

PIK-CR72-00.54 (California Pike)

Hydraulic Study

Pike County Engineer's Office
502 South Pike Street
Waverly, Ohio

November 11, 2022



ms consultants, inc.
engineers, architects, planners

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Hydraulic Analysis Summary

PIK-CR 72-0054 (California Pike) over a Tributary of Glade Run

Project Location and Hydrology

The project is located at Marion Township in Pike County, Ohio, where CR 72 (California Pike) crosses over a tributary of Glade Run. The 10-year storm is the design frequency according to the design year ADT of 250 and ODOT L&D Design Manual Vol. 2 (Section 1004.2). A hydrologic analysis was performed using StreamStats on the USGS website. The drainage area for the site was determined to be 0.28 square miles, and the main channel slope was estimated to be 235 feet per mile according to StreamStats. The peak flows reported by StreamStats are 159 cfs for the design-year (10-year) event, and 365 cfs for the 100-year event.

Existing Structure – 10' Span Steel Beam Bridge

The existing structure is a 10' span steel beam bridge with an estimated maximum waterway opening of about 98 square feet. The existing structure configuration was analyzed using HY-8 software, version 7.60. A 4.4% channel slope at the downstream end, determined based on the field survey data, was used to calculate the tail water elevation. Manning's roughness coefficient (n) of 0.045 was used for the channel and 0.035 was assigned to the waterway under the existing bridge. The 10-year headwater elevation is 733.68, and the 100-year headwater elevation is 735.99 based on the HY-8 analysis (see Table 1).

Proposed Replacement Structure - 10' Span x 8' Rise Precast Four-sided Concrete Box Culvert

The proposed replacement superstructure is a 34' long x 10' span x 8' rise precast four-sided concrete box culvert. The waterway opening is about 78 square feet, which is about 25% smaller than the existing waterway opening. The same Manning's roughness coefficient (0.045) for the downstream channel and 4.4% downstream slope were used to calculate the tail water elevation. Manning's roughness coefficient of 0.012 was assigned for the proposed concrete box culvert barrel in the HY-8 computation. The calculated 10-year headwater elevation is 732.71, which meets all the design criteria stipulated in ODOT L&D Design Manual Volume 2 (Section 1006.2) and is lower than the lowest edge of pavement (738.66±) by 5.95'. The calculated 100-year headwater elevation based on the HY-8 analysis is 735.15, which also clears the proposed roadway pavement by about 3.51'.

Since the design flow velocity is above 10 ft/sec for the design year, 36" thick, Rock Channel Protection (RCP), Type A, with geotextile fabric is proposed at the culvert outlet according to ODOT L&D Manual Vol. 2 Table 1107-1. In addition, due to the weak soil at the project site, the same type and thickness of RCP is also proposed at the culvert inlet to prevent potential soil erosion. Due to the existing winding layout at the culvert inlet, the stream will be realigned roughly 75' upstream.

Table 1 – Hydraulic Summary Table

HYDRAULIC SUMMARY TABLE			
PIK-CR 72-0054			
CR 72 over Tributary of Glade Run			
Storm Frequency	Peak Discharge	Outlet Velocity	Headwater Elevation
(year)	(cfs)	(ft./sec.)	(feet)
Existing 10' Span Steel Beam Bridge Effective Waterway Opening: ~ 98 sq. ft.			
10	158	12.88	733.68
100	363	16.09	735.99
Proposed 10' (Span) x 8' (Rise) Precast Four-sided Box Culvert Effective Waterway Opening: 78 sq. ft.			
10	159	12.62	732.71
100	365	15.19	735.15

Drainage Area = 0.28 sq. miles = 179.2 acres

Attachment 1

Project Location and StreamStats Output

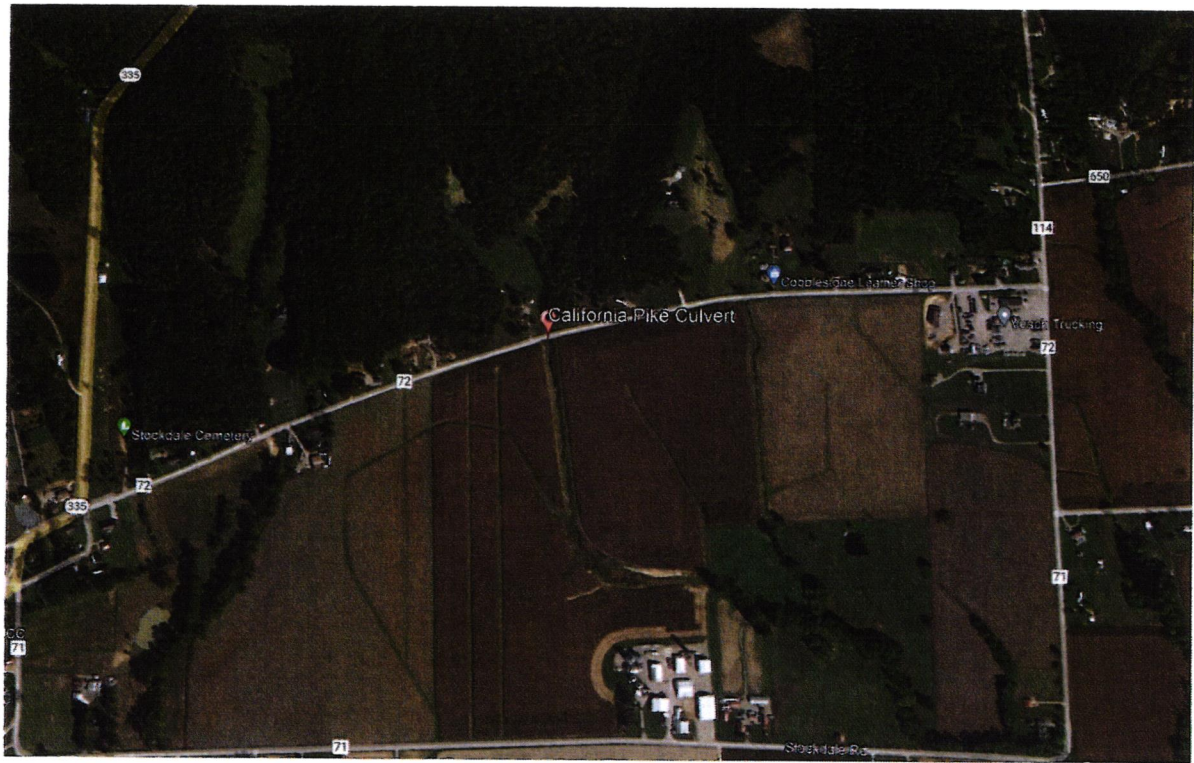


Figure 1. PIK-CR72-0054 (California Pike) Project Location

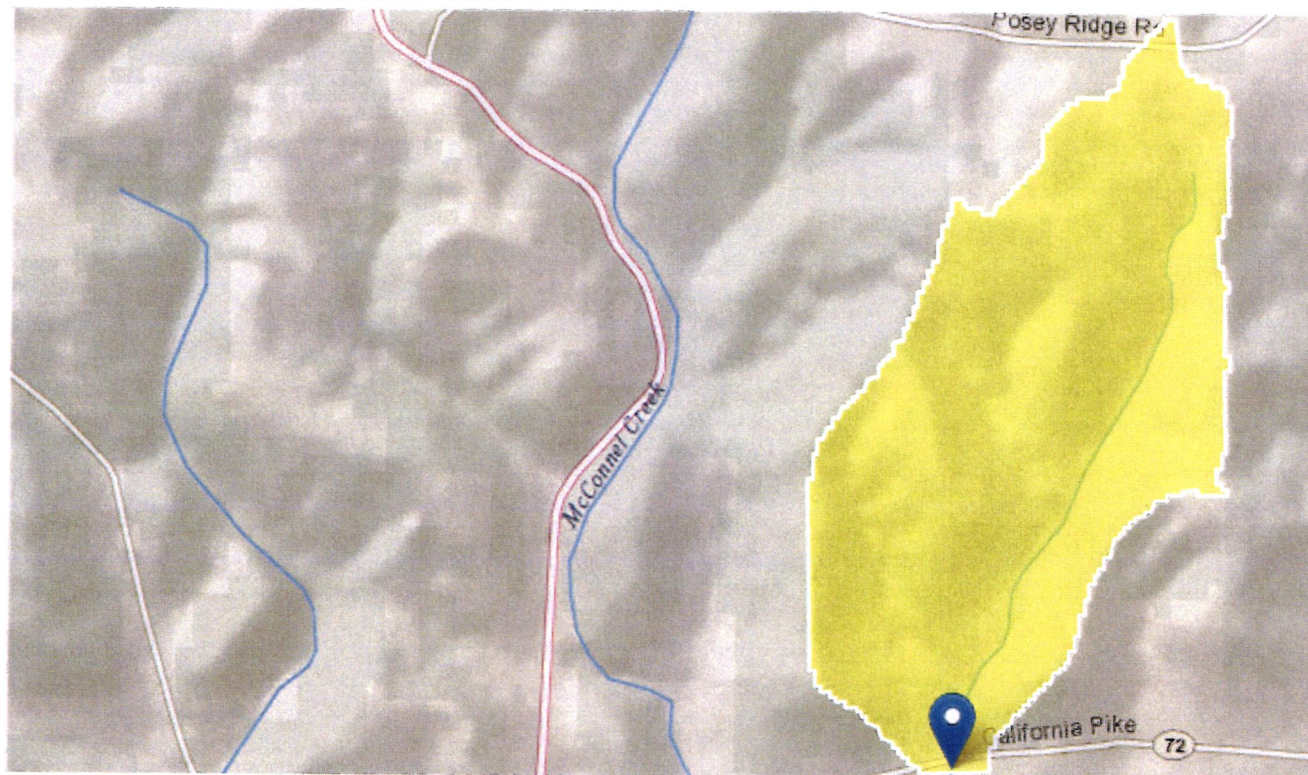
StreamStats Report

Region ID: OH

Workspace ID: OH20211004191051441000

Clicked Point (Latitude, Longitude): 38.96019, -82.84447

Time: 2021-10-04 15:11:10 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.28	square miles
OHREGC	Ohio Region C Indicator	0	dimensionless
OHREGA	Ohio Region A Indicator	1	dimensionless
CSL1085LFP	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 2D grid	231	feet per mi
LC92STOR	Percentage of water bodies and wetlands determined from the NLCD	0	percent

Parameter Code	Parameter Description	Value	Unit
STREAM_VARG	Streamflow variability index as defined in WRIR 02-4068, computed from regional grid	0.69	dimensionless
PRECIP	Mean Annual Precipitation	41	inches
LAT_CENT	Latitude of Basin Centroid	38.9663	decimal degrees
FOREST	Percentage of area covered by forest	77.3	percent
LONG_CENT	Longitude Basin Centroid	82.8428	decimal degrees

Peak-Flow Statistics Parameters [Peak Flow Full Model Reg A SIR2019 5018]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.04	5989
OHREGC	Ohio Region C Indicator 1 if in C else 0	0	dimensionless	0	1
OHREGA	Ohio Region A Indicator 1 if in A else 0	1	dimensionless	0	1
CSL1085LFP	Stream Slope 10 and 85 Longest Flow Path	231	feet per mi	1.53	516
LC92STOR	Percent Storage from NLCD1992	0	percent	0	25.35

Peak-Flow Statistics Flow Report [Peak Flow Full Model Reg A SIR2019 5018]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	ASEp
50-percent AEP flood	55.8	ft ³ /s	29.2	107	40.1
20-percent AEP flood	111	ft ³ /s	60.7	203	37.2
10-percent AEP flood	158	ft ³ /s	85.8	291	37.6
4-percent AEP flood	231	ft ³ /s	124	429	38.1
2-percent AEP flood	294	ft ³ /s	156	553	37.8
1-percent AEP flood	363	ft ³ /s	191	691	39.6
0.2-percent AEP flood	551	ft ³ /s	286	1060	40.3

Peak-Flow Statistics Citations

Koltun, G.F., 2019, Flood-frequency estimates for Ohio streamgages based on data through water year 2015 and techniques for estimating flood-frequency characteristics of rural, unregulated Ohio streams: U.S. Geological Survey Scientific Investigations Report 2019–5018, xx p. (<https://dx.doi.org/10.3133/sir20195018>)

Low-Flow Statistics Parameters [Low Flow Region B 2012 5138]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	1	1250
STREAM_VARG	Streamflow Variability Index from Grid	0.69	dimensionless	0.24	1.12

Low-Flow Statistics Disclaimers [Low Flow Region B 2012 5138]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Low-Flow Statistics Flow Report [Low Flow Region B 2012 5138]

Statistic	Value	Unit
1 Day 10 Year Low Flow	0.000758	ft ³ /s
7 Day 10 Year Low Flow	0.00113	ft ³ /s
30 Day 10 Year Low Flow	0.00206	ft ³ /s
90 Day 10 Year Low Flow	0.0081	ft ³ /s

Low-Flow Statistics Citations

Koltun, G.F., and Kula, S.P., 2013, Methods for estimating selected low-flow statistics and development of annual flow-duration statistics for Ohio: U.S. Geological Survey Scientific Investigations Report 2012–5138, 195 p. (<http://pubs.usgs.gov/sir/2012/5138/>)

Flow-Duration Statistics Parameters [Low Flow Region B 2012 5138]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	1	1250

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
STREAM_VARG	Streamflow Variability Index from Grid	0.69	dimensionless	0.24	1.12

Flow-Duration Statistics Disclaimers [Low Flow Region B 2012 5138]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Flow-Duration Statistics Flow Report [Low Flow Region B 2012 5138]

Statistic	Value	Unit
80 Percent Duration	0.0192	ft ³ /s

Flow-Duration Statistics Citations

Koltun, G.F., and Kula, S.P., 2013, Methods for estimating selected low-flow statistics and development of annual flow-duration statistics for Ohio: U.S. Geological Survey Scientific Investigations Report 2012–5138, 195 p. (<http://pubs.usgs.gov/sir/2012/5138/>)

Annual Flow Statistics Parameters [Low Flow LatLE 41.2 wri02 4068]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.12	7422
PRECIP	Mean Annual Precipitation	41	inches	34	43.2
LAT_CENT	Latitude of Basin Centroid	38.9663	decimal degrees	38.68	41.2

Annual Flow Statistics Flow Report [Low Flow LatLE 41.2 wri02 4068]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	ASEp
Mean Annual Flow	0.288	ft ³ /s	11.4	11.4

Annual Flow Statistics Citations

Koltun, G. F., and Whitehead, M. T., 2002, Techniques for Estimating Selected Streamflow Characteristics of Rural, Unregulated Streams in Ohio: U. S. Geological Survey Water-Resources Investigations Report 02-4068, 50 p
(<https://pubs.er.usgs.gov/publication/wri024068>)

Monthly Flow Statistics Parameters [Low Flow LatLE 41.2 wri02 4068]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.12	7422
LC92STOR	Percent Storage from NLCD1992	0	percent	0	19
PRECIP	Mean Annual Precipitation	41	inches	34	43.2
FOREST	Percent Forest	77.3	percent	0	99.1
LAT_CENT	Latitude of Basin Centroid	38.9663	decimal degrees	38.68	41.2
STREAM_VARG	Streamflow Variability Index from Grid	0.69	dimensionless	0.25	1.13

Monthly Flow Statistics Flow Report [Low Flow LatLE 41.2 wri02 4068]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	ASEp
January Mean Flow	0.425	ft ³ /s	16.6	16.6
February Mean Flow	0.627	ft ³ /s	11.9	11.9
March Mean Flow	0.66	ft ³ /s	14	14
April Mean Flow	0.639	ft ³ /s	11.2	11.2
May Mean Flow	0.476	ft ³ /s	19.5	19.5
June Mean Flow	0.216	ft ³ /s	27	27
July Mean Flow	0.11	ft ³ /s	28.2	28.2
August Mean Flow	0.0912	ft ³ /s	36.8	36.8
September Mean Flow	0.0614	ft ³ /s	43.6	43.6
October Mean Flow	0.0434	ft ³ /s	50.8	50.8
November Mean Flow	0.134	ft ³ /s	37.5	37.5
December Mean Flow	0.332	ft ³ /s	21.8	21.8

Monthly Flow Statistics Citations

Koltun, G. F., and Whitehead, M. T., 2002, Techniques for Estimating Selected Streamflow Characteristics of Rural, Unregulated Streams in Ohio: U. S. Geological Survey Water-Resources Investigations Report 02-4068, 50 p
(<https://pubs.er.usgs.gov/publication/wri024068>)

General Flow Statistics Parameters [Low Flow LatLE 41.2 wri02 4068]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.12	7422
LC92STOR	Percent Storage from NLCD1992	0	percent	0	19
STREAM_VARG	Streamflow Variability Index from Grid	0.69	dimensionless	0.25	1.13
LAT_CENT	Latitude of Basin Centroid	38.9663	decimal degrees	38.68	41.2

General Flow Statistics Flow Report [Low Flow LatLE 41.2 wri02 4068]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	ASEp
Harmonic Mean Streamflow	0.021	ft ³ /s	65.9	65.9

General Flow Statistics Citations

Koltun, G. F., and Whitehead, M. T., 2002, Techniques for Estimating Selected Streamflow Characteristics of Rural, Unregulated Streams in Ohio: U. S. Geological Survey Water-Resources Investigations Report 02-4068, 50 p
(<https://pubs.er.usgs.gov/publication/wri024068>)

Flow Percentile Statistics Parameters [Low Flow LatLE 41.2 wri02 4068]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.12	7422
LC92STOR	Percent Storage from NLCD1992	0	percent	0	19
STREAM_VARG	Streamflow Variability Index from Grid	0.69	dimensionless	0.25	1.13

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
LAT_CENT	Latitude of Basin Centroid	38.9663	decimal degrees	38.68	41.2
LONG_CENT	Longitude of Basin Centroid	82.8428	decimal degrees	80.53	84.6

Flow Percentile Statistics Flow Report [Low Flow LatLE 41.2 wri02 4068]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	ASEp
25th Percentile Flow	0.0627	ft ³ /s	29.2	29.2
50th Percentile Flow Median	0.168	ft ³ /s	40.3	40.3
75th Percentile Flow	0.364	ft ³ /s	47.9	47.9

Flow Percentile Statistics Citations

Koltun, G. F., and Whitehead, M. T., 2002, Techniques for Estimating Selected Streamflow Characteristics of Rural, Unregulated Streams in Ohio: U. S. Geological Survey Water-Resources Investigations Report 02-4068, 50 p (<https://pubs.er.usgs.gov/publication/wri024068>)

Bankfull Statistics Parameters [Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.07722	940.1535

Bankfull Statistics Parameters [Appalachian Plateaus P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.081081	536.995602

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.07722	59927.7393

Bankfull Statistics Flow Report [Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	8.96	ft
Bieger_D_channel_depth	0.778	ft
Bieger_D_channel_cross_sectional_area	7.04	ft ²

Bankfull Statistics Flow Report [Appalachian Plateaus P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	9.09	ft
Bieger_P_channel_depth	0.777	ft
Bieger_P_channel_cross_sectional_area	7	ft ²

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	7.91	ft
Bieger_USA_channel_depth	0.919	ft
Bieger_USA_channel_cross_sectional_area	8.59	ft ²

Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bieger_D_channel_width	8.96	ft
Bieger_D_channel_depth	0.778	ft
Bieger_D_channel_cross_sectional_area	7.04	ft ²
Bieger_P_channel_width	9.09	ft
Bieger_P_channel_depth	0.777	ft
Bieger_P_channel_cross_sectional_area	7	ft ²
Bieger_USA_channel_width	7.91	ft
Bieger_USA_channel_depth	0.919	ft
Bieger_USA_channel_cross_sectional_area	8.59	ft ²

Bankfull Statistics Citations

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G., 2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty,

17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_campaign=PDFCoverSheet)

Probability Statistics Parameters [P zero Flow 2012 5138]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	1	1250
STREAM_VARG	Streamflow Variability Index from Grid	0.69	dimensionless	0.24	1.12

Probability Statistics Disclaimers [P zero Flow 2012 5138]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Probability Statistics Flow Report [P zero Flow 2012 5138]

Statistic	Value	Unit
Probability zero flow 1Day	0.112	dim
Probability zero flow 7Day	0.0556	dim
Probability zero flow 30Day	0.00321	dim

Probability Statistics Citations

Koltun, G.F., and Kula, S.P., 2013, Methods for estimating selected low-flow statistics and development of annual flow-duration statistics for Ohio: U.S. Geological Survey Scientific Investigations Report 2012–5138, 195 p. (<http://pubs.usgs.gov/sir/2012/5138/>)

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Application Version: 4.6.2

StreamStats Services Version: 1.2.22

NSS Services Version: 2.1.2

Attachment 2
HY-8 Report (Existing 10' Steel Beam Bridge)

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 55.8 cfs

Design Flow: 159 cfs

Maximum Flow: 365 cfs

Table 1 - Summary of Culvert Flows at Crossing: Existing

Headwater Elevation (ft)	Total Discharge (cfs)	Steel Beam Bridge Discharge (cfs)	Roadway Discharge (cfs)	Iterations
732.14	55.80	55.80	0.00	1
732.66	86.72	86.72	0.00	1
733.12	117.64	117.64	0.00	1
733.68	159.00	159.00	0.00	1
733.94	179.48	179.48	0.00	1
734.31	210.40	210.40	0.00	1
734.67	241.32	241.32	0.00	1
735.01	272.24	272.24	0.00	1
735.34	303.16	303.16	0.00	1
735.66	334.08	334.08	0.00	1
735.99	365.00	365.00	0.00	1
739.31	720.64	720.64	0.00	Overtopping

Rating Curve Plot for Crossing: Existing

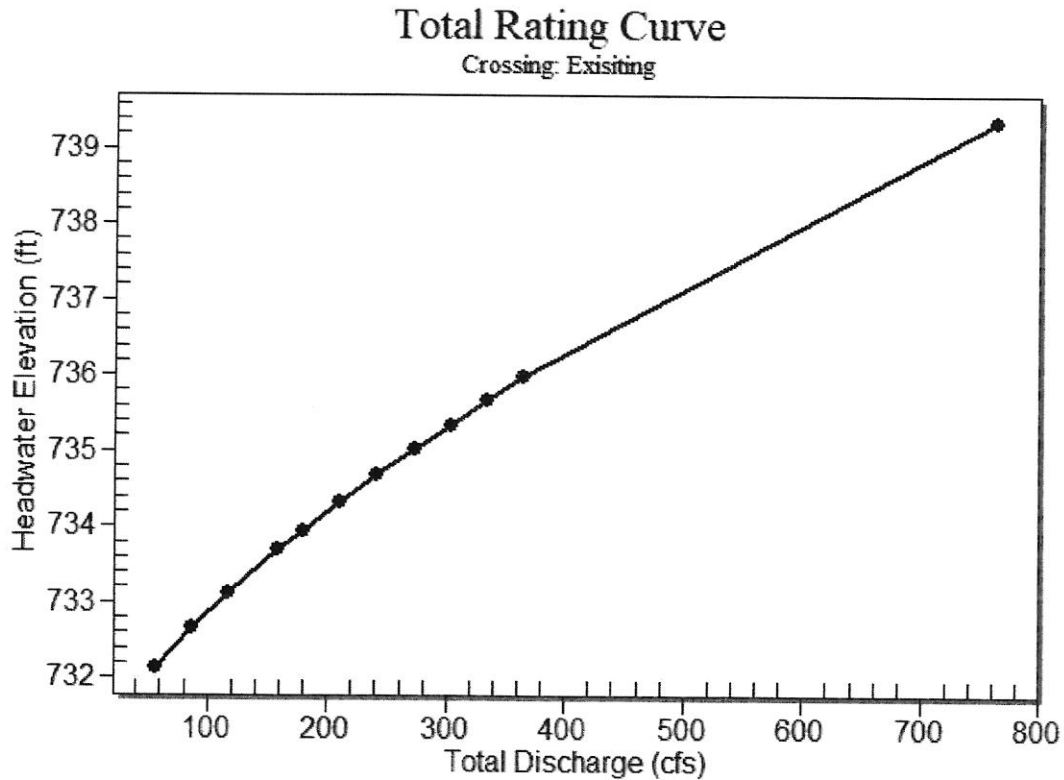


Table 2 - Culvert Summary Table: Steel Beam Bridge

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
55.80	55.80	732.14	1.529	0.0*	1-S2n	0.599	0.989	0.615	0.730	9.070	5.236
86.72	86.72	732.66	2.052	0.0*	1-S2n	0.798	1.327	0.798	0.948	10.871	6.128
117.64	117.64	733.12	2.514	0.0*	1-S2n	0.971	1.626	1.007	1.135	11.682	6.816
159.00	159.00	733.68	3.074	0.0*	1-S2n	1.179	1.988	1.235	1.355	12.879	7.554
179.48	179.48	733.94	3.332	0.0*	1-S2n	1.278	2.155	1.347	1.455	13.323	7.869
210.40	210.40	734.31	3.705	0.0*	1-S2n	1.417	2.396	1.510	1.596	13.936	8.296
241.32	241.32	734.67	4.059	0.242	1-S2n	1.552	2.625	1.668	1.728	14.468	8.678
272.24	272.24	735.01	4.399	0.507	1-S2n	1.682	2.845	1.824	1.853	14.928	9.025
303.16	303.16	735.34	4.726	0.770	1-S2n	1.808	3.056	1.975	1.972	15.352	9.343
334.08	334.08	735.66	5.055	1.031	1-S2n	1.930	3.260	2.123	2.085	15.740	9.637
365.00	365.00	735.99	5.382	1.291	1-S2n	2.050	3.459	2.268	2.193	16.094	9.911

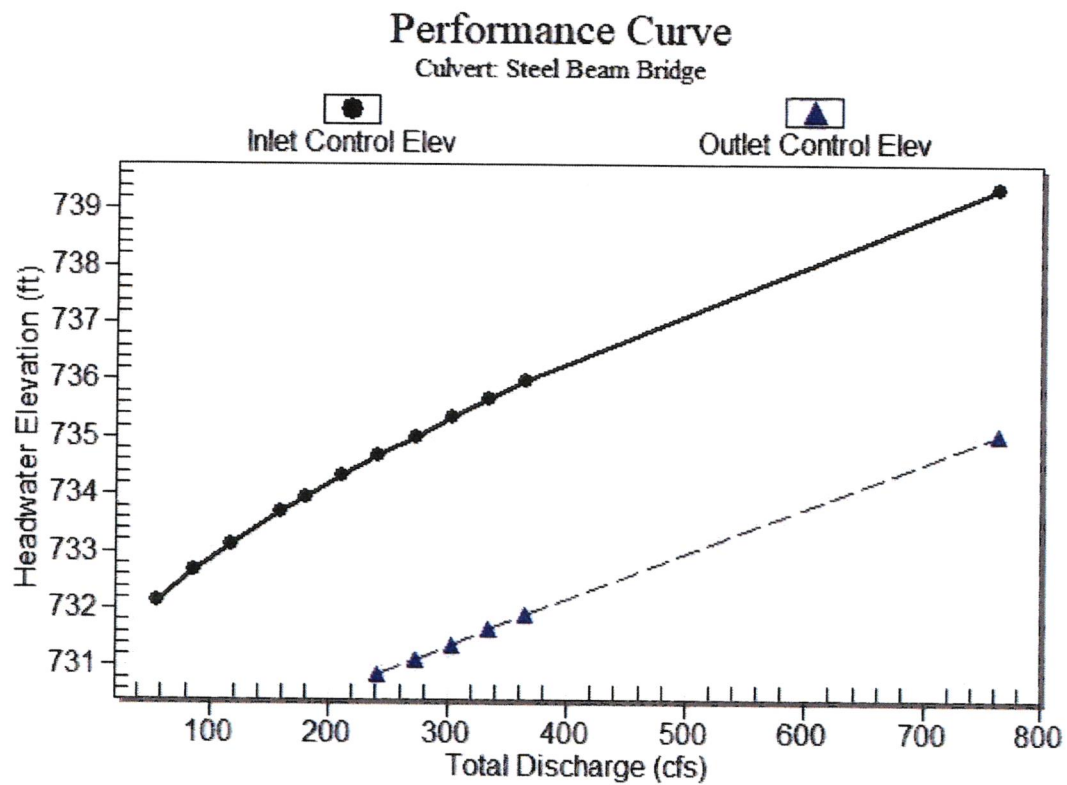
* Full Flow Headwater elevation is below inlet invert.

Straight Culvert

Inlet Elevation (invert): 730.61 ft, Outlet Elevation (invert): 728.06 ft

Culvert Length: 24.14 ft, Culvert Slope: 0.1063

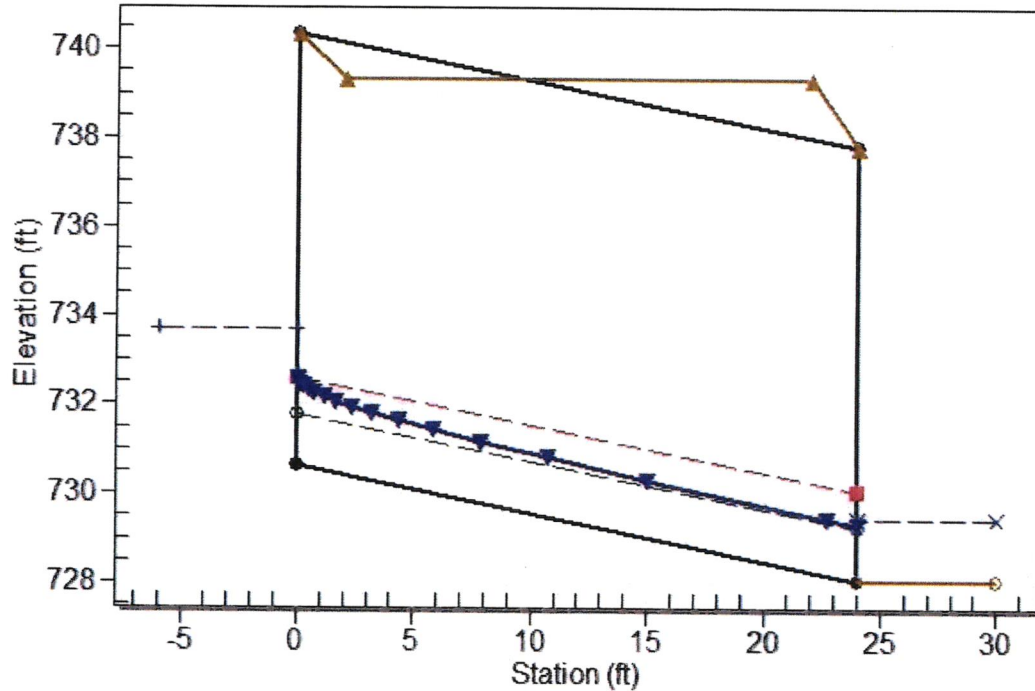
Culvert Performance Curve Plot: Steel Beam Bridge



Water Surface Profile Plot for Culvert: Steel Beam Bridge

Crossing - Existing, Design Discharge - 159.0 cfs

Culvert - Steel Beam Bridge, Culvert Discharge - 159.0 cfs



Site Data - Steel Beam Bridge

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 730.61 ft

Outlet Station: 24.00 ft

Outlet Elevation: 728.06 ft

Number of Barrels: 1

Culvert Data Summary - Steel Beam Bridge

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 9.75 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0350

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Existing)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
55.80	728.79	0.73	5.24	1.99	1.12
86.72	729.01	0.95	6.13	2.59	1.16
117.64	729.20	1.14	6.82	3.10	1.19
159.00	729.42	1.36	7.55	3.70	1.22
179.48	729.51	1.45	7.87	3.97	1.23
210.40	729.66	1.60	8.30	4.35	1.24
241.32	729.79	1.73	8.68	4.71	1.25
272.24	729.91	1.85	9.03	5.05	1.26
303.16	730.03	1.97	9.34	5.38	1.27
334.08	730.14	2.08	9.64	5.69	1.28
365.00	730.25	2.19	9.91	5.98	1.29

Tailwater Channel Data - Existing

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 13.50 ft

Side Slope (H:V): 1.50 (1:1)

Channel Slope: 0.0437

Channel Manning's n: 0.0450

Channel Invert Elevation: 728.06 ft

Roadway Data for Crossing: Existing

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 1000.00 ft

Crest Elevation: 739.31 ft

Roadway Surface: Paved

Roadway Top Width: 20.00 ft

Attachment 3

HY-8 Report (Proposed 10' Span x 8' Rise Precast Concrete Box Culvert)

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 55.8 cfs

Design Flow: 159 cfs

Maximum Flow: 365 cfs

Table 1 - Summary of Culvert Flows at Crossing: Proposed 10x8

Headwater Elevation (ft)	Total Discharge (cfs)	Proposed 10x8 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
731.05	55.80	55.80	0.00	1
731.61	86.72	86.72	0.00	1
732.11	117.64	117.64	0.00	1
732.71	159.00	159.00	0.00	1
732.99	179.48	179.48	0.00	1
733.39	210.40	210.40	0.00	1
733.77	241.32	241.32	0.00	1
734.13	272.24	272.24	0.00	1
734.48	303.16	303.16	0.00	1
734.82	334.08	334.08	0.00	1
735.15	365.00	365.00	0.00	1
739.31	783.19	783.19	0.00	Overtopping

Rating Curve Plot for Crossing: Proposed 10x8

Total Rating Curve

Crossing: Proposed 10x8

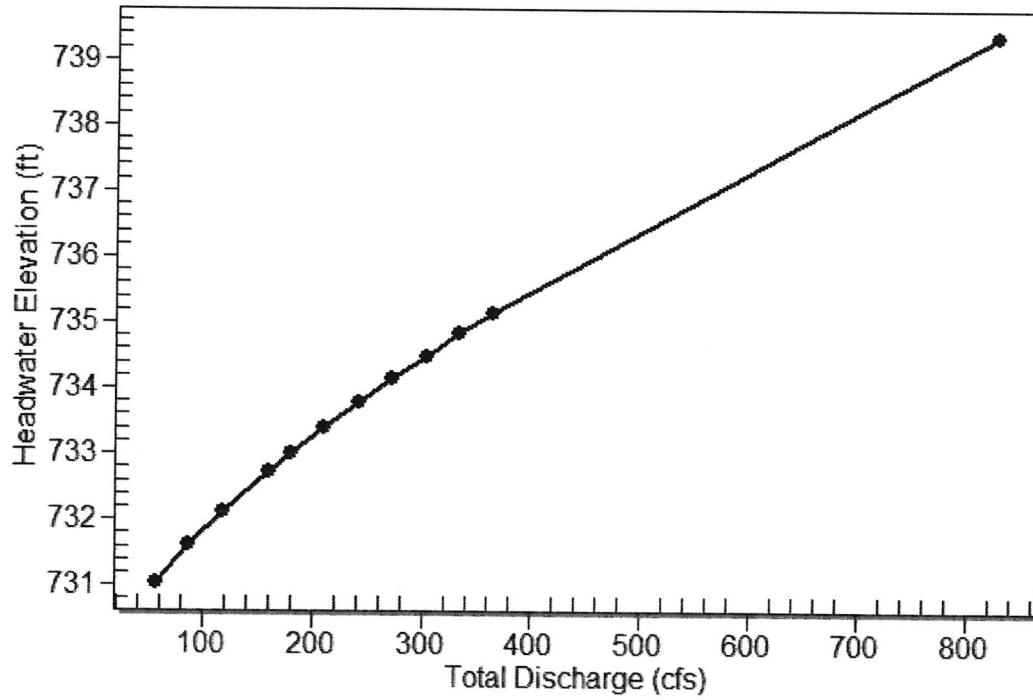


Table 2 - Culvert Summary Table: Proposed 10x8

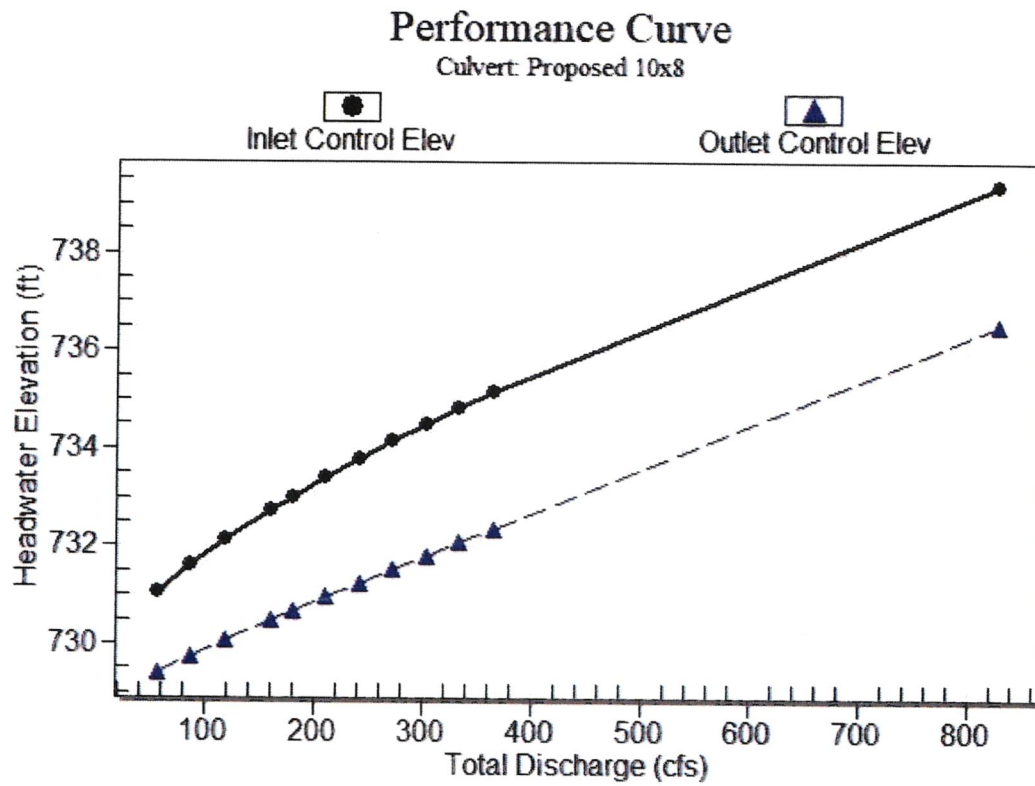
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
55.80	55.80	731.05	1.648	0.001	1-S2n	0.459	0.989	0.561	0.851	9.951	5.603
86.72	86.72	731.61	2.211	0.355	1-S2n	0.611	1.327	0.785	1.097	11.049	6.481
117.64	117.64	732.11	2.710	0.678	1-S2n	0.737	1.626	0.996	1.305	11.810	7.147
159.00	159.00	732.71	3.312	1.083	1-S2n	0.894	1.988	1.260	1.546	12.619	7.853
179.48	179.48	732.99	3.591	1.276	1-S2n	0.967	2.155	1.385	1.654	12.960	8.151
210.40	210.40	733.39	3.992	1.562	1-S2n	1.072	2.396	1.568	1.807	13.423	8.554
241.32	241.32	733.77	4.372	1.844	1-S2n	1.171	2.625	1.744	1.948	13.838	8.912
272.24	272.24	734.13	4.734	2.123	1-S2n	1.268	2.845	1.915	2.081	14.215	9.236
303.16	303.16	734.48	5.084	2.401	1-S2n	1.360	3.056	2.082	2.207	14.562	9.532
334.08	334.08	734.82	5.421	2.680	1-S2n	1.451	3.260	2.244	2.325	14.886	9.806
365.00	365.00	735.15	5.749	2.959	1-S2n	1.537	3.459	2.403	2.439	15.191	10.060

Straight Culvert

Inlet Elevation (invert): 729.40 ft, Outlet Elevation (invert): 728.40 ft

Culvert Length: 34.01 ft, Culvert Slope: 0.0294

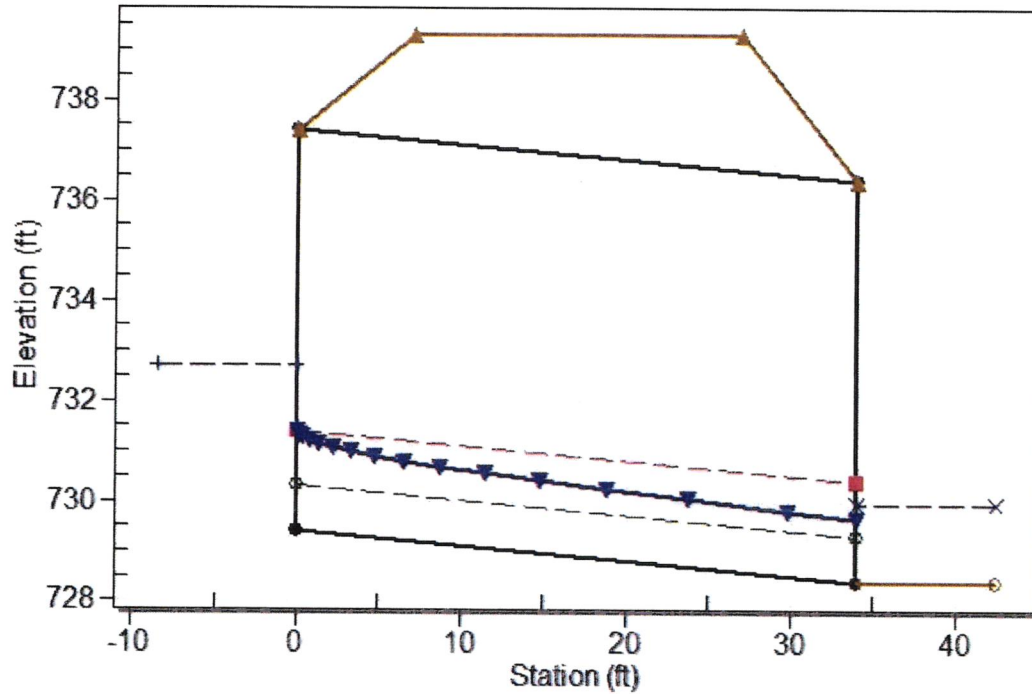
Culvert Performance Curve Plot: Proposed 10x8



Water Surface Profile Plot for Culvert: Proposed 10x8

Crossing - Proposed 10x8, Design Discharge - 159.0 cfs

Culvert - Proposed 10x8, Culvert Discharge - 159.0 cfs



Site Data - Proposed 10x8

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 729.40 ft

Outlet Station: 34.00 ft

Outlet Elevation: 728.40 ft

Number of Barrels: 1

Culvert Data Summary - Proposed 10x8

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Proposed 10x8)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
55.80	729.25	0.85	5.60	2.36	1.15
86.72	729.50	1.10	6.48	3.05	1.18
117.64	729.71	1.31	7.15	3.62	1.21
159.00	729.95	1.55	7.85	4.29	1.24
179.48	730.05	1.65	8.15	4.59	1.25
210.40	730.21	1.81	8.55	5.02	1.26
241.32	730.35	1.95	8.91	5.41	1.27
272.24	730.48	2.08	9.24	5.78	1.28
303.16	730.61	2.21	9.53	6.13	1.29
334.08	730.73	2.33	9.81	6.46	1.30
365.00	730.84	2.44	10.06	6.77	1.31

Tailwater Channel Data - Proposed 10x8

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 2.00 (1:1)

Channel Slope: 0.0445

Channel Manning's n: 0.0450

Channel Invert Elevation: 728.40 ft

Roadway Data for Crossing: Proposed 10x8

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 1000.00 ft

Crest Elevation: 739.31 ft

Roadway Surface: Paved

Roadway Top Width: 20.00 ft

Attachment 4

Site Photos



Photo 1 - Looking West on PIK-CR 72 (California Pike)



Photo 2 - Looking East along existing ditch on PIK-CR 72 (California Pike)



Photo 3 - Looking North upstream of tributary of Glade Run



Photo 4 - Looking South downstream of tributary of Glade Run



Photo 5 - Outlet of existing steel beam bridge



Photo 6 - Inlet of existing steel beam bridge



Photo 7 - Looking North/upstream at outlet, with exposed gas line shown