Baughman Creek & Unnamed Creek Flood Mitigation Plan

January 2011

Prepared for the City of Griswold
By the Cass Soil & Water Conservation District in conjunction with the Natural Resources Conservation Service and Iowa Department of Agriculture & Land Stewardship's Division of Soil Conservation

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I. BACKGROUND

In 2007, city leaders from Griswold approached the Cass Soil & Water Conservation District to ask for assistance in helping the city with flooding issues. Significant rainfall events occurred in the area that year and caused damage to residential homes, businesses, and city infrastructure.

The Cass Soil & Water Conservation District wrote and received a Development Grant from the Iowa Department & Land Stewardship – Division of Soil Conservation. The grant was used to fund a comprehensive study of the Baughman Creek and Unnamed Creek watersheds.

The Baughman Creek Watershed Project area is 10,278 acres and lies completely within Cass County Iowa. The project area is divided by two creeks, Baughman and Unnamed creek. Unnamed Creek drains an area which is 3,516 acres and Baughman Creek's drainage is 6,762 acres. Both watersheds are tributaries to the East Nishnabotna River. The Unnamed Creek drains the north half of the City of Griswold and runs directly west along the north side of Highway 92 where it outlets to the East Nishnabotna river. Baughman Creek drains the southern half of the City of Griswold and runs Southwest where it also outlets to the Nishnabotna river. Baughman Creek and Unnamed Creek flow into and through the city limits.

Located within the Unnamed Creek watershed is the Conklin Fish Farm County Park. This area is owned by the City of Griswold and leased by the Cass County Conservation Board. This popular thirty-six acre park is regularly used for camping and picnicking. This area was formerly used by the DNR in their fisheries division and boasts a productive ten acre pond.

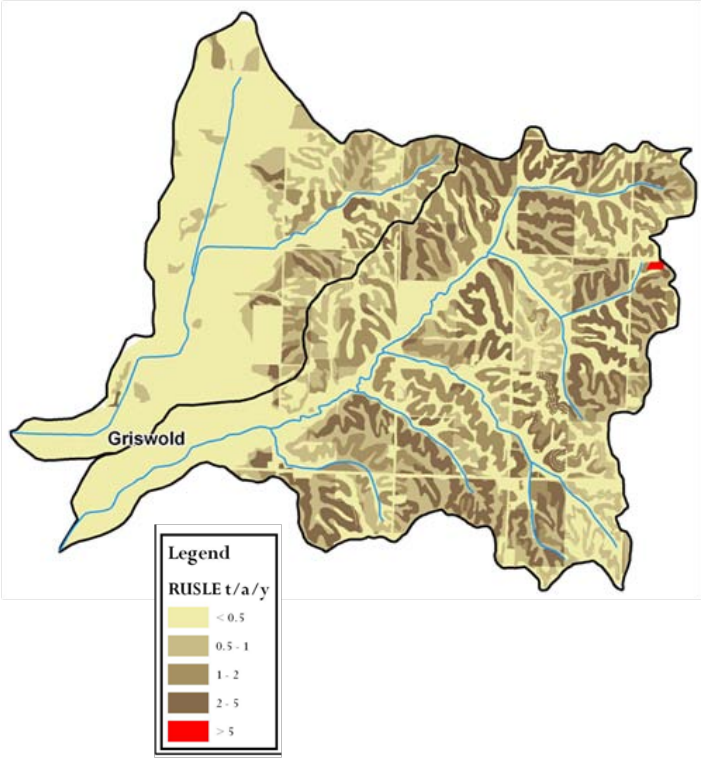
The drainage of these two watersheds has been severely altered in the past and is virtually uncontrolled, causing severe flooding within the city limits of Griswold and within the Conklin Fish Farm. During a flood event in 2007, ninety homes and nine businesses were flooded. Sediment and debris was deposited throughout the city. The City's sanitary sewer system failed causing raw sewage to travel downstream and also backup into many residents' basements. State Highways 48 and 92 were closed due to high water as well as Conklin Park. The chronic flooding has been a hardship to businesses as well as residents of the City.

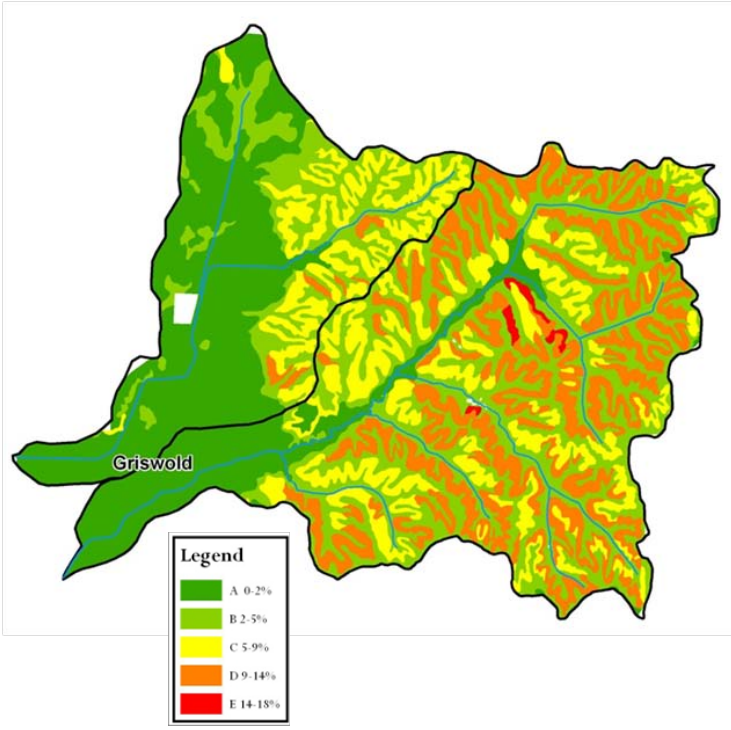
II. WATERSHED CHARACTERISTICS

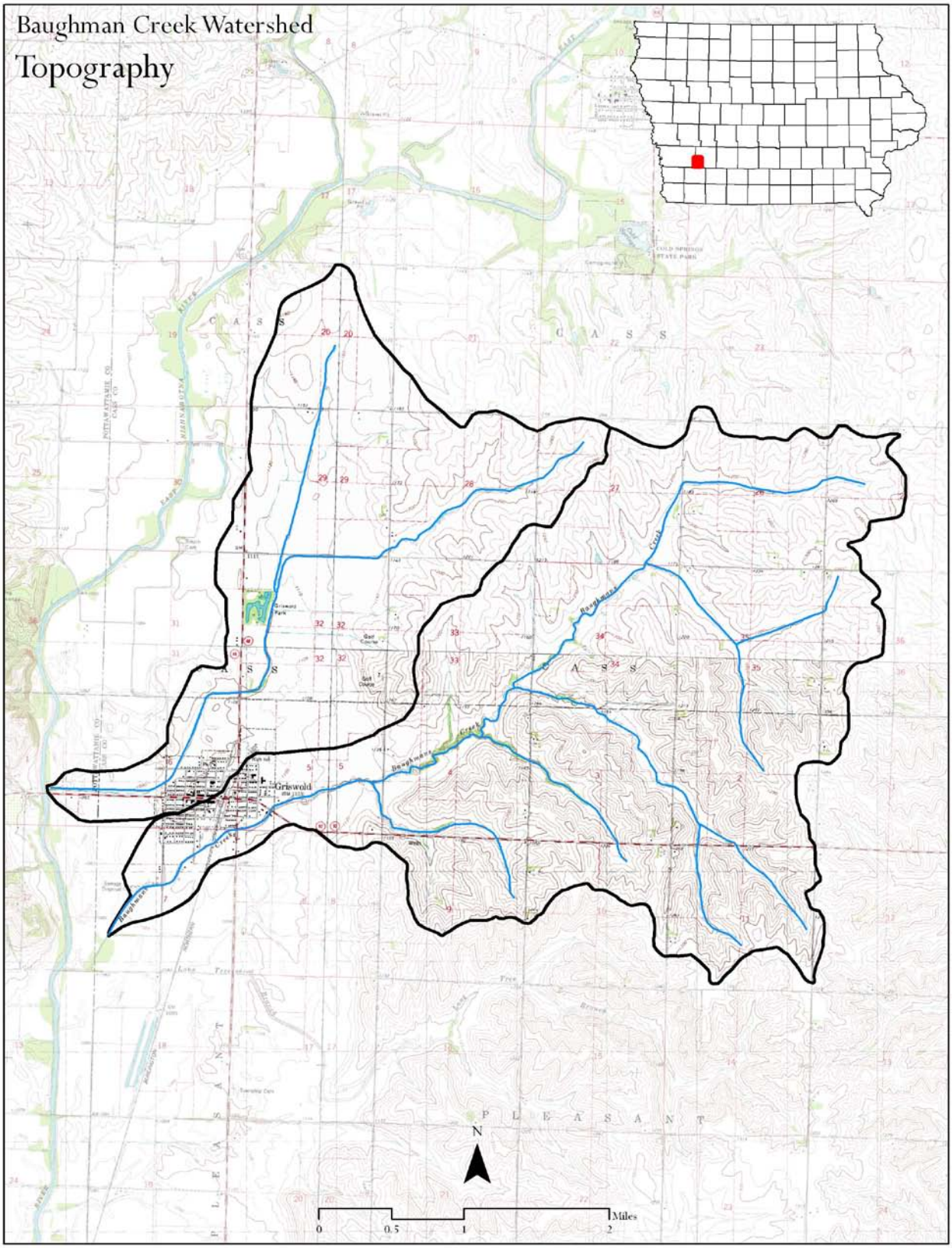
A. Geology and Topography

Soils of the area are dominated by the Marshall association which is found on broad ridge tops and smooth side slopes. Small areas of Adair and Shelby soils generally occur just down-gradient from the Marshall soils while the drainage areas consist of a Judson-Colo complex. The bottomlands of these two watersheds are in the Nodaway-Zook-Colo Association. These areas range from moderately well drained uplands to poorly drained bottoms without tiling.

Primarily due to the slope of the land, roughly the eastern two-thirds of the watershed is considered to be dominated by highly erosive soil types. For all practical purposes, areas within the watershed where there is a significant amount of grade also are dominated by these soil types. The following slope and soil loss maps illustrate this point.



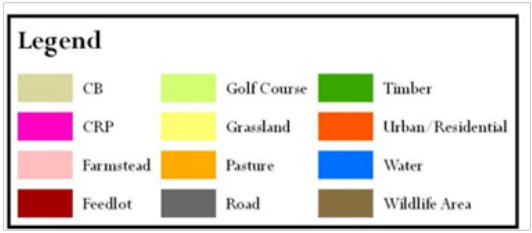


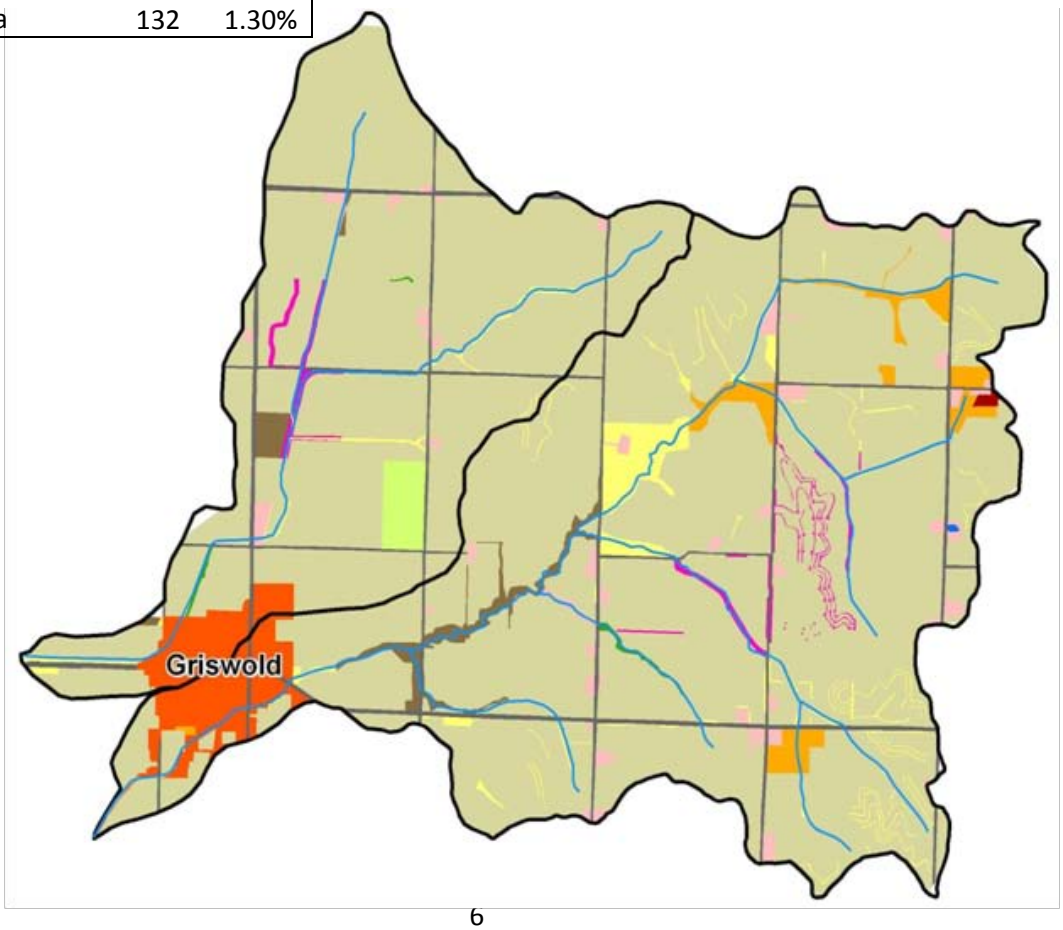

Baughman Creek Watershed
Topography
Griswold
N
0
0.5
1
2
Miles

B. Land Cover

Land use in the Baughman and Unnamed Creek Watersheds is dominated by row-crop production of corn and soybeans. Many landowners have installed terrace or contour buffer systems to help protect the farm land on the steeper slopes. Approximately one-quarter of the farms are practicing No-Till, half are practicing mulch tillage, and the other quarter are conventional tillage. The farms that practice conventional tillage are located on land that is less than five percent slope. Very little livestock exists in the watershed. There is limited pasture land and one feedlot located in the project area.

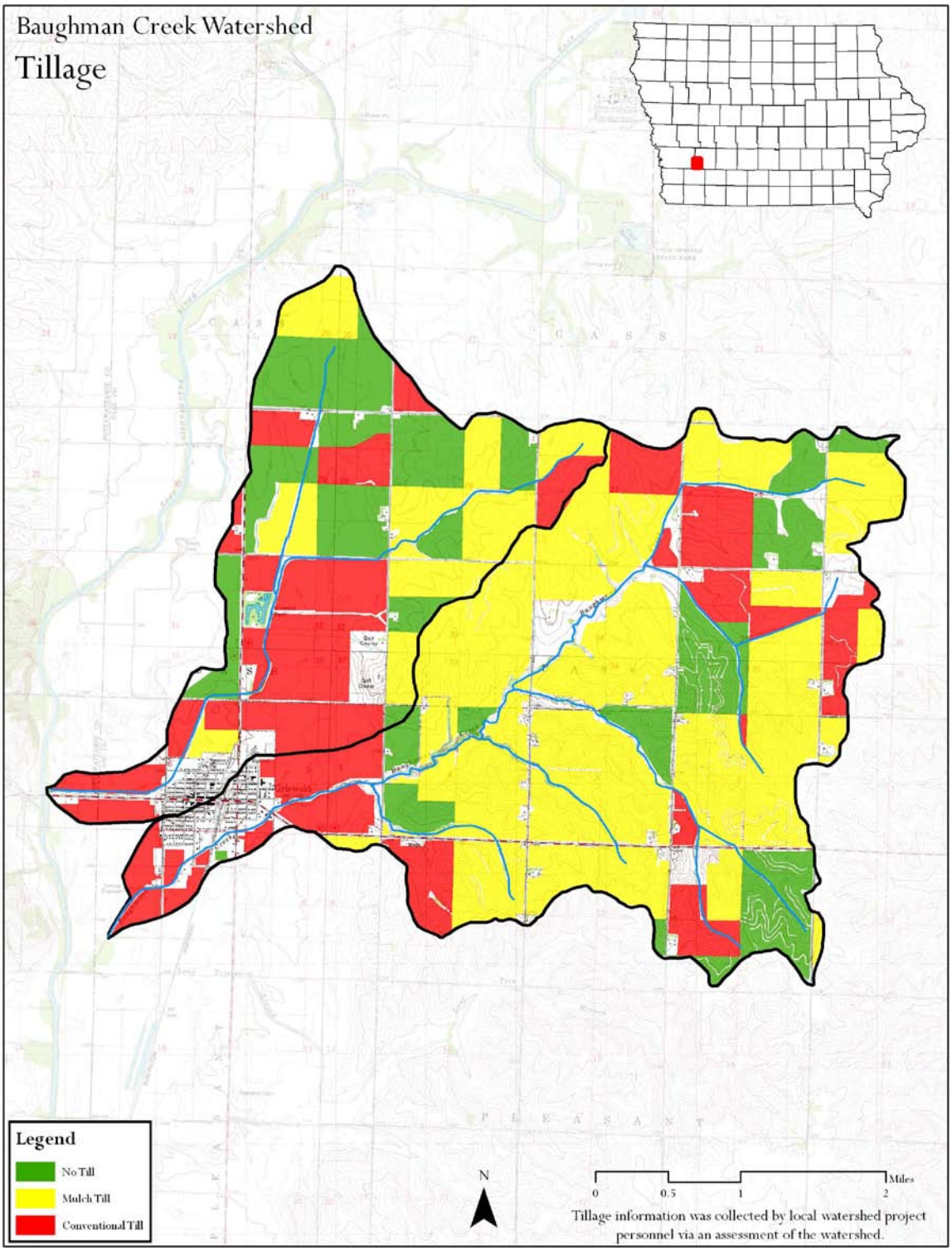
Land Use	Acres	%
Corn/Bean	8595.3	83.90%
CRP	87.4	0.90%
Farmstead	176.8	1.70%
Feedlot	6.1	0.10%
Golf Course	76.4	0.70%
Grassland	280.6	2.70%
Pasture	164	1.60%
Road	346.9	3.40%
Timber	14.2	0.10%
Urban/Residential	357.8	3.50%
Water	1.4	0.00%
Wildlife Area	132	1.30%





Baughman Creek Tillage Summary 2008

Tillage of Corn/Bean Land	Acres	%
Conventional Till Total	2,341.6	27.2%
Mulch Till Total	4,312.2	50.2%
No Till Total	1,941.5	22.6%



C. Climate

Cass County has a humid to sub-humid climate, with characteristically hot summers and cold winters. The temperature range between summer and winter is fairly wide with a summer average of 73 degrees Fahrenheit and 23 degrees during the winter months. Prevailing winds in the summer are from the southwest and in winter from the northwest. The average frost-free season is 152 days.

More than half the annual precipitation falls during the growing season. Precipitation in summer may come as gentle rains or short, heavy thunderstorms. In winter, precipitation comes mainly in the form of snowfall. The average annual rainfall is 31.8 inches with an average annual snowfall is 27.4 inches.

Periodically, torrential rains reap havoc on the City of Griswold such as was the case in 1993, 1998, 2007 and 2008. Undoubtedly flooding has become a more frequent problem in recent decades which is exemplified by the fact that each of these events was on the order of what is predicted to be a 100 year storm event.

D. Demographics

The July 2007 population for the City of Griswold was 955 people.

The total number of farmland acres in Cass County is 317,913. There are 763 farms within the county and average farm size is 417 acres. In 2007, the average market value of all farm products (livestock and crops) was $226,574. The average value of farm and buildings was $1,279,235.

Industries providing employment within the county include educational, health and social services (18.5%), manufacturing (18.2%) and retail trade (12.1%). In 2007, the median income for a household in the county was $39,447. About eleven percent of the population was below the poverty line. Given these rather meager income for most residents, the frequent flooding has come a particularly high cost to the community.

III. FACTORS INFLUENCING FLOODING

The City of Griswold has a long history of flooding due to landscape position of the city, unique watershed characteristics, and complex characteristics of the water drainage network. Understanding flow patterns of runoff from the watersheds, the capacity of the creeks, and their interface with the storm sewer network are important when evaluating the factors that influence the flooding associated with the City of Griswold. Additionally, the interaction

between these factors and how they are affected by high flows on the East Nishnabotna River must also be considered to develop an effective, yet complementary strategy.

A. Storm Frequency and Peak Discharge

Several computer tools were used to model the hydraulic conditions in the watershed and analyze water flow characteristics as it moved through the landscape. ArcMap version 9.2 is a tool which uses Global Information System mapping information to develop 2 foot elevation contours, stream cross sections and capacities, display the direction of overland flow for small drainage areas, and create maps to illustrate the findings.

Frequency discharges were computed using WinTR-55, a program that calculates the peak frequency discharge for a given rainfall, drainage area, time of concentration, and runoff curve number. In other words, this model creates graphs which depict the volume of water at different points along the stream system given a certain rainfall event. The frequency discharges calculated were 2 year, 5 year, 10 year, 25 year, 50 year, and 100 year events, and are statistically thought to occur 50%, 20%, 10%, 4%, 2% and 1 % of the time in any given year, respectively.

The backwater analysis tool, HEC-RAS version 4.0 was used to determine the capacity of the channels at several cross section locations. HEC-RAS provides a cross section rating of a channel; the relationship between water surface elevation and the discharge associated with it. Once the channel cross section rating is established, the frequency discharges from WinTR-55 are input and water surface elevations established.

The following peak discharges were developed using WinTR-55, a computer model which simulates peak discharges resulting from 24 hour rainfall events. The Time of Concentration hours were computed using two methods, the Travel Time Method which uses travel times for sheet, shallow concentrated, and channel flows and the Lag Method which uses the overall watershed slope and hydraulic length. This was done to compare the values. The structure delineations were accomplished using ArcMap with contours from the digital elevation models (DEM). Structure sites between 300-400 acres in drainage area were targeted to show their affect on peak discharges. The frequency discharges computed by WinTR-55 were compared to discharges computed from the USGS Regional Equations for Region 2 and found to be fairly close. The rainfall depths which are imbedded in WinTR-55 are from TP-40.

Storm Frequency, Duration and Intensity of Rainfall in Cass County, Iowa

Frequency	*Duration of—*						
	½ hour	*1 hour*	*2 hour*	*3 hour*	*6 hour*	*12 hour*	*24 hour*
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1 year_____	*1.1*	*1.3*	*1.6*	*1.7*	*2.0*	*2.2*	*2.6*
2 years____	*1.3*	*1.6*	*1.9*	*2.1*	*2.4*	*2.8*	*3.2*
5 years____	*1.7*	*2.1*	*2.5*	*2.7*	*3.1*	*3.6*	*4.1*
10 years___	*1.9*	*2.5*	*2.8*	*3.1*	*3.6*	*4.2*	*4.8*
25 years___	*2.2*	*2.8*	*3.3*	*3.6*	*4.1*	*4.8*	*5.4*
50 years___	*2.5*	*3.2*	*3.7*	*4.0*	*4.8*	*5.4*	*6.2*
100 years__	*2.8*	*3.6*	*4.1*	*4.5*	*5.2*	*6.0*	*6.8*

Based upon the storm frequencies and rainfall amounts, the peak discharge or the amount of runoff which would be produced was calculated for each watershed and is displayed in the following tables as cubic feet per second.

Baughman Creek Watershed

Uncontrolled drainage area – 6,762 acres
Runoff Curve Number – 76

Peak Discharges (cfs)

	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
"Without Project" Conditions	1112	1938	2560	3208	3887	4487

Unnamed Creek Watershed

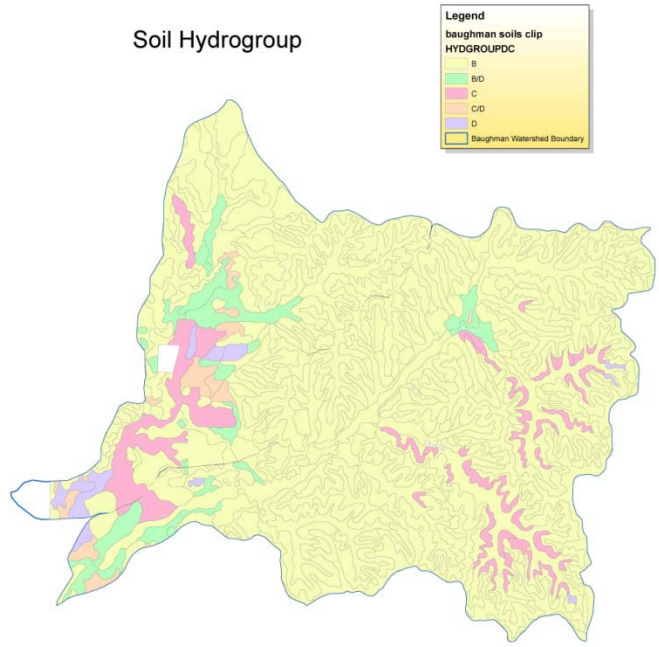
Uncontrolled drainage area – 3,516 acres
Runoff Curve Number – 79

Peak Discharges (cfs)

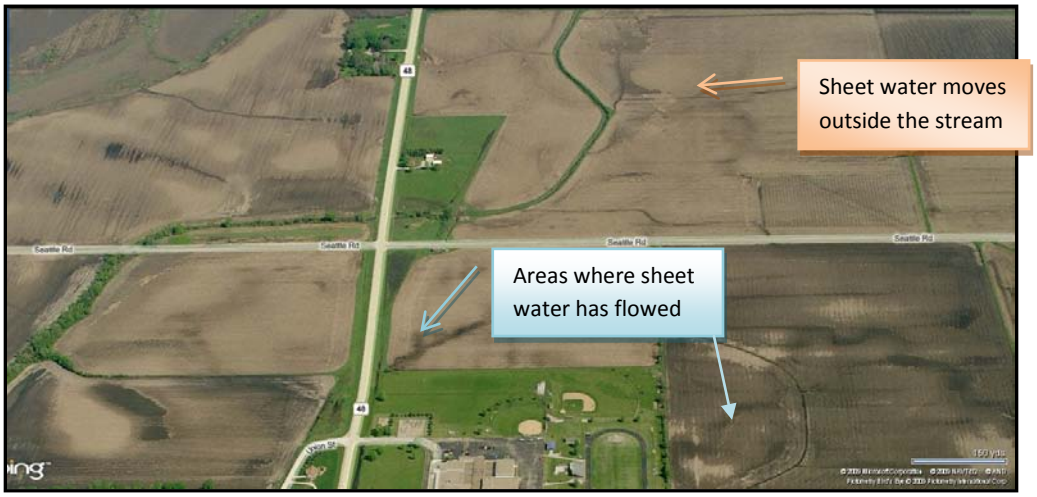
	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
"Without Project" Conditions	712	1189	1541	1910	2281	2609

B. Sheet Water and Shallow Concentrated Flow

Once precipitation reaches the ground, water can infiltrate into the soil profile or move across the surface as runoff. The rate at which water infiltrates varies by the unique properties of the each soil type, land cover, and specific types of land use practices are taking place. Soils composed of a high percentage of sand or silt allow water to infiltrate through it quite rapidly because it has large, well-connected pore spaces. Soils dominated by clay have low infiltration rates due to their smaller sized pore spaces and the shape of the clay particles that prevent water from permeating down through the soil profile. Surface runoff generally occurs when the rainfall intensity exceeds the rate of infiltration or when the soil has reached its water holding capacity.



When water runs across the surface it can be described as moving in either a confined or unconfined flow. Unconfined water flow moves across the surface in broad sheet water and shallow concentrated flows which are often associated with sheet and rill erosion. Confined flow refers to water confined to physical features such as a stream. The illustration below shows how a significant amount of water moves through the system as unconfined flow which is somewhat contrary to conventional thought. It is important to understand the volumes of water which are expected to be dealt with during various rainfall events, how the water moves through the system, and stream flow conditions in producing adequate measures of flood control.



The map below shows elevations at 2 foot intervals or contours lines. Since water flows perpendicular to the contours, close contours in the hills east produce faster runoff and more definitive flow patterns than the areas in the flood plain where contours are further apart and without consistent patterns. The flood plain contours suggest water would slow and seek many different directions, especially within the city limits. However, the general direction of flow is towards the Nishnabotna River.

Utilizing these 2 foot contours, areas can be depicted where water is concentrated and also flow directions can be identified for both watersheds. The bright red are flows within the Unnamed Creek watershed and the burgundy is flow direction for the Baughman Creek watershed.

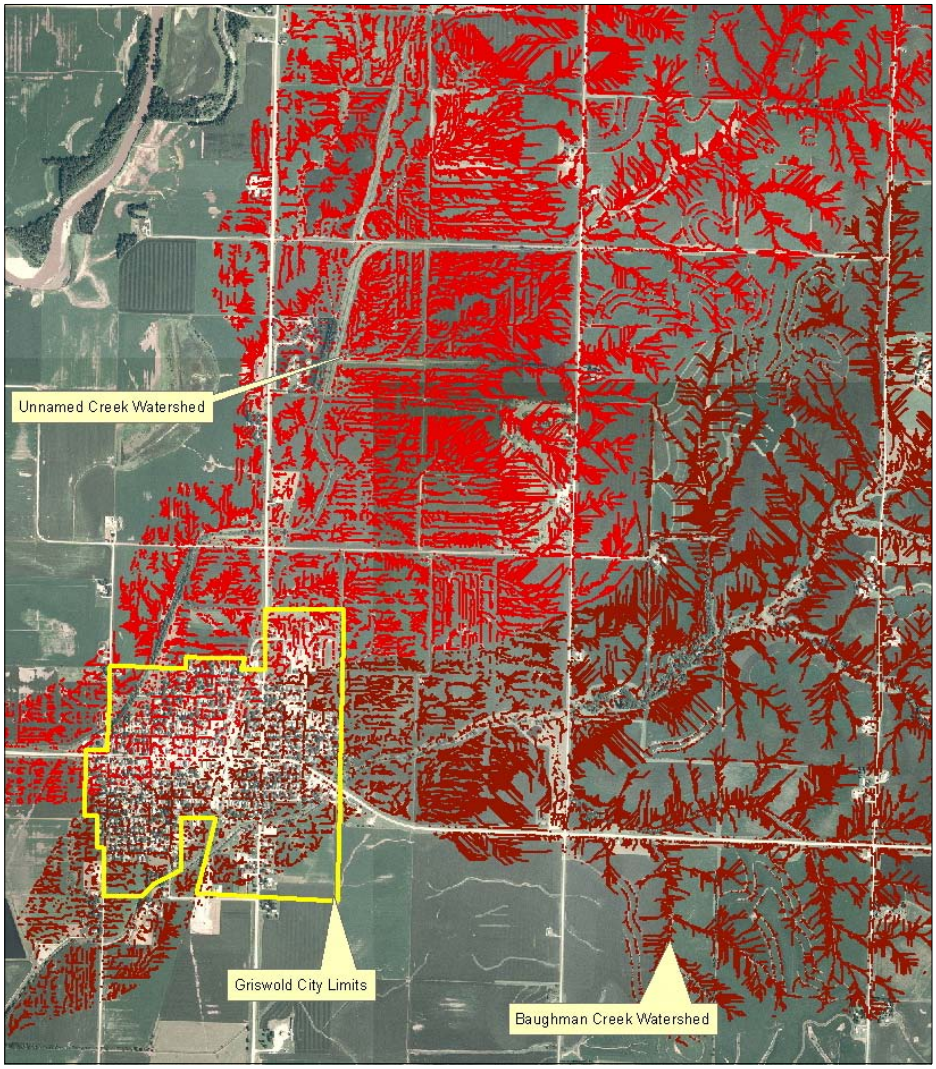


Figure 1 Flow Direction Baughman Creek and Unnamed Creek

Zooming in closer to show more details in the area of Highway 92 and Baughman Creek on the east side of town, raised roads direct flow into the ditches while farming practices east of town alter flow patterns as well. What is noteworthy is that the flow lines do not cross into Baughman Creek meaning that lower flows cannot get into the stream channel to be conveyed out of town. This is due to the build-up of soil on the channel banks which appear as short earthen berms, but is likely dredged material from previous stream modifications.

Figure 2 Hwy 92 and Baughman Creek Flow Direction.

The illustration below shows a reach of Baughman Creek as it passes through Griswold on the south side of town. Some flow patterns are more defined toward the west although the city streets become a conveyance mechanism for much of the flow. Again, small flows are unable to enter Baughman Creek from the adjacent areas.

Figure 3 Baughman Creek Flow Direction in the Southern Portions of the City of Griswold.

Flow direction on the north side of town in Unnamed Creek watershed again reveals sheet and concentrated flows which stop short without entering the channel. These flows instead pool in areas of the city and on cropland instead of being conveyed out of the watershed. The lower right hand side of the map shows flows go north and is conveyed through a culvert under Seattle Road. Some flow is shown going through the culvert under Highway 48, but the map suggests that runoff is not able to enter the channel and be drained away.

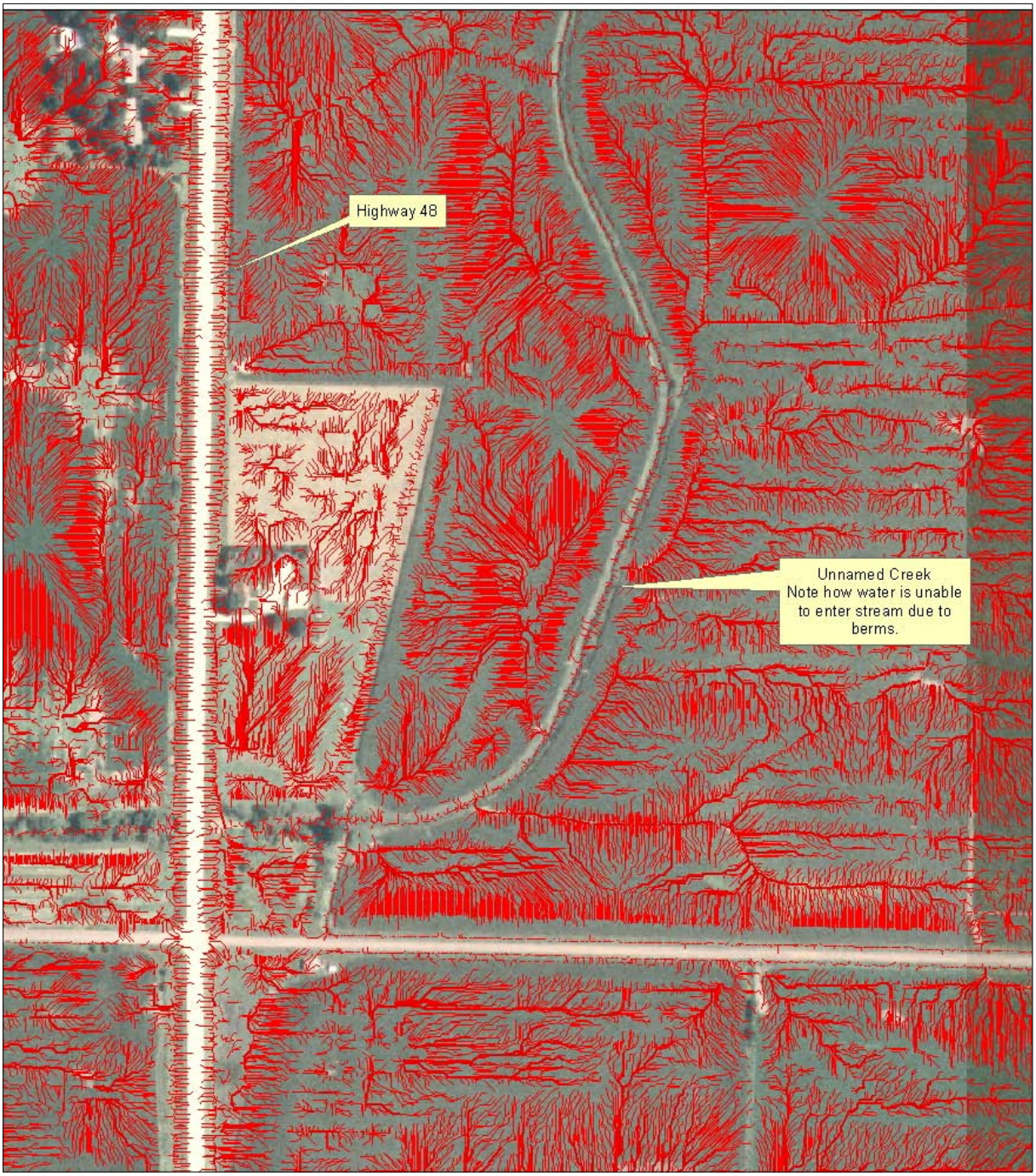


Figure 4 Unnamed Cr Flow Direction on the North Side of Griswold.

C. Stream Flow

As has been illustrated in the previous section, sheet water and shallow concentrated flow entering the City is a significant contributor to the flooding problems in Griswold. Perhaps more in line with conventional thought, flood waters coming out of the stream banks during peak discharges is also a significant part of the problem. Flood waters come out of the bank when the rate and/or the amount of rainfall exceed the capacity of the stream channel. To further investigate this issue, as series of cross sections of the stream channel were surveyed at several locations. The location of each stream cross section can be identified in the map below. The actual elevations can be viewed in the Attachments which also shows water levels in the stream channels during different rainfall events (peak discharges). The entire analysis of the cross sectional flow can be viewed in these attachments.

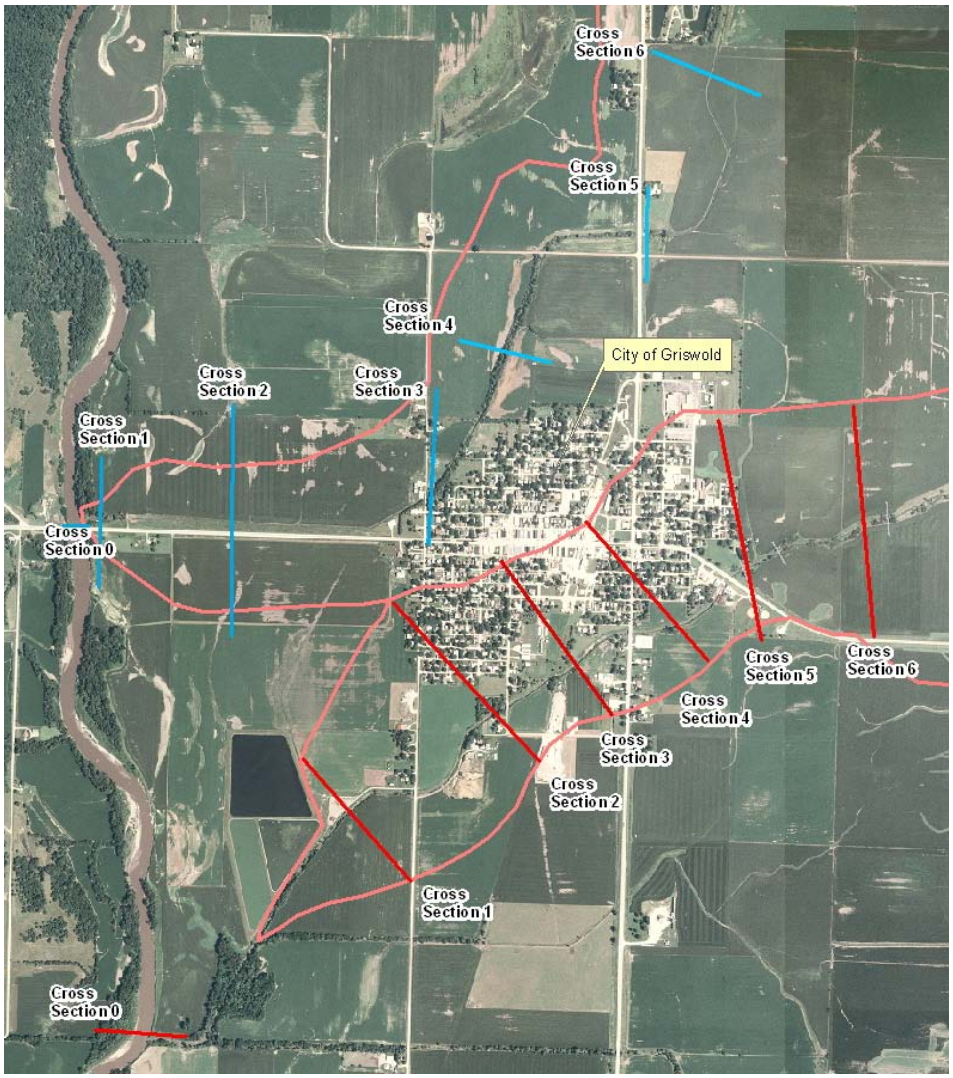


Figure 5 Location of stream cross sections surveys.

Baughman Creek, just upstream of Highway 92 at Cross Section 4 has the capacity of approximately a 25-year storm with a peak of 3,208 cfs. The rainfall which generates this runoff is 5.4 inches in 24 hours. It is during this type of event that it becomes evident that Baughman Creek first comes out of its banks and floods surrounding areas. That is not to say that those surrounding areas may not already be submerged due to the fact that many of those areas are lower than the bank heights of Baughman Creek. Again, water coming into the City from sheet, shallow concentrated flow and direct rainfall itself, is not able to make it to the channel since these adjacent areas are lower in elevation than the channel bank itself.

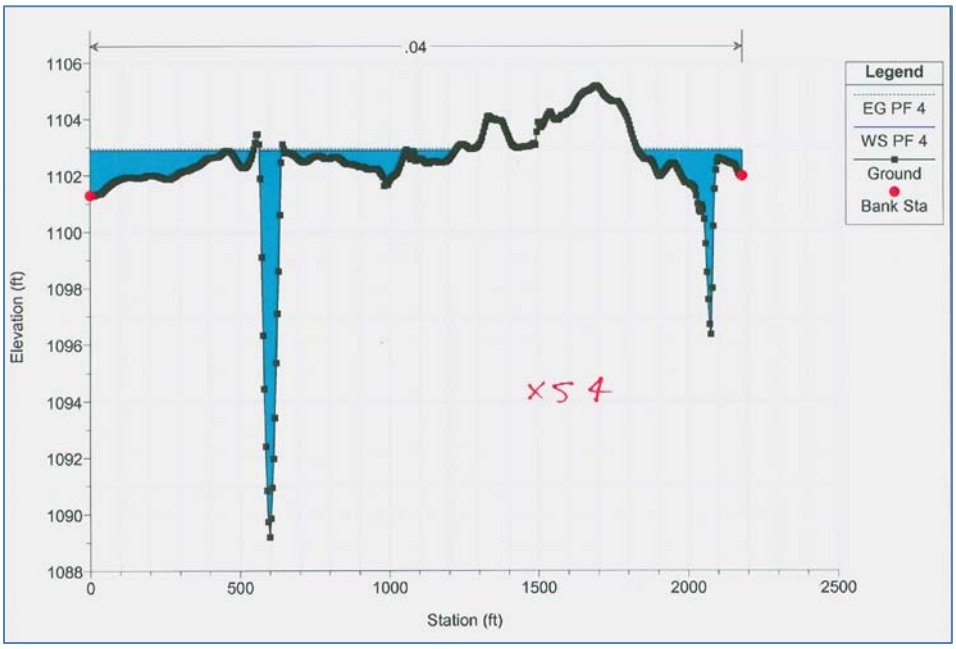


Figure 6 An illustration of Cross Section 4 on Baughman Cr depicting water coming out of the bank at this stream during a 25-Year Peak Discharge rainfall event.

Unnamed Creek in the northwest area of Griswold has a much smaller channel capacity than Baughman Creek. In fact, the only cross section that can completely contain the 2-year discharge is Cross Section 1, just upstream of the Nishnabotna River. All other cross sections show flow outside the channel for the 2-year flood. Once again, the bank elevations are higher than the adjacent areas so runoff cannot enter the channel and water is pooled in those areas.

All flood frequencies were evaluated assuming bank full elevations on the Nishnabotna River for both creeks. The backwater affect was greater for Baughman Creek than for Unnamed Creek. The flood profile for Baughman creek shows backwater to Cross Section 1 which is 4210 feet upstream of the Nishnabotna River. The backwater for Unnamed Creek did not noticeably elevate flooding, possibly because the slope of the channel is much higher than Baughman's channel slope.

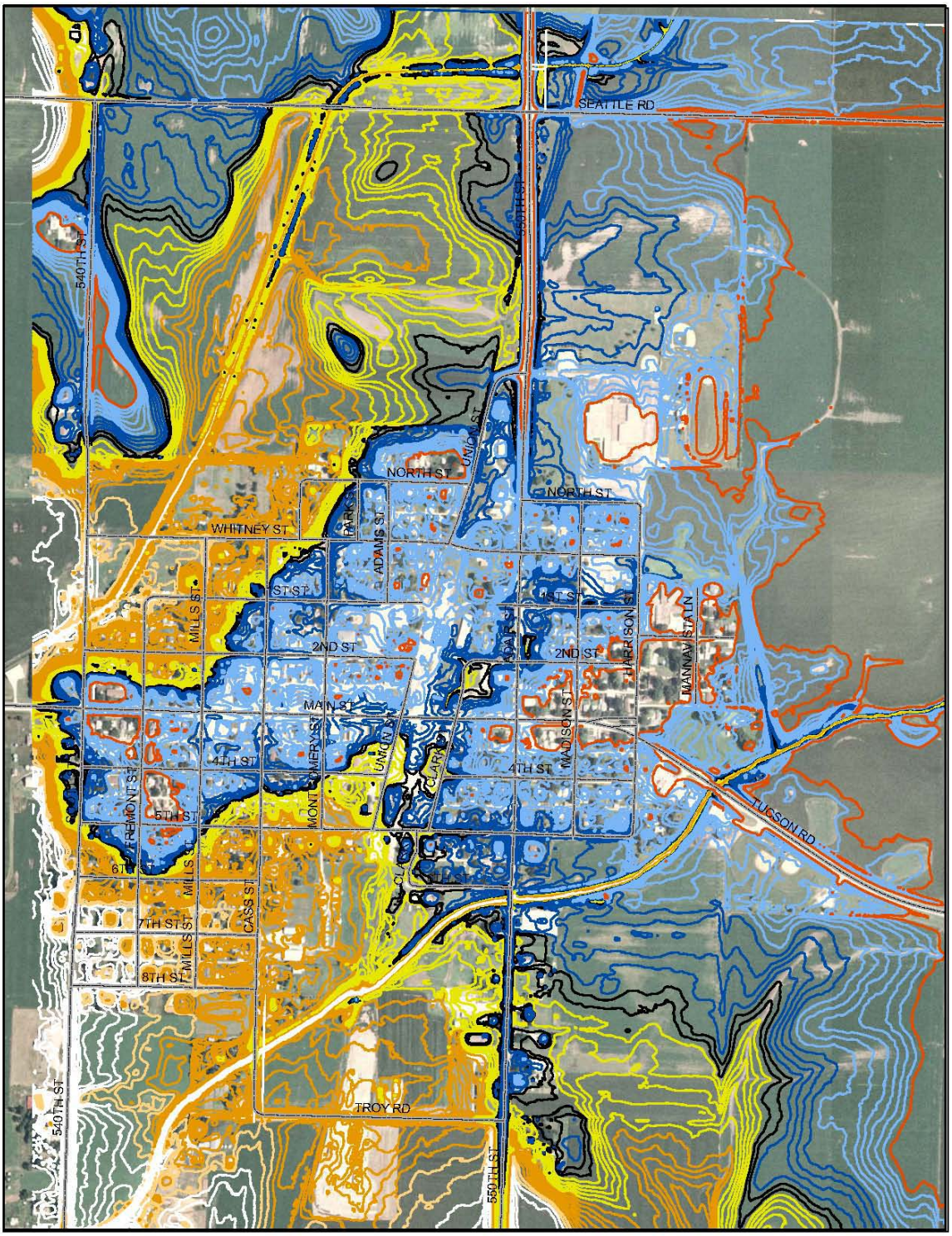
Another important aspect of stream flow involves the ability of the stream to convey water unrestricted through the City. A restriction that creates a bottleneck where the flow cannot pass through the stream itself forces the flow up and out of the banks. In an effort to evaluate these processes, all bridges were surveyed to determine how much water could pass through before the bridge itself began to restrict flow. The total CFS describes what the bridge is capable of flowing while the low CFS is what the bridge will pass when water is at bank full elevation. The graphs in the Attachments show clearly how the bridges are elevated above the surrounding landscape so as to not flow to maximum capacity without flooding areas upstream.

The Iowa Department of Transportation as-built plans for the Highway 92 Bridge, on the east side of Griswold, show that a 100 year storm event of 4300 cubic feet second (cfs) can be passed without restricting flow. These plans also show that the bridge could back water to elevation 1105.5. At or above this elevation water is pushed towards town and overtops the highway near Harrison Street. The digital 2 foot contour maps and landowner observations confirm this scenario. State owned bridges and culverts will pass the 100 yr storm event however when full will cause minor flooding in and around town.

The survey of all county and city-owned bridges shows that a 100-year storm event cannot pass without restriction. The most severe restriction occurs at the North Scott Street Bridge on the northwest side of town within City limits. During a 2-year storm event (712 cfs) this bridge only has the capacity to pass a total of 650 cfs with a low of 273 cfs. Although the channel has a higher capacity the bridge and the grade control structure below it greatly restrict flow. Modifications to this bridge are further complicated by a plethora of utilities that surround it making future modifications difficult.

These investigations show that the restrictions from bridges to be a significant problem in addition to the overall capacity of the stream channel. The Unnamed Creek stream, in particular, simply does not have much capacity to pass most storm events. The Baughman Creek stream channel does have a much greater capacity than Unnamed, however flow is still restricted. The South Scott Street Bridge poses the most restriction, passing less than a ten year storm event before flood waters get out of bank.

The following map is a ½ ft contour map which is color ramped, White->Red, according to flow restrictions. Notice how the highways grade towards town. Also notice the areas that could be impounded by the bridges.


SEATTLE RD
540TH ST
NORTH ST
WHITNEY ST
PARK ST
ADAMS ST
UNION ST
1ST ST
2ND ST
MILLS ST
MAIN ST
4TH ST
5TH ST
6TH ST
7TH ST
8TH ST
FREMONT ST
MONTGOMERY ST
CASS ST
CLARK ST
MADISON ST
HARRISON ST
MANNAY STA LN
TUCSON RD
TROY RD
550TH ST

D. Storm Sewer Network

Due to the fact that the entities charged with preparing this plan are primarily charged with assessing and planning in rural watershed areas, an intensive investigation was not conducted of water as it flows through the City of Griswold itself. However, a number of observations were made as these plans were being developed with respect to the interface between stream system and the storm sewer network. Several water courses within City limits were observed to be full of silt deposits or in need of additional grade improvements. This restricts water flows from entering the stream channels and ultimately being carried out of the city limits.

As mentioned previously, a number of instances were observed where water flow was impeded due to elevation differences between adjacent lands and the stream bank resulting in water being impounded on private property. Also prevalent were storm sewer outlets which directed these flows but had insufficient grade with respect to storm flows in the stream channel. Several instances were observed where storm sewer outfalls were at an elevation below the critical elevation of peak flow elevations within the stream channel. In these situations, the elevation of the storm sewer outfall is below the projected 25-year peak flow elevation. When the elevation of the flow in the stream is above the storm sewer outfall, pressure is equalized inhibiting the flow and resulting in water being pooled within the city limits. Although many of the outfall elevations could not be raised above the peak discharge of the stream flow during major storm events, it is evident that these outlets are compromised by water levels within the stream as the following images depicts.

Figure 7 Storm Baughman Creek sewer outfall below the elevation of a 25-year peak discharge.

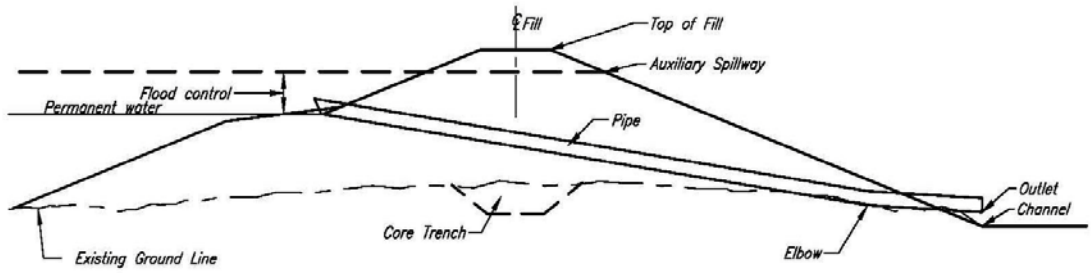
IV. FLOOD MITIGATION STRATEGIES

A. Watershed Practices

Throughout the planning process a number of watershed practices were identified which could be implemented in an effort to reduce the impacts of flooding to the City of Griswold. Although these practices have the ability to lessen impacts to varying degrees, there are a number of variables associated with each which may create challenges in getting the practices installed. Practice cost, acceptance by property owners, and maintenance after installation are just a few obstacles which will need to be evaluated for each of the recommended practices.

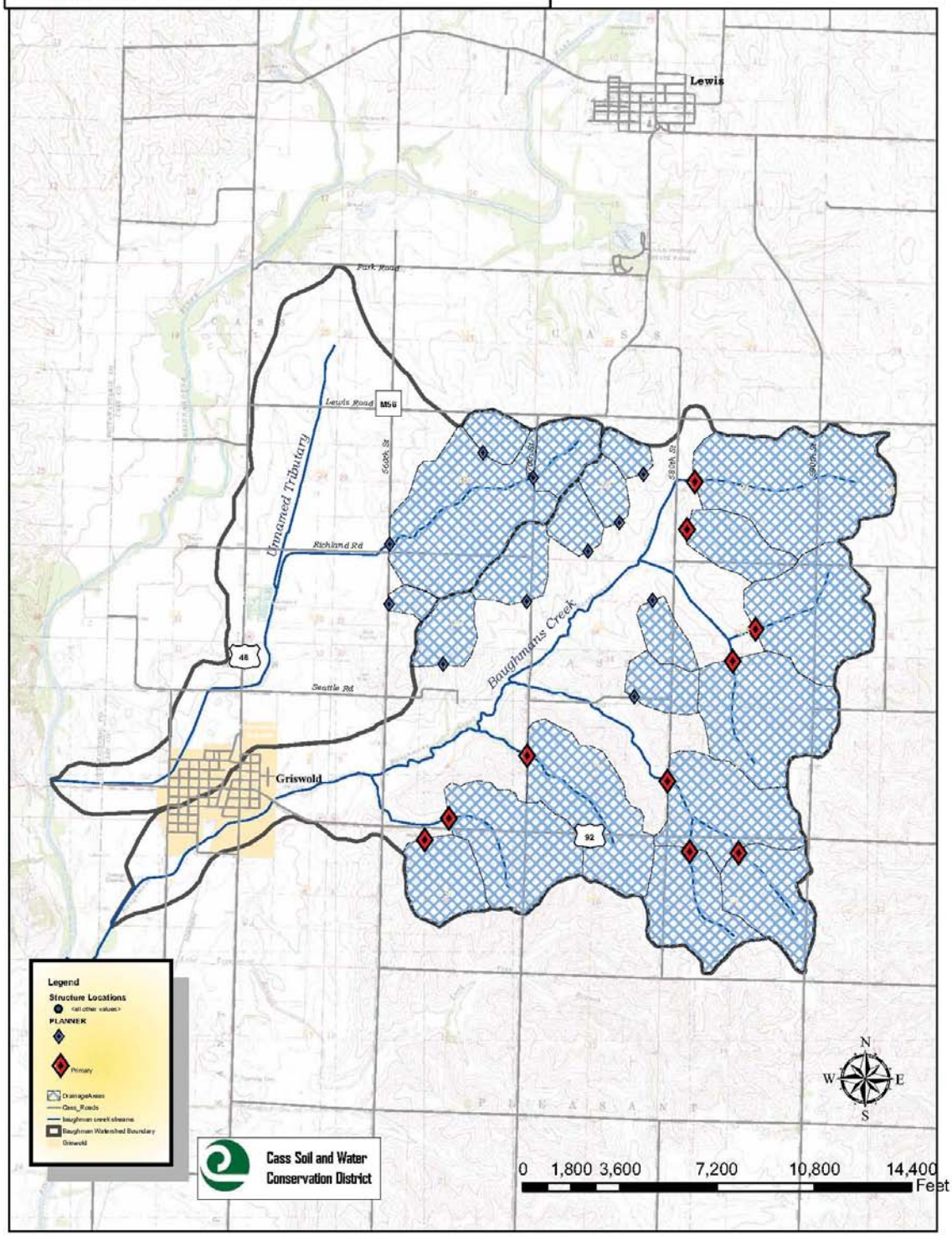
1. Flood Control Structures

The primary and most successful practice in reducing flooding impacts is the construction of flood control structures in upland settings. These practices slow down water during large rainfall events. These structures are essentially a pond with a large amount of temporary flood water storage between the principal pipe and auxiliary spillway.



The drainage area above Griswold was evaluated for the potential of building such structures. During the evaluation process twenty-one possible structure locations were identified. Ten priority locations were identified which, due to their drainage acres, would have the most pronounced impact on flooding.

Proposed Structure Locations



The following table summarizes the reduction in peak flows if six of the priority sites were constructed.

Baughman Creek Watershed

Cass County, Iowa

Uncontrolled drainage area – 6,762 acres

Runoff Curve Number – 76

Runoff Curve Number with Terraces – 72

Peak Discharges (cfs)

	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
"Without Project" Conditions	1112	1938	2560	3208	3887	4487
Future w/ 6 structures	748	1303	1721	2157	2614	3017
(% red.)	(33%)	(33%)	(33%)	(33%)	(33%)	(33%)

Structure Drainage Area (acres)

Site 1 – 381.7

Site 2 – 334.4

Site 3 – 394.5

Site 4 – 393.6

Site 5 – 360.6

Site 6 - 350.3

Total – 2215 (32.7% of total drainage area)

The following landowners have been identified as owning land where priority structures would be placed:

1. Mike Marshall
2. William Walkinshaw Trust*
3. John & Brent Bierbaum
4. Steven Forsyth
5. Bi Kap Farms
6. Virginia Steffen
7. Helen Longsteth
8. Marilyn Freund

(* Indicates having more than one site)

The estimated pool areas (areas covered by permanent and temporary water) range between six and fifteen acres. The estimated costs for these structures range between $43,000 and $100,000. These cost estimates are for construction only.

During preliminary meetings with these landowners, we discovered some reluctance on their part to install these structures on their land. This reluctance stemmed from the fact that these structures are planned on areas that are being used for row crop production. There is very little pasture in the entire watershed so consequently, there is little need for ponds to water livestock. These landowners felt as though they were being asked to have a pond on their land, which was of little value to them personally. This doesn't mean the landowners are unwilling to install these practices. It simply means the city and its partners need to come up with a creative package to offer these landowners which is different than the traditional watersheds NRCS has worked with in the past.

One of the ways to clear this barrier is to offer the landowners compensation for their land. This can be done by purchasing an easement on the land where the structure lies and the access to it.

2. Large Flood Control Structure

It is important to note that the purpose of the flood control structure is to slow down water. The goal can be accomplished with ten small structures or one big structure. One possible location was identified for such a structure. The area which would be flooded is primarily pastureland. The structure encompasses seven of the ten priority sites. The pool area would be 87.5 acres. The structure would cost approximately $1,000,000.

Structure B-1 was designed using the Sites computer program. The "future with B-1 in place" discharge came from running WinTR-55 with the controlled drainage area (4275 acres behind B-1) removed from the total drainage area of 6,762 acres.

The structure, B-1, was designed as a high hazard structure because of its proximity to Griswold. The design criteria requires 100-year discharges be stored behind the structure before any flow is allowed through the auxiliary spillway. The top of dam was set using the Probable Maximum Precipitation for this area and is 26.5 inches of rain in 6 hours. The principal spillway is a 42" Reinforced Concrete Pipe and the auxiliary spillway is 400 feet wide. The structure would be 44.6 feet tall. The permanent pool would be 87.5 surface acres.

The following is a summary of the peak flow reductions.

Baughman Creek Watershed With Site B-1

Cass County, Iowa

Uncontrolled drainage area – 6,762 acres

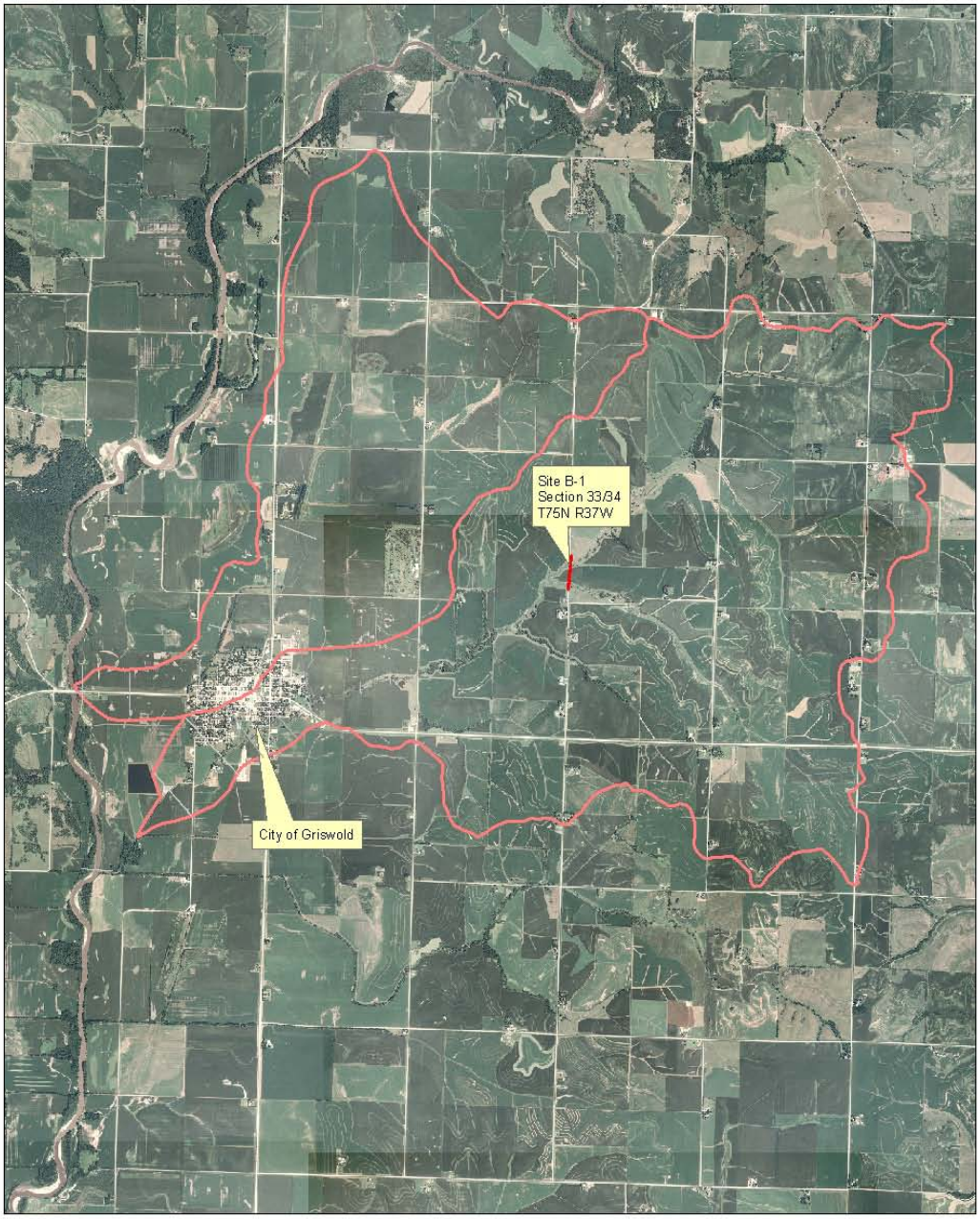
Controlled drainage area from site B1 – 4,275 acres (63% of watershed)

Runoff Curve Number – 76

Peak Discharges (cfs)

	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
"Without Project" Conditions	1112	1938	2560	3208	3887	4487
"With Project" Future w/ B-1 in Place	715	1254	1657	2088	2525	2907
Reduction In Peak Flows	36%	35%	35%	35%	35%	35%

Baughman Watershed
Potential Flood Control Structure B-1
Cass County, Iowa



N
W E
S

5,800 2,900 0 5,800 Feet

NRCS

L. Foreman
Hydrologist
NRCS
Des Moines, Iowa

3. Terracing

During the Development Grant process, a tillage survey was completed. During this survey, it was noted that a minimal number of terraces had been installed in the Baughman Creek Watershed. During meetings with landowners in the watershed, questions were raised about the effectiveness of installing terraces to control the flooding.

The hydrology study performed by NRCS looked at the effects of terracing on the peak discharge of water in the Baughman Creek Watershed. The study looked at scenarios where ten, twenty, and thirty percent of the watershed was terraced. The Peak Discharges on a twenty five year storm were reduced by 1.3 percent, 2.7 percent, and 4.1 percent respectively. Based on this information, NRCS concludes that terracing alone will have little impact on the flooding in Griswold.

However, terracing does provide other benefits to practices that do have more impact on the flooding situation. Terraces would trap sediment and prevent it from filling up the proposed flood control structures. Trapping the sediment will also be beneficial to increase the capacity of both the Baughman Creek and Unnamed Creek. Terraces would also prevent debris such as corn stalks from flowing downstream and collecting underneath infrastructure such as bridges, which reduces the amount of water the bridges flow.

4. Diversion/ Drainage Ditch

Surface water from the east of Griswold has a significant impact on residents and businesses on that side of town, as well as the school. It is proposed that a small diversion be constructed to divert the surface water back to Baughman Creek. The current drainage ditch could also be dug out and reshaped.

The diversion would be short in height, and designed in a way so that it could be farmed over with normal farming practices. It would be designed to keep smaller, flash surface flows away from the city. The diversion would currently have little to no effect during a large storm event since Highway 92 would likely back water over the top of the diversion.

If the City of Griswold chooses to construct such a diversion, future considerations would need to be made in terms of maintaining the diversion, as well as future development and expansion of the City itself.

Under the best of conditions, agricultural operations would deteriorate the diversion over time. Constant monitoring and maintenance of the diversion would need to be figured into the city's budget to maintain the diversion's effectiveness. Future development would need to be

carefully planned, should it happen in this area.

Cost Estimate						
East Dike						
					11/18/2010	
Item	Quantity		Unit Price		Cost	
Clearing & Grubbing	1	Acre	$1,000.00	/Acre	$ 1,000.00	
Earthfill, 3ft top, 10:1 Side Slopes	2456	Cu.Yd.	$2.00	/Cu.Yd.	$ 4,912.00	
Seeding	3	Acres	$ 200.00	/Acre	$ 600.00	
	Total Cost				**$ 6,512.00**	

B. Stream Corridor Improvements

Unnamed Creek Improvements

The Unnamed Creek crosses Highway 48 on the north side of its intersection with Seattle Road. During several discussions with people from the Griswold area, it was believed the culvert did not have the capacity to pass the water from an entire 100 year storm. Jeff Godwin, NRCS Area Engineer, carefully examined the area.

According to Iowa Department of Transportation (IDOT) As-Built Engineering plans, the capacity of the culvert is 3,072 cubic feet per second (cfs) when the water reaches the elevation of the road (1105.94) and 2,510 cfs at the top of the headwall (1104.00). Jeff has determined, according to this information, the culvert has the ability to pass the water from an entire 100 year storm and more without overtopping Highway 48.

Jeff began to investigate Seattle Road east of Highway 48. It was discovered in areas, Seattle Road is as much as 3.6 feet lower than the Highway. This allows water to easily flow over Seattle Road, southward into the City of Griswold.

It is NRCS's recommendation that a 1,500 feet stretch of Seattle Road be raised to the level of Highway 48 at the intersection of Seattle Road. This would take approximately 3,000 cubic yards of earth fill to accomplish this.

By raising Seattle Road, this would force water to flow through the culvert under Highway 48 as it was intended to do. The culvert will need to be monitored and properly maintained to continue to function.

Once water passes through highway 48 it encounters two more restrictions of flow, one being the bridge on Seattle Road and the next being the bridge on Scott Street. Stream channel gradients in this stretch of stream average .10%. In order to pass a 100yr storm event the Unnamed creek would have to be cleared of all trees and widened approximately 100ft and dug out to an eight foot average depth. Both the bridges on Seattle Road and Scott Street would have to be widened in order to pass such a flow without raising the flood waters. A levee could also be constructed which would lessen the amount of channel modification. There are several utilities that would have to be moved, one being the natural gas pumping station, in order for these improvements to take place.

Cost Estimate							
Seattle Road Raising							
						11/18/2010	
Item		Quantity		Unit Price		Cost	
Clearing & Grubbing		1	Acre	$1,000.00	/Acre	$1,000.00	
Earthfill, 20ft top, 3:1 Side Slopes		3115	Cu.Yd.	$2.00	/Cu.Yd.	$6,230.00	
Seeding		4	Acres	$ 500.00	/Acre	$2,000.00	
		Total Cost				**$9,230.00**	

Baughman Creek Improvements

Baughman Creek exhibits much of the same problems as the Unnamed Creek. The bridges are not designed to pass a 100 yr storm and are much higher than the surrounding landscape, therefore water backs up and spreads out, flooding the town. In order to pass a 100 yr storm all of the bridges on Baughman creek should be widened as well as the channel. A combination of widening and constructing levees could also be a possibility. A channel 100 ft wide 8 ft deep would pass the 100 yr storm event.

Stream Widening

Cost Estimate							
Widening Baughman Creek							
						11/18/2010	
Item		Quantity		Unit Price		Cost	
Clearing & Grubbing		27	Acre	$2,000.00	/Acre	$ 54,000	
Excavation, 100ft wide channel, 2:1 Side Slopes, 8 ft deep		133,333	Cu.Yd.	$2.00	/Cu.Yd.	$ 266,666	
Seeding		27	Acres	$ 500.00	/Acre	$13,500	
		Total Cost				**$ 334,166**	
					+	**3 New Bridges**	
					+	**Moving Utility**	

Cost Estimate							
Widening No-Name Creek							
						11/18/2010	
Item		Quantity		Unit Price		Cost	
Clearing & Grubbing		16	Acre	$2,000.00	/Acre	$32,000.00	
Excavation, 100ft wide channel, 2:1 Side Slopes, 6 ft deep		67,000	Cu.Yd.	$2.00	/Cu.Yd.	$134,000	
Seeding		16	Acres	$ 500.00	/Acre	$8,000.00	
		Total Cost				**$174,000**	
					+	**New Bridge**	
					+	**Moving Utility**	

Improvements within City Limits

According to the plan developed by MSA Professional Services Inc much of the cities storm sewer infrastructure is inadequate and needs to be updated in order to convey a 5-year storm event. For more information concerning this topic please refer to the storm water system study. Reducing the amount of water entering town would drastically help the storm water outlets function properly. When Baughman Creek runs full the storm sewer outlets become submerged, neutralizing pressure and reducing flow from the outlets.

During a 6 inch rain event 81,457 gallons of water runs off of a half acre impervious lot. Finding ways to infiltrate this water could drastically aide in flood prevention. Urban practices such as rain gardens, bio-swales, bio-retention cells, infiltration trenches, sediment control basins for new development and porous pavement can help infiltration and reduce flood risk. The following are examples of urban conservation practices and their descriptions.

Bioretention Cells: Bioretention involves the capture and infiltration of stormwater runoff from impervious urban surfaces to treat pollutant loads. Bioretention also reduces the volume of hot, dirty runoff that reaches receiving waters via storm sewers. Bio-cells are depressions that are sized and located to capture and temporarily pond runoff. Below ground, an engineered subgrade goes down 42" to 48". The subgrade has a perforated drain pipe in a rock bed, covered by a sandy loam soil mixture. Typically ponding depth will range from 6" to 9" and should drain down in 12 to 24 hours. Bio-cells are planted to appear garden like, and use of native plant species is encouraged. Bio-cells typically are used in settings with large impervious surfaces (i.e. parking lots) where extensive land grading (disturbance) has occurred.

Bioswales: Bioswales are vegetated drainage ways that convey runoff. Typically, the subgrade of a bioswale is engineered to ensure infiltration of runoff from small rains. When big rains occur, the bioswale will infiltrate the dirty first flush of runoff and then convey excess runoff to receiving waters. Maintaining and enhancing natural drainage ways can save money by eliminating the need to install storm sewers.

Native Landscaping: One of the easiest ways to enhance the landscape's ability to manage water more sustainably is to strategically install landscaping that features native plants of the tallgrass prairie region. Native plants have deep root systems that will help build soil quality which increases infiltration and reduces runoff. Native plants are tolerant of weather extremes and don't need fertilizers or pesticides. Native plants also create habitat for birds, wildlife, butterflies and

other species. After establishment, native landscaping is cheaper to maintain.

Permeable Pavement: Transportation surfaces (roads, parking lots, driveways) account for over 60% of impervious urban surfaces. Permeable pavement allows rainfall to infiltrate down rather than running off into storm sewers. Rainfall moves into a rock chamber below the pavement. A bio-film develops on the aggregate of the rock chamber where micorobes live. The microbes capture pollutants such as hydrocarbons and break them down. Water in the pore space between the aggregate either percolates out and down through surrounding soils or moves to a perforated drain pipe installed in the rock chamber. Water is slowly released to become ground flow or enter surface waters after it has been cleaned and cooled by moving through the pavement and underground rock chamber.

Rain Gardens: Rain gardens perform bioretention services but do not have an engineered subgrade. Rain gardens rely on healthy soils with good infiltration and percolation rates to manage ponded runoff water. A thorough soils investigation is needed to ensure a proposed rain garden site has soils with adequate percolation rates. **Rain gardens** are typically used in residential settings to manage runoff from smaller impervious surface surfaces like roofs. In some residential development, soils are altered and compacted and require an engineered subgrade to ensure drain down time of 12 to 24 hours.

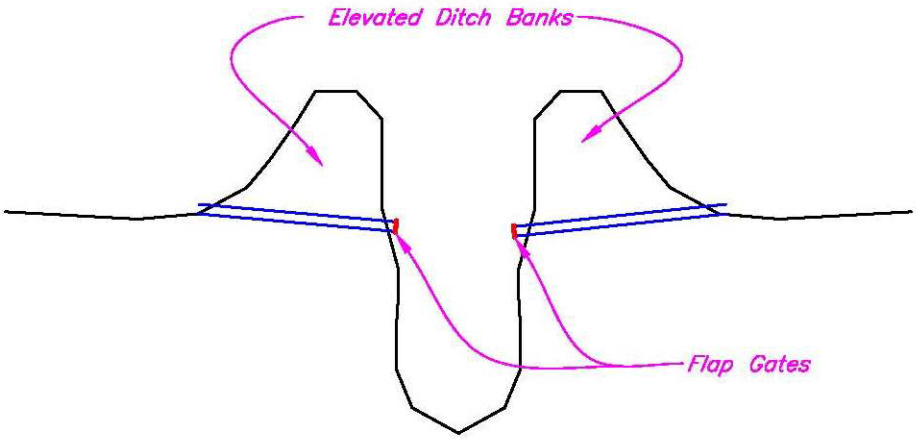
Soil Quality Restoration: Healthy soils can infiltrate and store large quantities of rainfall. A typical prairie soil should have had the pore space to store about 2.5" to 3" of rain in the top foot of soil, and probably twice that much in the first 4 feet of the soil profile. If soils have been altered and compacted by grading or construction activities, they lose their ability to infiltrate and store water. Poor soil quality means lawns will generate runoff after only a small amount of rain. Restoring soil compost applications will help restore soil quality after new construction. Aeration and compost applications will increase water holding capacity on existing lawns with poor soil quality involves increasing organic matter in the soil and increasing pore space. Deep tillage and quality.

More information on Urban Conservation can be viewed at:

http://www.nrcs.usda.gov/search.asp?site=IA&ct=IA&qu=Urban+Conservation&Go.x=13&Go.y=4

Flow direction cuts

Areas where water is not allowed to reenter the creek due to elevated stream banks pipes and flap gates could be installed. This would get rid of the ponding effect created in these areas, allowing surface water from the city to drain away faster.



- Flap gate installation

V. FLOOD MITIGATION RECOMMENDATIONS

a. **Creation of a formalized Flood Mitigation Board.** This Board would be charged with spearheading Flood Mitigation Planning efforts in the future. This Board should be comprised of representatives from the City of Griswold, Cass County Board of Supervisors, Cass Soil and Water Conservation District, Natural Resource Conservation District, Iowa Department of Agriculture and Land Stewardship, landowners, City of Griswold residents, and other key project stakeholders. Collaborative representation for the Board is critical in holding all entities accountable and ensuring that that the flood related efforts, which affect all of Cass County, are eventually realized. This Board would be charged with ensuring that the following recommendations are enacted. Additionally, strong consideration should be given to creating a 28E Agreement amongst these entities to ease the transfer of funds for project activities.

b. Pursue the installation of watershed-related flood mitigation practices. Collaborating with the above-mentioned entities, the installation of the flood mitigation outlined in this plan should be prioritized and pursued. It is of utmost importance that fair compensation be negotiated with landowners that may potentially be impacted in order for those individuals to adopt these practices.

c. Create a revenue stream to fund flood mitigation activities. Local revenue streams for flood mitigation efforts are not only important to fund the installation of mitigation practices but also become imperative to attract other sources of funding from State and Federal entities. These funds help fill the void where provisions from other programs are prohibited or where budgetary shortfalls exist.

d. Complete the evaluation and planning for the City storm sewer network while taking into consideration the findings of this plan. All plans for the City storm sewer network should take into consideration flow directions, streambank elevations, outfall elevations with respect to peak discharges, stream channel restrictions, and the conditions of existing drainage ways within the City. Although not discussed within the plan, consideration should be given to finding alternative outlets to the storm sewer as opposed to utilizing the stream.

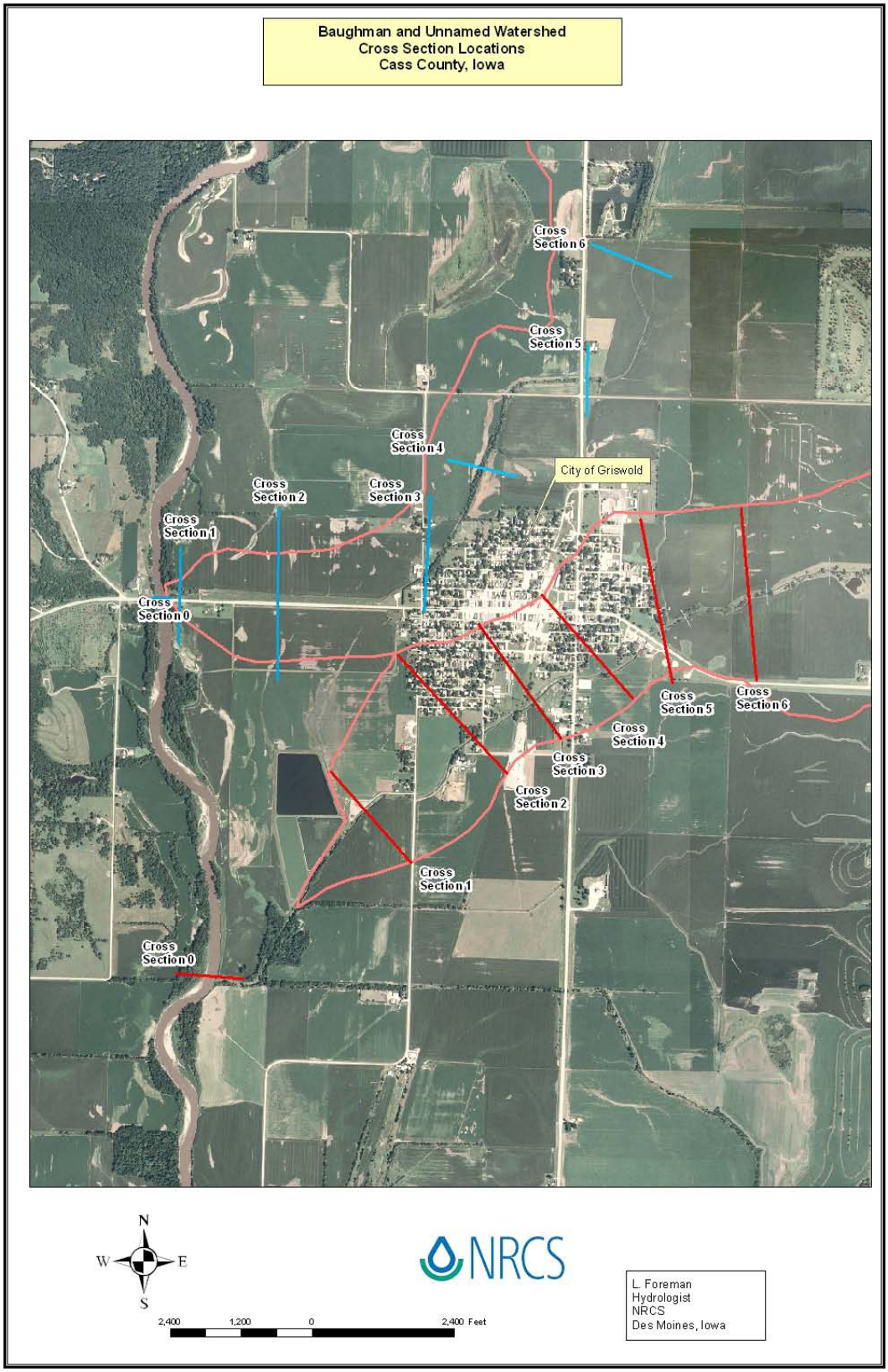
e. Evaluate options to address bridge restrictions. Bridge replacement or modification options should be carefully considered to determine the cost versus benefit of addressing this issue.

f. Implement stream corridor improvements. Only upon addressing the restriction issues associated with bridges should efforts to improve the stream corridor be made.

VI. Summary

In summary a combination of practices will likely need to be constructed in order to provide flood relief to the city. Structures in the upland would slow the water before reaching town and would lessen the scale of any channel modifications or levees around town. Serious modifications to infrastructure will need to take place if no structures are built on the uplands. Bridges and existing channels will have to be widened in order to safely pass water around town. The current storm water system will have to be modified to allow for more flow, paying special attention to the outlets. If the outlets are submerged, the new pipes will not flow to full capacity. Any type of urban conservation practices which infiltrate water will lessen the amount of flooding within city limits. Finally a Flood Mitigation Board should be created to ensure that flood mitigation strategies are funded and carried out in an organized manner.

VII. ATTACHMENTS


Baughman and Unnamed Watershed
Cross Section Locations
Cass County, Iowa
Cross Section 6
Cross Section 5
Cross Section 4
City of Griswold
Cross Section 2
Cross Section 3
Cross Section 1
Cross Section 0
Cross Section 5
Cross Section 6
Cross Section 4
Cross Section 3
Cross Section 2
Cross Section 1
Cross Section 0
N
W
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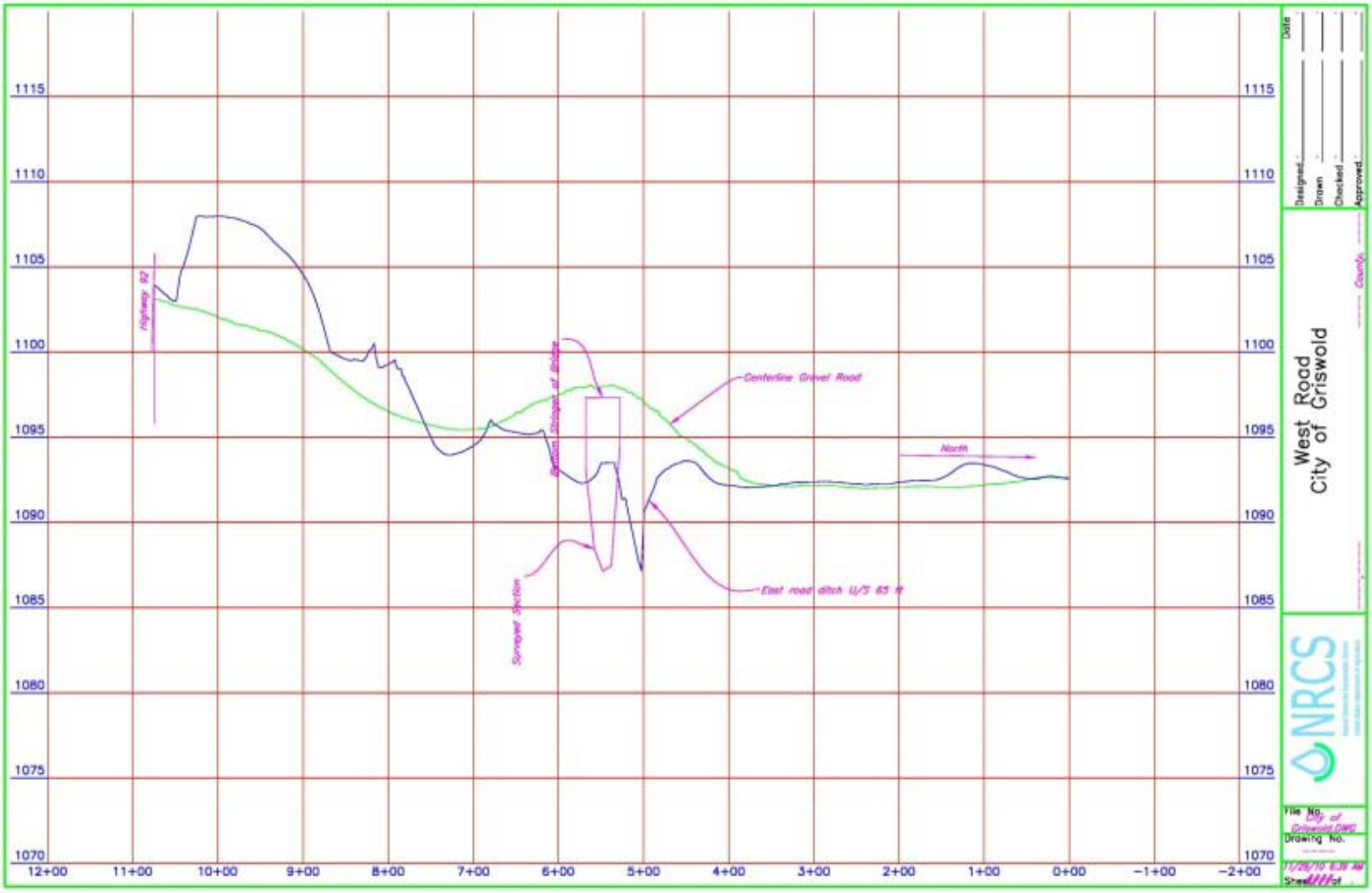
2,400
1,200
0
2,400 Feet
NRCS
L. Foreman
Hydrologist
NRCS
Des Moines, Iowa

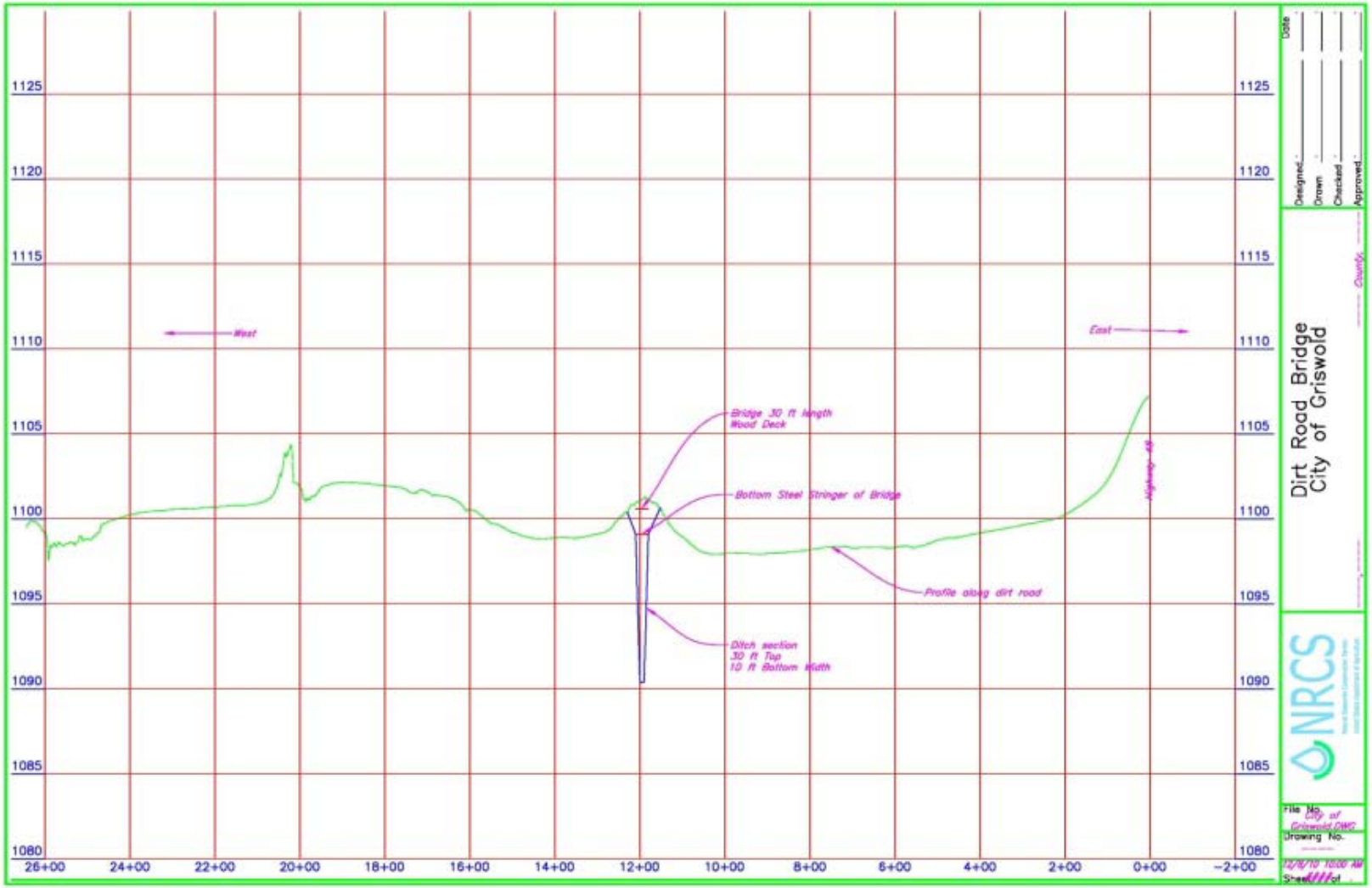
North Scott St Bridge

Total Cfs= 650 cfs, Low =273 cfs



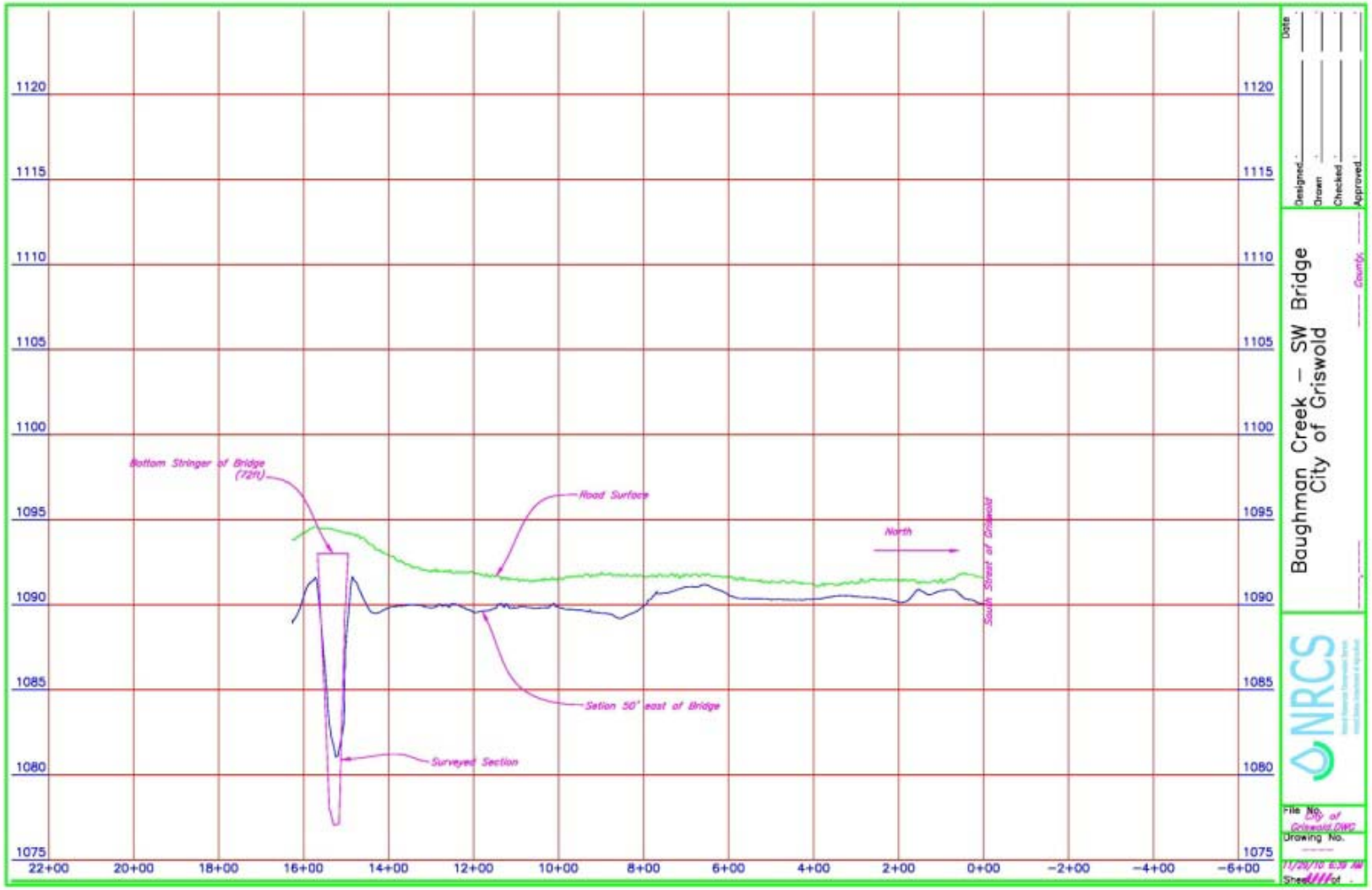
Seattle Rd Bridge

Total= 696 cfs, Low= 552 cfs



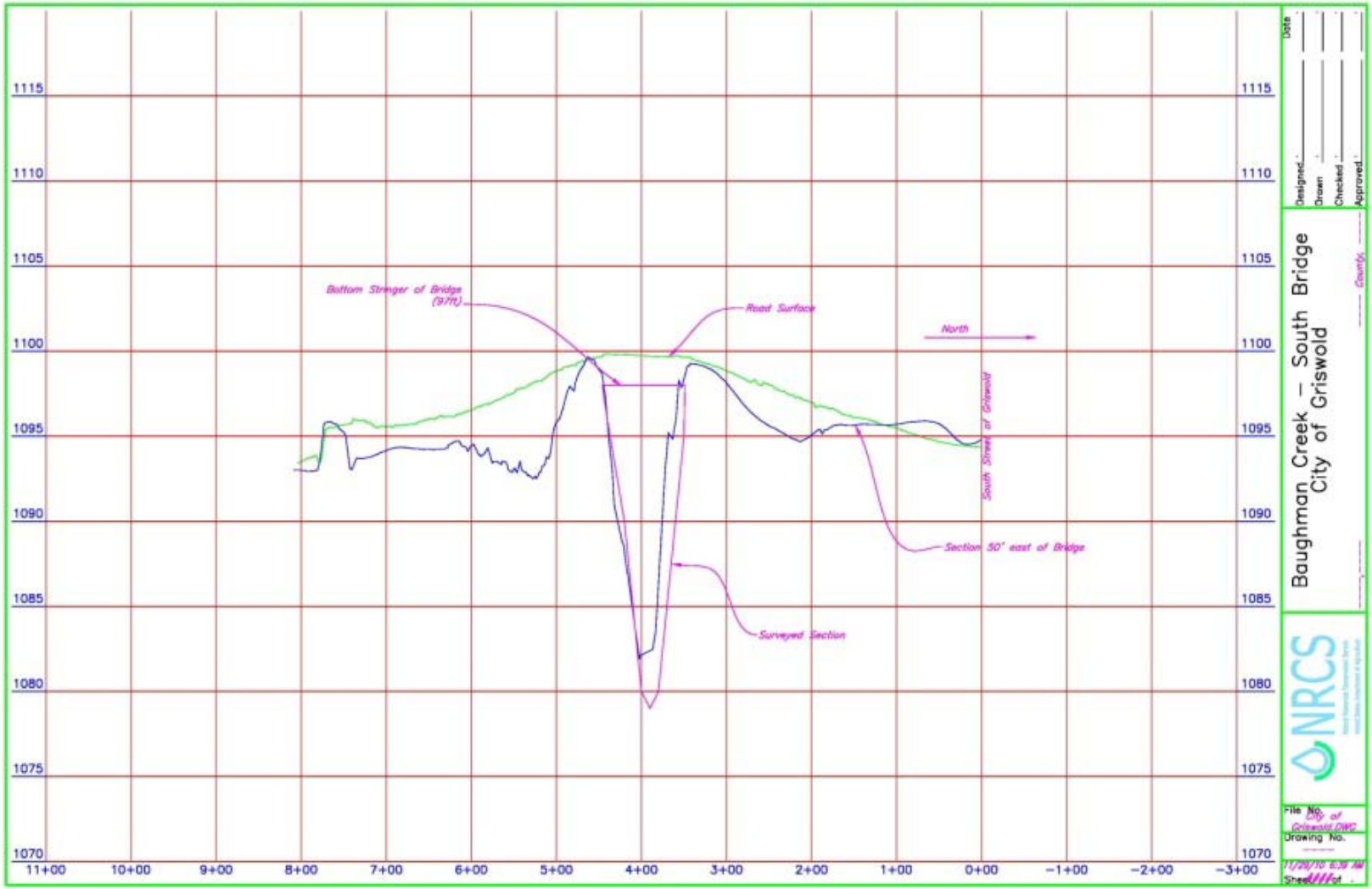
South Scott St Bridge

Total= 2,954 cfs, Low = 2,104 cfs



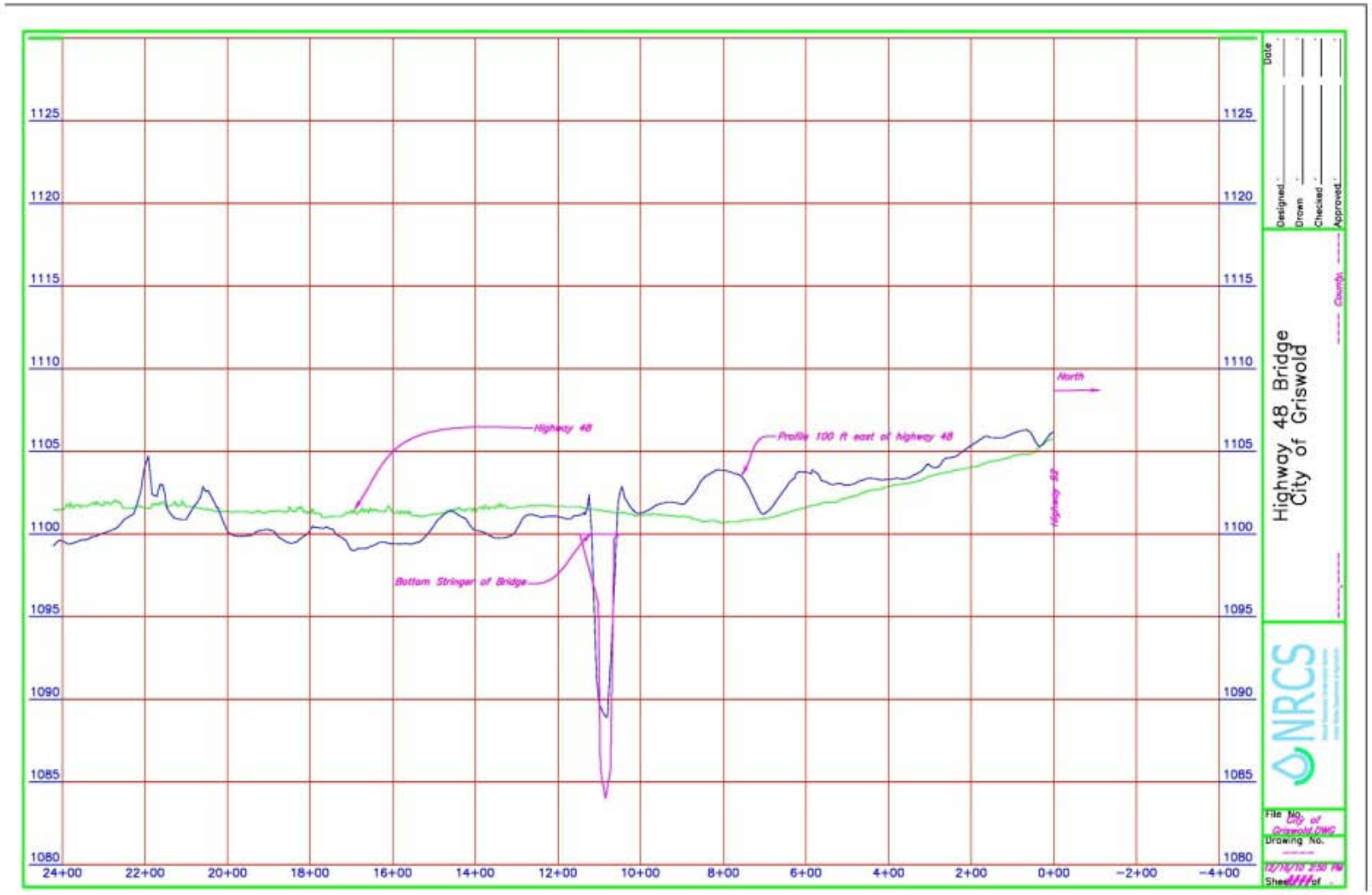
Troy rd Bridge

Total= 4,204 cfs, Low= 2,869 cfs



Highway 48

Total= 2,300 Cfs, Surrounding banks fill bridge to full capacity



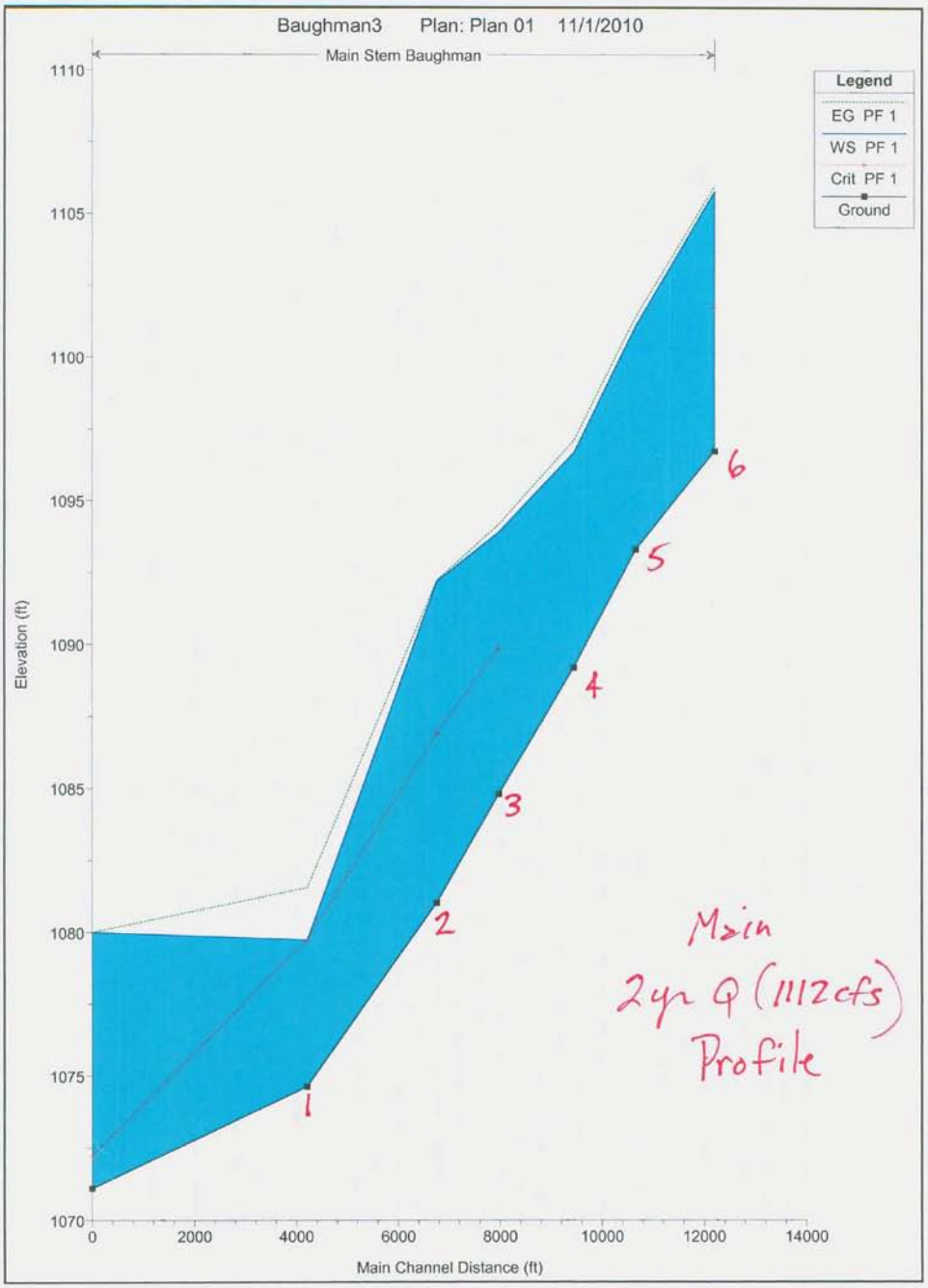
Highway 48 Double Box Culvert

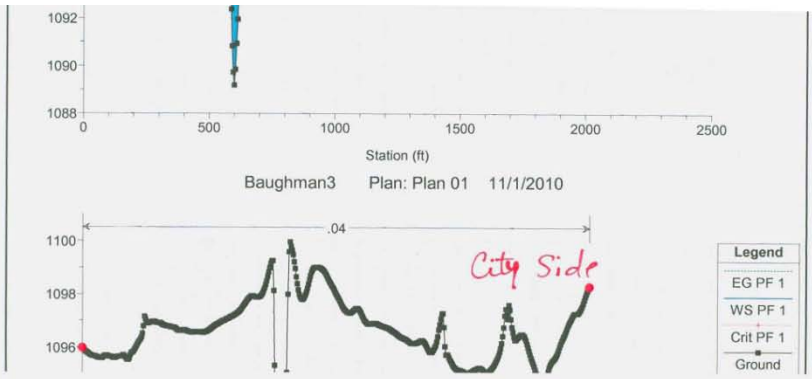
Total= 3072 cfs

The double box culvert on Highway 48 never flows to full capacity because the elevation of the road falls off the nearer it gets town. This pushes water towards and through town where it then passes through a road culvert or overtops the highway.

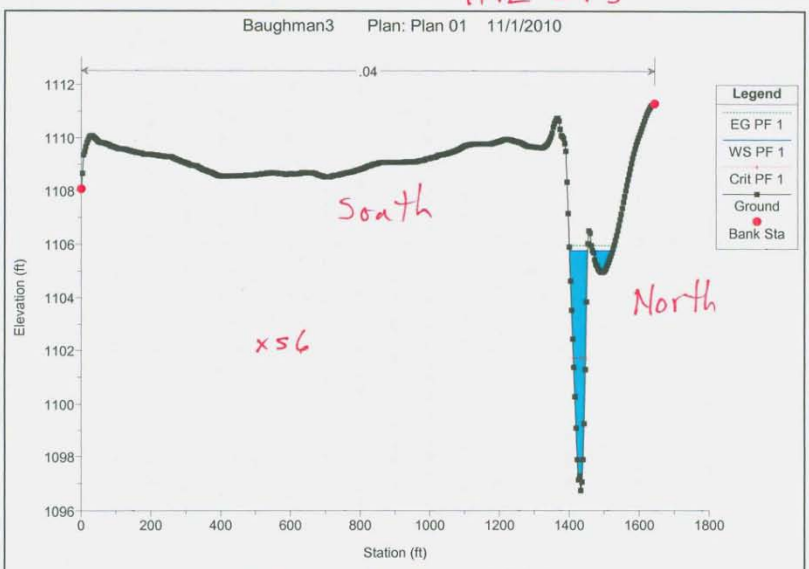
Baughman Creek Cross Sections

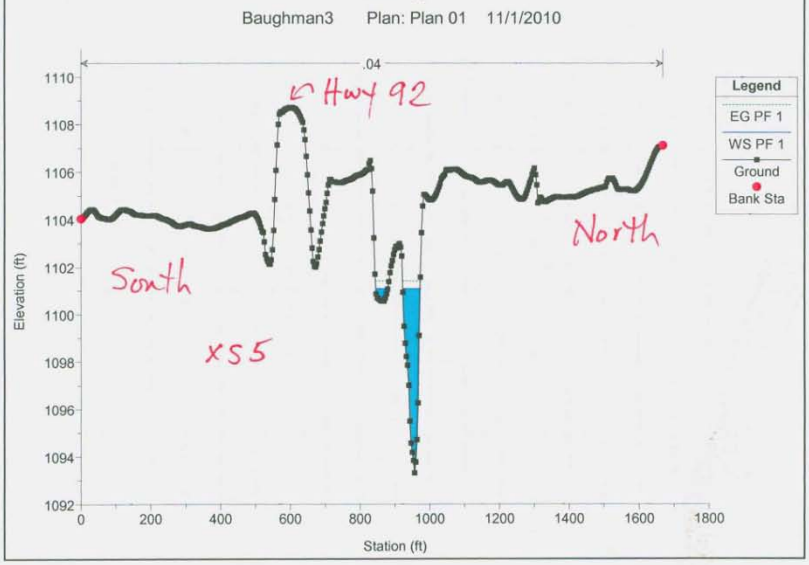
CROSS SECTIONS



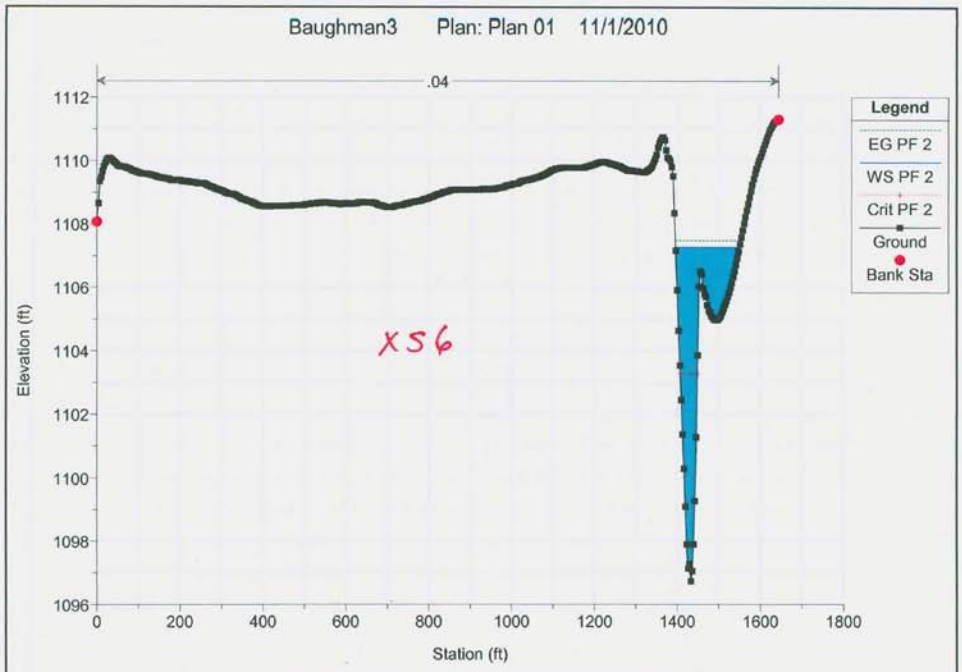


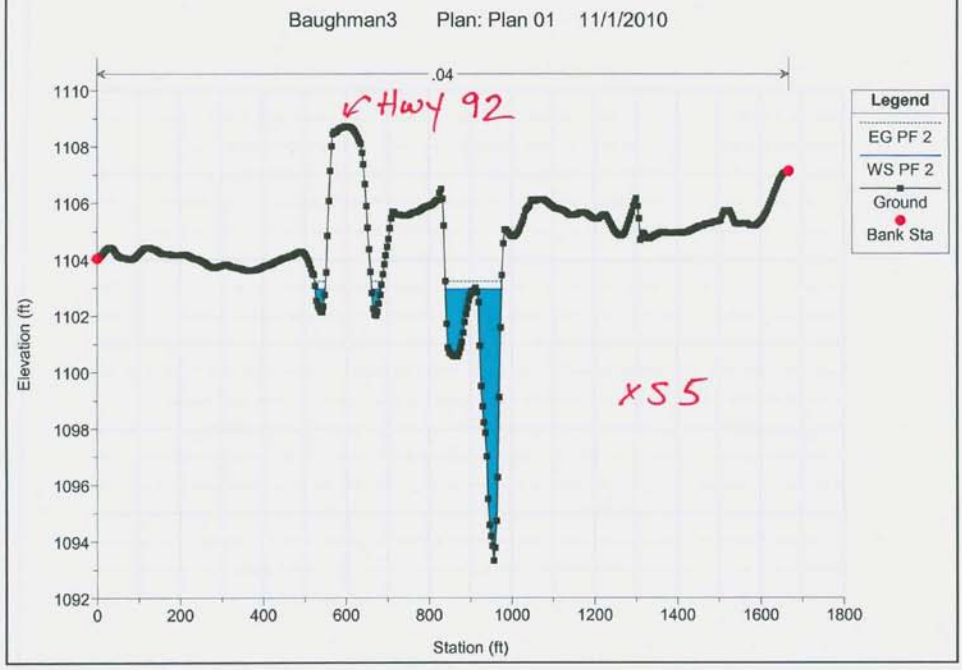
Baughman 2 year Discharge 1112 cfs





Baughman 5-year Discharge
1938 cfs





Baughman3 Plan: Plan 01 11/1/2010
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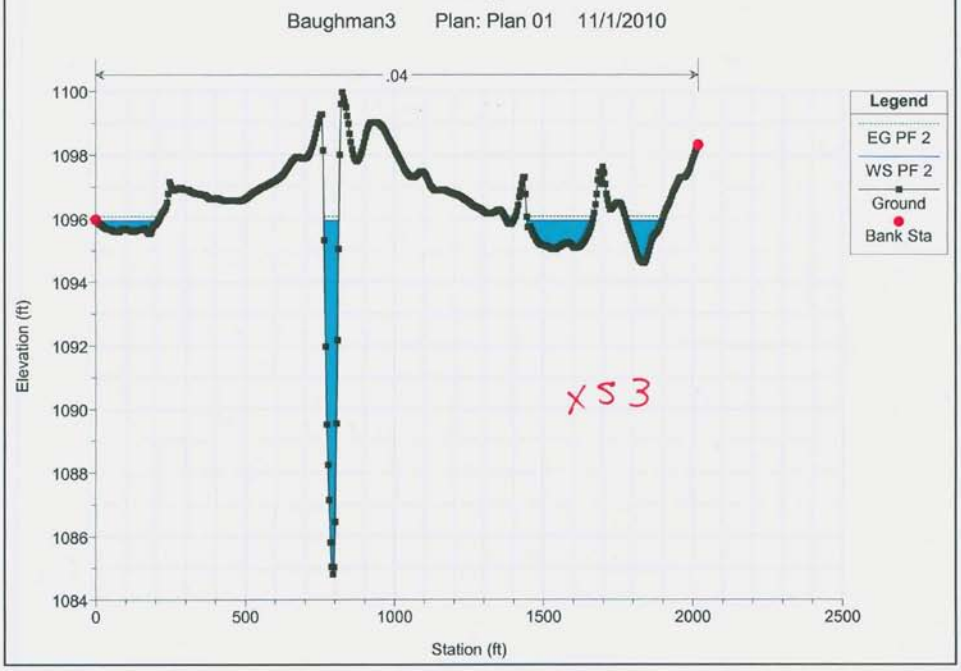
Legend
EG PF 2
WS PF 2
Ground
Bank Sta
XS4
Elevation (ft)
Station (ft)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Legend
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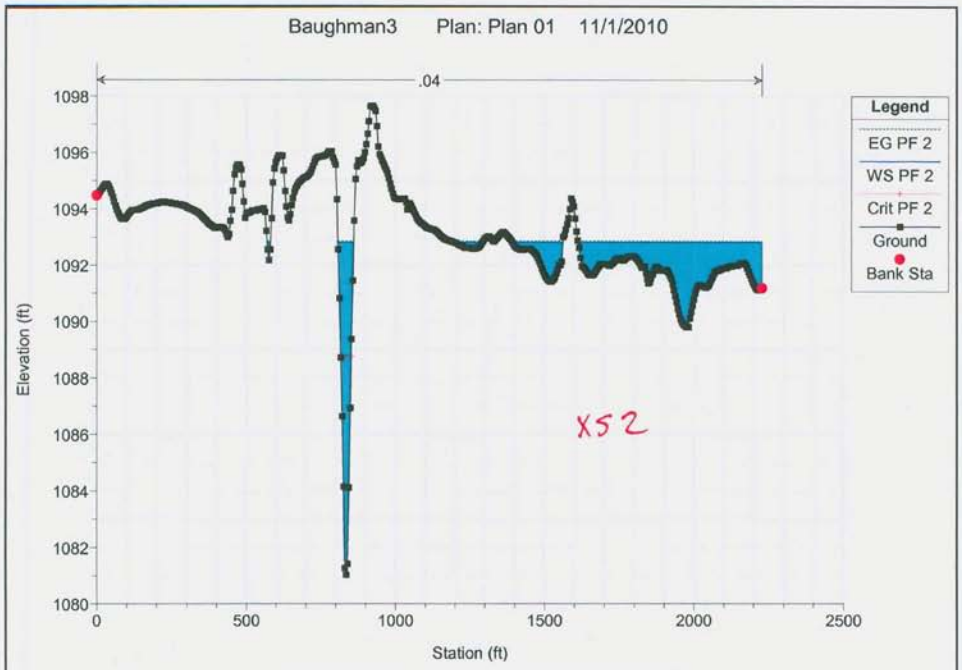
WS PF 2
Ground
Bank Sta
XS3
Elevation (ft)
Station (ft)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Legend
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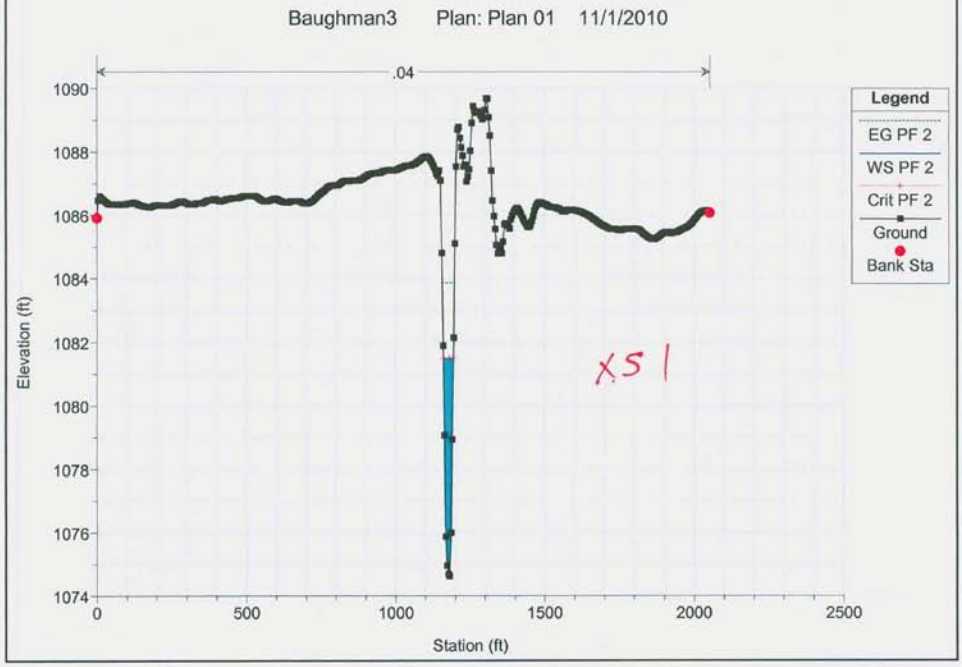
Crit PF 2
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS2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Bank Sta
Elevation (ft)
Station (ft)
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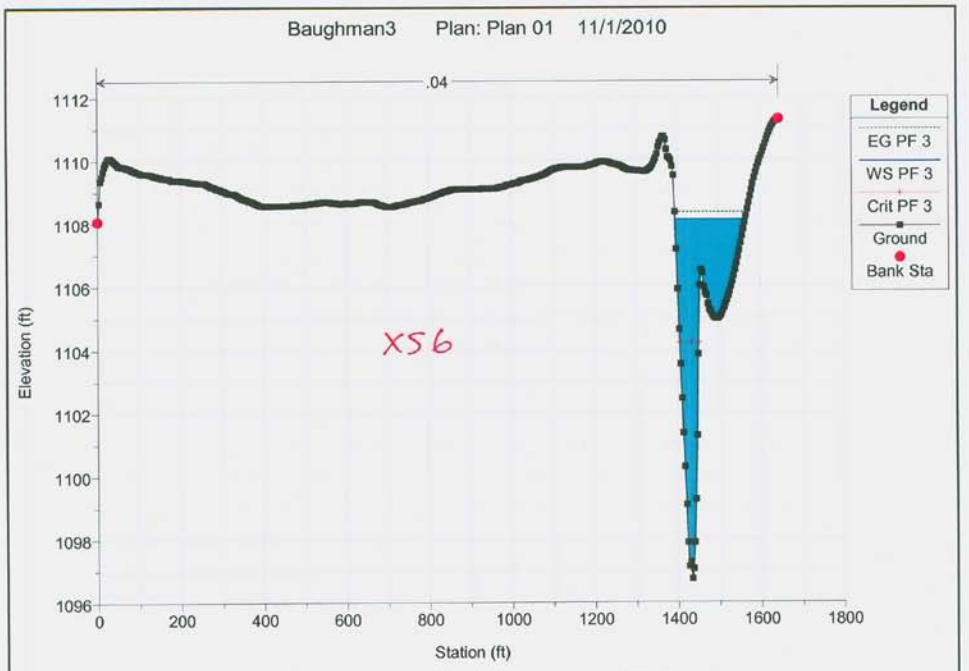
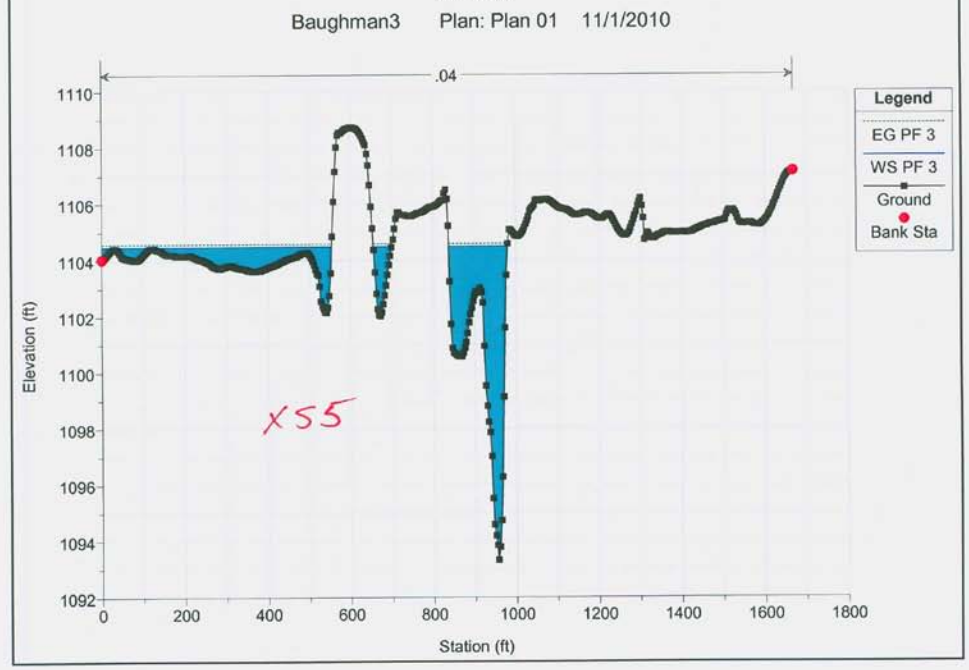
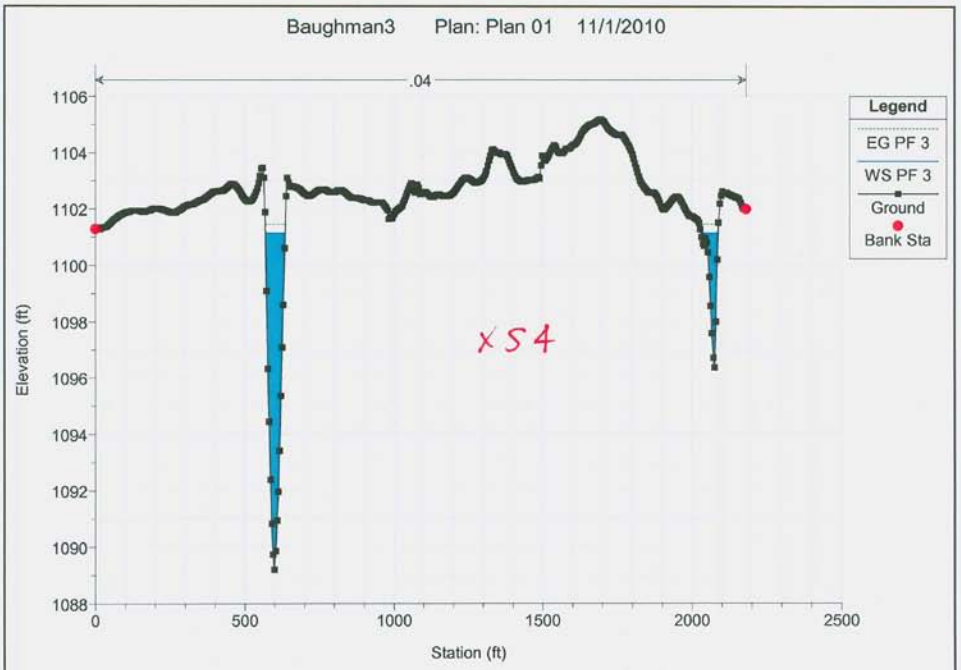
Baughman 10-year Discharge 2,560 cfs






Baughman3 Plan: Plan 01 11/1/2010
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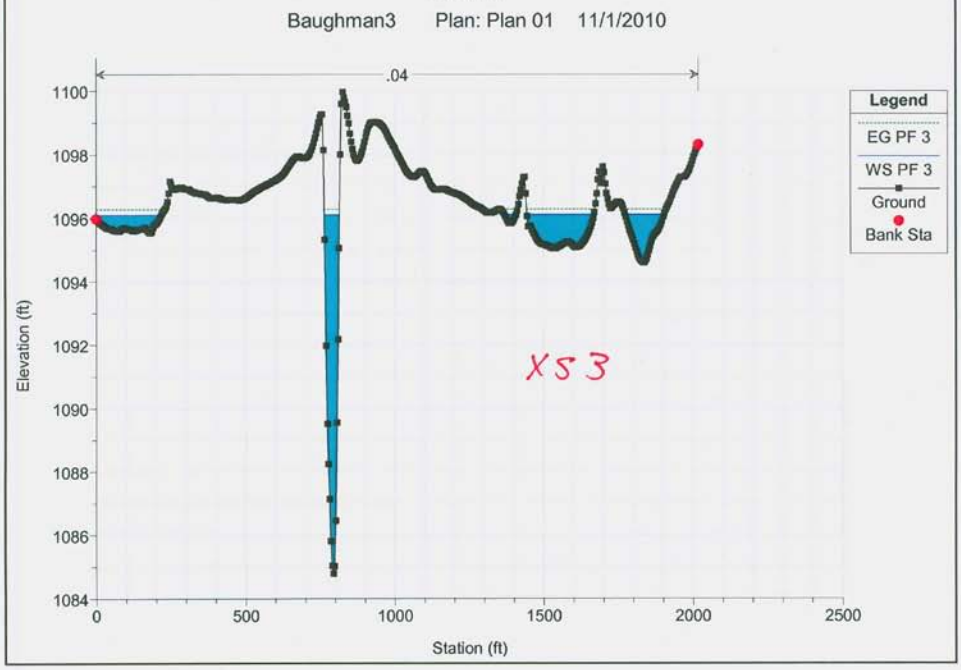
Legend
EG PF 3
WS PF 3
Ground
Bank Sta
XS4
Elevation (ft)
Station (ft)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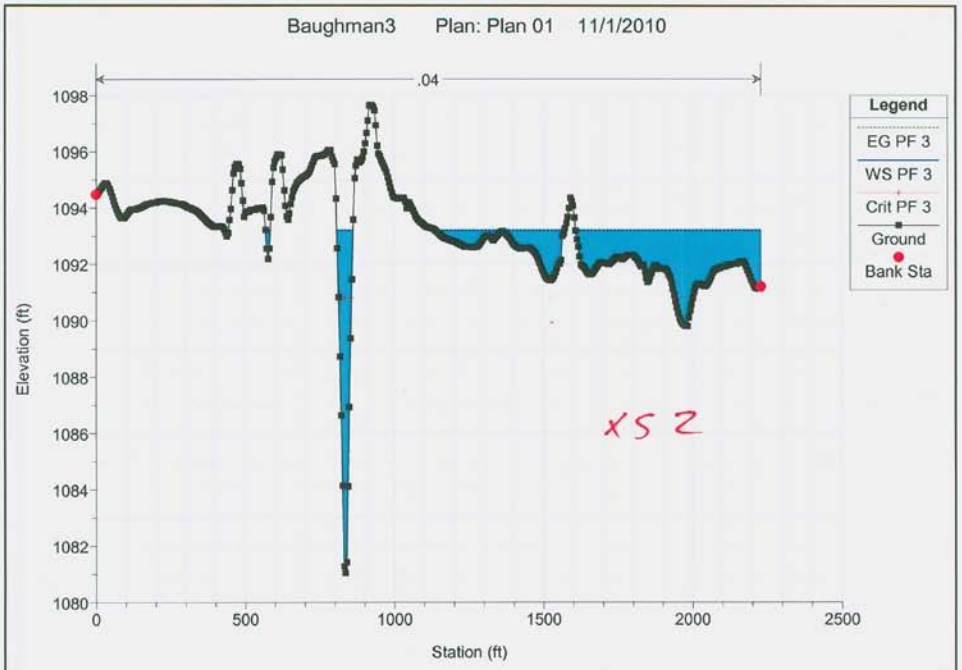
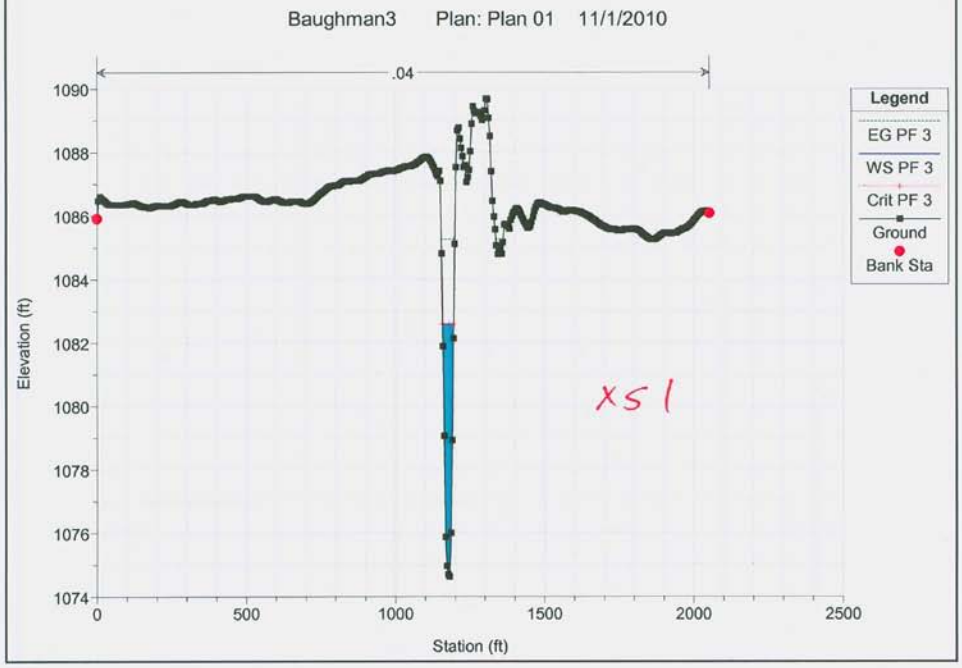
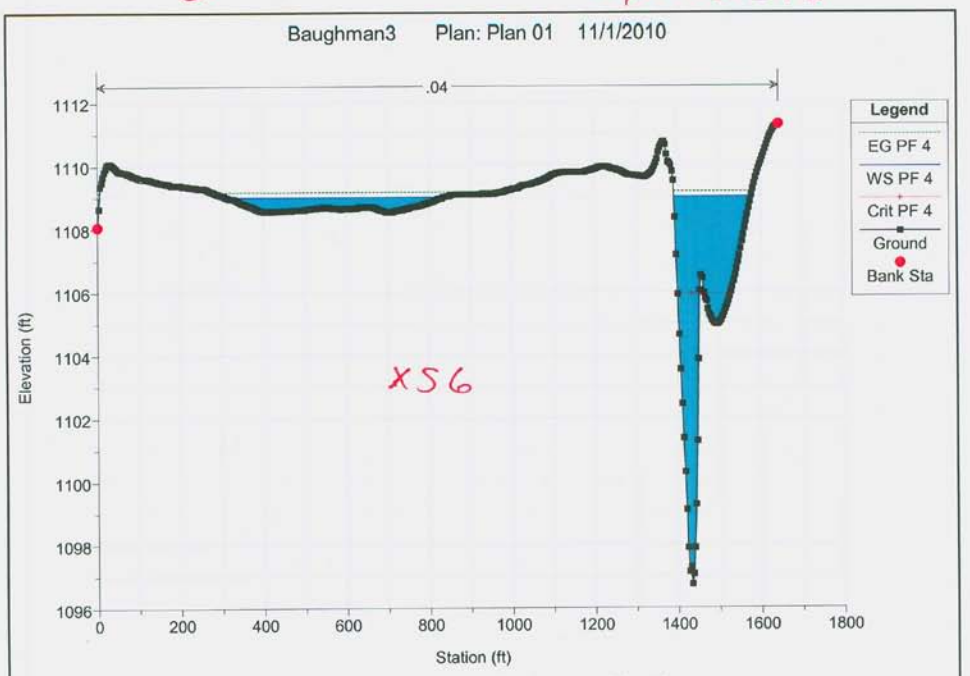
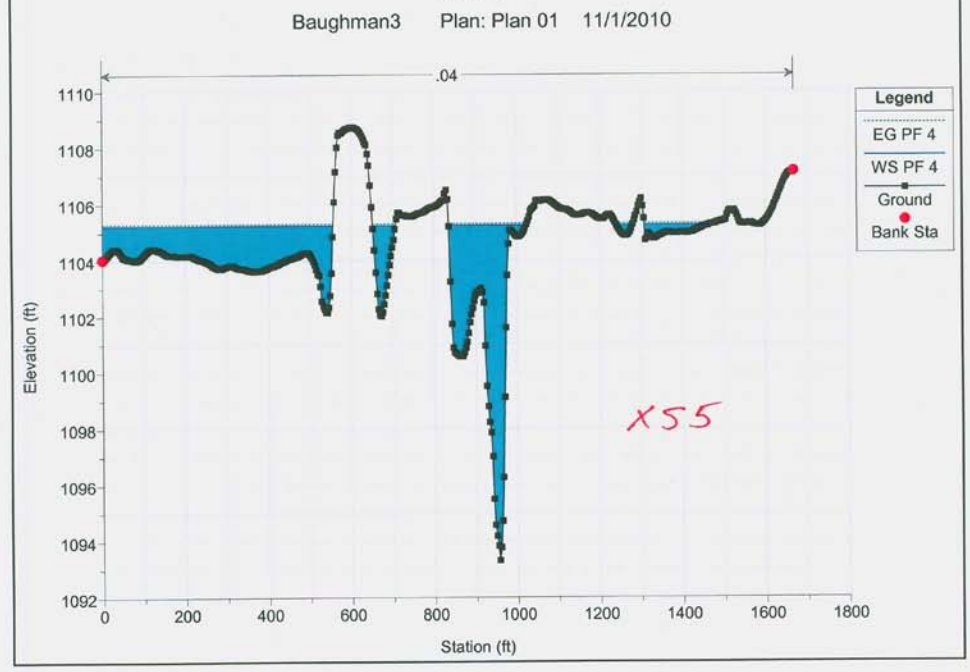
Legend
EG PF 3
WS PF 3
Ground
Bank Sta
XS3
Elevation (ft)
Station (ft)

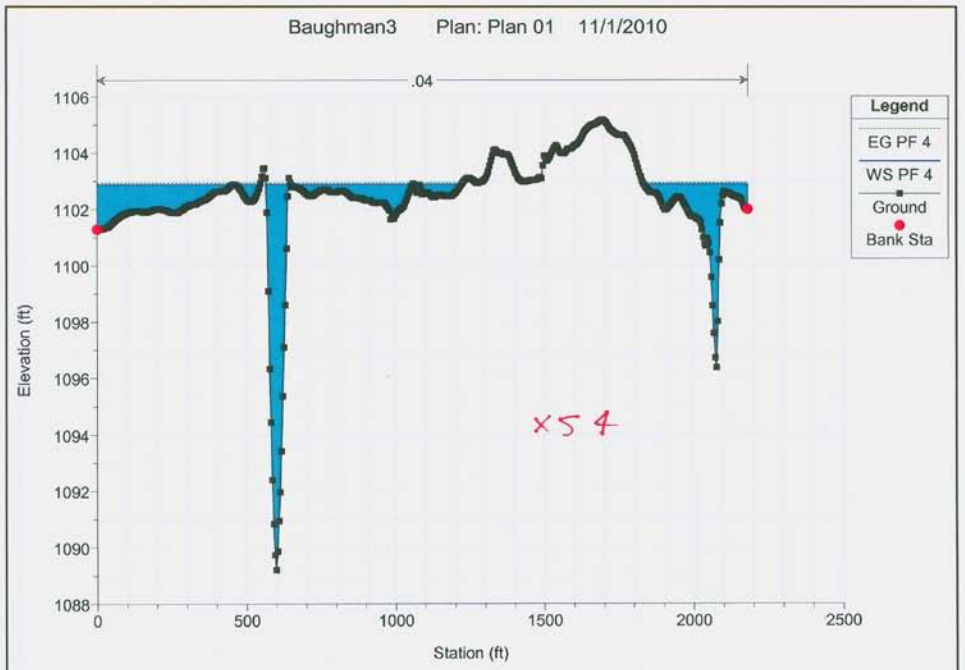

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 3
WS PF 3
Crit PF 3
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS 2

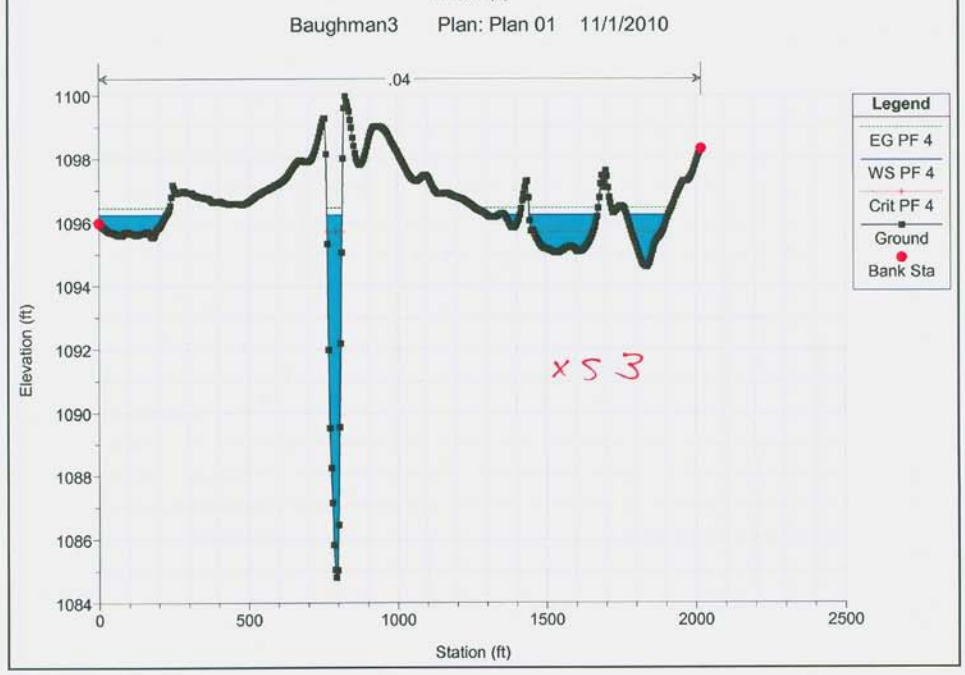

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 3
WS PF 3
Crit PF 3
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS 1

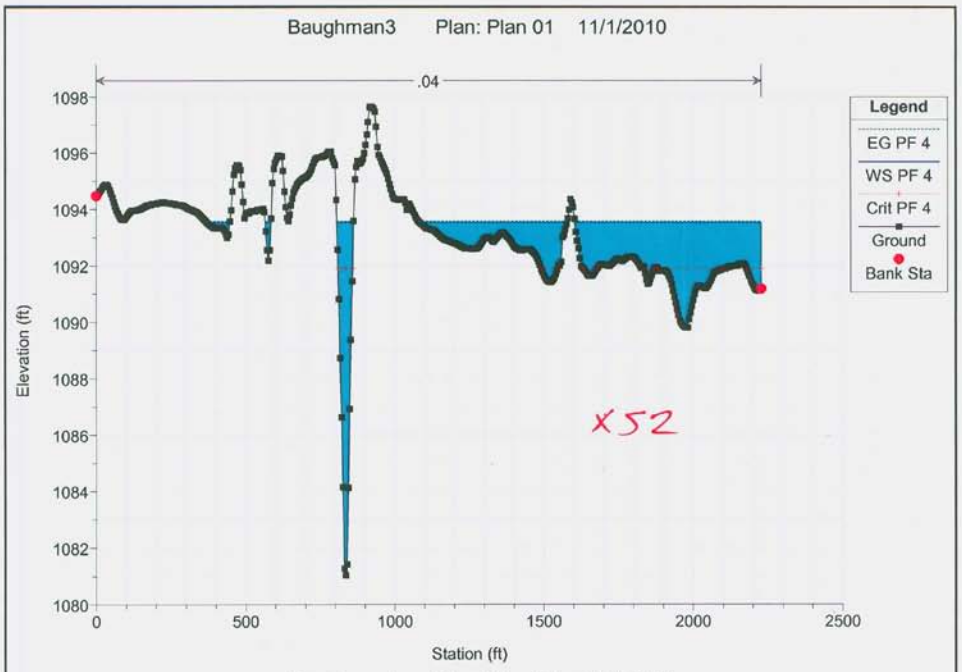
Baughman 25 year Discharge 3,208 cfs

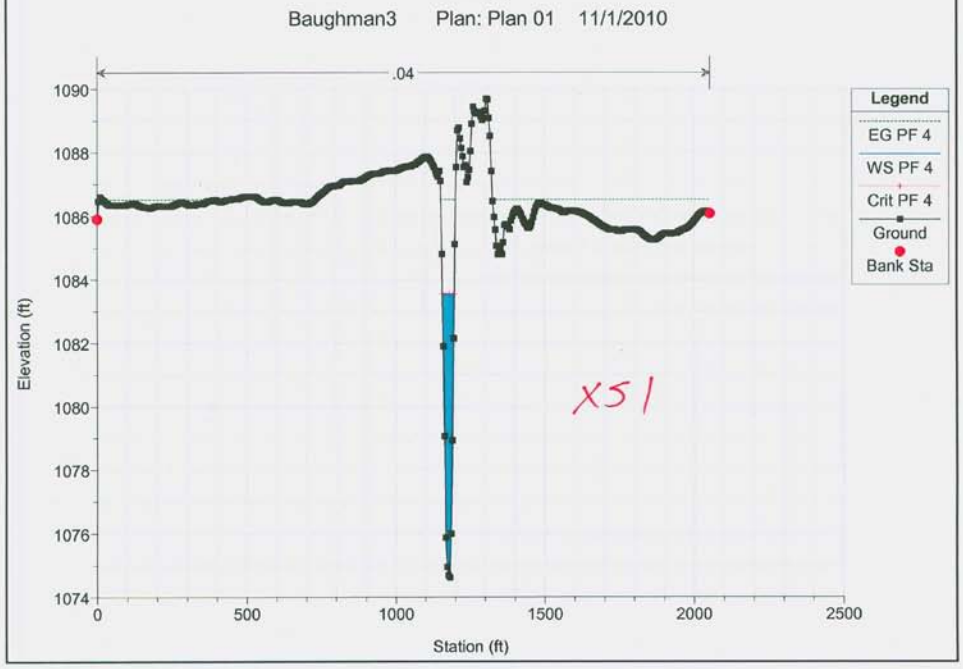




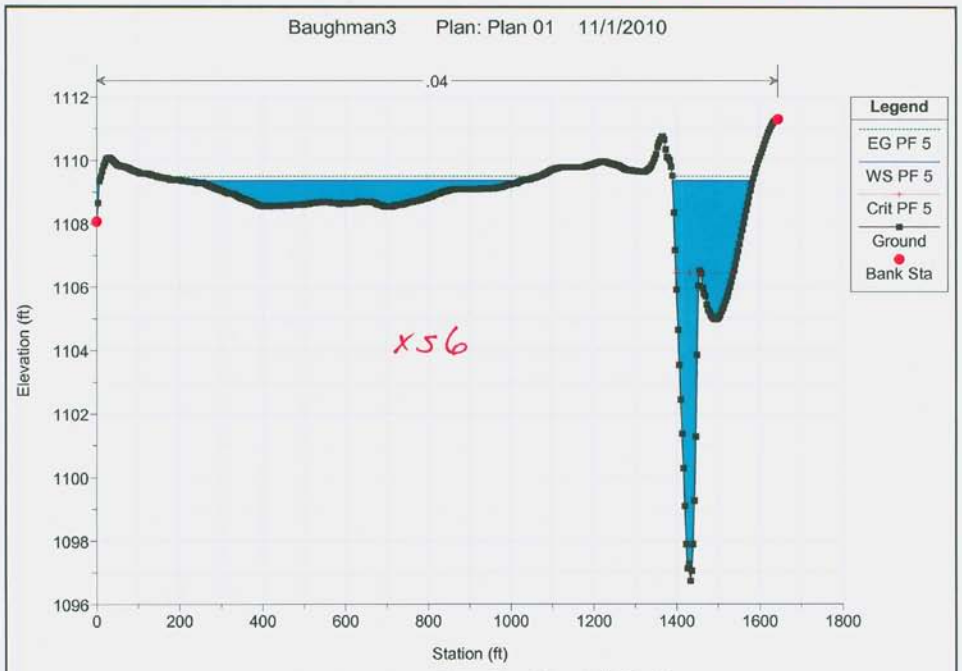

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 4
WS PF 4
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS 4

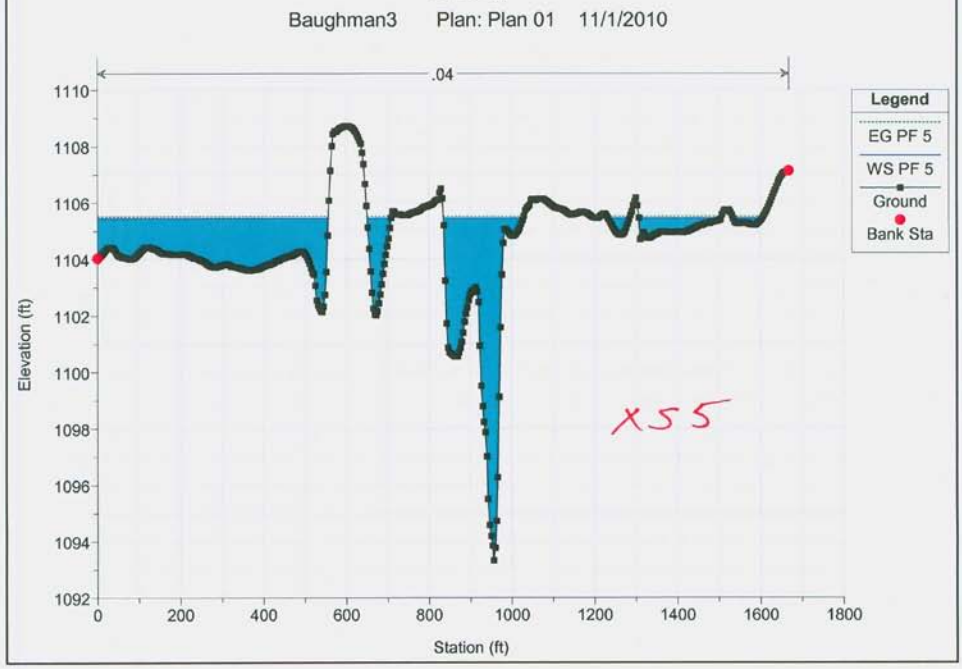

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 4
WS PF 4
Crit PF 4
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS 3

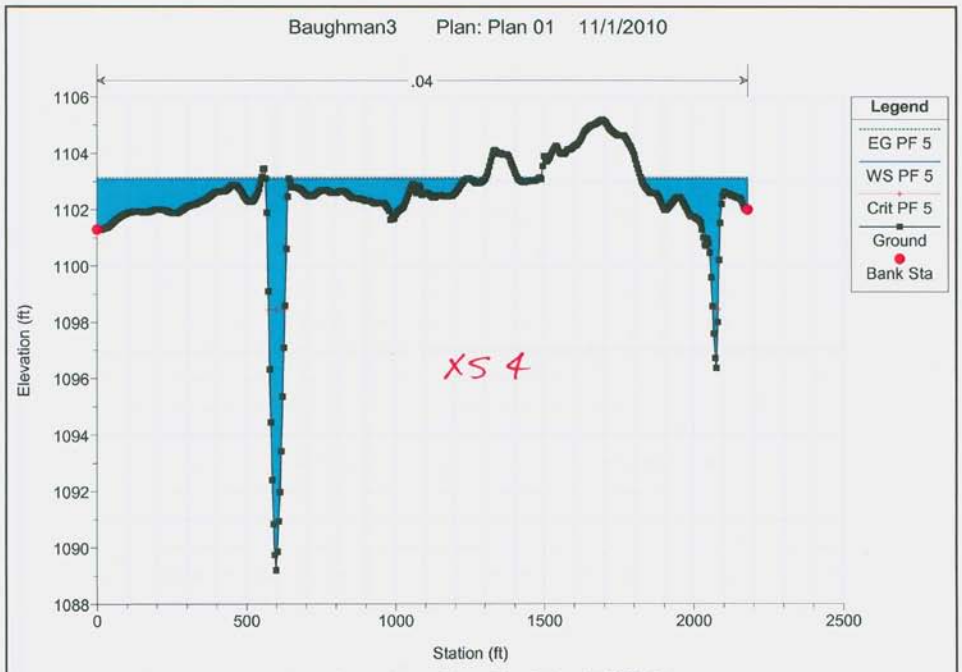

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 4
WS PF 4
Crit PF 4
Ground
Bank Sta
Elevation (ft)
Station (ft)
X52

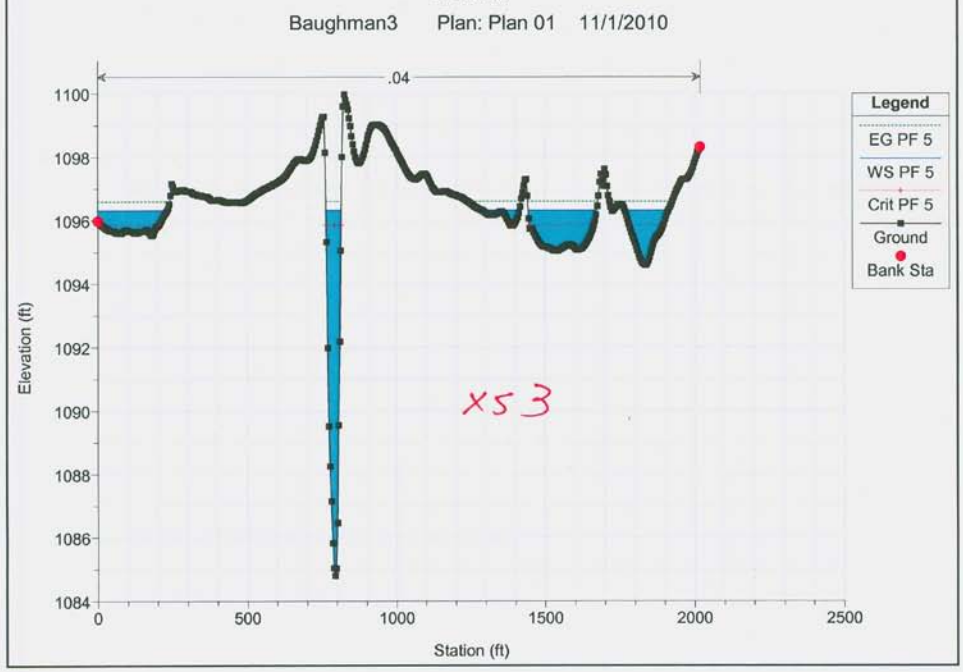

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 4
WS PF 4
Crit PF 4
Ground
Bank Sta
Elevation (ft)
Station (ft)
X51

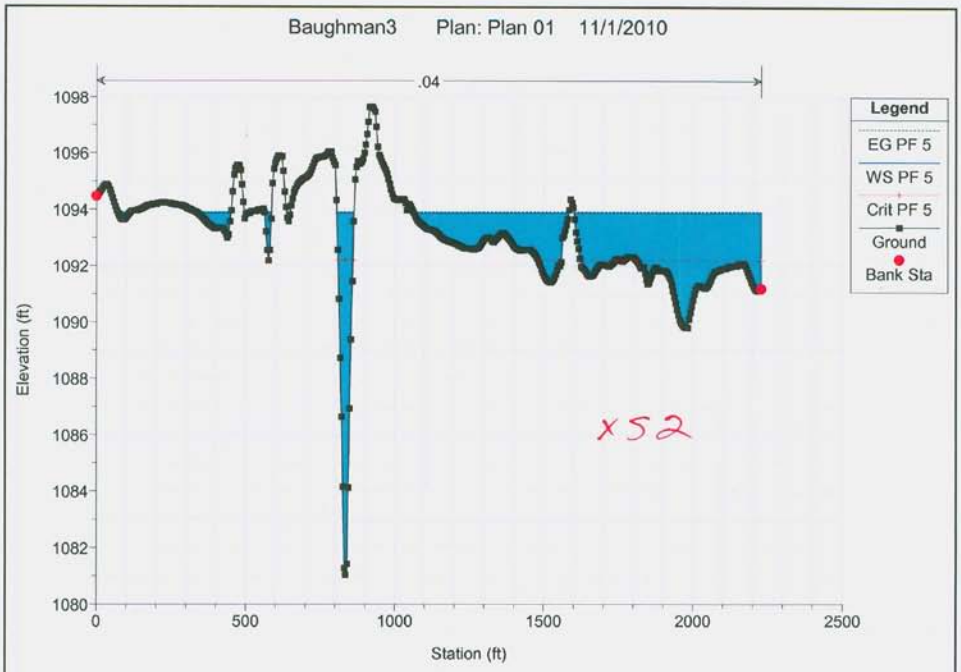
Baughman 50 year Discharge 3887 cfs

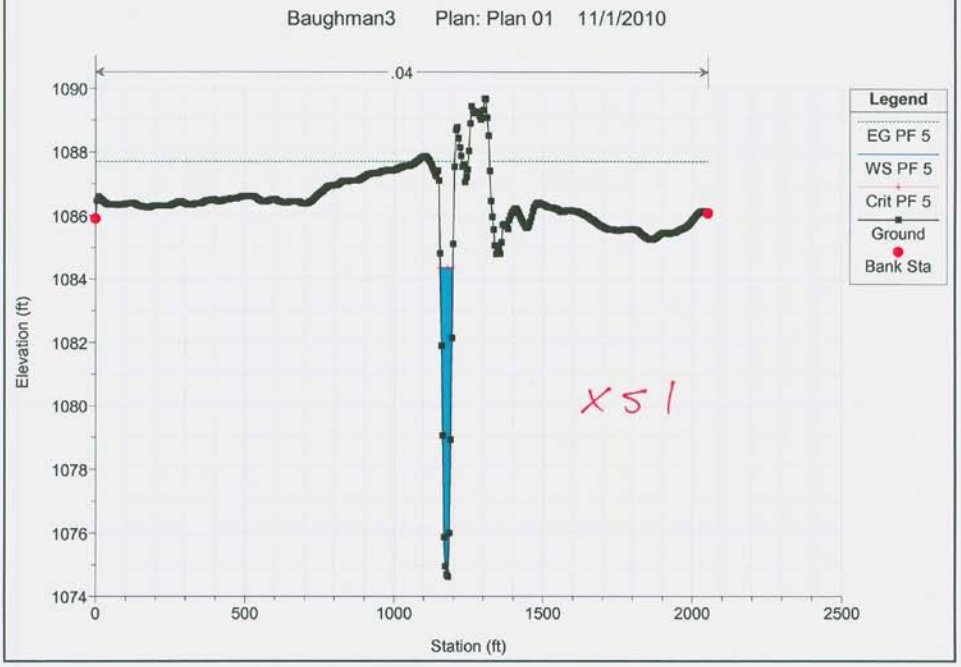




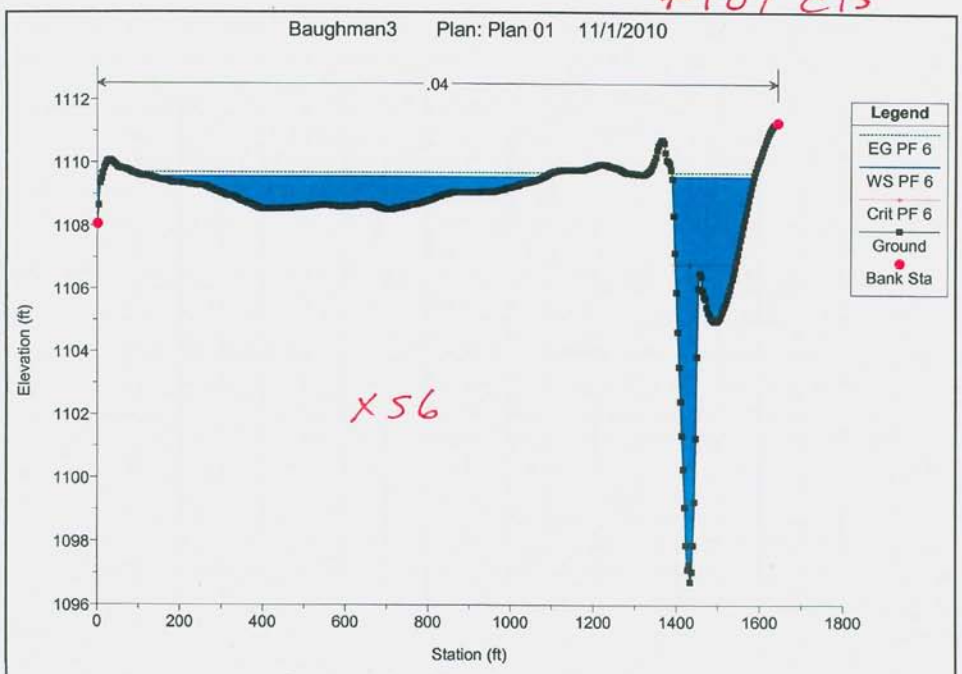

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 5
WS PF 5
Crit PF 5
Ground
Bank Sta
XS 4
Elevation (ft)
Station (ft)

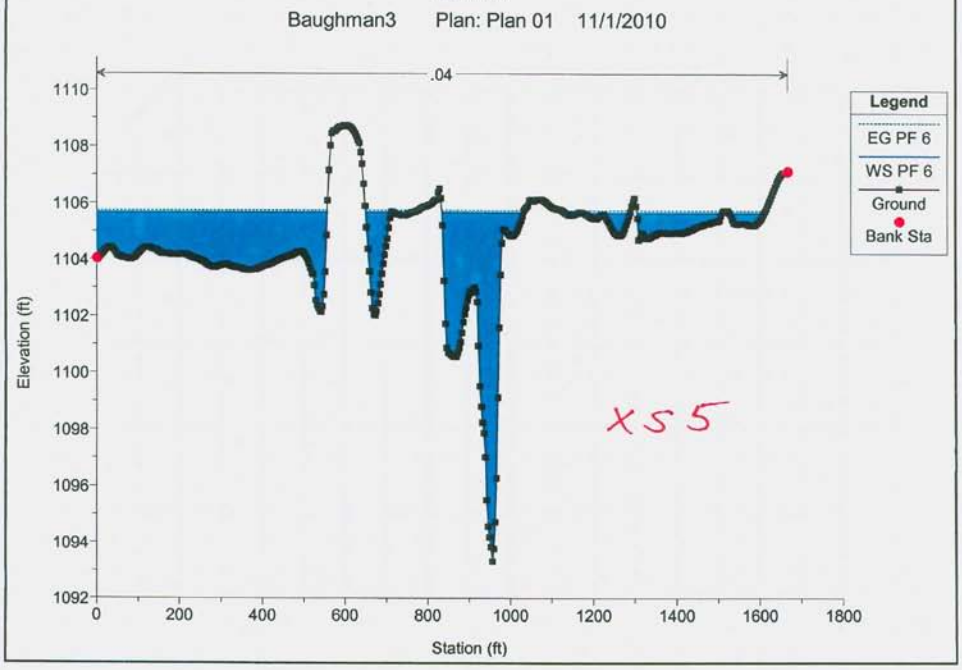

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 5
WS PF 5
Crit PF 5
Ground
Bank Sta
XS 3
Elevation (ft)
Station (ft)

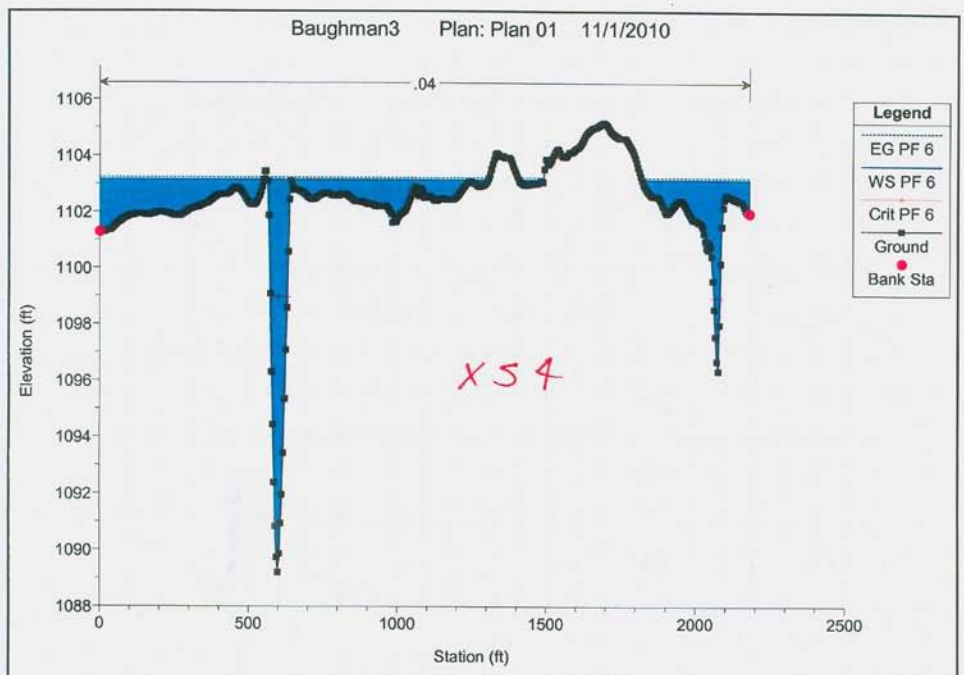

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 5
WS PF 5
Crit PF 5
Ground
Bank Sta
Elevation (ft)
Station (ft)
X52

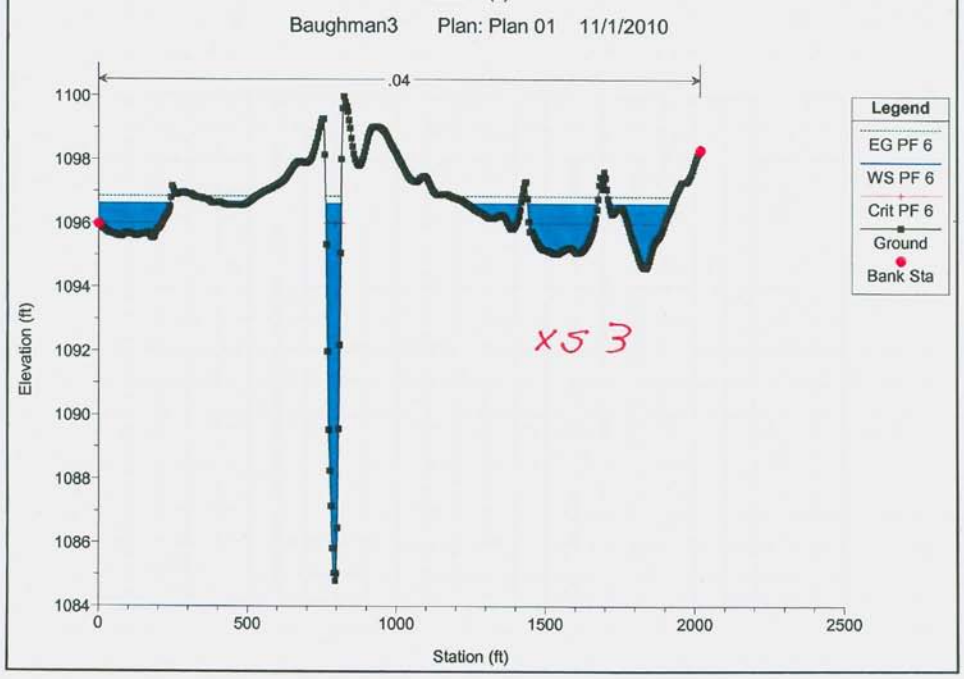

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 5
WS PF 5
Crit PF 5
Ground
Bank Sta
Elevation (ft)
Station (ft)
X51

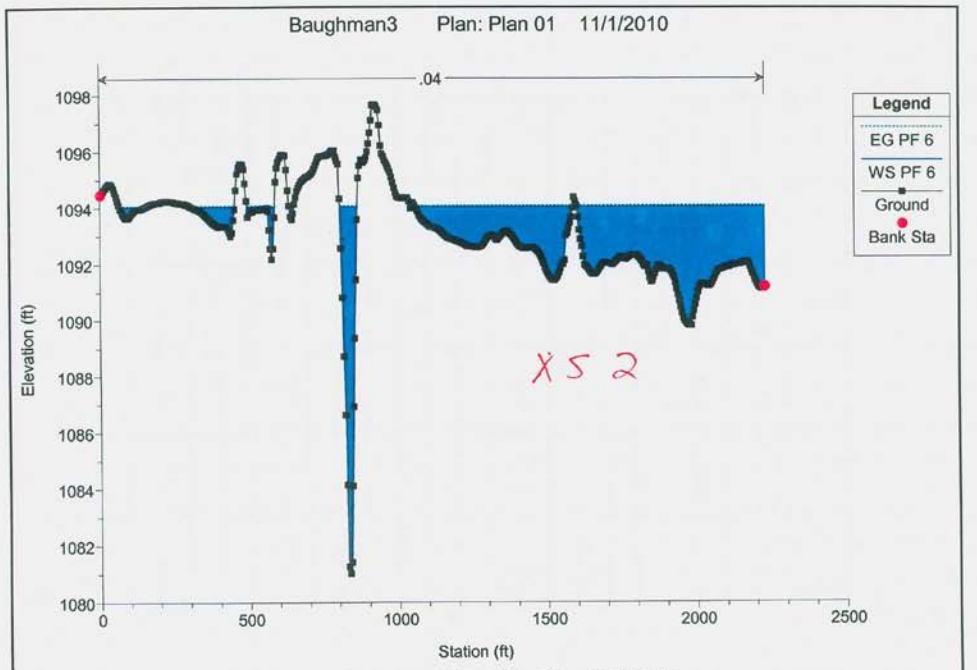
Baughman Cr. 100yr Discharge 4487 cfs

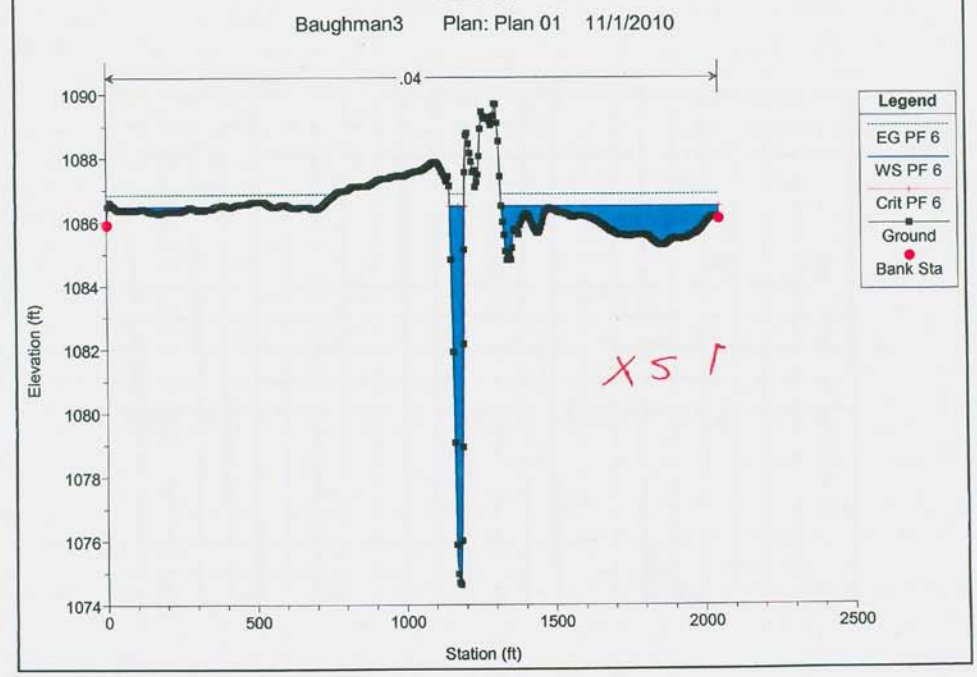





Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 6
WS PF 6
Crit PF 6
Ground
Bank Sta
XS4
Elevation (ft)
Station (ft)

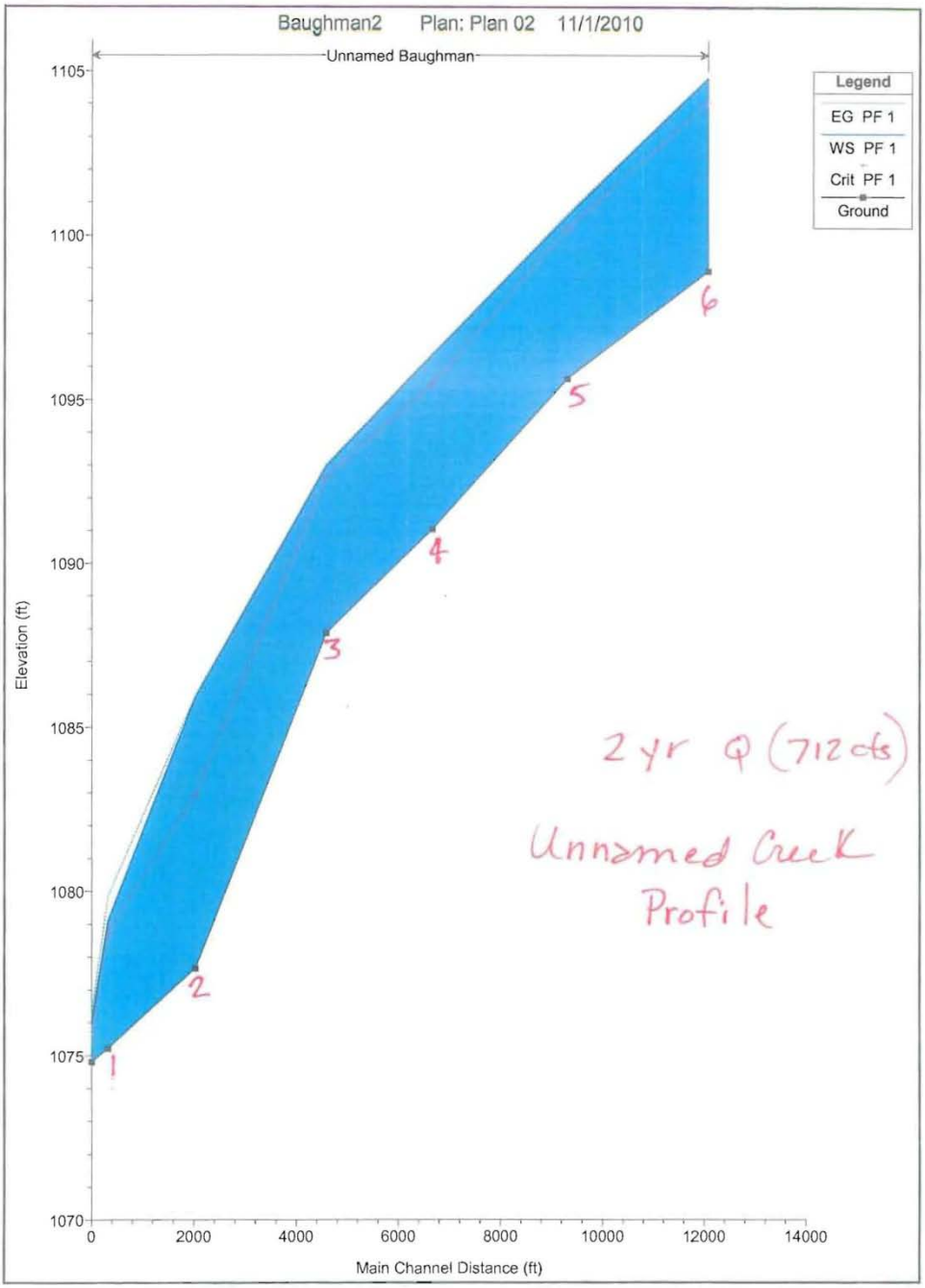

Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 6
WS PF 6
Crit PF 6
Ground
Bank Sta
XS3
Elevation (ft)
Station (ft)


Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 6
WS PF 6
Ground
Bank Sta
XS 2
Elevation (ft)
Station (ft)


Baughman3 Plan: Plan 01 11/1/2010
.04
Legend
EG PF 6
WS PF 6
Crit PF 6
Ground
Bank Sta
XS 1
Elevation (ft)
Station (ft)

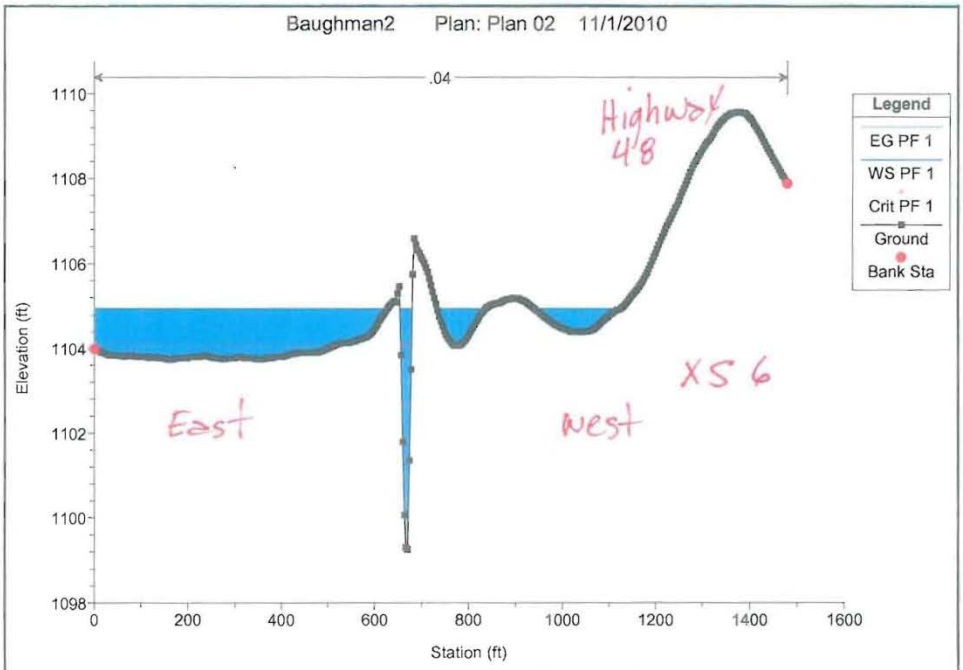
Unnamed Creek Cross Sections

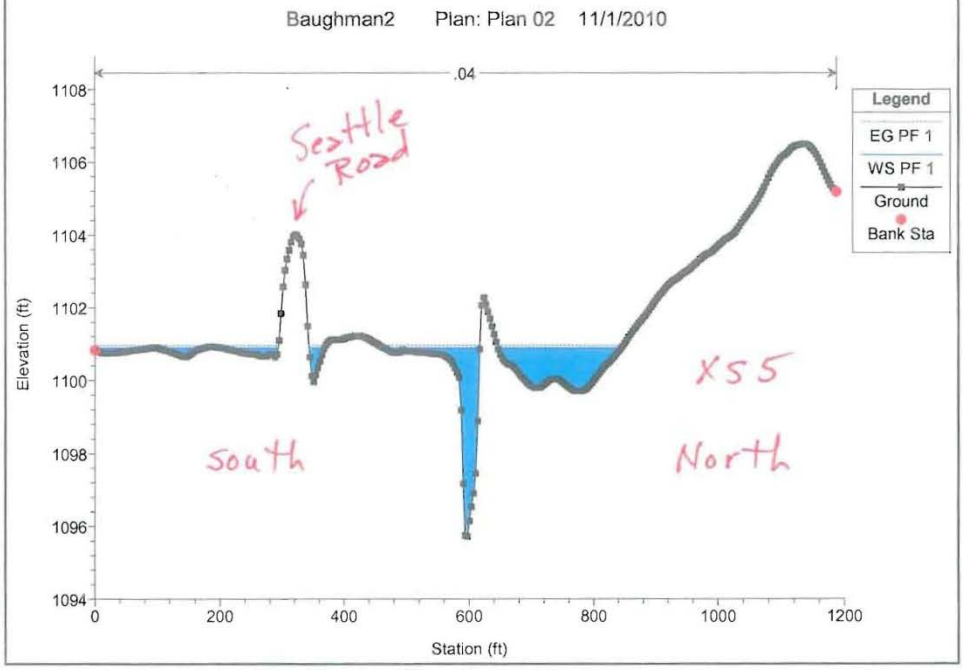
CROSS SECTIONS

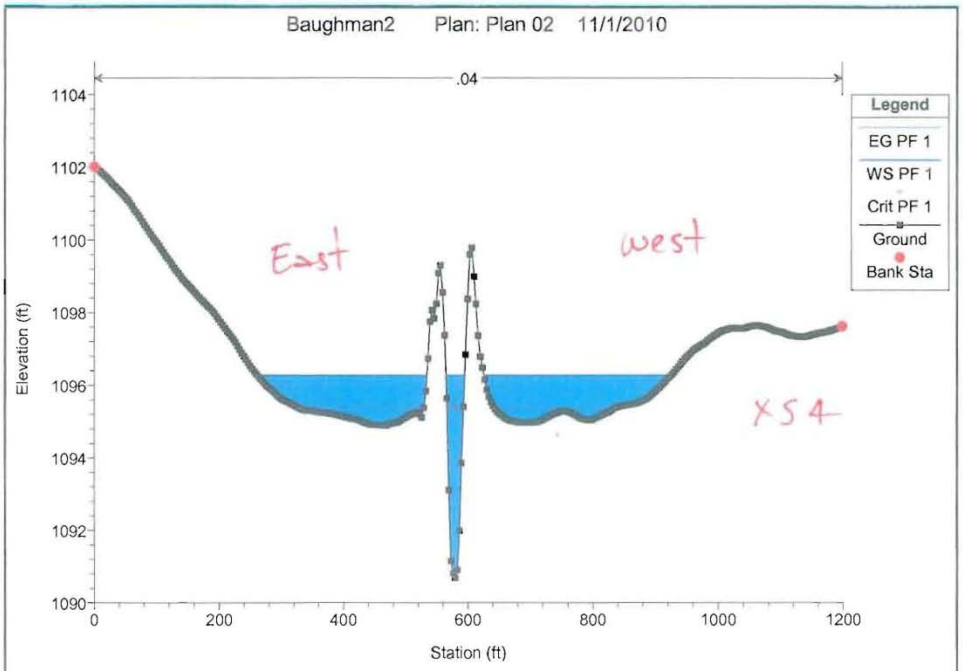


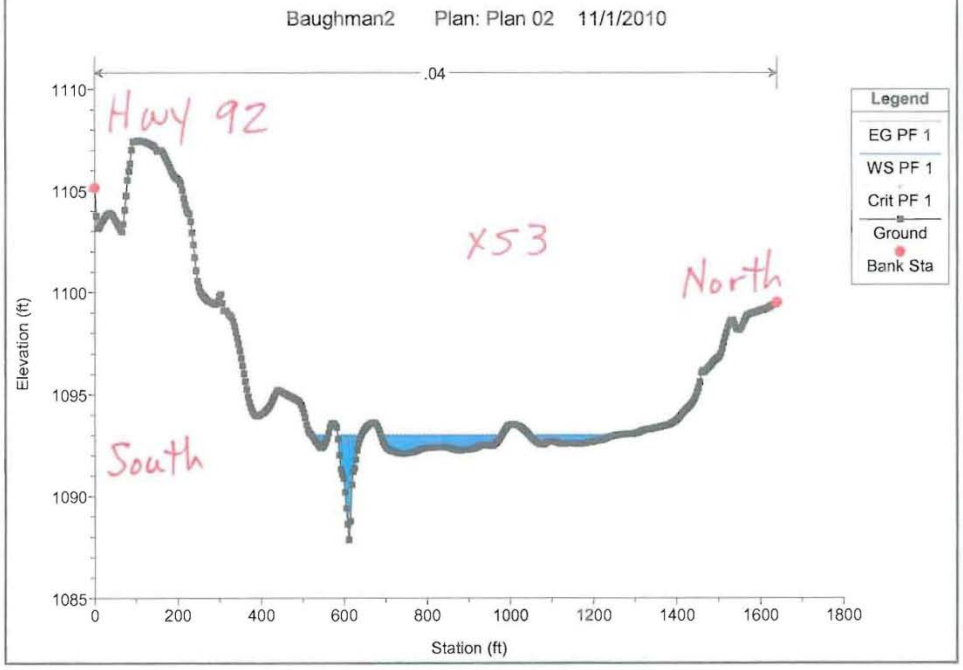
Unnamed Creek

2yr - 712 cfs

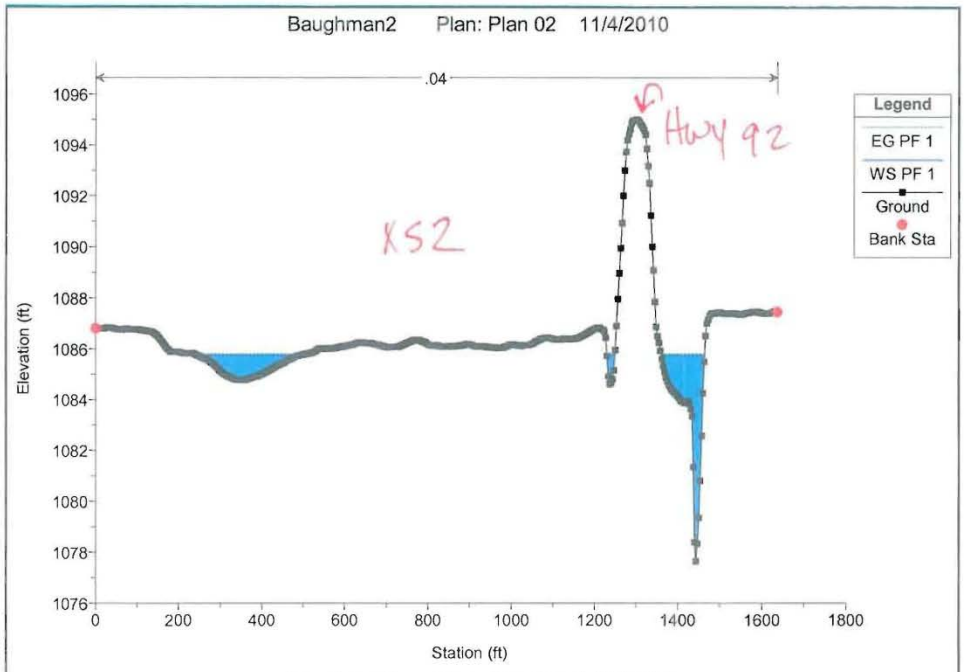


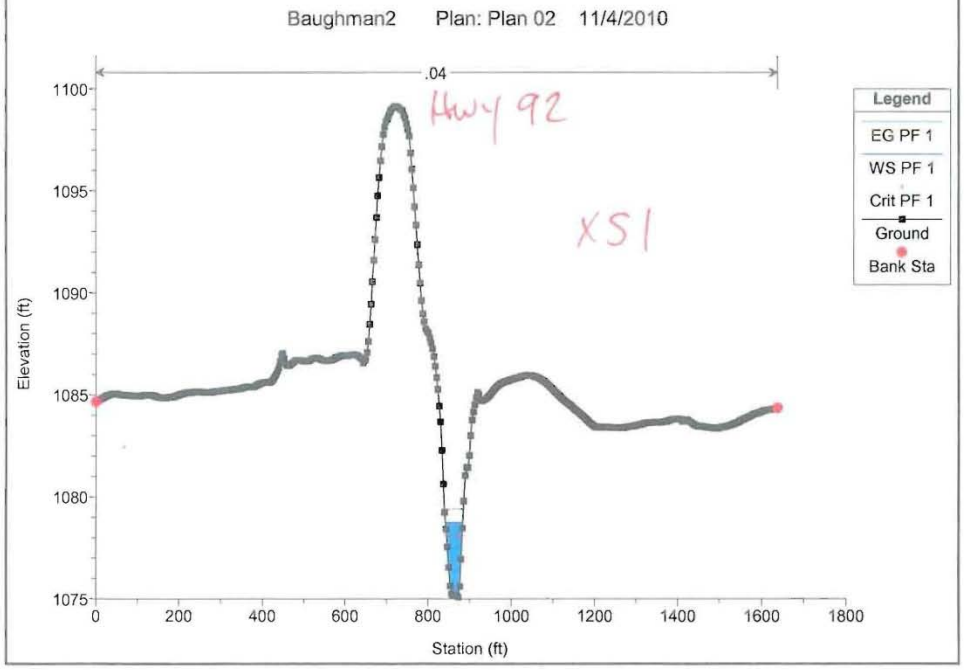



Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
East
west
XS4
Elevation (ft)
Station (ft)

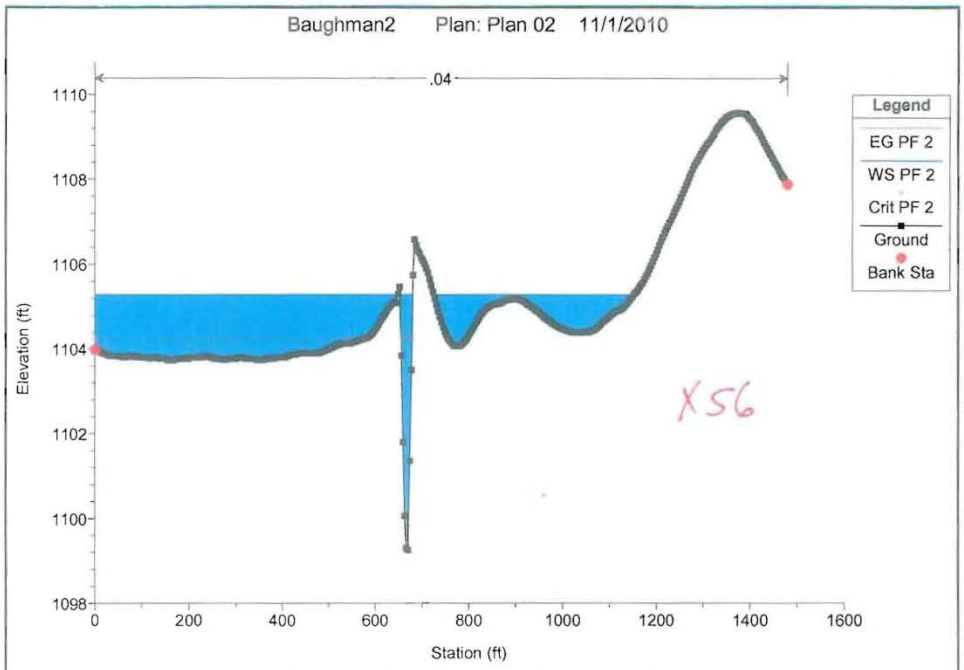

Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Hwy 92
XS3
North
South
Elevation (ft)
Station (ft)

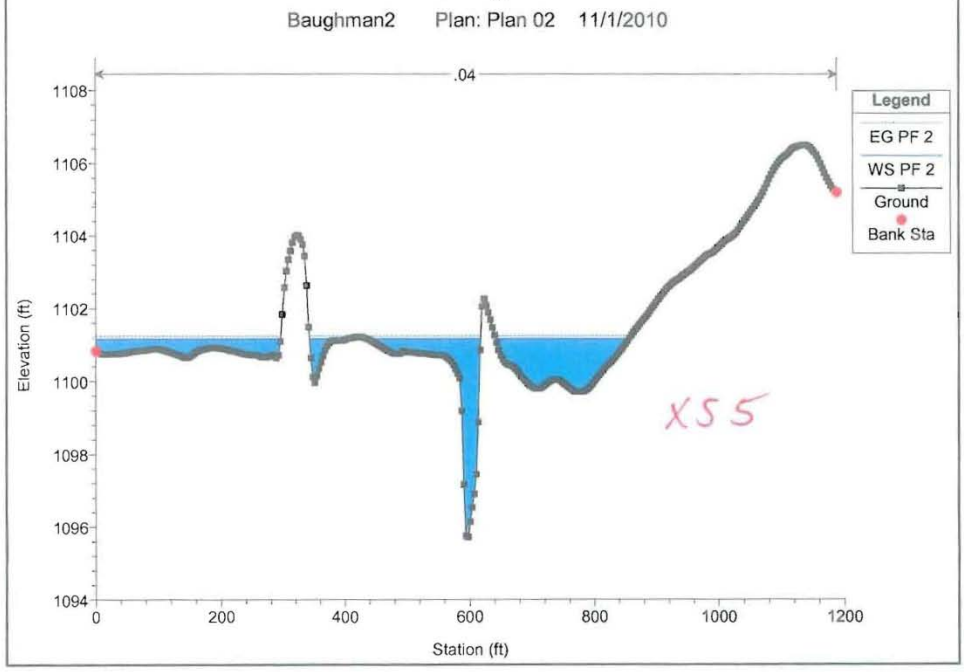
2yr

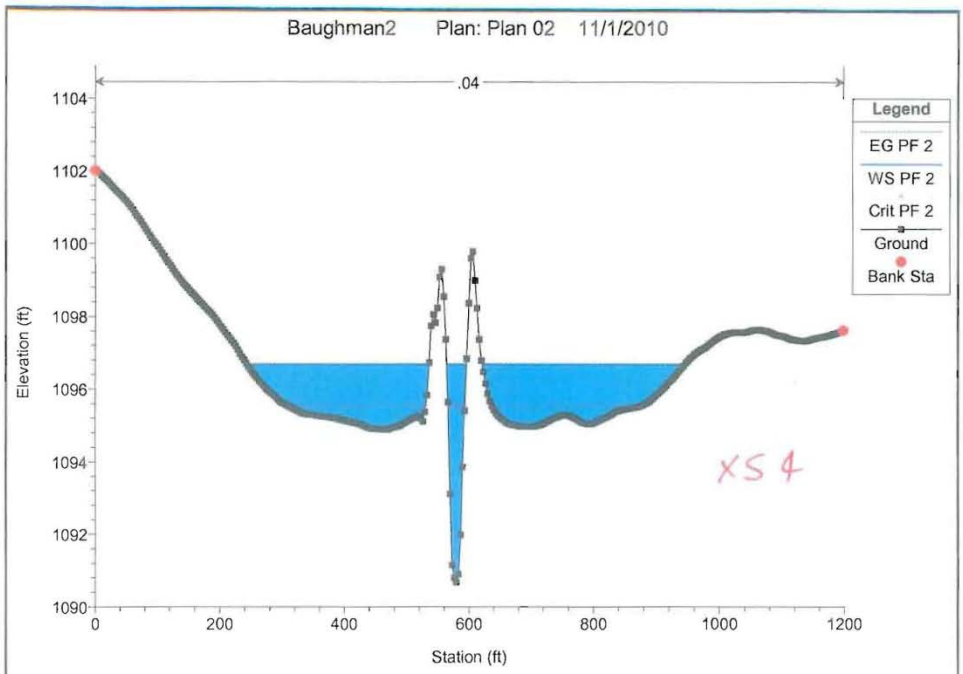

Baughman2 Plan: Plan 02 11/4/2010
.04
Hwy 92
XS2
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

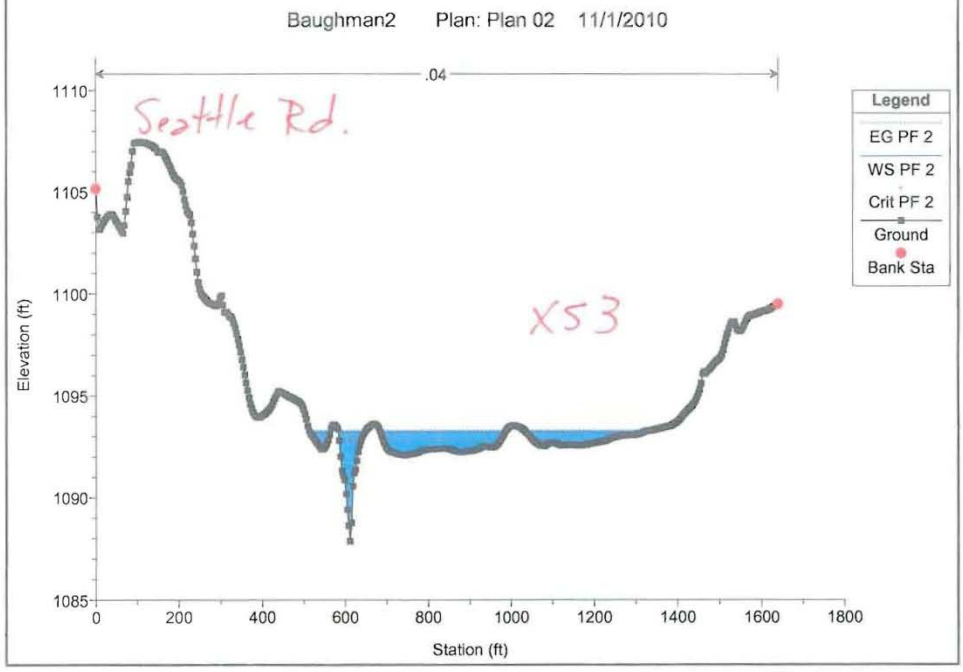

Baughman2 Plan: Plan 02 11/4/2010
.04
Hwy 92
XS1
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

5yr - 1189cfs

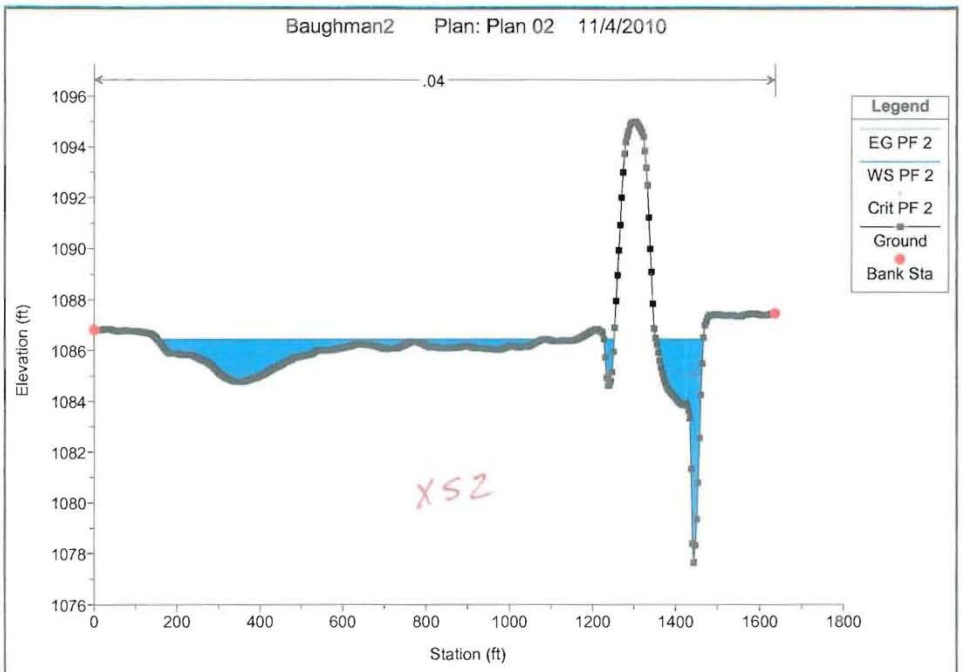

Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 2
WS PF 2
Crit PF 2
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS6

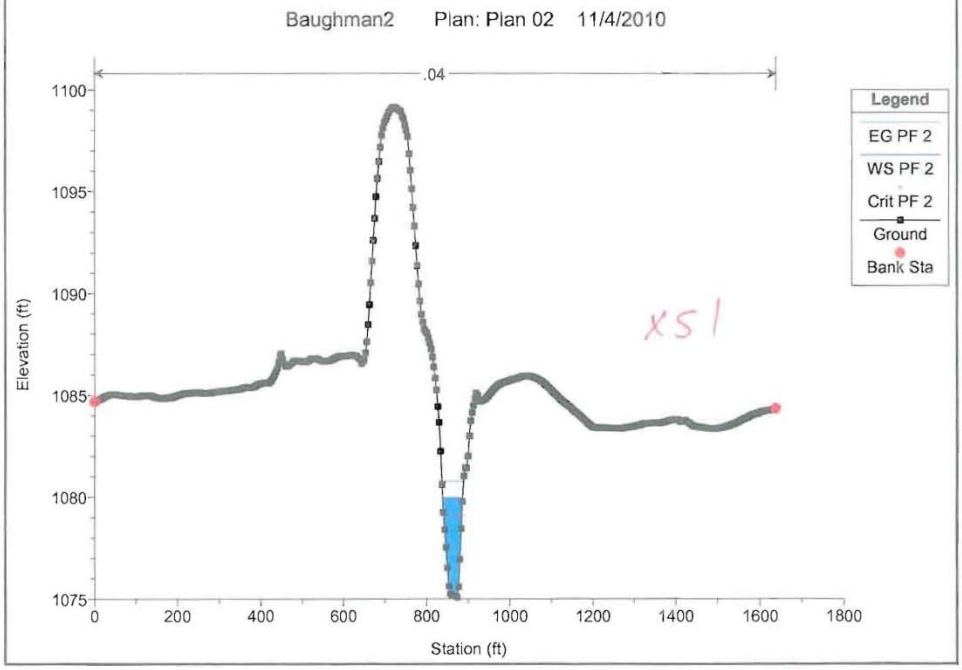

Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 2
WS PF 2
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS5


Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 2
WS PF 2
Crit PF 2
Ground
Bank Sta
XS 4
Elevation (ft)
Station (ft)

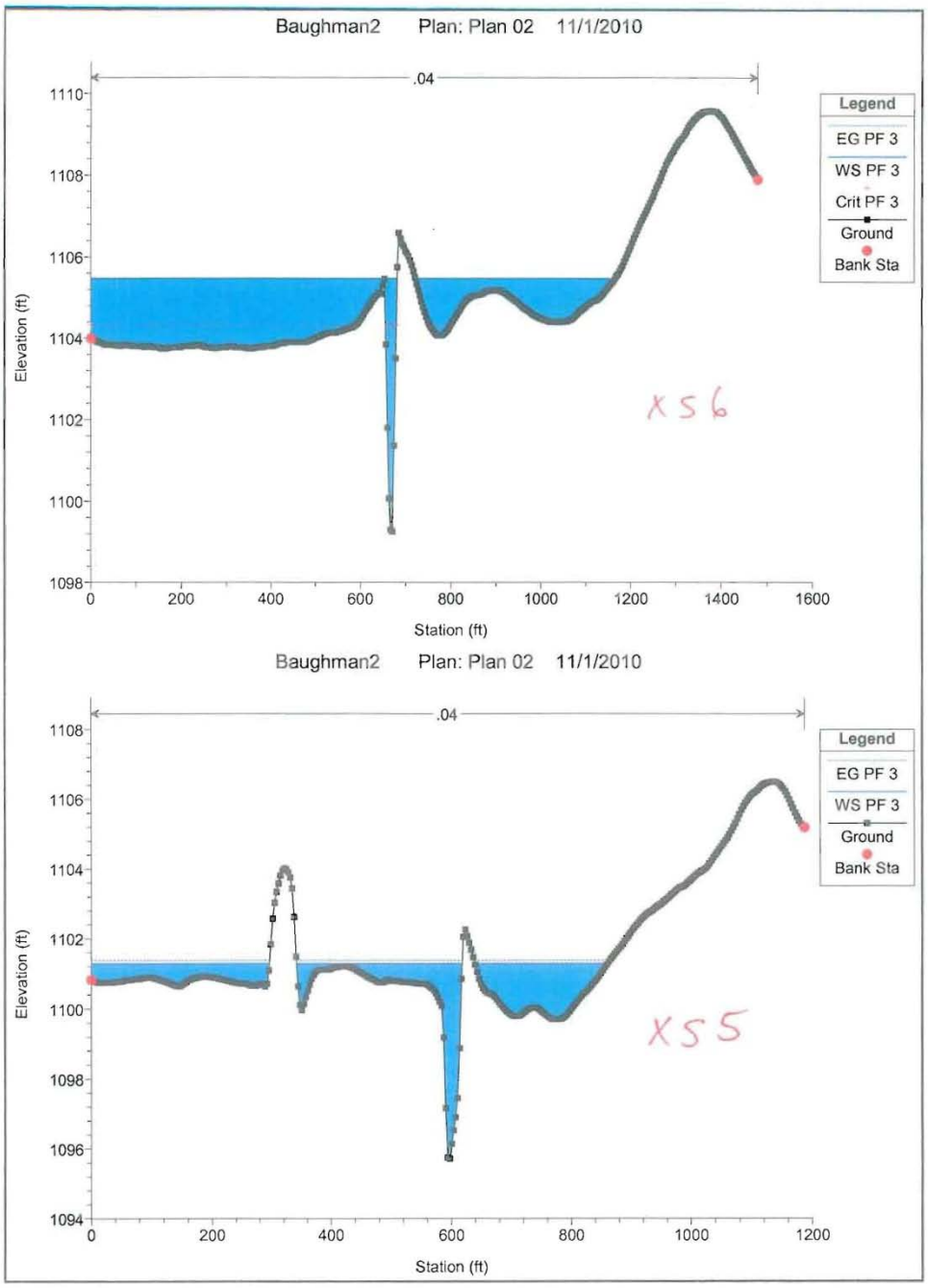

Baughman2 Plan: Plan 02 11/1/2010
.04
Seattle Rd.
Legend
EG PF 2
WS PF 2
Crit PF 2
Ground
Bank Sta
XS 3
Elevation (ft)
Station (ft)

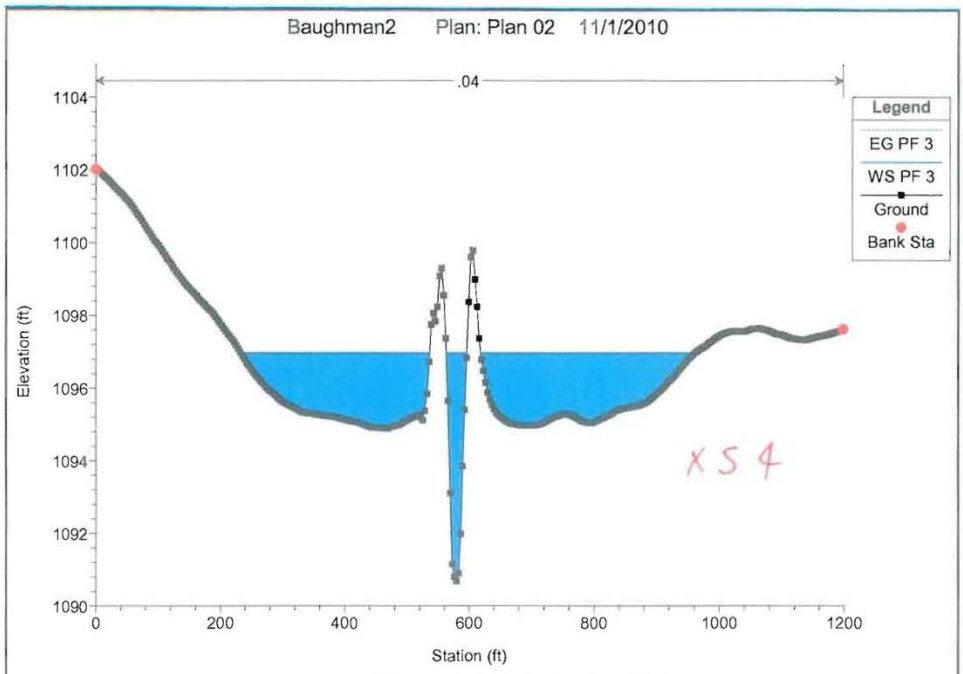
5yr

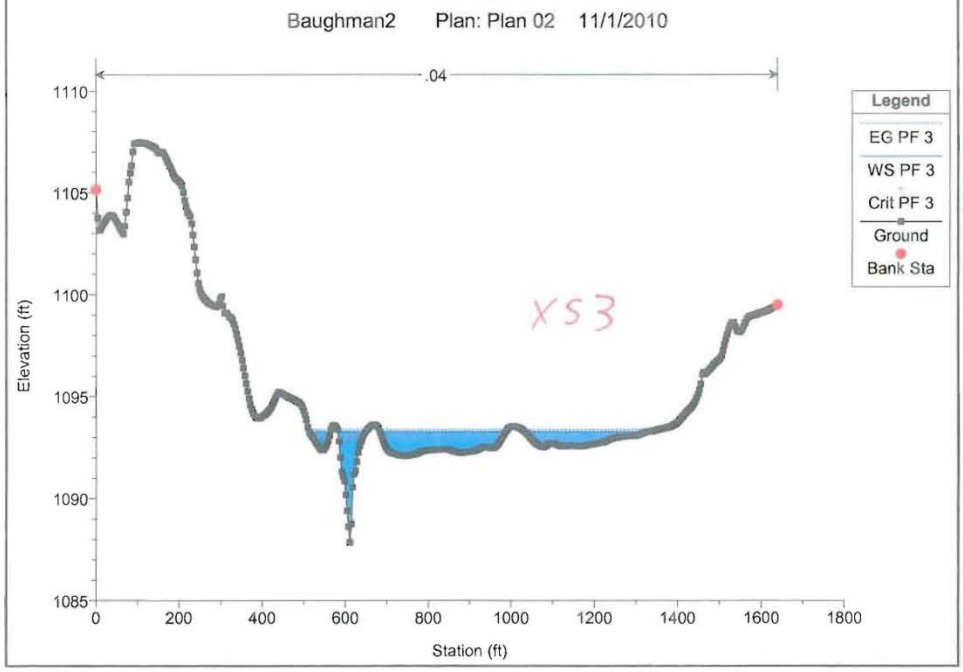

Baughman2 Plan: Plan 02 11/4/2010
.04
Legend
EG PF 2
WS PF 2
Crit PF 2
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS2


Baughman2 Plan: Plan 02 11/4/2010
.04
Legend
EG PF 2
WS PF 2
Crit PF 2
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS1

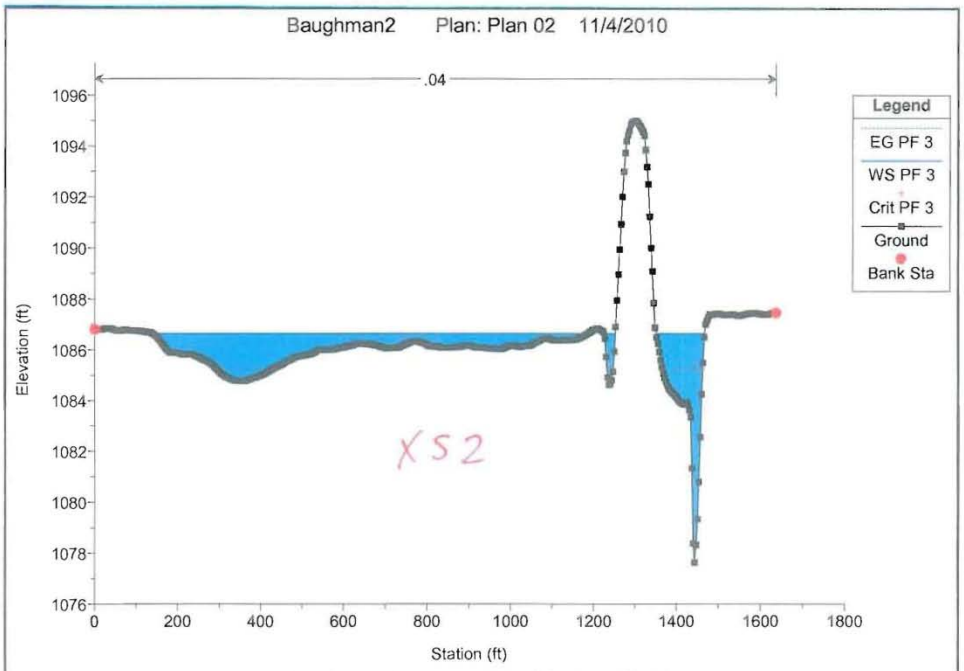
10yr - 1541 cfs

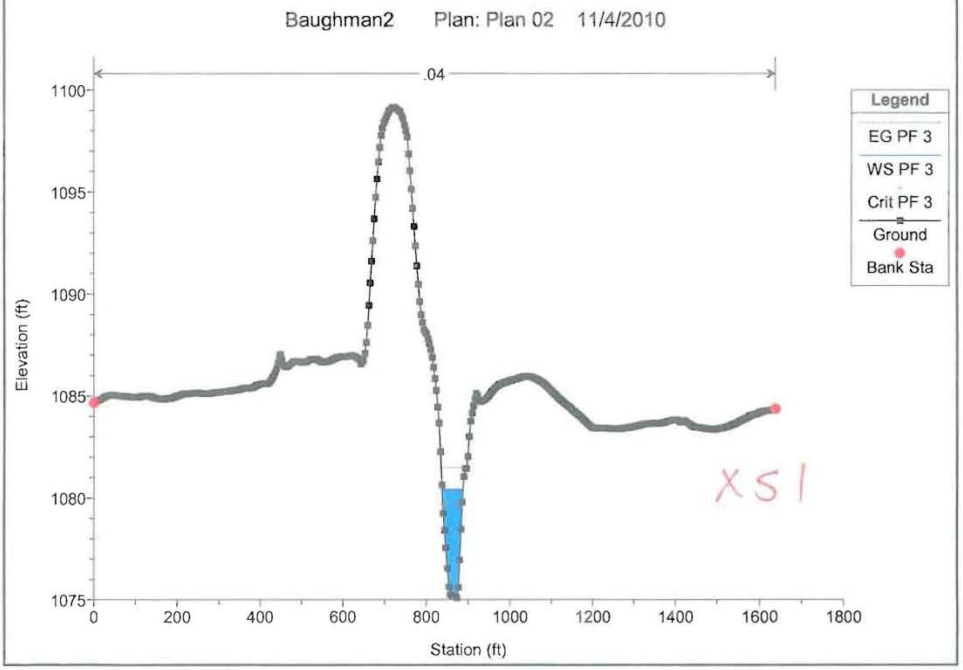



Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 3
WS PF 3
Ground
Bank Sta
XS 4
Elevation (ft)
Station (ft)

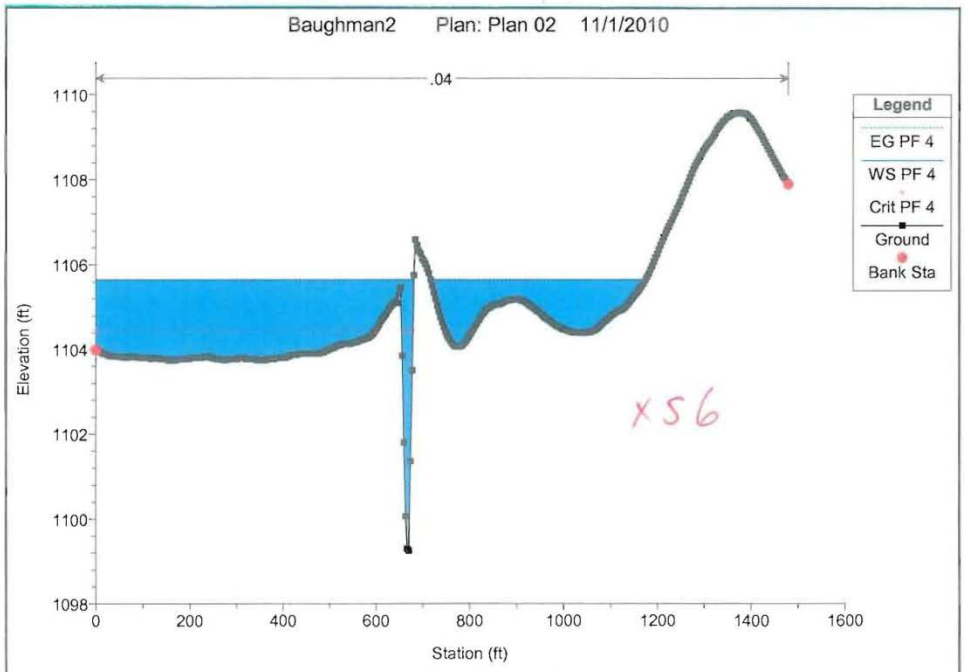

Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 3
WS PF 3
Crit PF 3
Ground
Bank Sta
XS 3
Elevation (ft)
Station (ft)

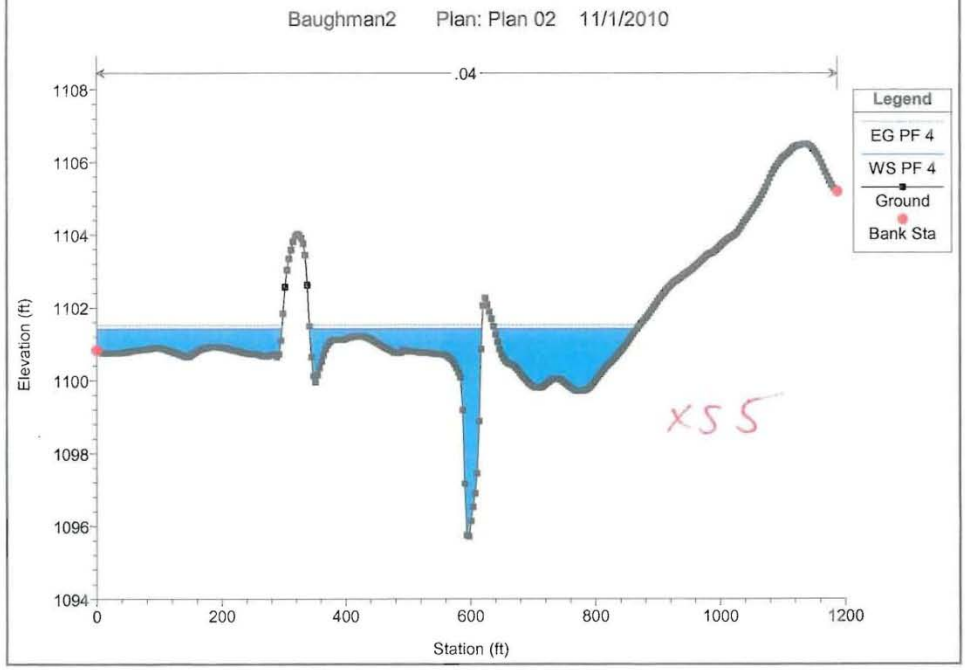
10 yr

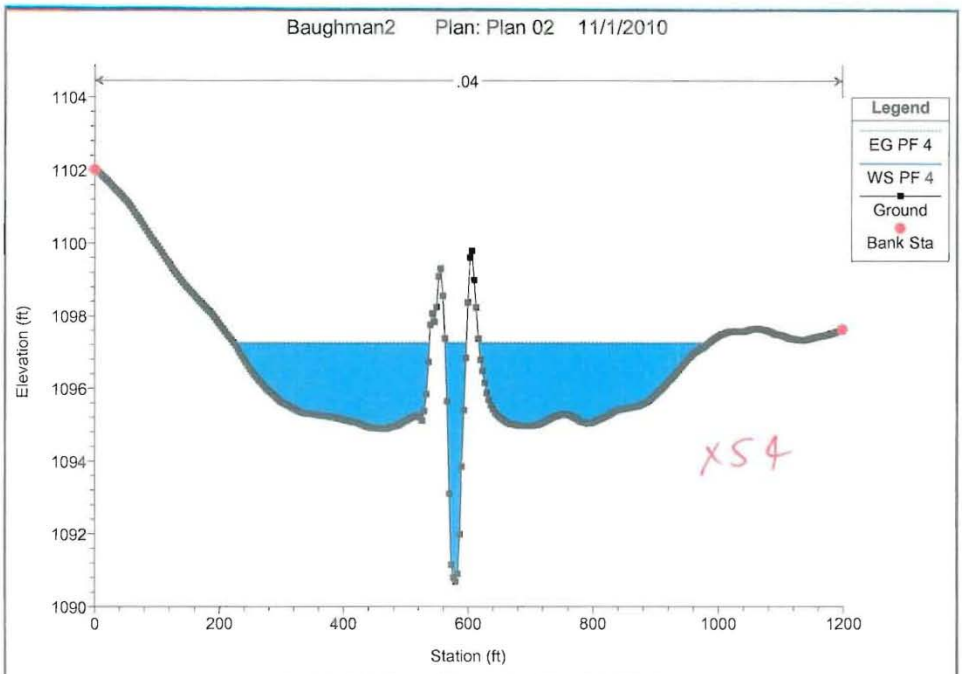

Baughman2 Plan: Plan 02 11/4/2010
.04
Legend
EG PF 3
WS PF 3
Crit PF 3
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS2

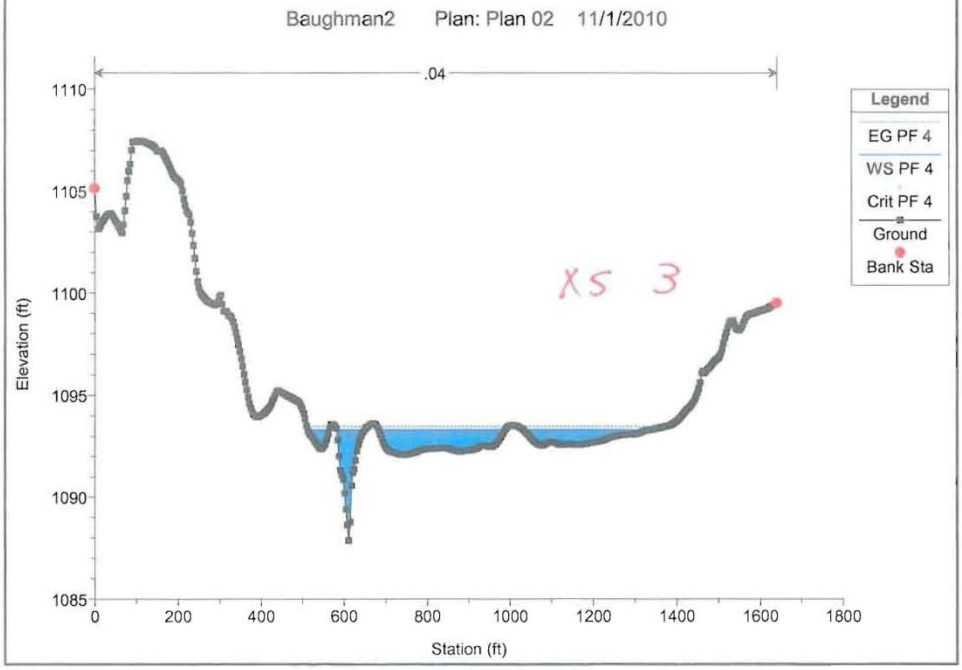

Baughman2 Plan: Plan 02 11/4/2010
.04
Legend
EG PF 3
WS PF 3
Crit PF 3
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS1

25yr-1910 cfs

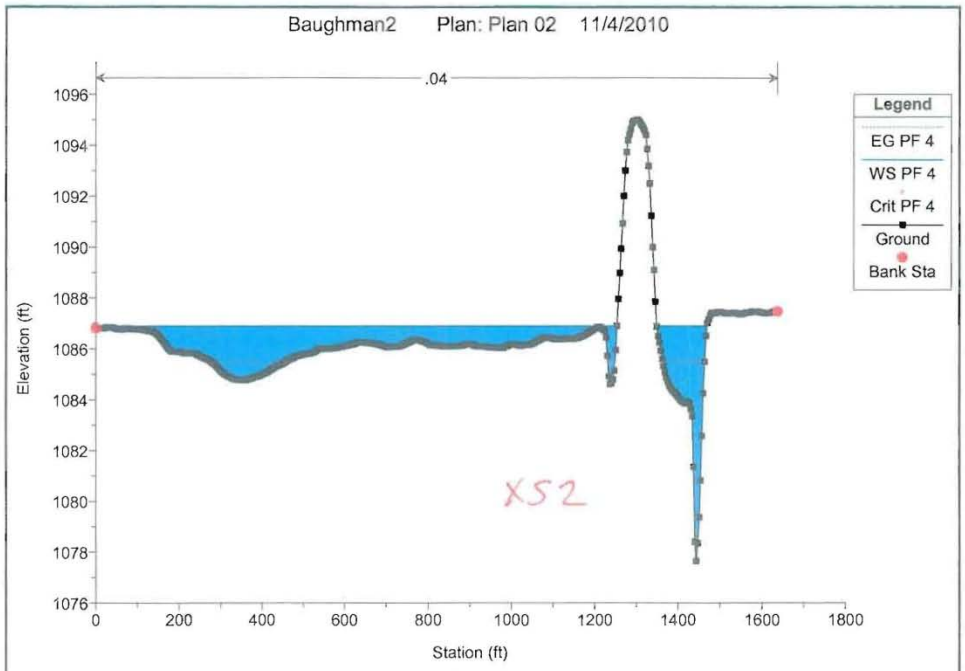


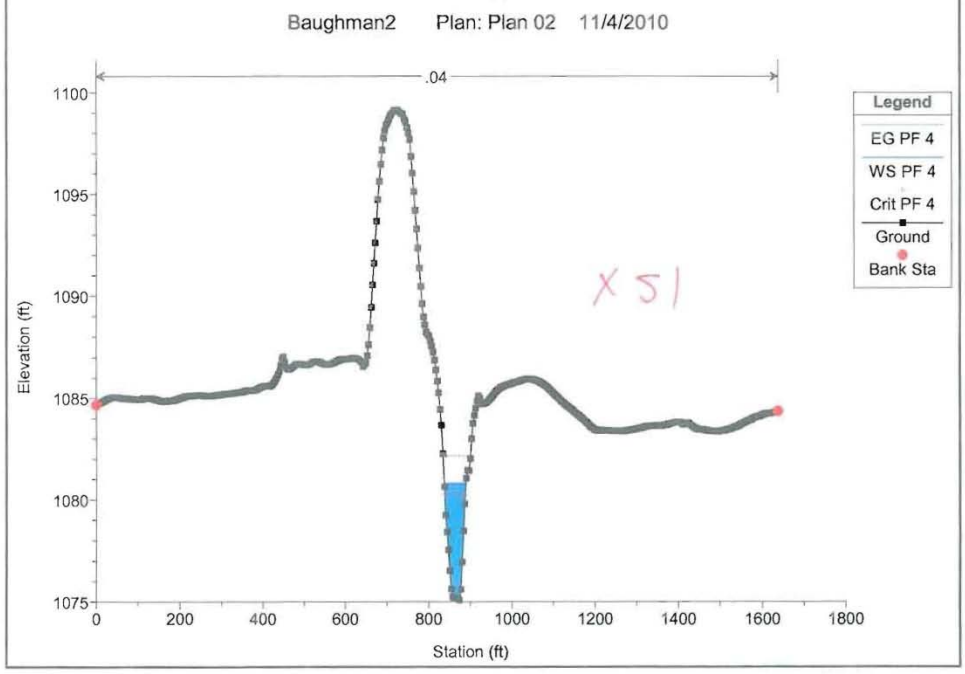



Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 4
WS PF 4
Ground
Bank Sta
XS4
Elevation (ft)
Station (ft)

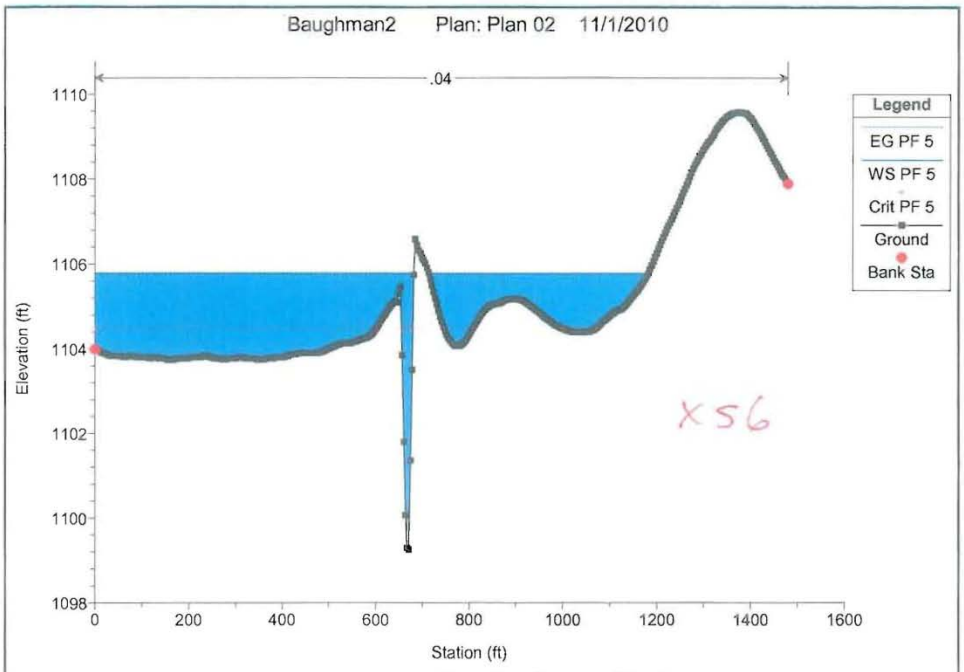

Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 4
WS PF 4
Crit PF 4
Ground
Bank Sta
XS 3
Elevation (ft)
Station (ft)

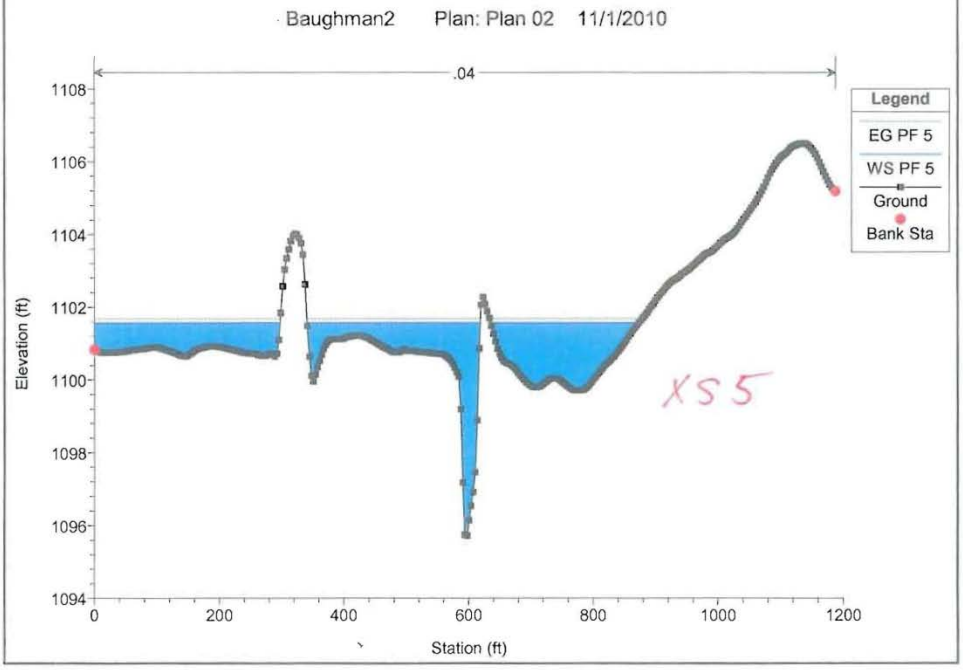
25 yr

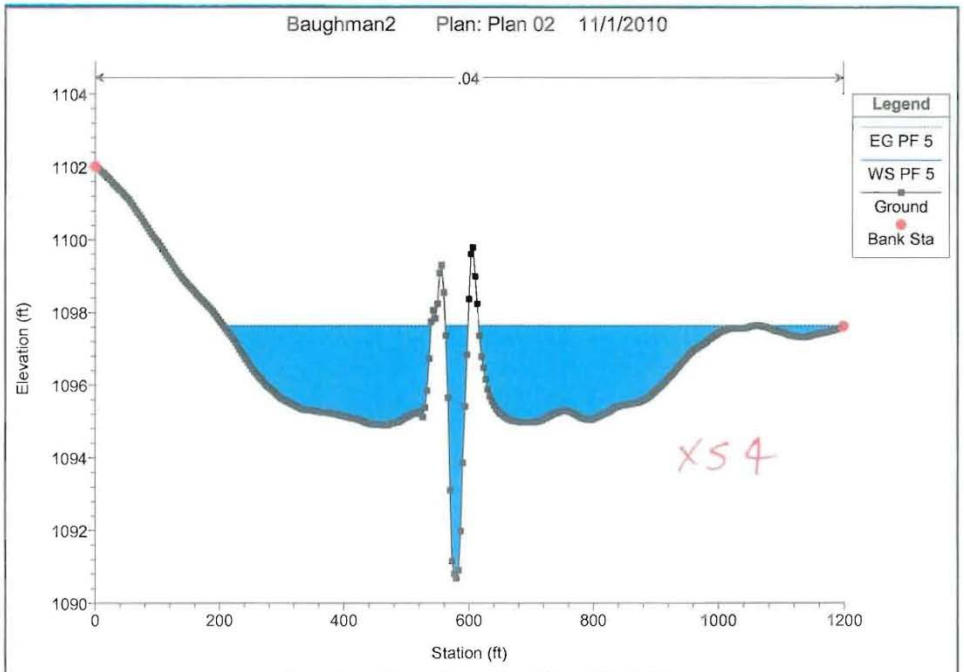

Baughman2 Plan: Plan 02 11/4/2010
.04
Legend
EG PF 4
WS PF 4
Crit PF 4
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS2

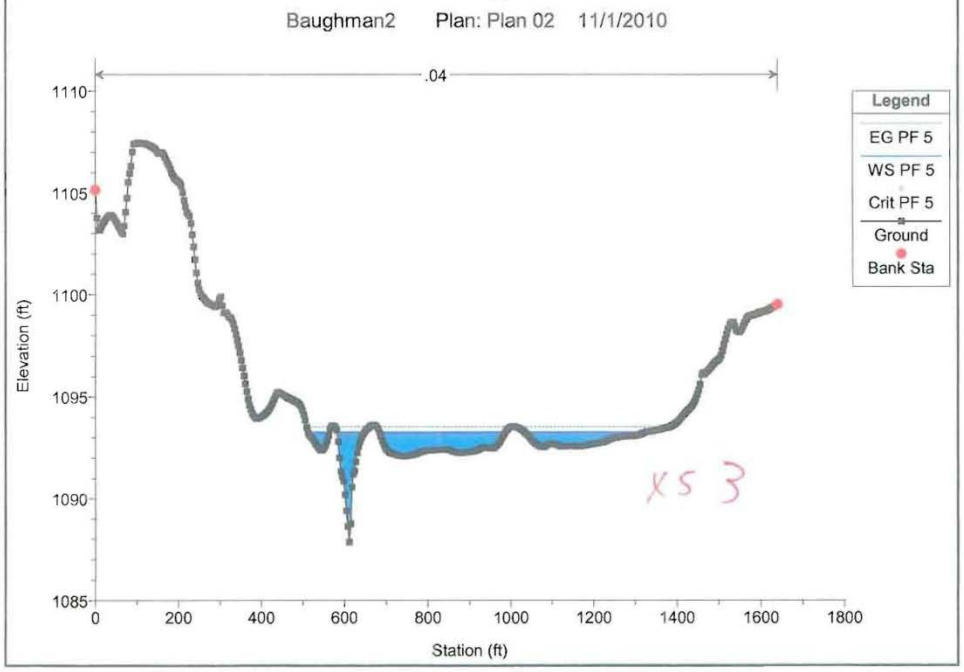

Baughman2 Plan: Plan 02 11/4/2010
.04
Legend
EG PF 4
WS PF 4
Crit PF 4
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS1

50yr - 2281 cfs

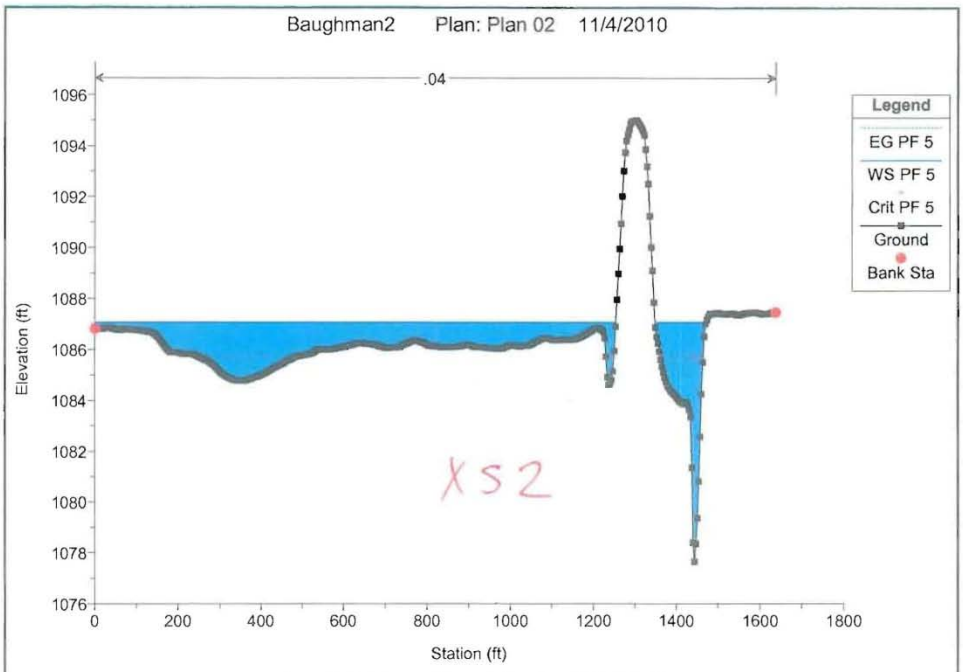





Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 5
WS PF 5
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS 4


Baughman2 Plan: Plan 02 11/1/2010
.04
Legend
EG PF 5
WS PF 5
Crit PF 5
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS 3

50yr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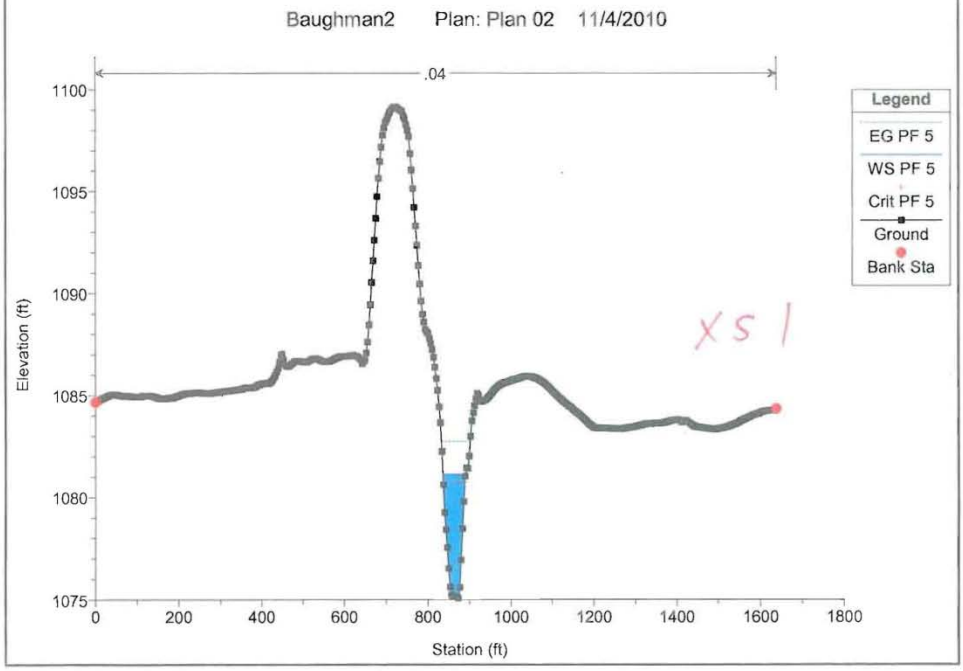
Bank Sta
Elevation (ft)
Station (ft)
XS2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Legend
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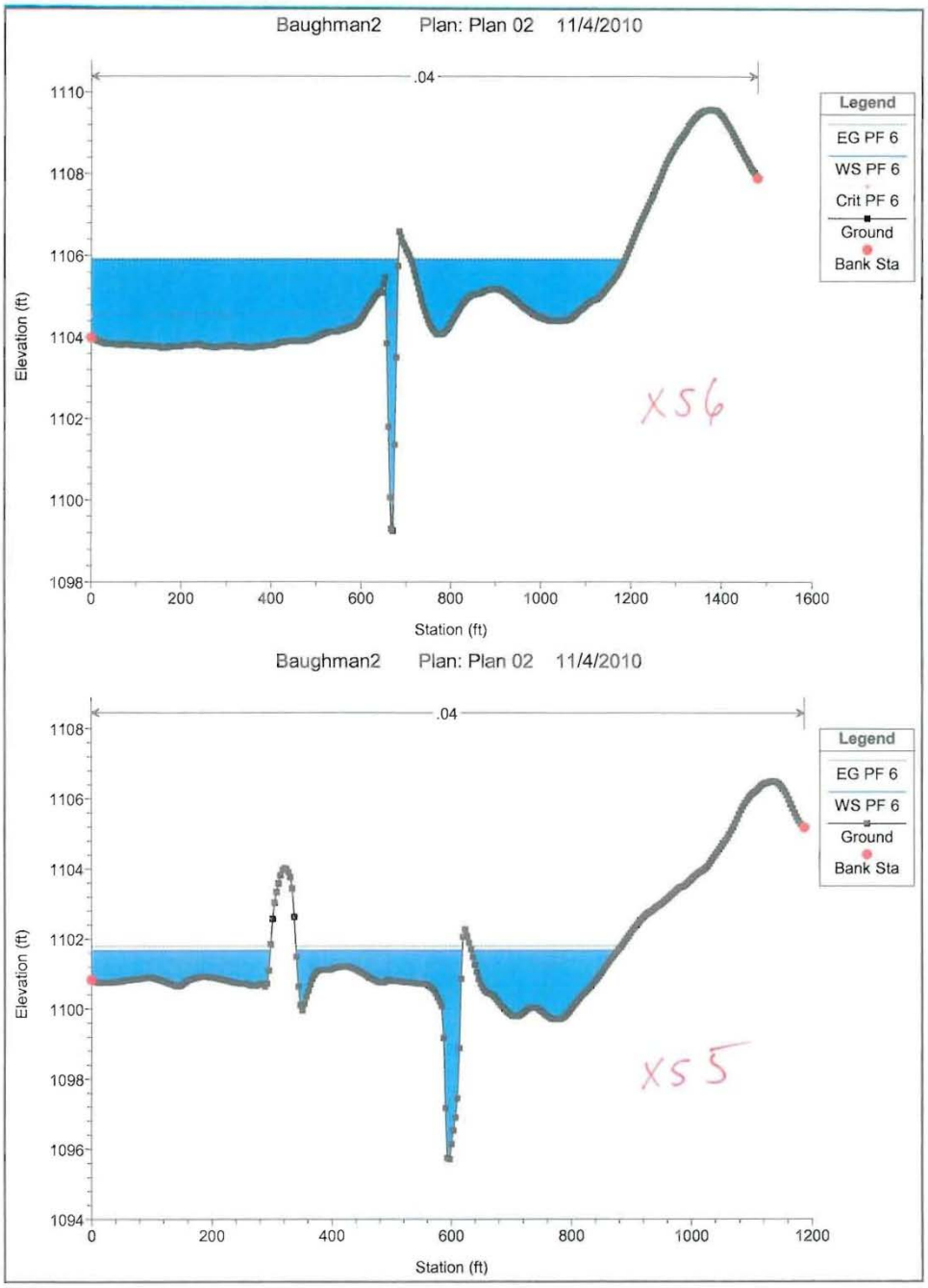
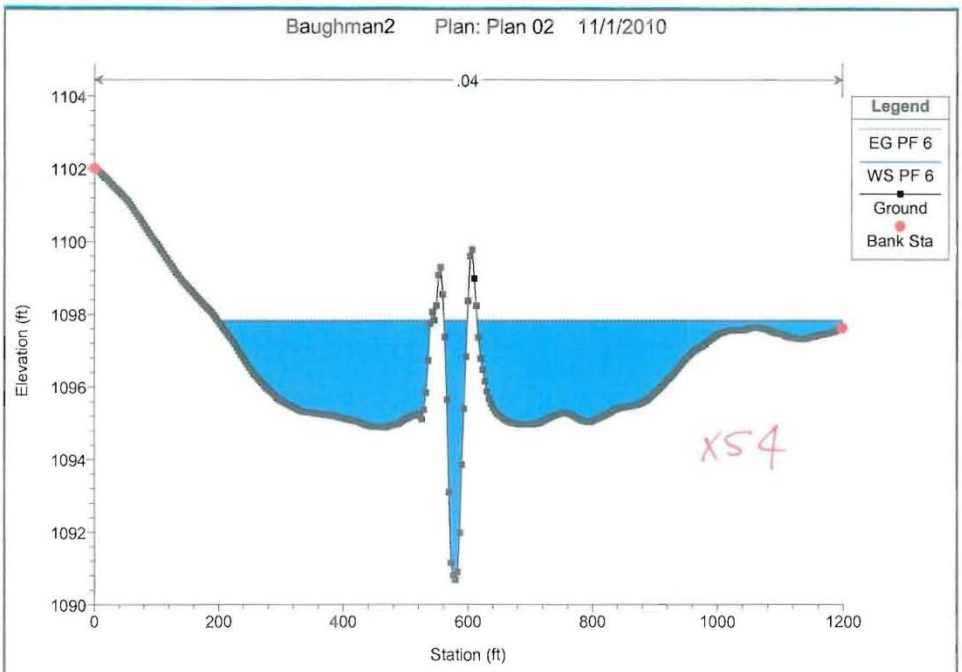
Ground
Bank Sta
Elevation (ft)
Station (ft)
XS1

Unnamed

100yr Discharge

cfs

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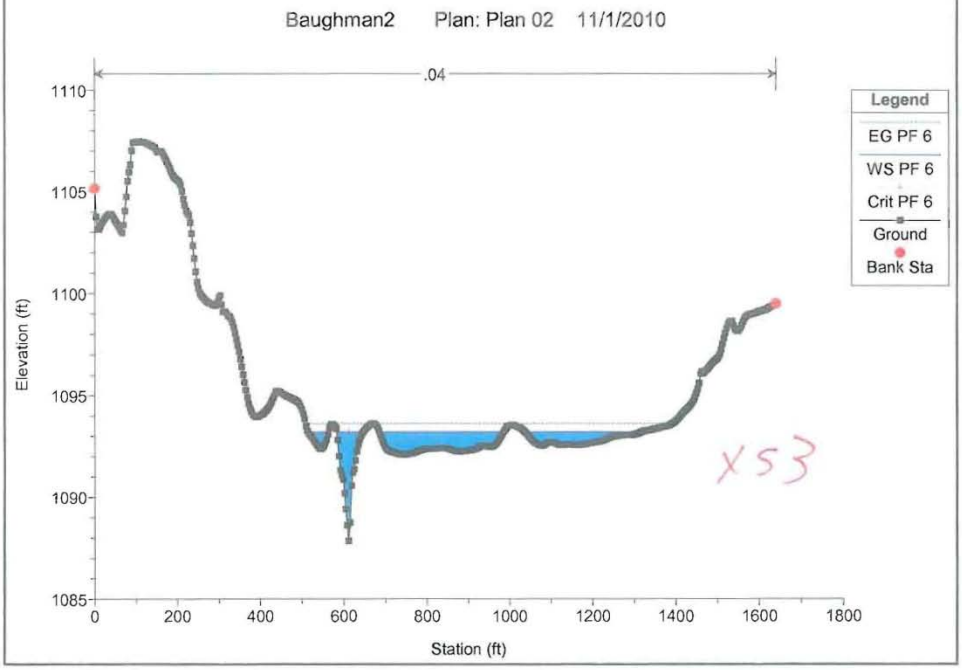
Ground
Bank Sta
Elevation (ft)
Station (ft)
X54


Baughman2 Plan: Plan 02 11/1/2010
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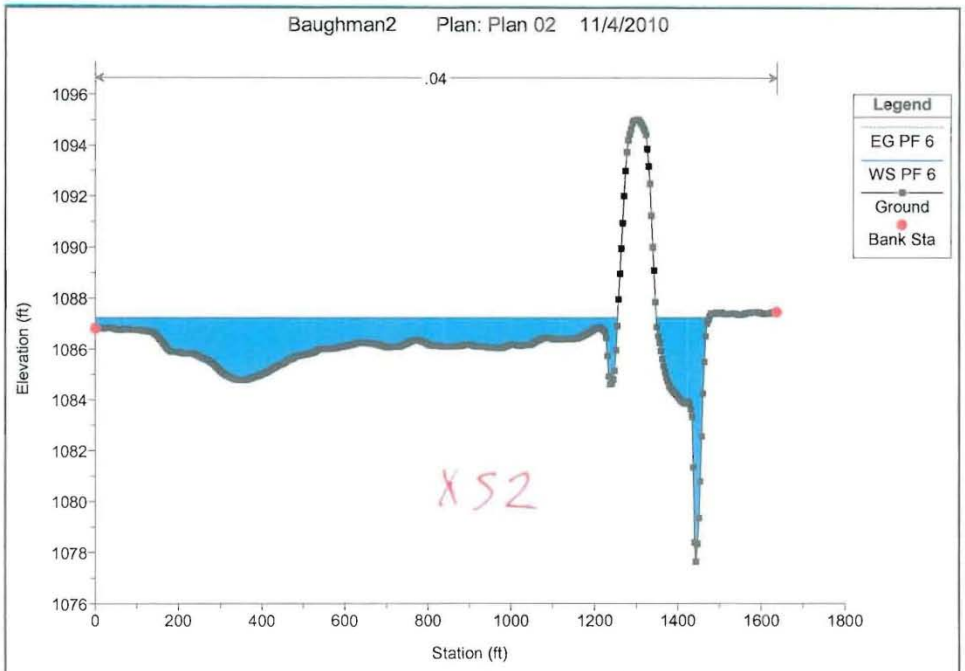
Legend
EG PF 6
WS PF 6
Crit PF 6
Ground
Bank Sta
Elevation (ft)
Station (ft)
X53

100yr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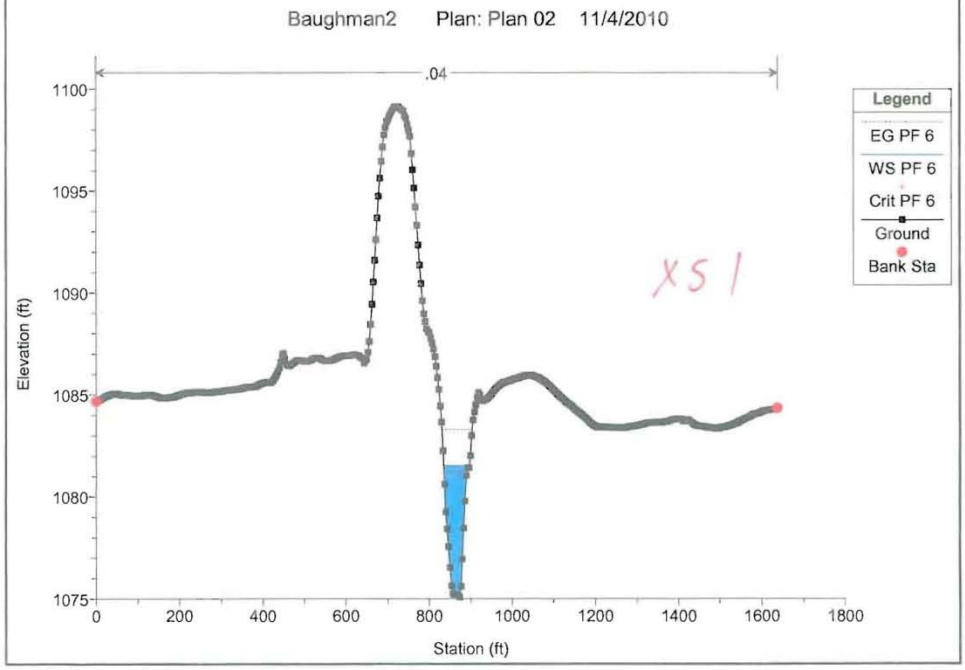
Legend
EG PF 6
WS PF 6
Ground
Bank Sta
XS2
Elevation (ft)
Station (ft)


Baughman2 Plan: Plan 02 11/4/2010
.04
Legend
EG PF 6
WS PF 6
Crit PF 6
Ground
Bank Sta
XS1
Elevation (ft)
Station (ft)

Flood Control Structure Estimates

Disclaimer Statements

Estimate: This estimate is for planning purposes only. In no way shall it be construed as an engineering design. This estimate is valid only for low hazard dams. Planning for moderate and high hazard dams requires an on site investigation as well as additional evaluation of the hydrology and hydraulics by a licensed engineer.

Cost: This is a preliminary cost estimate for planning purposes only. The final construction cost may vary depending on actual site conditions, timing of construction, availability of fill materials, inflation, competitive bid process, construction method, etc.

Water Level: There is no guarantee that a pond in this location will fill and/or remain filled with water to the principal spillway crest elevation.

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Aerial View of Pond

Site 2

Pond Information and Estimated Cost

Pond Depth:	9.5 feet
Pond Surface Area:	7.87 acres
Dam Top Width:	12 feet

5 feet stage
10-12 acres
temporary water

Item	Subtotal
Dam, Berm, and Core Trench Fill	$26,587.62
Core Trench Excavation	$2,374.26
Principal Spillway Pipe	$4,465.01
Grubbing	$2,400.00
Seeding	$3,000.00
Fencing	$0.00
Total:	$38,826.89

15" CMP

$20,000 drains

$55,000 - $60,000 range

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Aerial View of Pond

Site 3

Pond Information and Estimated Cost

Pond Depth:	13 feet
Pond Surface Area:	8.03 acres
Dam Top Width:	12 feet

6 feet stage
10-15 ac
temporary water

Item	Subtotal
Dam, Berm, and Core Trench Fill	$25,090.32
Core Trench Excavation	$2,055.14
Principal Spillway Pipe	$5,096.55
Grubbing	$2,400.00
Seeding	$3,000.00
Fencing	$0.00
Total:	$37,642.01

15" CMP

$20,000 drains

$55,000 - $60,000 range

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Aerial View of Pond

Site 4a

Pond Information and Estimated Cost

Pond Depth:	6 feet
Pond Surface Area:	5.12 acres
Dam Top Width:	10 feet

~ 4.5' stage
~ 5-8 acres
temporary water

Item	Subtotal
Dam, Berm, and Core Trench Fill	$15,286.80
Core Trench Excavation	$1,807.96
Principal Spillway Pipe	$3,553.44
Grubbing	$2,400.00
Seeding	$3,000.00
Fencing	$0.00
Total:	$26,048.20

15" CMP

$15,000 drains

$40,000 to $45,000 range

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"Way Pleasant"

Aerial View of Pond

Site 4b

Pond Information and Estimated Cost

Pond Depth:	12 feet
Pond Surface Area:	5.62 acres
Dam Top Width:	12 feet

5 feet of stage (temporary storage)
5-8 acres temporary in addition to 5.62 permanent

Item	Subtotal
Dam, Berm, and Core Trench Fill	$19,230.03
Core Trench Excavation	$1,846.23
Principal Spillway Pipe	$4,761.98
Grubbing	$2,400.00
Seeding	$3,000.00
Fencing	$0.00
Total:	$31,238.24

15" CMP

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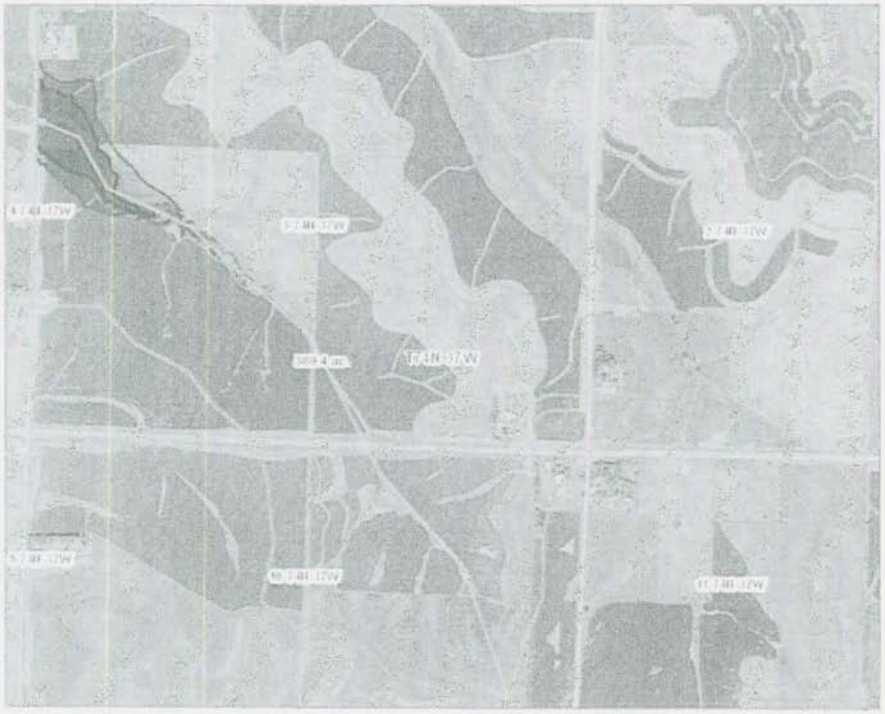
$15,000 drains

$45,000 - $50,000 range

Aerial View of Pond

Site 5 possible road structure



Pond Information and Estimated Cost

5 feet stage

Pond Depth:	16 feet
Pond Surface Area:	9.63 acres
Dam Top Width:	12 feet

Item	Subtotal	
Dam, Berm, and Core Trench Fill	$26,948.82	← + $10,000
Core Trench Excavation	$2,846.15	
Principal Spillway Pipe	$6,450.99	15" CMP
Grubbing	$6,000.00	
Seeding	$4,500.00	
Fencing	$0.00	
Total:	$46,745.96	

$25,000 drains

$80,000 – $100,000 range

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Aerial View of Pond

Site 6

Pond Information and Estimated Cost

Pond Depth:	15 feet
Pond Surface Area:	7.87 acres
Dam Top Width:	12 feet

5 1/2 feet stage
8-12 acres
temporary water

Item	Subtotal
Dam, Berm, and Core Trench Fill	$27,051.62
Core Trench Excavation	$2,229.73
Principal Spillway Pipe	$5,445.42
Grubbing	$2,400.00
Seeding	$3,000.00
Fencing	$0.00
Total:	$40,126.77

15" CMP

$20,000 drains

$60,000 to $65,000 range

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Aerial View of Pond

Site 7

Pond Information and Estimated Cost

Pond Depth:	10 feet
Pond Surface Area:	3.9 acres
Dam Top Width:	12 feet

4 feet stage
5-8 acres
temporary water

Item	Subtotal
Dam, Berm, and Core Trench Fill	$16,660.18
Core Trench Excavation	$1,880.82
Principal Spillway Pipe	$3,699.92
Grubbing	$2,400.00
Seeding	$3,000.00
Fencing	$0.00
Total:	$27,640.92

12" CMP

12,500 drains

$40,000 to $45,000 range

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Aerial View of Pond

Site 8

Pond Information and Estimated Cost

Pond Depth:	11.5 feet
Pond Surface Area:	3.05 acres
Dam Top Width:	12 feet

4.5 ft. stage > temporary water
4-6 ac

Item	Subtotal
Dam, Berm, and Core Trench Fill	$17,819.25
Core Trench Excavation	$1,673.77
Principal Spillway Pipe	$4,011.44
Grubbing	$1,200.00
Seeding	$2,250.00
Fencing	$0.00
Total:	$26,954.46

12" CMP

$12,500 drains

$38,000 to $43,000 range

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