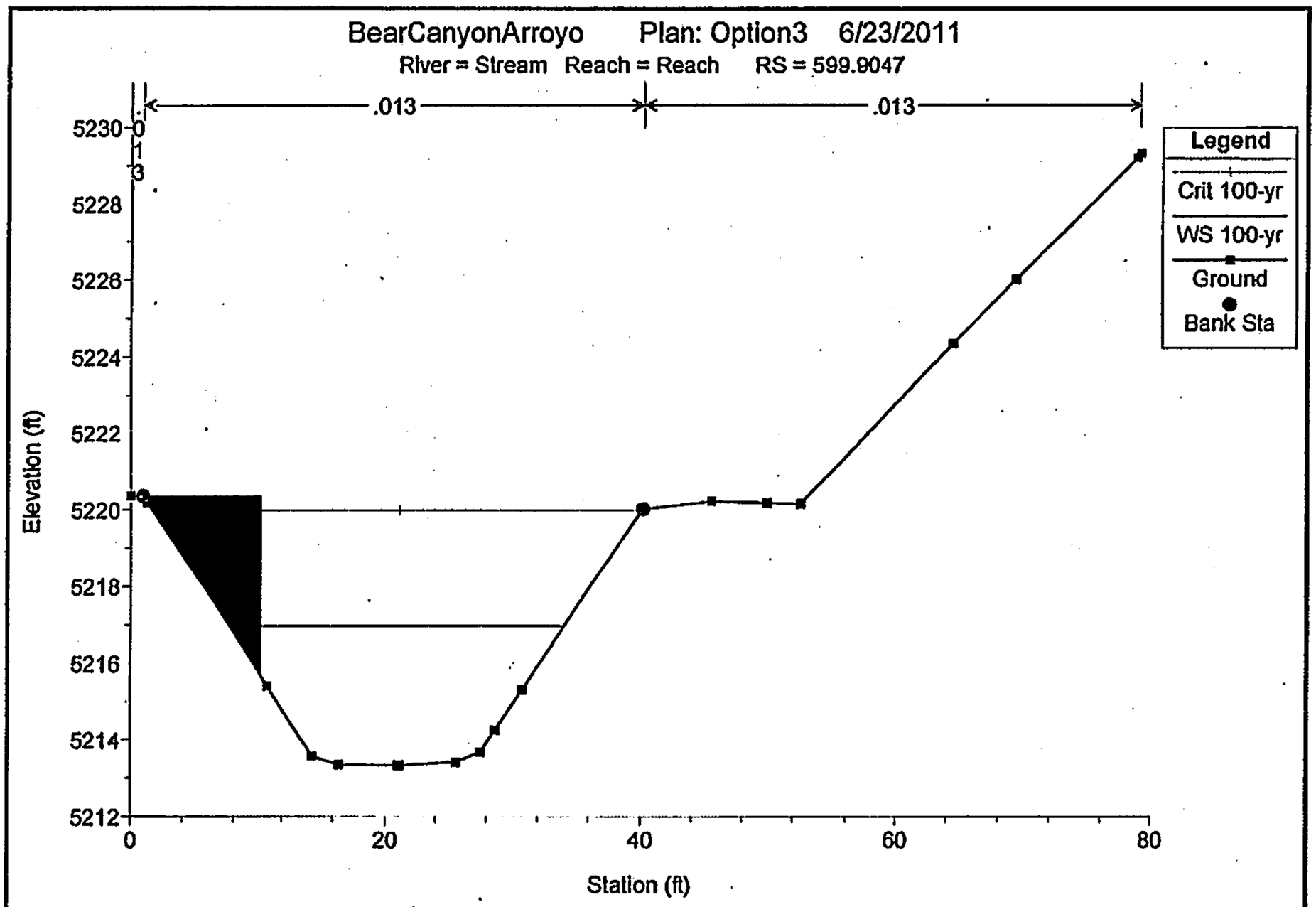
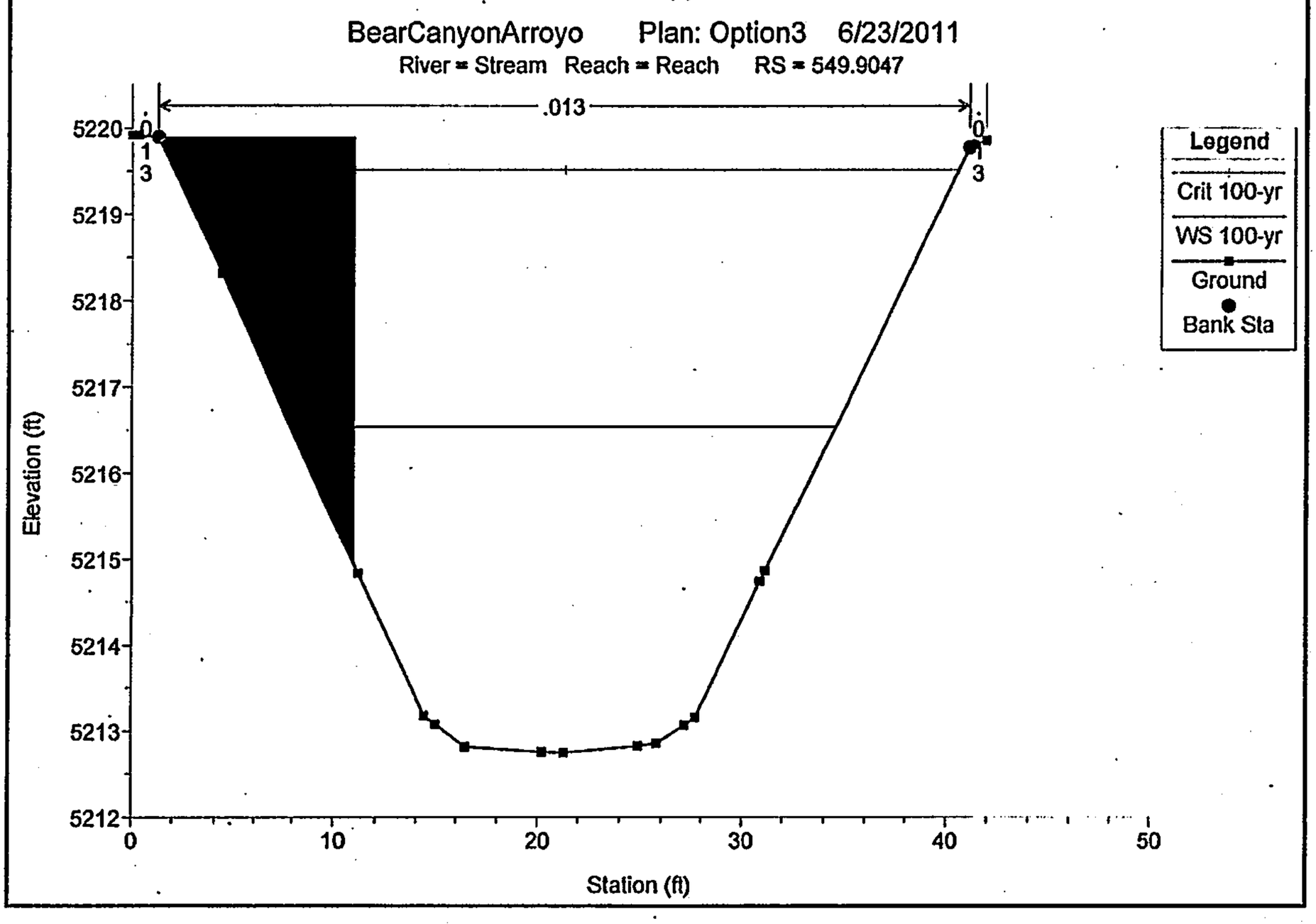
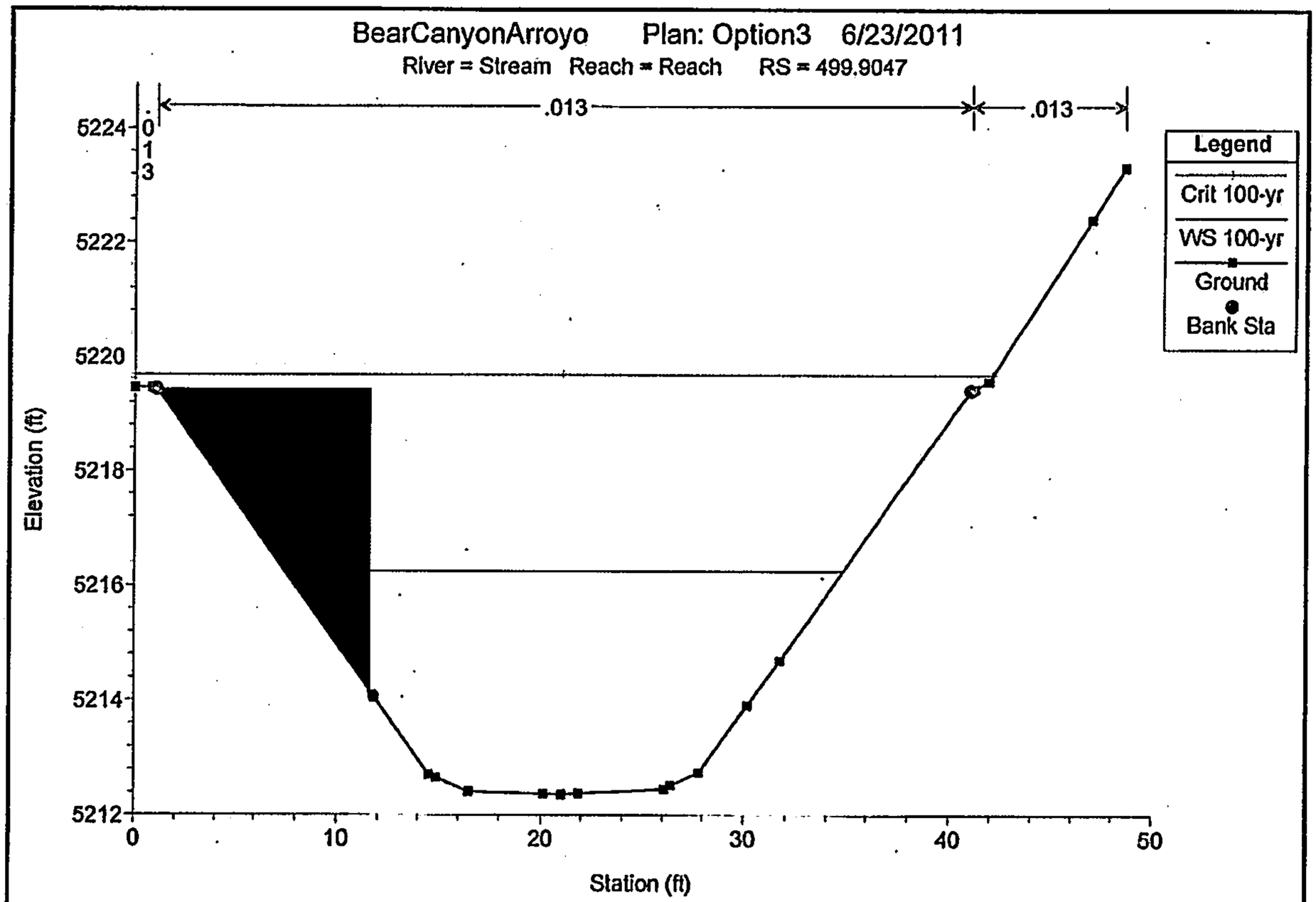
20
40
60
80
Station (ft)

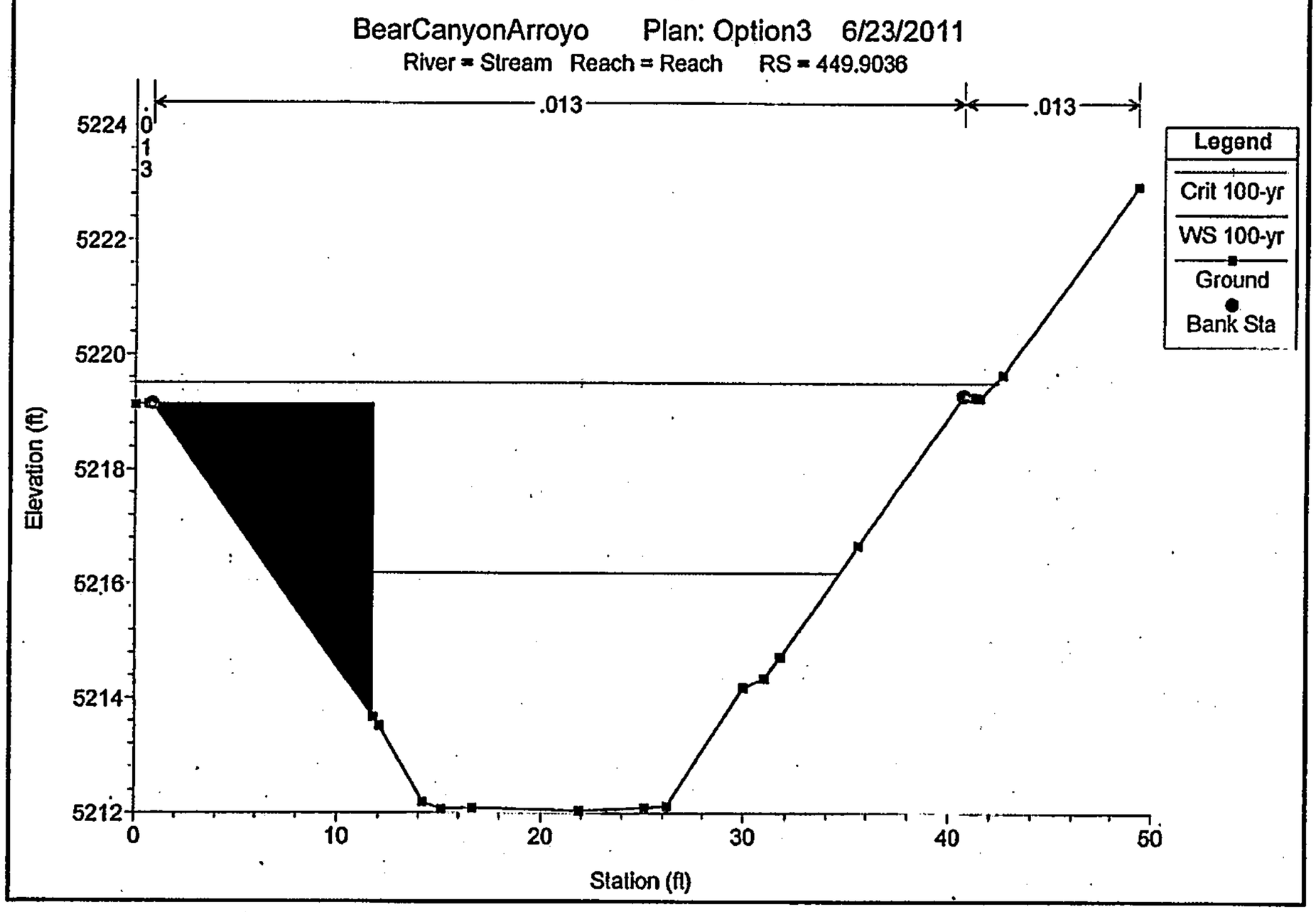

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 699.9047
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

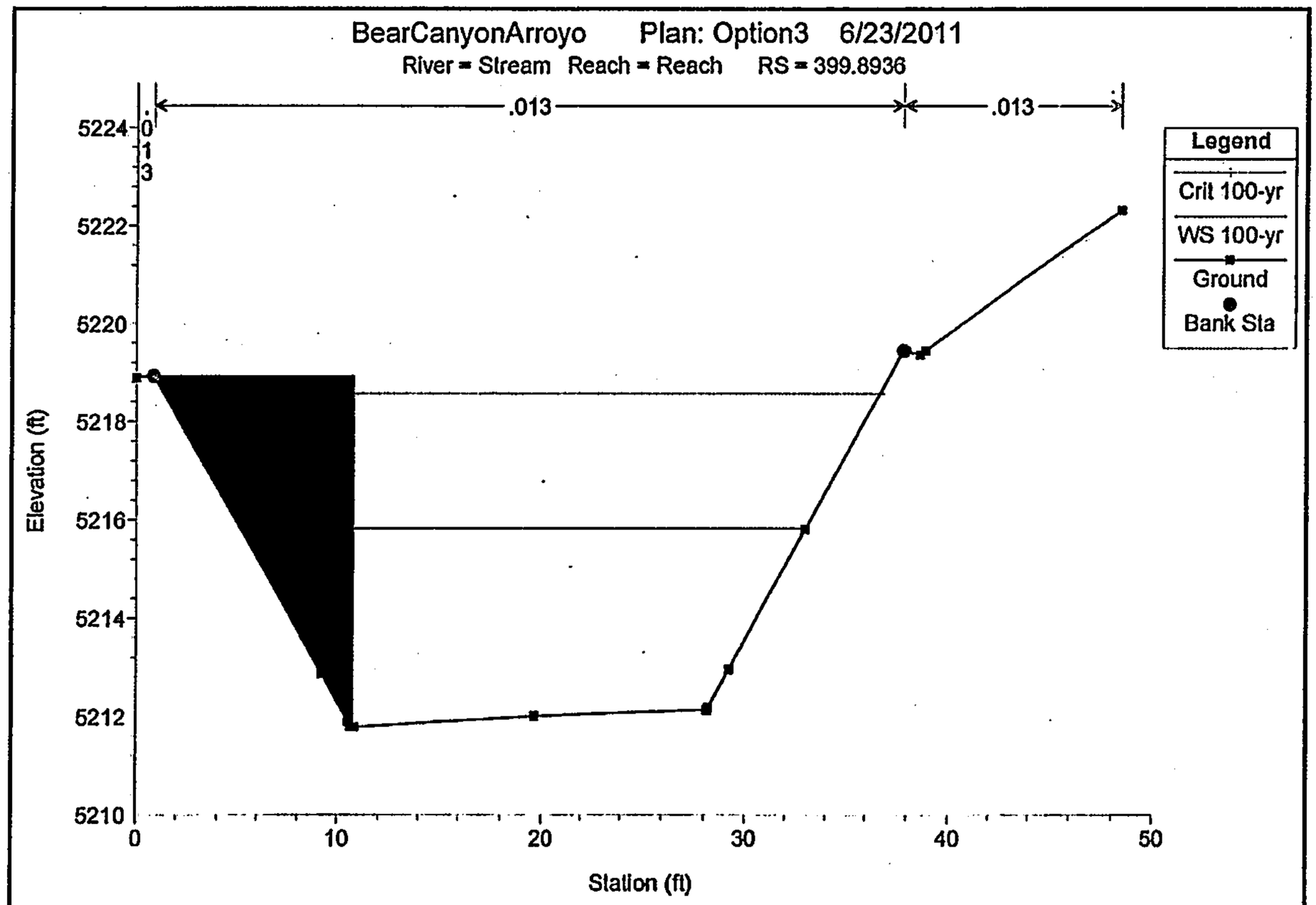

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 649.9047
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

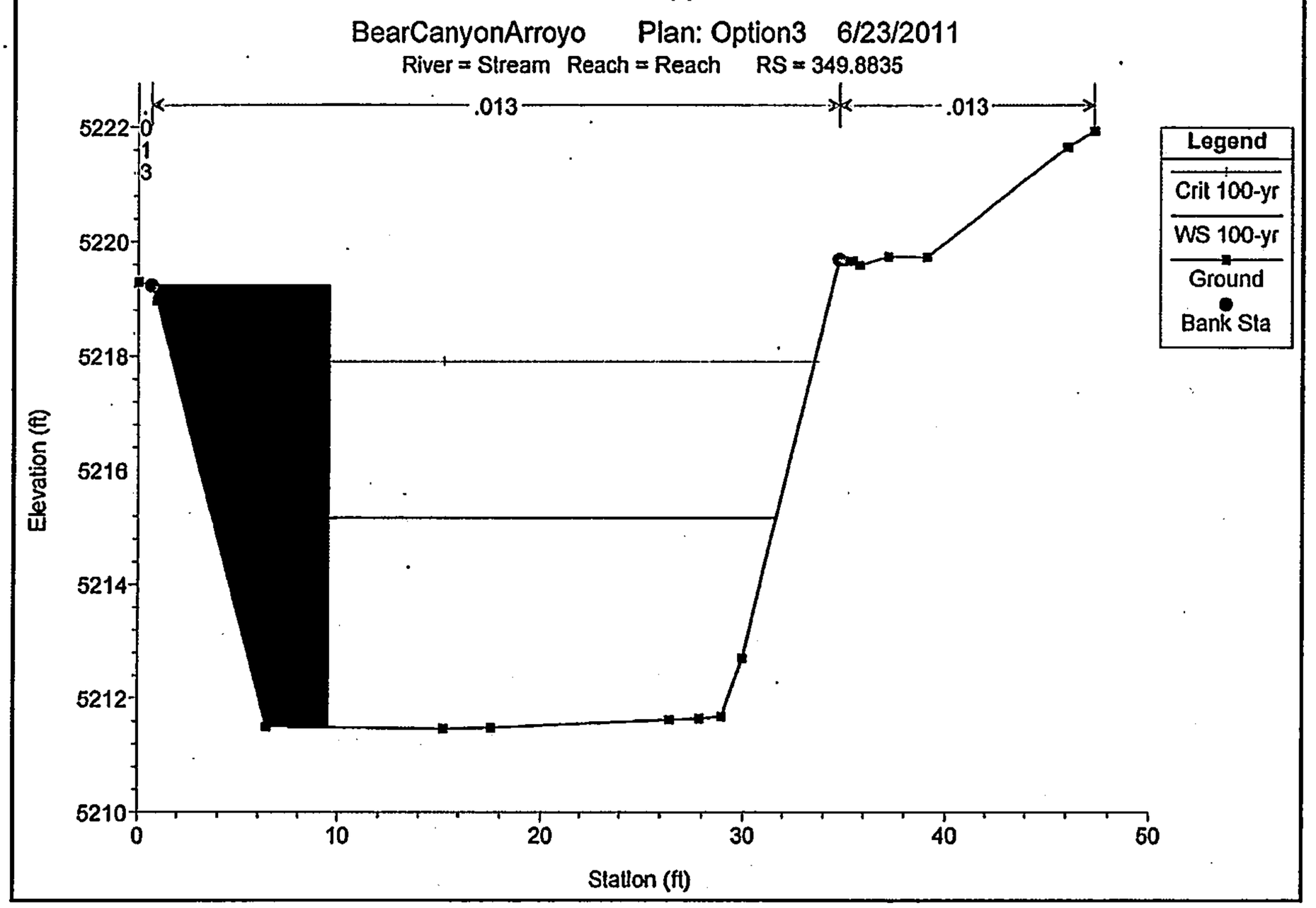

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 599.9047
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 549.9047
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 499.9047
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5224
5222
5220
5218
5216
5214
5212
0
10
20
30
40
50
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 449.9036
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5224
5222
5220
5218
5216
5214
5212
0
10
20
30
40
50
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 399.8936
.013
.013
0
1
3
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5224
5222
5220
5218
5216
5214
5212
5210
0
10
20
30
40
50
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 349.8835
.013
.013
0
1
3
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
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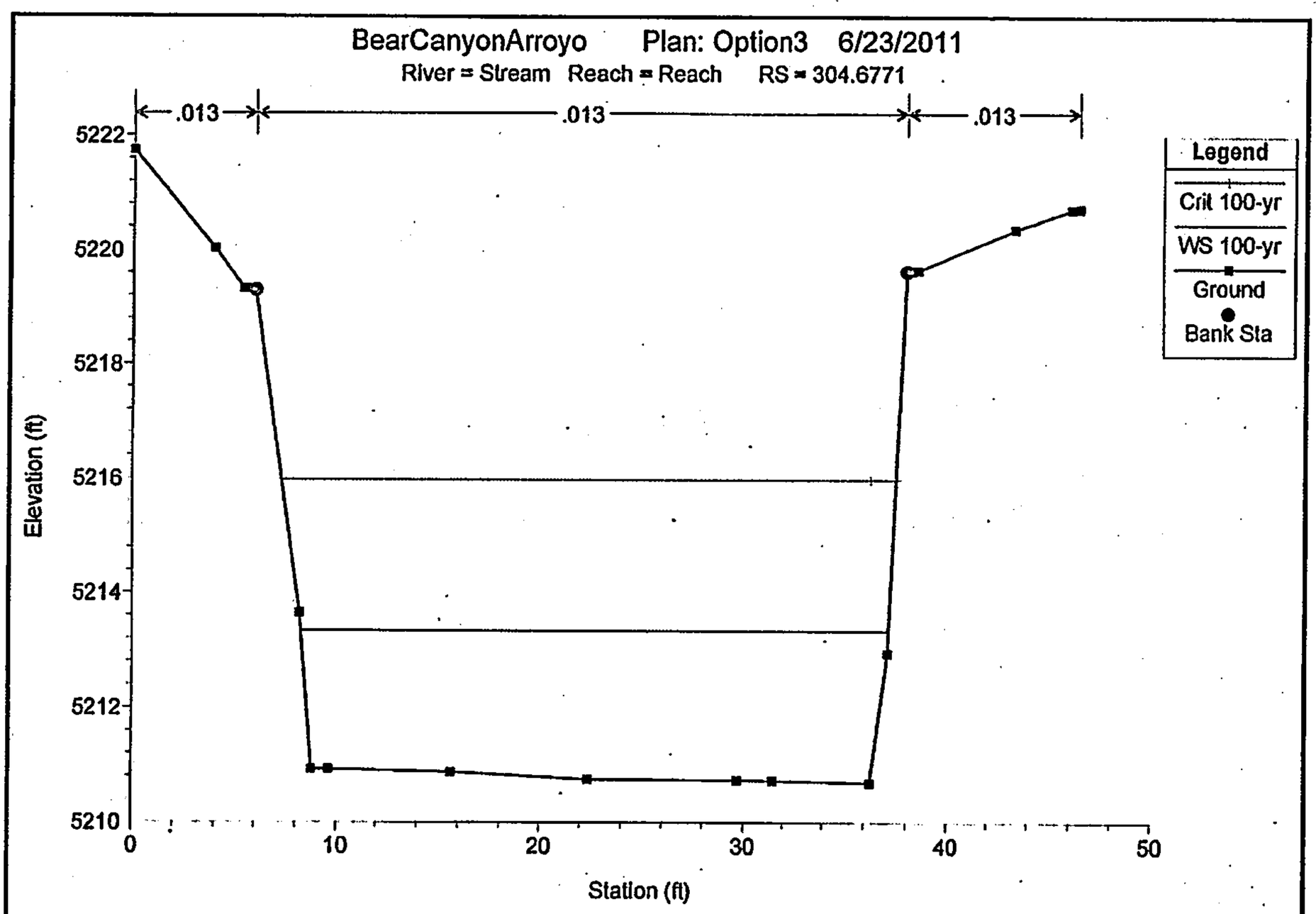
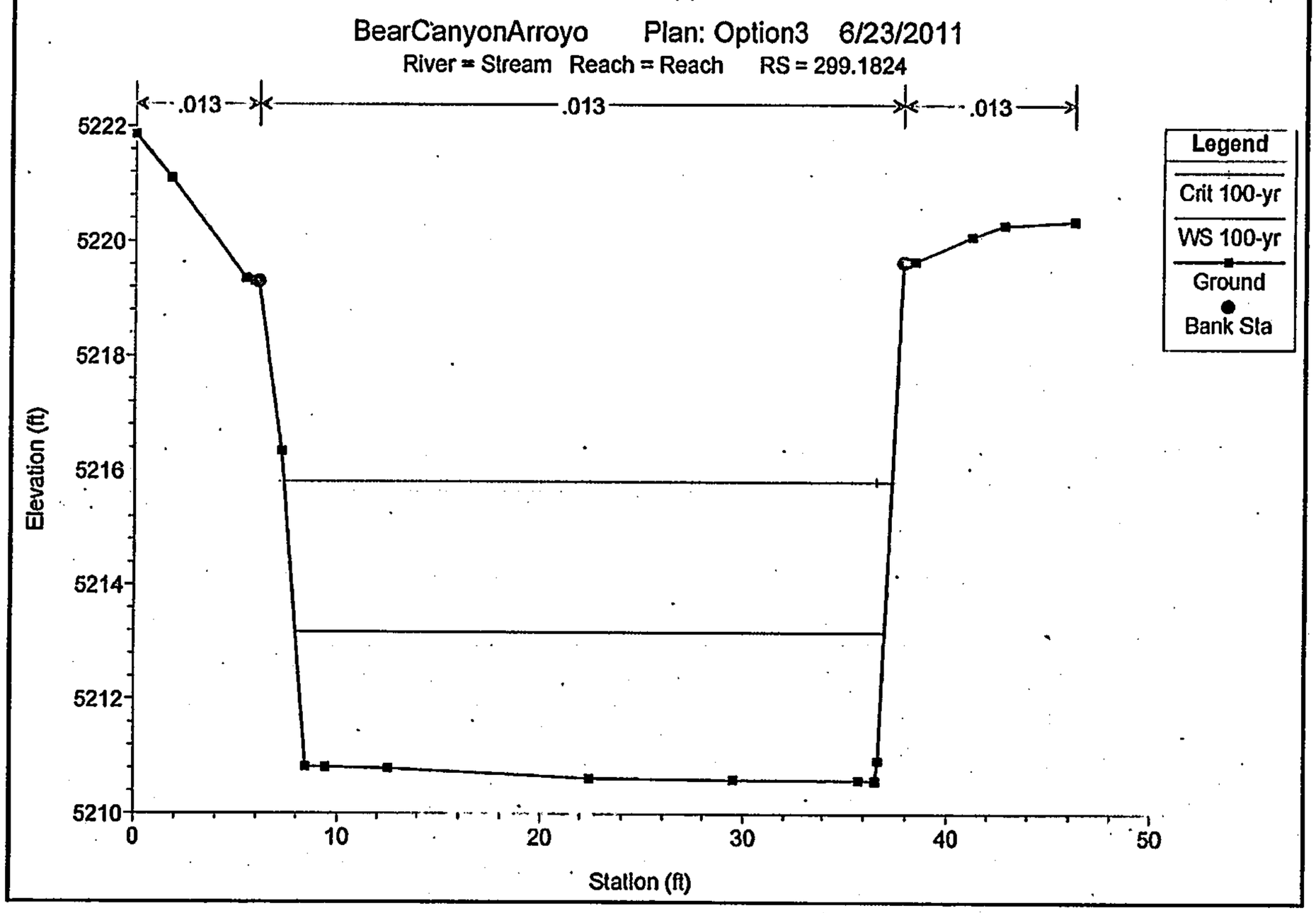
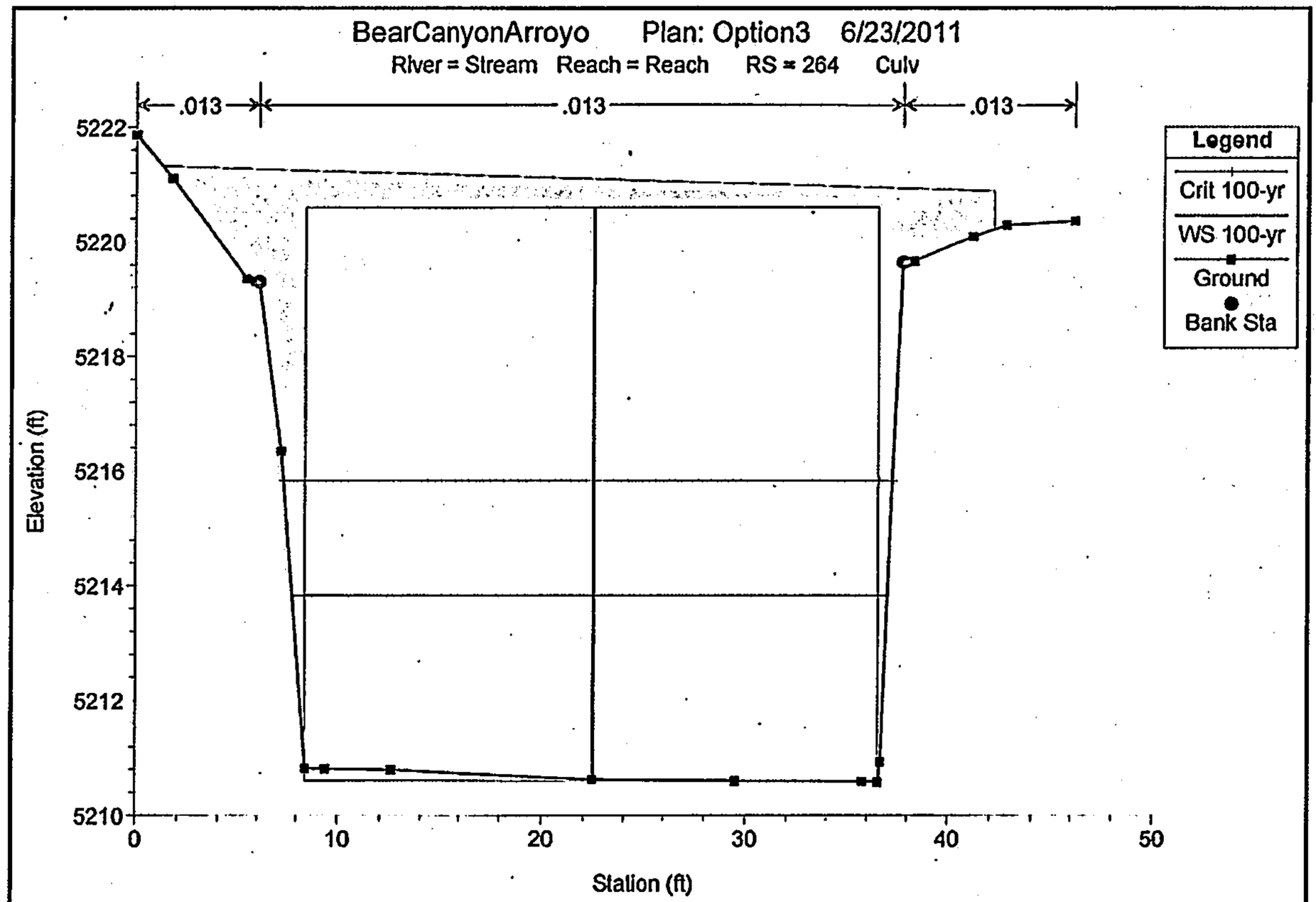
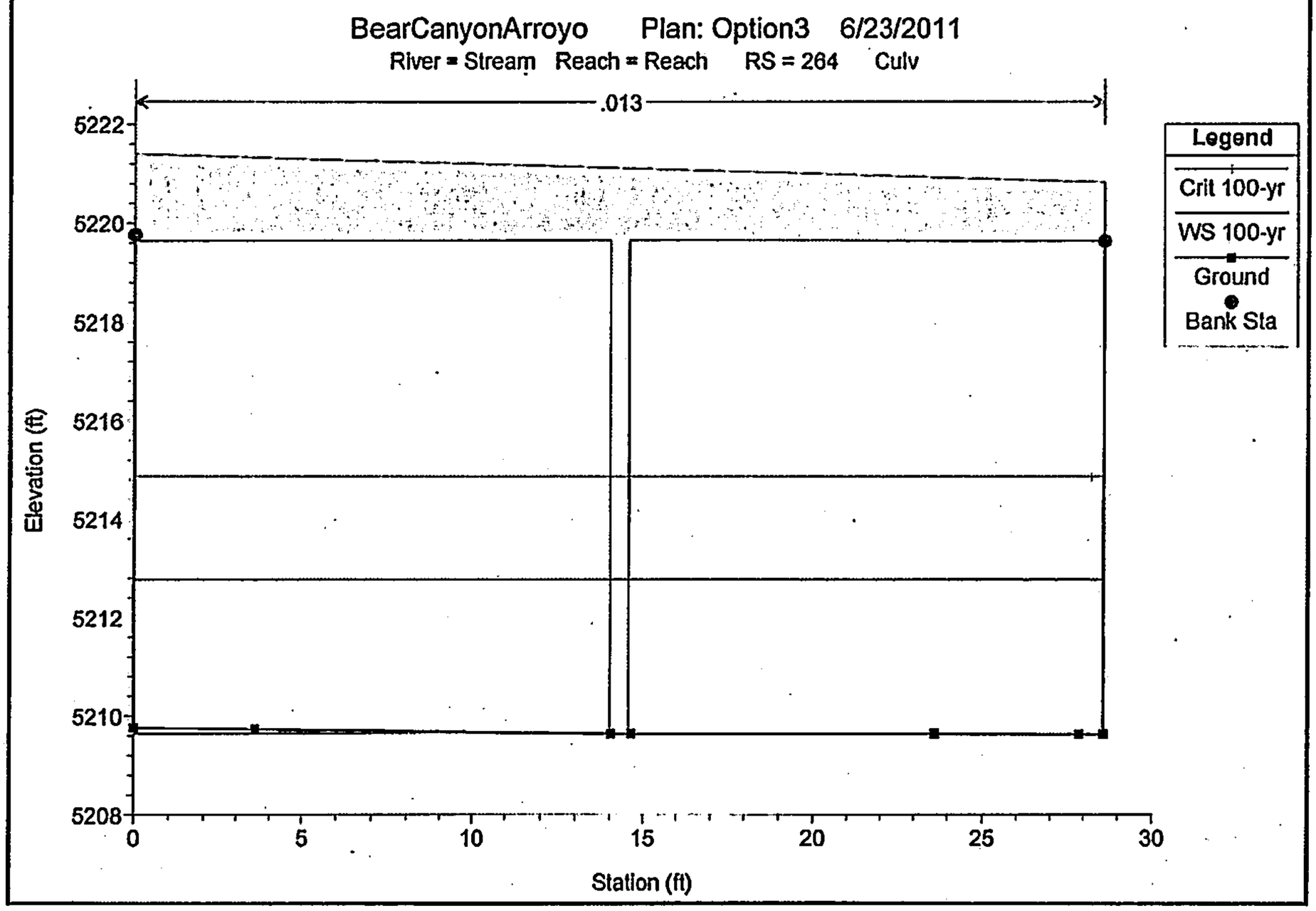
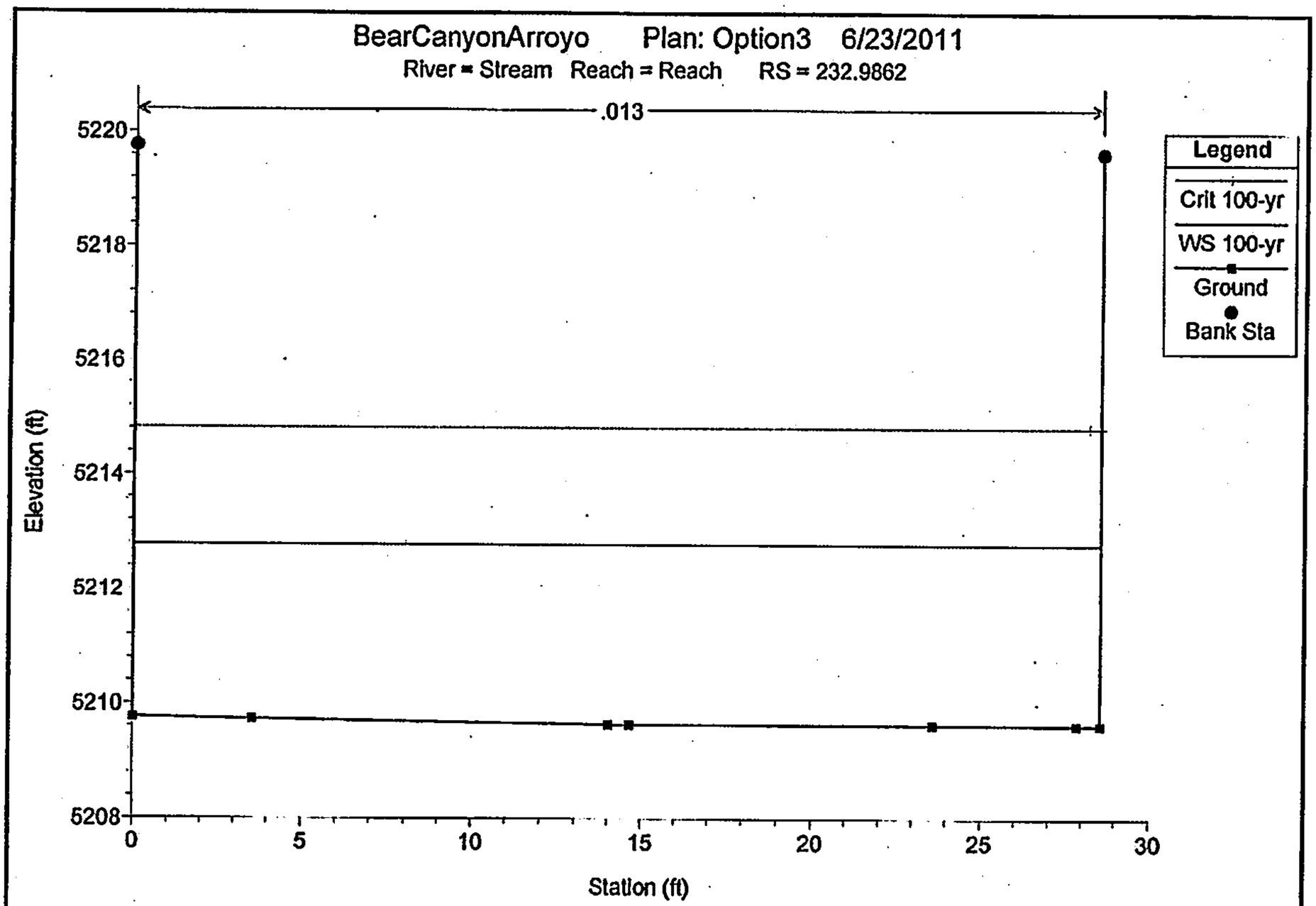
5220
5218
5216
5214
5212
5210
0
10
20
30
40
50
Station (ft)

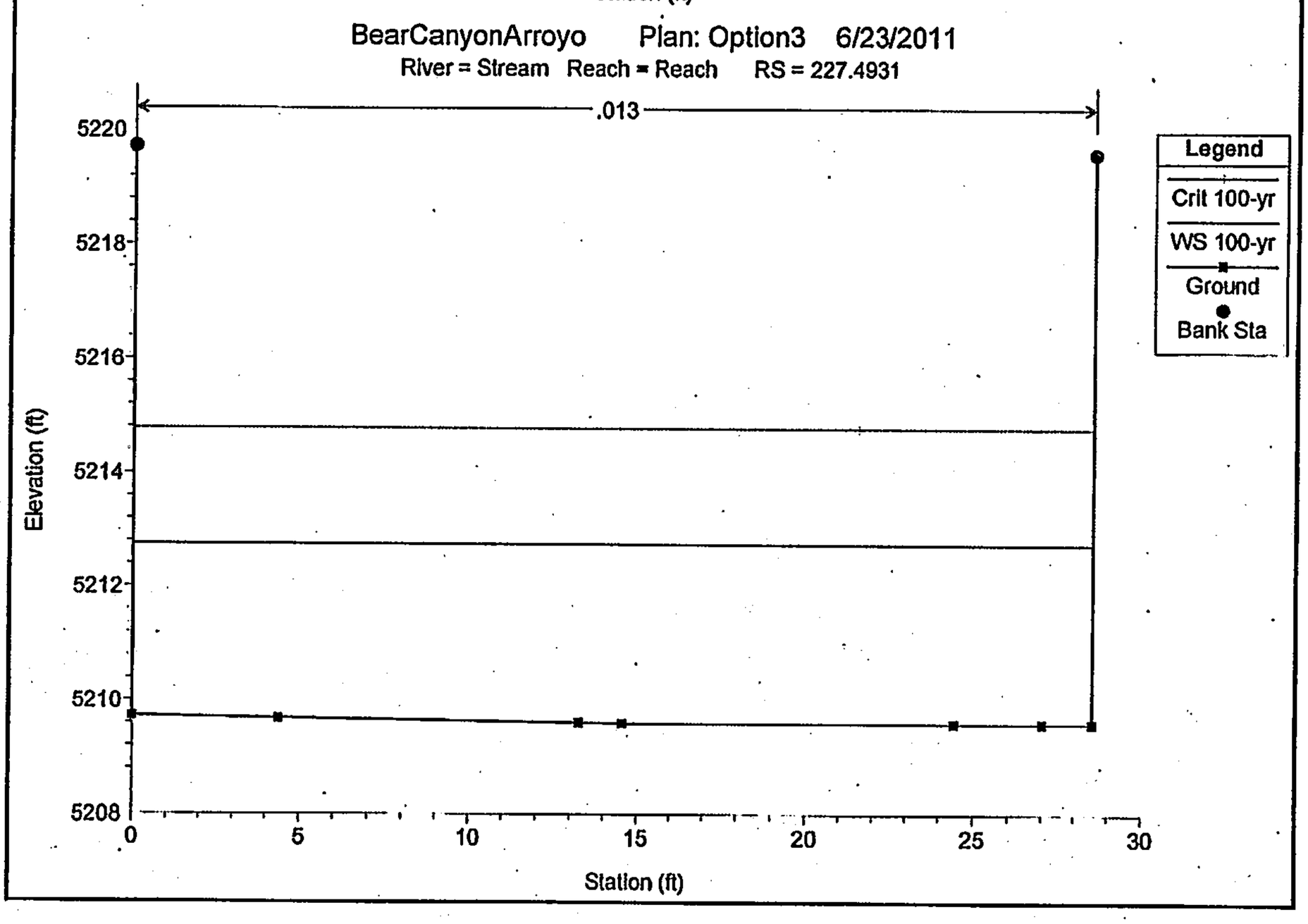

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 304.6771
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5222
5220
5218
5216
5214
5212
5210
0
10
20
30
40
50
Station (ft)

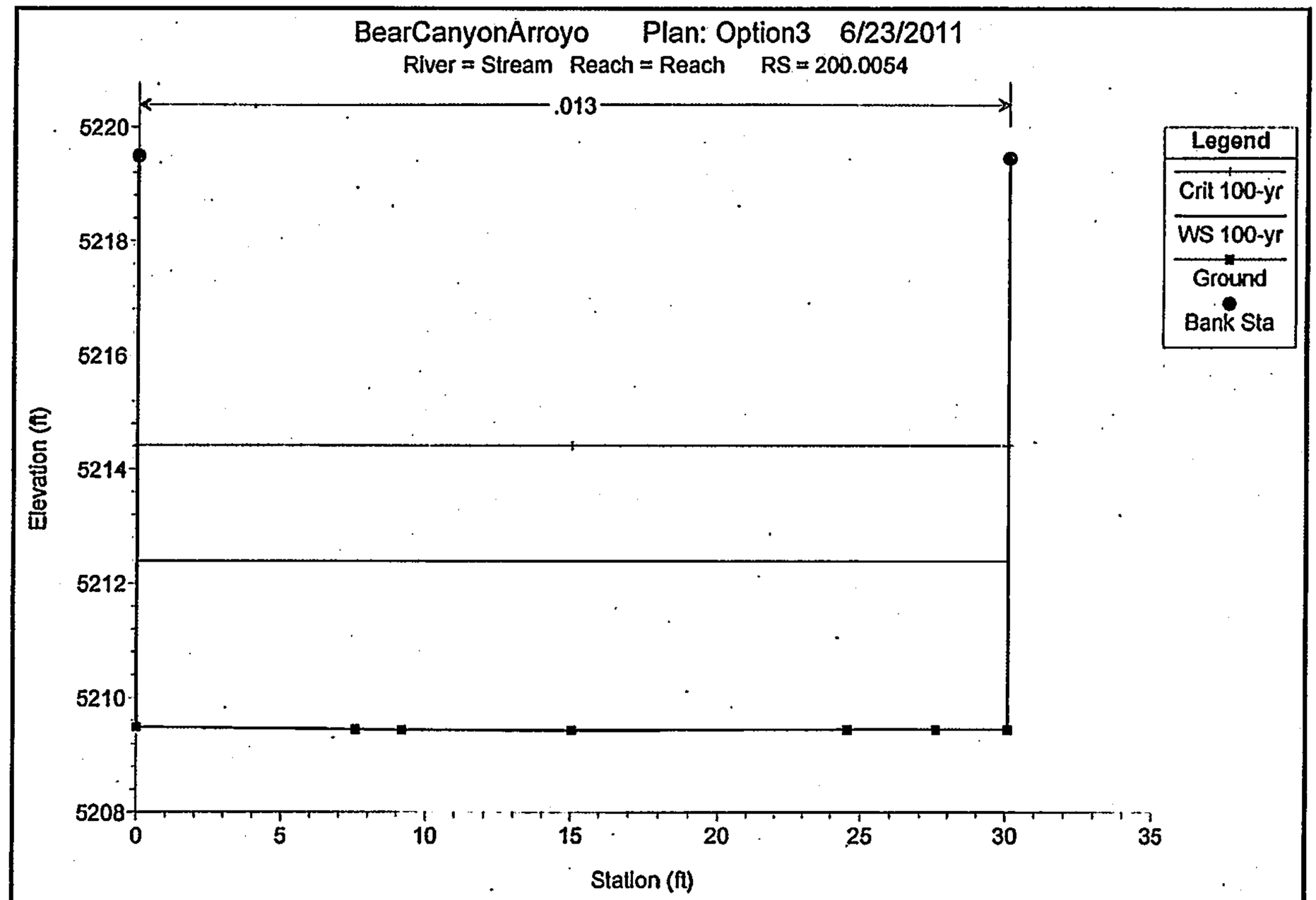

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 299.1824
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5222
5220
5218
5216
5214
5212
5210
0
10
20
30
40
50
Station (ft)

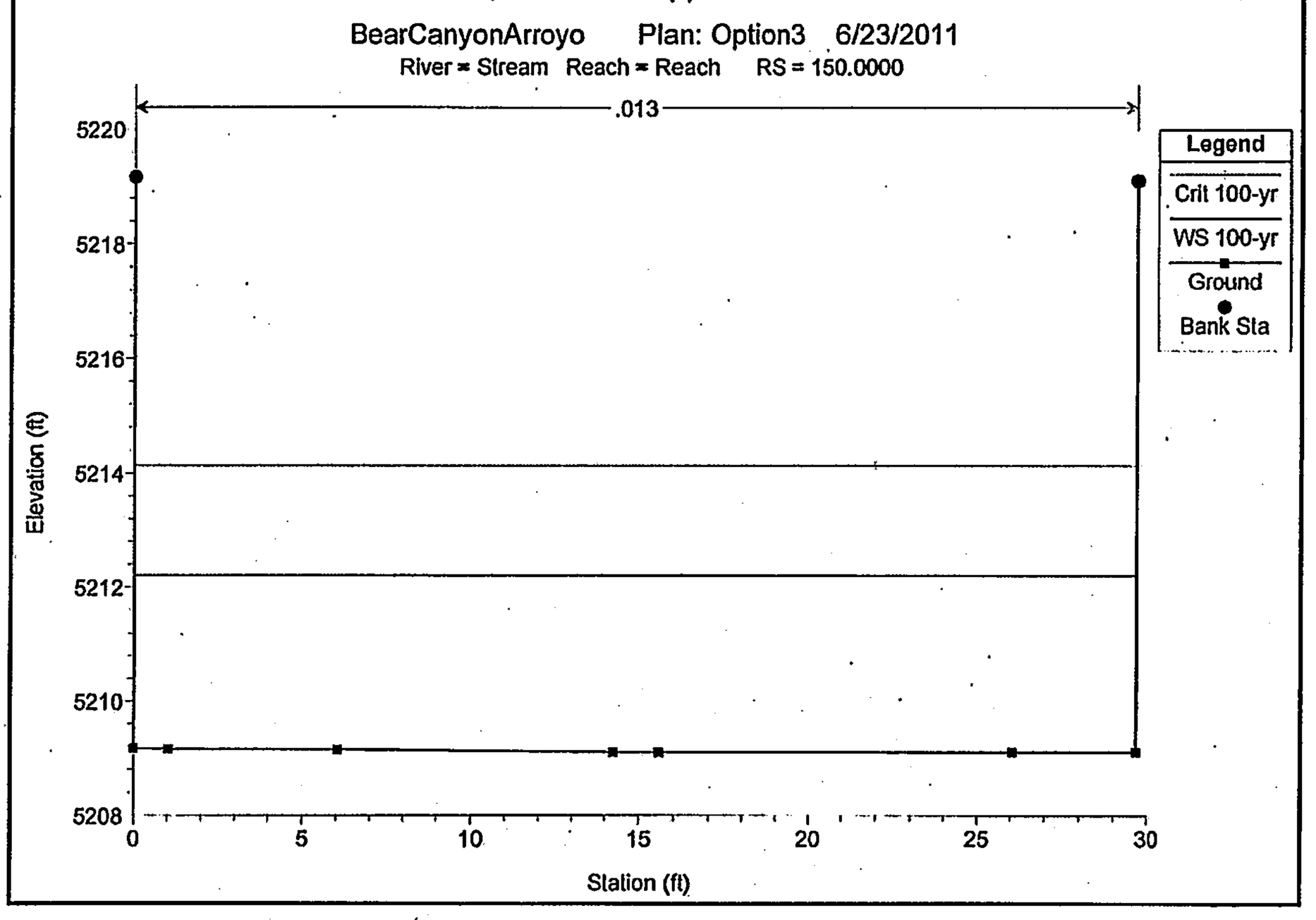

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 264 Culv
.013
.013
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5222
5220
5218
5216
5214
5212
5210
0
10
20
30
40
50
Station (ft)

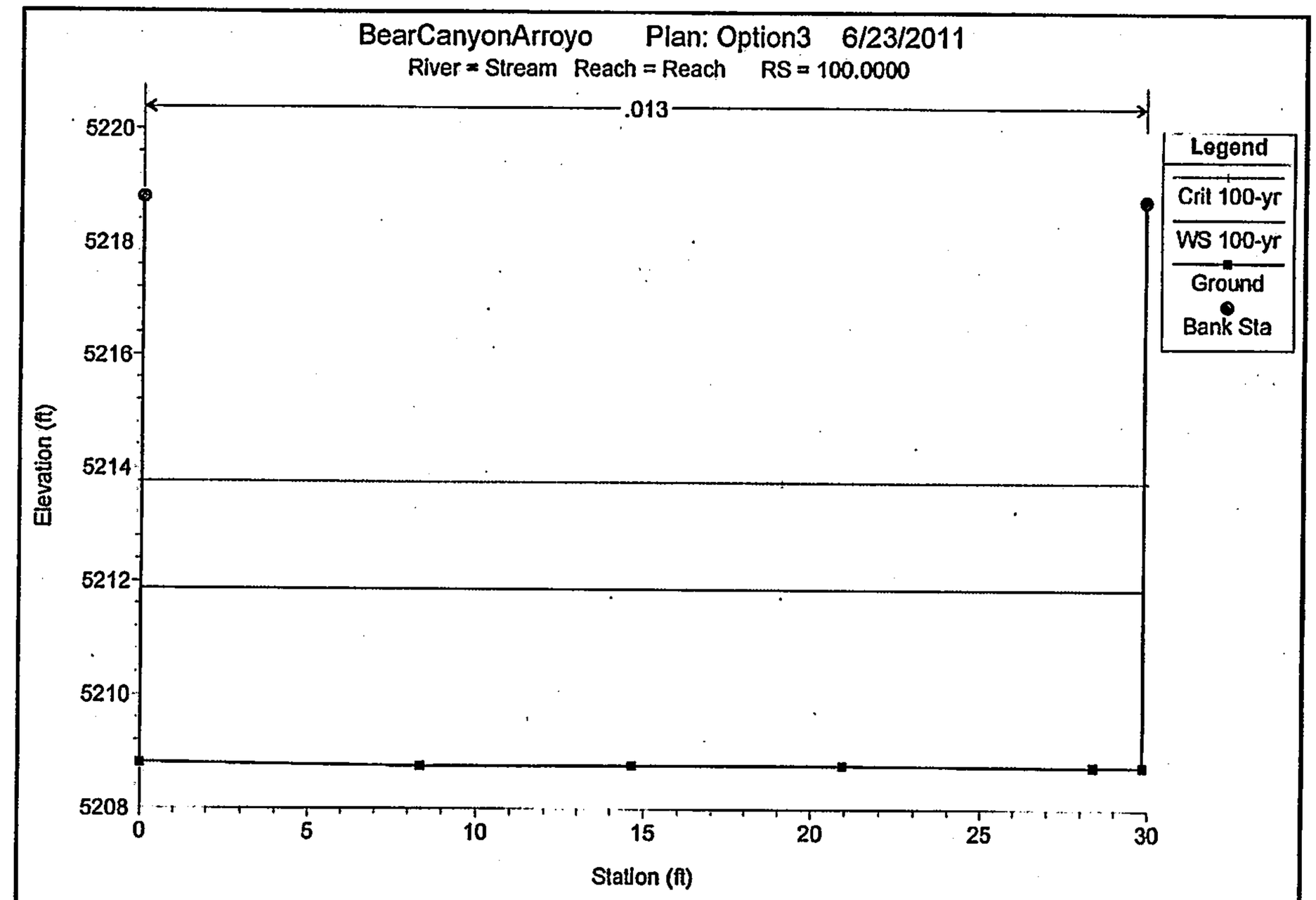

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 264 Culv
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5222
5220
5218
5216
5214
5212
5210
5208
0
5
10
15
20
25
30
Station (ft)

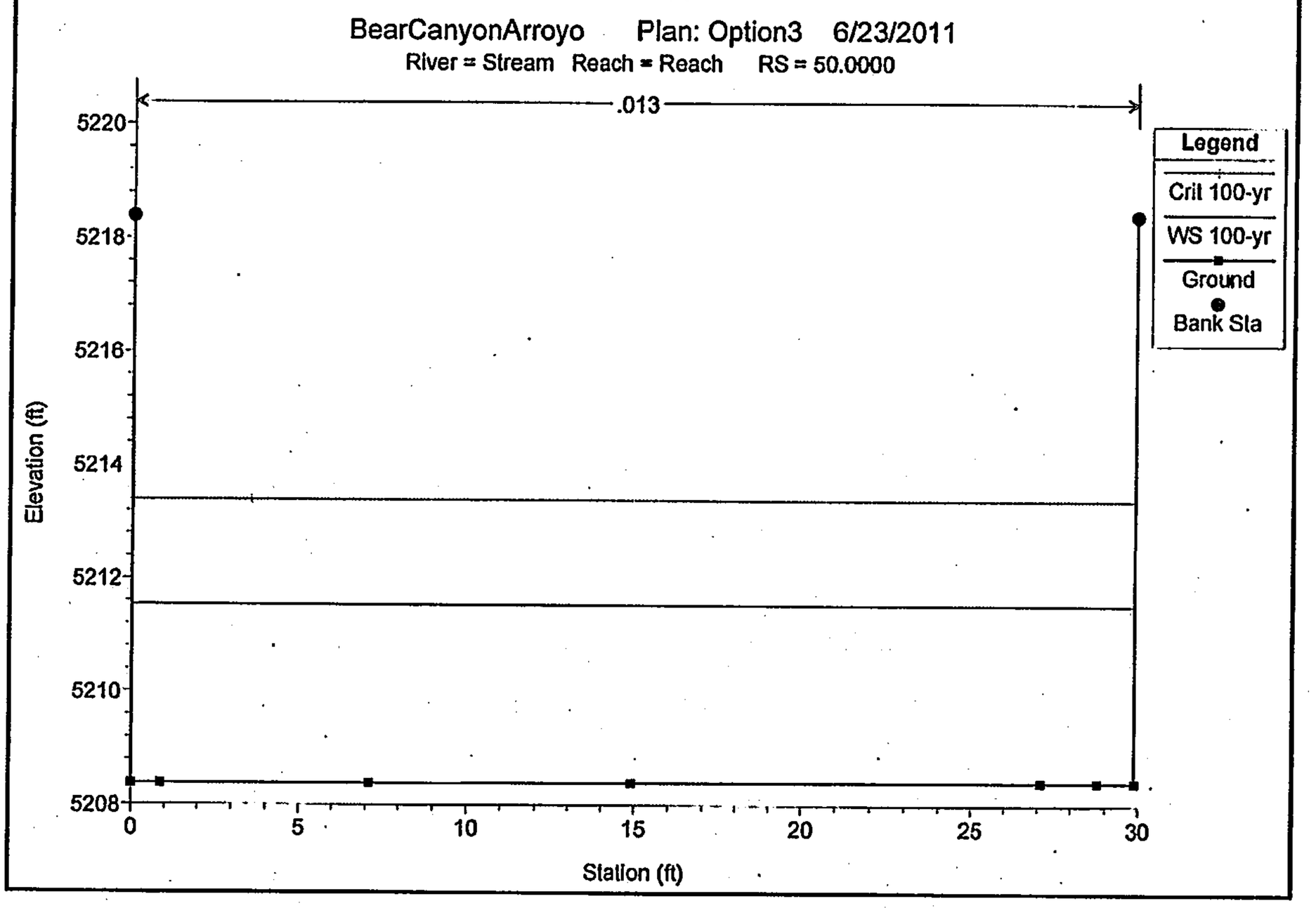

BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 232.9862
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5220
5218
5216
5214
5212
5210
5208
0
5
10
15
20
25
30
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 227.4931
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5220
5218
5216
5214
5212
5210
5208
0
5
10
15
20
25
30
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 200.0054
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5220
5218
5216
5214
5212
5210
5208
0
5
10
15
20
25
30
35
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 150.0000
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5220
5218
5216
5214
5212
5210
5208
0
5
10
15
20
25
30
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 100.0000
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5220
5218
5216
5214
5212
5210
5208
0
5
10
15
20
25
30
Station (ft)


BearCanyonArroyo Plan: Option3 6/23/2011
River = Stream Reach = Reach RS = 50.0000
.013
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
5220
5218
5216
5214
5212
5210
5208
0
5
10
15
20
25
30
Station (ft)

Bear Canyon Arroyo Trail
Freeboard Calculations - Option 3

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	LOB Elev (ft)	ROB Elev (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Freeboard Required	Freeboard Avail	Δ	Freeboard Wall Top Elevation
Reach	1799.904	100-yr	1900	5233.4	5242.75	5242.33	5239.93	5239.93	5242.07	0.001701	11.75	161.76	38.21	1.01	1.78	2.4	0.62	None Required
Reach	1749.904	100-yr	1900	5232.87	5245.33	5244.96	5238.6	5239.43	5241.84	0.002981	14.44	131.55	34.84	1.31	1.85	6.36	4.51	None Required
Reach	1699.904	100-yr	1900	5232.32	5244.69	5244.69	5237.63	5238.82	5241.6	0.003942	16	118.78	33.34	1.49	1.89	7.06	5.17	None Required
Reach	1649.904	100-yr	1900	5231.55	5243.2	5243.13	5236.6	5238.09	5241.3	0.004927	17.39	109.28	32	1.66	1.92	6.53	4.61	None Required
Reach	1599.904	100-yr	1900	5230.84	5240.07	5240.13	5235.8	5237.46	5240.99	0.005664	18.28	103.92	31.36	1.77	1.95	4.27	2.32	None Required
Reach	1549.904	100-yr	1900	5230.29	5237.32	5237.25	5235	5236.8	5240.65	0.006341	19.07	99.62	30.71	1.87	1.96	2.25	0.29	None Required
Reach	1499.904	100-yr	1900	5229.68	5236.66	5236.68	5234.32	5236.22	5240.29	0.006864	19.61	96.89	30.46	1.94	1.97	2.34	0.37	None Required
Reach	1449.904	100-yr	1900	5229.04	5236.16	5236.04	5233.6	5235.59	5239.9	0.007375	20.14	94.35	30.11	2	1.98	2.44	0.46	None Required
Reach	1399.904	100-yr	1900	5228.38	5235.45	5235.49	5232.89	5234.93	5239.48	0.007837	20.6	92.23	29.76	2.06	2.00	2.56	0.56	None Required
Reach	1349.904	100-yr	1900	5227.72	5234.95	5234.87	5232.19	5234.31	5239.05	0.008238	21.02	90.38	29.34	2.11	2.01	2.68	0.67	None Required
Reach	1299.904	100-yr	1900	5226.83	5234.32	5234.22	5231.35	5233.52	5238.59	0.008989	21.59	88	29.21	2.19	2.02	2.87	0.85	None Required
Reach	1249.904	100-yr	1900	5226.55	5233.71	5233.56	5230.91	5233.11	5238.14	0.008899	21.58	88.03	29.15	2.19	2.02	2.65	0.63	None Required
Reach	1199.904	100-yr	1900	5226	5233.08	5232.96	5230.27	5232.5	5237.67	0.00923	21.83	87.03	29.14	2.23	2.02	2.69	0.67	None Required
Reach	1149.904	100-yr	1900	5225.38	5232.4	5232.32	5229.65	5231.92	5237.19	0.009427	22.03	86.26	28.94	2.25	2.03	2.67	0.64	None Required
Reach	1099.904	100-yr	1900	5224.76	5231.71	5231.45	5229.02	5231.31	5236.69	0.009707	22.23	85.47	28.94	2.28	2.03	2.43	0.40	None Required
Reach	1049.904	100-yr	1900	5224.1	5231.11	5231.17	5228.35	5230.67	5236.19	0.009958	22.47	84.56	28.71	2.31	2.04	2.76	0.72	None Required
Reach	999.9047	100-yr	1900	5223.49	5230.5	5230.53	5227.66	5230.01	5235.66	0.010221	22.7	83.69	28.52	2.34	2.04	2.84	0.80	None Required
Reach	949.9047	100-yr	1900	5222.76	5229.69	5229.78	5226.9	5229.29	5235.12	0.010653	23.01	82.59	28.5	2.38	2.05	2.79	0.74	None Required
Reach	899.9047	100-yr	1900	5221.74	5228.8	5228.81	5225.85	5228.32	5234.52	0.011453	23.63	80.4	28.16	2.46	2.06	2.95	0.89	None Required
Reach	849.9047	100-yr	1900	5220.42	5227.38	5227.32	5224.36	5226.94	5233.83	0.013008	24.7	76.91	27.81	2.62	2.08	2.96	0.88	None Required
Reach	799.9047	100-yr	1900	5218.74	5225.73	5225.63	5222.6	5225.37	5233.04	0.014859	25.93	73.28	27.24	2.79	2.11	3.03	0.92	None Required
Reach	749.9047	100-yr	1900	5216.94	5222.94	5223.11	5220.65	5223.54	5232.14	0.01677	27.2	69.85	26.38	2.95	2.14	2.29	0.15	None Required
Reach	699.9047	100-yr	1900	5215.36	5222.47	5222.26	5218.98	5221.86	5231.19	0.018371	28.03	67.78	26.27	3.08	2.15	3.28	1.13	None Required
Reach	649.9047	100-yr	1900	5214.15	5221.17	5221.08	5217.75	5220.73	5230.23	0.018567	28.35	67.03	25.45	3.08	2.16	3.33	1.17	None Required
Reach	599.9047	100-yr	1900	5213.33	5220.36	5220.02	5216.97	5219.99	5229.29	0.01742	28.16	67.47	23.83	2.95	2.16	3.05	0.89	None Required
Reach	549.9047	100-yr	1900	5212.75	5219.9	5219.78	5216.54	5219.52	5228.28	0.016085	27.49	69.11	23.6	2.83	2.15	3.24	1.09	None Required
Reach	499.9047	100-yr	1900	5212.36	5219.43	5219.41	5216.25	5219.68	5227.31	0.014613	26.68	71.21	23.23	2.69	2.13	3.16	1.03	None Required
Reach	449.9036	100-yr	1900	5212.04	5219.15	5219.29	5216.19	5219.51	5226.36	0.012876	25.58	74.27	22.9	2.5	2.12	2.96	0.84	None Required
Reach	399.8936	100-yr	1900	5211.79	5218.94	5219.45	5215.83	5218.58	5225.61	0.012505	25.09	75.72	22.25	2.4	2.10	3.11	1.01	None Required
Reach	349.8835	100-yr	1900	5211.46	5219.24	5219.69	5215.17	5217.91	5224.97	0.012533	25.12	75.62	22.08	2.39	2.08	4.07	1.99	None Required
Reach	304.6771	100-yr	1900	5210.69	5219.29	5219.62	5213.34	5215.97	5224.19	0.01876	26.44	71.87	28.9	2.95	2.04	5.95	3.91	None Required
Reach	299.1824	100-yr	1900	5210.58	5219.3	5219.64	5213.18	5215.81	5224.08	0.019204	26.5	71.7	29.03	2.97	2.04	6.12	4.08	None Required
Reach	264		Culvert															
Reach	232.9862	100-yr	1900	5209.63	5219.76	5219.63	5212.78	5214.82	5219.89	0.010021	21.4	88.81	28.57	2.14	1.95	6.85	4.90	None Required
Reach	227.4931	100-yr	1900	5209.6	5219.72	5219.6	5212.75	5214.78	5219.83	0.009948	21.35	88.98	28.54	2.13	1.95	6.85	4.90	None Required
Reach	200.0054	100-yr	1900	5209.43	5219.49	5219.45	5212.39	5214.42	5219.54	0.010582	21.45	88.56	30.09	2.2	1.94	7.06	5.12	None Required
Reach	150	100-yr	1900	5209.11	5219.17	5219.11	5212.21	5214.13	5218.9	0.009439	20.76	91.53	29.68	2.08	1.93	6.9	4.97	None Required
Reach	100	100-yr	1900	5208.75	5218.8	5218.75	5211.87	5213.76	5218.39	0.00911	20.49	92.74	29.85	2.05	1.92	6.88	4.96	None Required
Reach	50	100-yr	1900	5208.38	5218.38	5218.41	5211.54	5213.39	5217.89	0.008782	20.24	93.89	29.88	2.01	1.92	6.84	4.92	None Required