GLMRIS

Great Lakes and Mississippi River Interbasin Study

Aquatic Nuisance Species | Ecosystems | Navigation | Recreation | Flood Risk Management | Water Use

Aquatic Nuisance Species Controls Report

Wabash-Maumee Basin Connection

Fort Wayne, Indiana

APPENDIX D
Value Engineering Study

US Army Corps of Engineers®
BUILDING STRONG®

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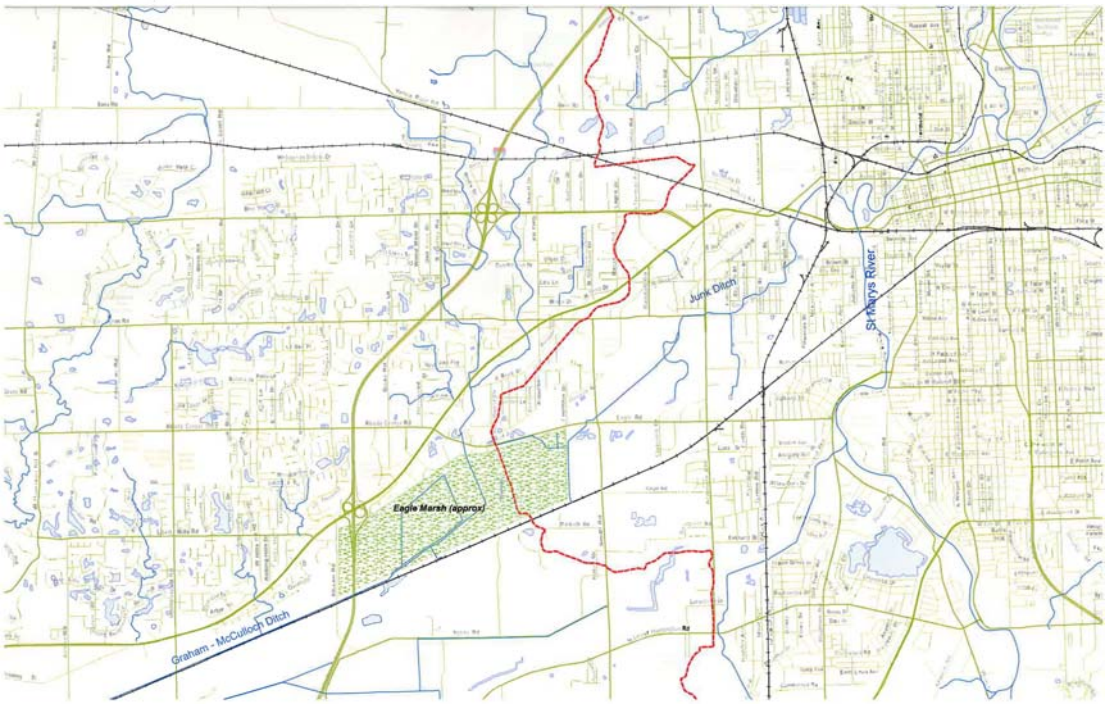
Final Report

Value Engineering Study

US Army Corps of Engineers®

Louisville District



Wabash-Maumee River Basin Connection Study

Fort Wayne, IN

February 2011

Strategic Value Solutions, Inc.

Value Improvement Specialists

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Final

Value Engineering Study Report

for

Wabash-Maumee River Basin Connection Study

Fort Wayne, IN

February 2011

Prepared for:

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ACKNOWLEDGEMENTS

Strategic Value Solutions, Inc. would like to express our appreciation to the Louisville District USACE staff members who assisted us in the review of this project. Particular thanks go to David Nance, PG for providing valuable insights into project issues and to Ben Robertson, AVS for assisting in the coordination and management of this study.

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Section 1

Executive Summary

SECTION 1
EXECUTIVE SUMMARY

This report presents the results of a Value Study conducted by Strategic Value Solutions, Inc. (SVS) on the plan of the Wabash-Maumee River Basin Connection Study project for the US Army Corps of Engineers, Louisville (the District).

P2 Number:	114597
Design/Construction Strategy:	Design-Bid-Build
Level of Project Development:	Planning
Design Firm:	In-house design

The Value Study included a 3-day (24-hour) value methodology workshop that was conducted with a multidisciplinary team in Louisville, KY on January 19-21, 2011.

PROJECT DESCRIPTION SUMMARY

The Asian Carp, *Hypophthalmichthys* spp. is within 20 miles of Eagle Marsh, the natural intersection of the Wabash and Maumee River basins. The marsh is shallow, generally less than 18 inches deep and receives backwater flows from both basins under flood conditions. The carp is moving towards the marsh from the Wabash basin and has the potential to cross into the Great Lakes basin. Should the fish succeed, it has the potential to cause material harm to the region's $7 billion commercial fishery and create long-term ecological and economic damage to interests in the US and Canada. The fish multiply rapidly and consume the aquatic plants, phytoplankton, zooplankton and small mollusks forming the base of the food chain which supports the Great Lakes ecosystem.

According to Doug Keller of IDNR Division of Fish and Wildlife, the carp can swim in as little as one foot of water and can jump 10 ft vertically and about 20 ft horizontally. It is highly adaptable to varying flow conditions and water chemistry. The fish were seen attempting to jump over Williams Dam on the East Fork of the White River, a 20-ft high concrete dam .

As a temporary measure, Indiana DNR in cooperation with Little River Wetland Project and the NRCS has constructed a fence across Eagle Marsh. The fence post is embedded five feet into the marsh and reinforced against debris and ice flows from the Maumee River. It also has panels that can be removed in case of major flows to protect Fort Wayne, IN from a flood rise associated with the barrier. The barrier is robust but poses minimal impediment to flood flows. The fence will prevent adult Asian Carp from crossing the watershed divide. The fence is placed across a part of the marsh where water flows are too slow to maintain buoyancy of the eggs, so that even if the carp spawn next to the fence, the eggs will likely not survive.

By agreement with NRCS and IDNR the fence is permitted for five years after which it must be removed or its status will need to be revised . Replacement with another barrier is not out of the question but specific features would have to be negotiated.

Critical information regarding the actual risk of carp migration across the watershed boundary is not yet available nor is detailed, quantitative data concerning the minimum size of tributary up which the carp will migrate, their flow preferences as well as triggers for migration, parameters for egg viability, and other information vital to an effective design.

The Project Design Team is gathering data and formulating a set of alternatives.

VALUE STUDY TEAM

The team members that comprised this multidisciplinary Value Team are listed on the introductory pages of this report. In this instance, the value study team members are predominantly members of the Project Development Team. This is a Value Planning Study and early in project development.

All other participants of the study are provided in Appendix A.

VALUE METHODOLOGY

This Value Study used the international standard Value Methodology established by SAVE International, the Value Society. The Value Methodology (VM) uses a six-phase process executed in a workshop format with a multidisciplinary team. Value is expressed as the relationship between functions and resources where function is measured by the performance requirements of the customer and resources are measured in materials, labor, price, time, etc. required to accomplish that function. VM focuses on improving Value by identifying the most resource efficient way to reliably accomplish a function that meets the performance expectations of the customer.

With this process, the Value Team identifies the essential project functions and alternative ways to achieve those functions, and then selects the best alternatives to develop into workable solutions for value improvements.

Additional information about the Value Study processes used in the generation of the results presented is provided in Section 3 of this report.

STUDY CONSIDERATIONS

This section describes some of the key considerations identified during the Value Study.

Action Items

The following were identified as action items for the Value Team. These are aspects of the project or specific issues that the District project development team (PDT) or other stakeholders have asked the Value Team to review for validation of the current concept or to offer alternative solutions.

- None were identified

Key Agreements

There are typically a number of agreements, formal and informal, which affect the decision-making throughout the planning and design process. The following were identified as key agreements for the Value Team to consider when identifying alternative solutions.

- If the project is to be constructed under Section 206, Ecosystem Reconstruction, a $7.5 million cap applies. However, a 65%-35% cost share is required. So far no cost share partner has been identified. If a suitable project and partner are identified, it could be built in 18 months. A stakeholder entity could be created by a collaboration of Great Lakes entities to cost share on this project.

- The project could be constructed under Section 506 also Ecosystem Restoration which has no defined project limit. Congressional authorization would be required to construct a specific project.

- Little River Wetlands Project is the private not-for-profit owner of the Eagle Marsh project. Little River owns 50% of the land and provides routine maintenance. IDNR owns the rest of the 1100 acres site. The cooperation of both groups was crucial in getting the fence built. The site has a NRCS easement which required a cooperative use agreement that has a 5-year term after which time the fence must be removed if other arrangements are not in place.

- NRCS has been approached by several nearby landowners interested in joining the Wetland Reserve Program. If successful this may generate additional acerage for flood storage. Collaboration with NRCS may increase the viability of some proposed approaches.

Critical Assumptions

Through the planning and design process, many assumptions have to be made in order to advance the project. The following were identified as some of the critical assumptions affecting the decision-making on this project.

- Per IDNR regulation, any construction within the floodplain cannot induce stages for the 1% chance exceedence event greater than 0.14 feet on other properties.

- Asian carp poses the most credible near-term threat, although tubenose goby and northern snake-head present a long-term threat.

- Any incorporation of the berms along Graham McCulloch Ditch into an Asian Carp barrier may trigger a requirement for these berms to be upgraded to current USACE levee standards. The berms on this project are not designed as flood control projects and do not function as flood control projects. They more closely resemble spoil pile berms constructed to train flow from the Graham McCulloch Ditch to the west.

- As a contingent value, the team is using 0.65 cfs as the lower boundary for flow necessary for a successful spawning run. Where the wetland widens and the velocity drops, the operating assumption is that the eggs die. The eggs need about 2 feet per second.

- Primary flood risks are assumed to arise from backwater from the St. Mary's and Maumee Rivers and some risk from headwaters flows but little risk from the western side.

- Because headwater flooding is very flashy the carp risk may largely associated with the fish being already in the Graham-McCulloch Ditch at the time a flood occurs.

- The current assumption is that a potential pathway between the edge of the landfill and the railroad has been blocked. The 2009 FIS indicates the area near former landfill is at a higher elevation.

Critical Constraints

Constraints or limits on the Value Study are used to define the boundaries between project aspects that the project stakeholders will consider changing and those that cannot be changed. These constraints may result from a variety of political, technical, schedule, or environmental causes. Excessive constraints tend to inhibit the team's ability to identify creative opportunities for value improvement. Inadequately defined constraints can result in the team's effort being wasted in areas where there is no possibility of change.

Constraints identified for this study were:

- Roger Setters (USACE) noted that there are legal and institutional barriers because the primary benefits are accrued by out of state parties. Congress did not give USACE any dispensation to not have cost share or refrain from placing management burden on a local entity.

- Must not cause flooding in the neighboring communities. Local flooding at 10% recurrence intervals is a major problem for some parts of Ft. Wayne near Junk Ditch.

- The neighboring communities are skeptical of flood risk assurances and will likely require demonstrable proof such as real-time monitoring before accepting any barrier approach

- Project is limited to engineering solutions and does not address approaches such as public education. The project team noted that this is a potential shortcoming because the team perceives a real risk in deliberate or accidental introduction of carp across the wetland divide.

Management Strategy Risks

From the Value Team's understanding of the project management plan, the following risks and opportunities were identified.

- Risk assessment is not yet completed. Other invasive species that may be relevant to this study are *hydrilla* and possibly goby however very unlikely because of the physical factors for their movement. The snakehead, currently in Arkansas, is of concern over the longer term.

- USACE is unwilling to pay for and maintain a directional flow meter because they believe that a short term project will be built before the meter provides valuable data. As Dave Nance, PG of IDNR noted invasive species migration is a larger problem with far reaching consequences and that we need much more data to better manage this and

other invasive species. He urges a more long-term approach and argues that this is a good site for a study area.

- The hydraulic and hydrologic information are incomplete. The development team does not yet know what flood frequency on the St. Mary's will flood Eagle Marsh via Junk Ditch. There are stage and flow gages in the downtown Ft. Wayne area on the Maumee and St. Josephs but they are relatively new.

Quality Objectives

Often, the District project development team or other stakeholders have specific quality objectives for the project. For this project, none were identified by the PDT.

WORKSHOP RESULTS

The purpose of the workshop is to identify and develop alternative concepts that will improve the overall value of the project. In order to be successful at identifying alternatives, it is essential that the Value Team first understand the project objectives and the problems that must be solved. For this reason, the workshop began with presentations by the District's project management to define the project objectives and to provide background information on the project. This was followed by a more detailed presentation of the project plan by the project development team on how the plan will accomplish the project's objectives. This was followed by a more detailed presentation of the existing barrier by Dave Nance, PG of IDNR describing the design parameters and strategies chosen to meet the project's objectives.This Information Phase of the workshop was followed by an in-depth analysis of the functional requirements of the project. A complete understanding of the basic functions that must be accomplished in order to successfully achieve the mission of the project is essential for the team to identify feasible alternatives to the current concept.

Using function analysis and Function Analysis System Technique (FAST) diagramming, the team defined the basic functions of this project as *Block Path.* Key secondary functions that supported this basic function(s) included *Trap Fish, Create Barrier, Separate Basins and Handle Ice*. Analysis of the functions intended to be performed by the project, helped the team focus on the mission of the project and, consequently, how to identify alternative concepts that would still meet the mission while exploring opportunities for value enhancement.

Analyzing the functions of this project gave the team the following key insights:

- The project could be designed to counter the threat of a single species or could include deterrents to multiple invasive species.

- Ice management poses significant design and maintenance challenges for barrier-type projects.

- Trapping fish may be viable as parameters are developed on what inititates movement.

With an understanding of the functional requirements, the Value Team transitioned to the Creative Phase of the workshop and brainstormed on all of the possible ways to accomplish each of those functions. The team generated 111 ideas for potential approaches to achieve the

project's goals which included the 19 ideas previous generated by the project development team.

Based on the team members' professional judgment and input from the District representatives, 11 of these ideas were selected for developing into Value Alternatives. Two of these were from 19 ideas proposed by the development team before the workshop. Furthermore, the team selected Alternative Prev. B-4 as the baseline, and organized the remaining alternatives into 9 scenarios. Prev. B-4 was selected since it was proposed by the development team prior to the workshop.

Value Alternatives

Table 1-1, at the end of this section, includes a complete list of all the Value Alternatives developed. This table shows the number and title of each alternative as well as a summary of the cost savings. The cost savings shown are the capital or first cost savings only.

It should be noted that Value Studies are working sessions for the purpose of developing and recommending alternative approaches to the current plan. As such, the results presented are of a conceptual nature and are not intended as a final design. Detailed feasibility assessment and final design development of any of the alternatives or suggestions presented herein, should they be accepted, remain the responsibility of the District.

Some alternatives presented in this report are variations of a common concept and others are alternatives to a specific aspect of the plan. Thus, not necessarily all alternatives in this report can be implemented as selection of some may preclude or limit the use of others.

These potential savings do not reflect any costs for redesign, which must be considered. Moreover, the full benefit and impact of many of the alternatives goes beyond the cost savings to include improved project performance of required functions.

Optimum Combination of Alternatives

After completing the development of the Value Alternatives, the team reviewed the composite list of alternatives to identify what they believed to be the optimum combination of alternatives. This combination represents the best value solution for the project in the opinion of the Value Team. The review concluded that the maximum project benefits would be realized by combining the alternatives as detailed in Table 1-2 – Optimum Combination.

This combination results in the following potential cost savings:

CB-2 First Cost	$493,000
CB-28 First Cost	$1,023,000
Cost Savings compared to Prev B-4	$2,757,000

The savings from some of the individual Value Alternatives have been adjusted to account for overlapping savings when combined with other Value Alternatives. The calculations for these savings can be found in the Cost Information Appendix to this report.

Design Suggestions

In addition to the Value Alternatives, the team also identified 5 design suggestions. These are suggestions for changes or clarifications to the project documents that did not have an identifiable or quantifiable cost impact that could be determined within the scope of the workshop. The design suggestions from this study are included in Section 5 of this report.

Additional Benefits

A Value Study typically results in benefits beyond cost savings. These benefits are generated as a part of an alternative, design suggestion, or from an observation made by the team or one of the other participants during the workshop. Below are some of the benefits realized from this study, in addition to the cost savings discussed above.

- A more detailed understanding of the risks posed by each of the target species (carp, goby and snakehead) particularly the Asian carp was generated in the workshop and prepared in a summary report, Design Suggestion G-10.

CONCLUSIONS

While a comprehensive effort to separate the Wabash and Maumee River basins provides the most complete solution to blocking the path to Lake Erie, the team concluded that it is not feasible given the time and budget constraints of the current project. The team also acknowledged the insufficient information and, possibly insufficient time to acquire measurements and develop data necessary to inform an optimum solution.

In the near term, the team has elected to focus on a straightforward barrier with the primary purpose of blocking adult carp. The study revealed more complete strategies for blocking carp at Huntington dam as well as in Eagle Marsh. The alternatives nominated as optimum combinations address debris and ice flows, flood protection, protection of Eagle Marsh and potentially barriers for other invasive species. These alternatives also allow adaptive management and can be monitored and modified as the threats are better defined.

The team had not considered contacting colleagues in the Northwest on how to manage fish with jumping and shallow-water slithering capacity. Although much of this expertise is expended protecting salmon and other desirable species by diverting them from intake structures or otherwise directing their path, the same knowledge may be invaluable in deterring invasive fish. This avenue should be pursued.

Table 1-1
Summary of Alternatives

Scenario No.	Alt. Included	Description	First Cost	First Cost Savings
BASELINE	Prev-B-4	Rock/sand berm parallel to I-69 combined with realignment of Graham McCulloch Ditch - variations include sand core berm w/ rock cover; excavation of ditch realignment material used for berm; one or series of innovative release structures **FIRST COST $4,273,000**	$4,273,000	
1				
	CB-2	Create a vertical drop structure	$493,000	
	CB-28	Berm (permeable) with underdrains	$1,023,000	
				$2,757,000
2				
	CB-3	Enhance the fence	$1,780,000	**$2,493,000**
3				
	CB-4	Create a fence berm combination	$332,000	**$3,941,000**
4				
	CB-2	Create a vertical drop structure	$493,000	
	CB-9	Build a permeable barrier (riprap)	$531,000	
				$3,249,000
5				
	CB-25	Build structure and pump around	$863,500	**$3,409,500**
6				
	CB-31	Reroute Graham-McCulloch Ditch to Junk ditch and create barrier downstream floodwall	$5,027,000	**($748,000)**
7				
	CB-35	Build barrier for the longest economic crest for lowest flow depth	No costs developed	

Scenario No.	Alt. Included	Description	First Cost	First Cost Savings
8				
	SB-2	Create storage in both basins	$2,361,000	**$1,911,500**
	Prev B-12	Create a fence or barrier at Huntington Dam	No costs developed	

Table 1-2
Optimum Combination of Alternatives

Alt. No.	Description	First Cost Savings
Combination 1		
Prev B-12	Create a fence or barrier at Huntington Dam	No costs developed
Combination 2		
CB-2	Create a vertical drop structure	$493,000
CB-28	Berm (permeable) with underdrains	$1,023,000
	Total	**$2,757,000**

Section 2

Project Description

SECTION 2
PROJECT DESCRIPTION

The Wabash-Maumee River Basin Connection Study is a planning level study whose purpose is to prevent the Asian Carp and secondarily, other invasive fish species from crossing the basin divide at Eagle Marsh and entering the Maumee watershed draining to Lake Erie. The marsh is near Fort Wayne, Indiana and is the saddle point between the Wabash Basin and the St. Mary's River. The St. Mary's and the St. Joseph's rivers form the Maumee River. (see map on next page)

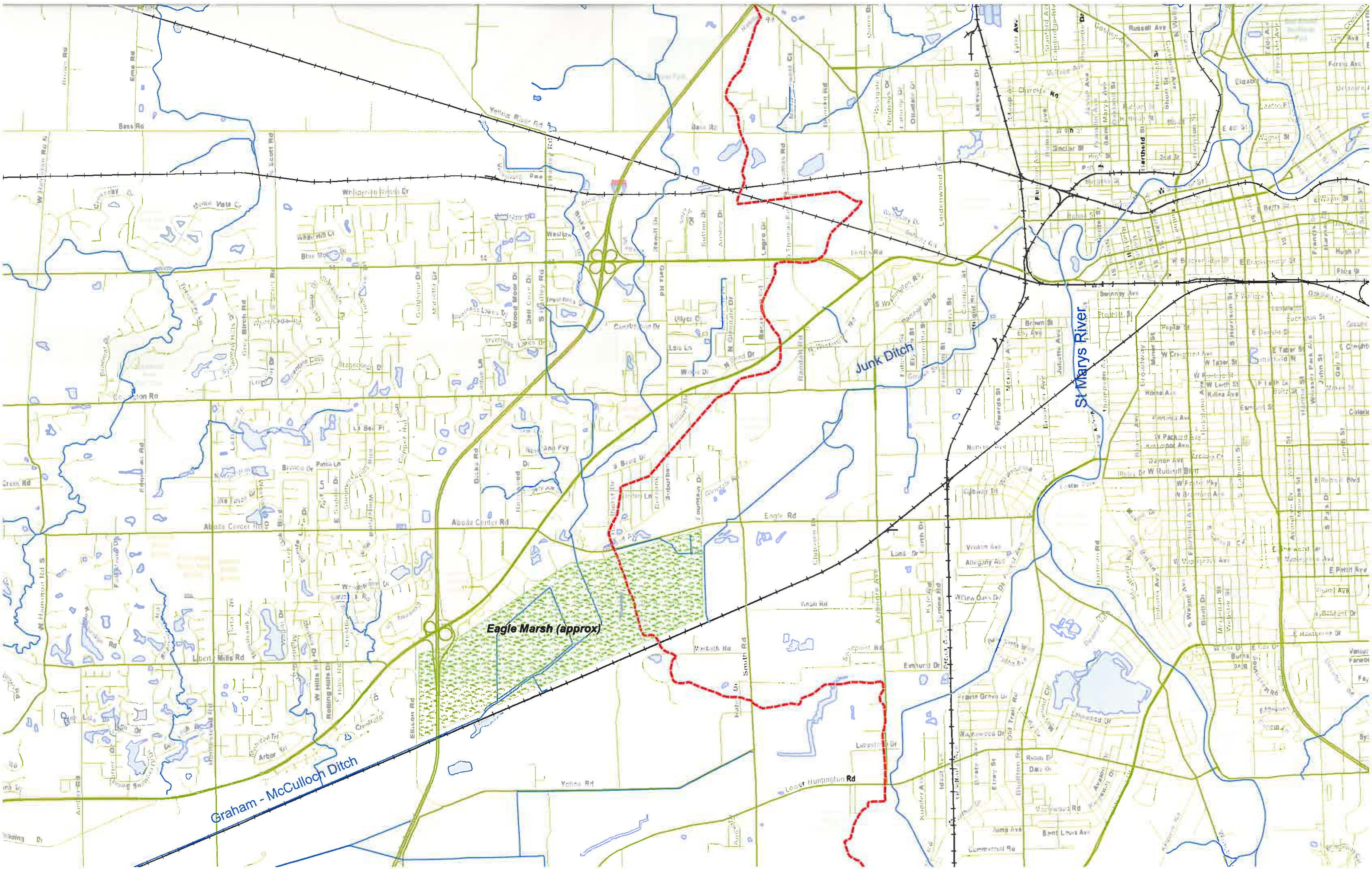
Although 53 invasive species threaten the region, the most imminent threat is posed by the members of the Asian Carp family particularly bighead and silver carp. These fish have expanded their range into the Wabash basin and were sighted attempting to jump the low-head dam at Williams Dam on the East Fork of the White River.

Figure 1. Eagle Marsh – Photo courtesy of TetraTech

They are presently about 20 miles downstream of Eagle Marsh.

Figure 2. Graham-McCulloch Ditch – Photo courtesy of TetraTech

The fish multiply rapidly and consume the aquatic plants, phytoplankton, zooplankton and small mollusks forming the base of the food chain which supports the Great Lakes ecosystem. If the fish establish breeding populations in the Lakes, the economic and ecological implications are serious. US Fish and Wildlife estimates the economic value of the sport and commercial industries in the Great Lakes at between $4.5 and $7 billion and the economic value of waterfowl hunting at $2.6 billion. The damage that these fish would do to hunting, fishing and recreational boating is a source of considerable debate but the desirability of denying carp access to the Great Lakes is not. The primary access route is through the Chicago Sanitary and Ship Channel and much of the national effort is focused on blocking that route. The present project seeks to deny access through the minor route between the Junk Ditch and Graham-McCulloch Ditch through the Eagle Marsh.


Eagle Marsh (approx)
Graham - McCulloch Ditch
Junk Ditch
St Marys River
Bass Rd
Covington Rd
Aboite Center Rd
Eagle Rd
Liberty Mills Rd
Yohne Rd
Lower Huntington Rd
Smith Rd
Engle Rd
Knoll Rd
Ellison Rd
Russell Ave
Broadway
Hartman Rd

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There are several constraints that form the project approach. The marsh receives flows from several sources many of which contribute to frequent flooding in either Ft. Wayne or Huntington, IN. Any physical barrier must be designed to avoid exacerbating this problem. Moreover, in the design team's estimation, any such barrier must include demonstrable proof that flood levels are not increased. A hydraulic model demonstrating no-net-rise would likely not be sufficient while on-site, real-time monitoring of water depth would be. Alterations to Junk Ditch or Graham McCollouch Ditch are particularly influenced by this constraint. A physical barrier in the marsh will most likely include some combination of a highly permeable barrier that does not restrict water flow, construction of regional storage sufficient to lower flood elevations in both the Wabash and Maumee basins and prevent trans-basin mixing, or diversion of flows away from the marsh in such a manner as to avoid additional flooding.

The absence of a suitable sponsor also presents a challenge. This project is not exempt from the 65% federal-35% local sponsor requirement. The primary beneficiaries of a successful project are commercial and recreational interests near Lake Erie. Neither Indiana state agencies nor the City of Ft. Wayne have expressed a strong interest in the necessary cost sharing agreement. The protection of Eagle Marsh and urban flood control are understandably higher priorities. Development of a Great Lakes-based public-private compact to agree to the cost-share requirement is one alternative. Designing the project to include sufficient local benefits to attract a local sponsor is another. Presently $7.5 million including sponsor cost share is authorized under Ecosystem Restoration can be expended to design and build the project. If the estimated cost exceeds $7.5 million the project must then go through the more typical feasibility process. The absence of a compelling reason for local sponsorship coupled with the agreement to remove the temporary fence within five years constitutes significant constraints on the project.

The absence of rigorous technical information regarding both the local hydraulics and the necessary conditions for carp migration further complicate this project. The precise conditions in which backwater effects produce flows across the wetland of sufficient depth and velocity are not well defined. At present, it appears that successful migration of the carp across the wetland requires that the fish be in the Wabash headwaters steam during or within a few hours of backwater incursion from the Maumee basin. The area does not have a sufficient stage or flow gauge history to construct a thorough risk assessment of this occurrence. The triggers for carp spawning runs are broadly defined. It is clear that this fish is highly adaptable; it is less clear how to create a sufficiently inhospitable environment to serve as an effective carp deterrent without serious harm to native species.

Adult carp are temporarily excluded by a reinforced chain-link fence across Eagle Marsh. IDNR was the lead agency responsible for the design and construction of the 1,177-foot main fence and 494-foot supplemental debris fence. The marsh is an NRCS wetland restoration site and is jointly owned and maintained by the Little River Wetlands Project and IDNR.

Center Section of the Fence
with Debris Fence

Above photos courtesy of Dave Nance

The schedule for the project is not yet developed but given the operating constraints, the time frame is between 18 months and 5 years.

SECTION 3

VALUE STUDY PROCESS

SECTION 3
VALUE STUDY PROCESS

This section describes the process used to conduct this Value Study and the significant findings of the Value Team. This Value Study used the international standard Value Methodology established by SAVE International, the Value Society. The standard establishes the specific 6-Phase, sequential process, and the objectives of each of those phases, but does not standardize the specific activities in each phase.

Value Methodology (VM) is the general term that describes the structure and process for executing the Value Workshop. This systematic process was used with a multidisciplinary team to improve the value of the project through the analysis of functions and the identification of targets of opportunity for value improvement.

The **VM Job Plan** provides the structure for the activities associated with the Value Study. These activities are further organized into three major stages:

1. Pre-Workshop preparation
2. VM Workshop
3. Post-Workshop documentation and implementation

Figure 3-2 at the end of this section shows a diagram of the VM Job Plan used for this Value Study.

DEFINING VALUE

Within the context of VM, Value is commonly represented by the following relationship:

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

In this expression, functions are measured by the performance requirements of the customer, such as mission objectives, risk reduction and quality improvements. Resources are measured in materials, labor, price, time, etc. required to accomplish the specific function. VM focuses on improving Value by identifying the most resource efficient way to reliably accomplish a function that meets the performance expectations of the customer.

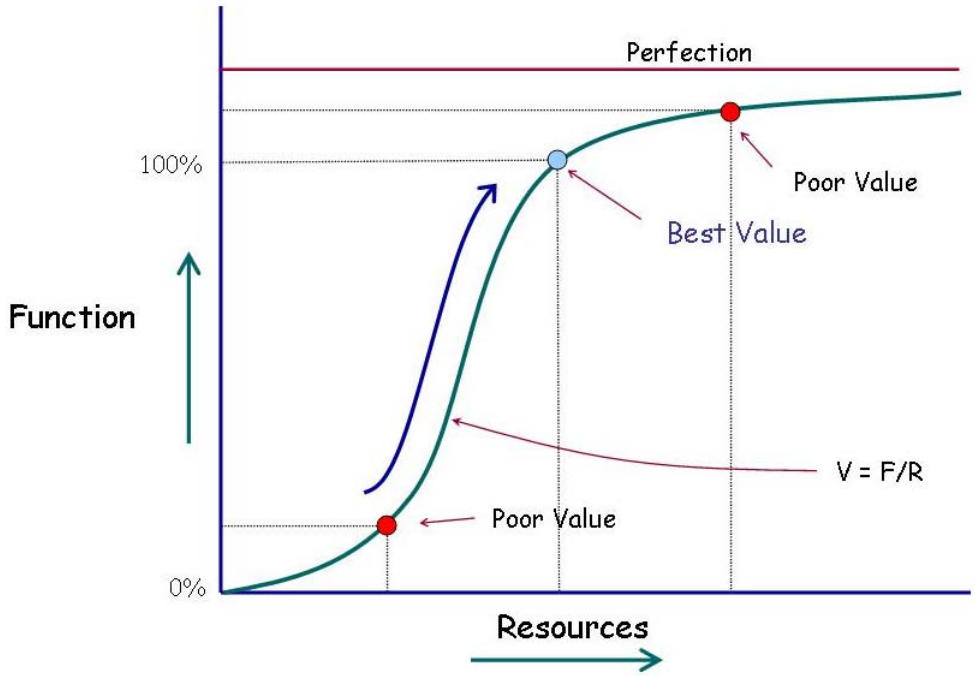
It can be seen from this relationship that Value is improved or increased by:

1. Increasing function without increasing resource consumption. Some increase in resources is acceptable as long as there is a greater increase in function performance.
2. Decreasing resources without decreasing function. Again, some decrease in function may be acceptable if the corresponding decrease in resources is significant enough.

Ideally, the Value Team looks for opportunities to increase function and concurrently decrease resource requirements. This will achieve the best value solution.

This Value concept is illustrated in the Figure 3-1, The Value Curve. This figure shows a hypothetical curve from plotting the value expression above. This curve will asymptotically approach perfection. The best value solution for a given project or project element will be found at the knee of the curve. At this point the required function or functions have been achieved to 100% of the required level with a corresponding minimum resource commitment. To attempt to increase the function performance beyond this level will result in a resource consumption that has a higher worth than the marginal increase in function. This results in a poor value solution. Conversely, a poor value solution can also be the result of not achieving the function to 100% of the requirement. In this case, an incremental increase in resources delivers significant increase in function performance. The Value Methodology is used to identify the poor value decisions in a project and then develop alternative solutions to better align the project along this curve to achieve a best value solution.

Figure 3-1
The Value Curve™



This understanding of how Value is affected by changes in function or resources provides the foundation for all SVS Value Studies. The following paragraphs describe the process we used to understand the functional requirements and how we identified value improvement alternatives.

PRE-WORKSHOP

Prior to the start of the workshop, the team was tasked with reviewing the most current documentation on the project development. This was done to familiarize them with the project plan and to prepare them for asking questions of the project stakeholders during the project presentations at the beginning of the workshop. Much of the background information for this study was generated by the District in-house staff. Other pre-workshop activities included:

- Coordinating workshop logistics and communicating those to the various participants
- Providing guidance to the District on presentation content for the project introduction
- Scheduling workshop participants and assigning tasks to ensure the team is prepared for the workshop
- Gathering necessary background information on the project and making sure project documentation is distributed to the team members

Materials furnished to the team by the District are listed in the Appendix.

VM WORKSHOP

The VM workshop was an intensive session during which the project plan was analyzed to optimize the balance between functional requirements and resource commitments (primarily capital and O&M costs).

The VM Job Plan used by SVS includes the execution of the following phases during the workshop:

1. Information Phase
2. Function Analysis Phase
3. Creative Phase
4. Evaluation Phase
5. Development Phase
6. Presentation Phase

Information Phase

At the beginning of the workshop, it was important to understand the background of the project from which the plan was developed. This background was provided in an oral overview by the District. The overview and subsequent project analysis provided information on the following topics:

- Rationale why this project is necessary

- Project objectives that have governed the proposed plan
- Rationale for the proposed plan configuration
- Explanation of plan features, criteria, and assumptions
- Value Study constraints
- Project cost

The District project management presentation provided the team with an overview of the goals, issues, and expectations for the project. The District and the Value Team also finalized the Value Study constraints. This was followed by the District's project development team's more detailed presentation on the project plan and an explanation of the rationale behind key plan decisions. Further, this gave the project development team an opportunity to share their issues and concerns about the project from their perspective.

From these presentations, the Value Team noted the following key information:

- Asian carp are reported as attempting to jump a dam
- Detailed information as to the stimuli to begin upstream migration is limited
- It is not known how far upstream Asian carp will migrate into headwater streams.
- Threats from other species are still being defined
- The hydraulic and hydrologic conditions under which Eagle Marsh becomes a viable bridge between the Wabash and Maumee basins are ill-defined
- Water levels in Eagle Marsh influence urban flooding in Ft. Wayne, IN and other communities; therefore any manipulation at the marsh must be accomplished without exacerbating flooding in populated areas.
- There is no apparent local sponsor for this project. On the contrary, local interests may perceive any changes to the marsh as increasing their already problematic flooding.

Function Analysis Phase

Function Analysis is the heart of the VM process and is the key activity that differentiates the VM process from other problem solving or improvement practices. During the Function Analysis Phase of the VM Job Plan, functions are identified that describe the expected outcomes of the project under study. Function Analysis also defines how those outcomes are expected to be accomplished by the plan. These functions are described using a two-word, active verb and measurable noun pairing.

This identification and naming convention of project functions enables a more precise understanding by limiting the description of a function to an *active verb* that operates on a *measurable noun* to communicate what work an item or activity performs. This naming

convention also helps multidisciplinary teams to build a shared understanding of the functional requirements of the project.

Function Determination

Defining functional requirements for the project allowed the District to be sure that the facility, with the current plan, would fulfill the needed purposes. The entire project was analyzed to determine what functions are being accomplished by the current plan. Required functions were retained. Some functions were not necessary to accomplish the mission of the project and thus became candidates for deletion.

During the Function Analysis Phase, the Value Team used various function analysis techniques to analyze the project. This analysis helped the team confirm its understanding of the overall project objectives and analyzed the functions of key project elements. The Value Team Leader led the team through an in-depth discussion of the possible functions of each key project element to clearly and precisely identify the purposes of each.

FAST Diagram

Function analysis was enhanced by using a graphical mapping tool known as the *Function Analysis System Technique* (FAST), which allows team members to understand how the functions of a project relate to each other. The resulting FAST Diagram allowed quick visualization of the logical relationship between project functions and the project as a whole. The FAST diagram is in the Function Analysis section of the Appendix.

The FAST Diagram is structured such that moving to the right of any function answers the question, “How are we accomplishing this function?” Moving to the left of any function answers the question, “Why are we accomplishing this function?” Elements that are vertically connected occur “When” or as a consequence of the function it is connected to on the horizontal path.

The diagram shows on the far left that the ultimate function or the mission that must be accomplished by this project is to Block Passage. This is accomplished by (Narrate or read the FAST diagram for the reader)

The functions between the two dashed lines, called Scope Lines, represent the functional elements of the project which are within the scope of the Value Study. The first column of functions (basic functions) within the left Scope Line represents the functions that must occur in order for this project to successfully accomplish its mission. The remaining functions (secondary or support functions) represent how the current plan has chosen to accomplish those basic functions.

Function Findings

From the function analysis of this project, the team concluded that:

- The project could be designed to counter the threat of a single species or could include deterrents to multiple invasive species.
- Ice management poses significant design and maintenance challenges for barrier-type projects.
- Trapping fish may be viable as parameters are developed on what inititates movement

- The three primary measures by which invasive species can be deterred in this case are creating a barrier, separating the basins and potentially trapping.

In addition to identifying the essential project functions, this phase of the workshop also serves two other objectives:

1. The unification of the individual Value Team members into a synergistic, cohesive team, and

2. The stimulation of creative ideas prior to beginning the subsequent creative phase.

The function analysis worksheets are included in the Appendix.

Creative Phase

This step in the VM process involved generating ideas using creativity techniques. The team recorded all ideas regardless of their feasibility. In order to maximize the Value Team's creativity, evaluation of the ideas was not allowed during the creative phase. The team's effort was directed toward a large quantity of ideas. These ideas were later screened in the Evaluation Phase of the workshop.

The creative ideas generated by the team are included in the Appendix. The list also includes ratings for each idea based on the Evaluation Phase of the workshop. These lists should be carefully reviewed, as there may be other good ideas not developed by the team because of time constraints. These should be further evaluated or modified to gain the maximum benefit for the project.

Evaluation Phase

In this phase of the workshop, the team selected the ideas with the most merit for further development.

After an initial vote, the Value Team Leader assessed how many ideas could be developed into Value Alternatives within the remaining duration of the workshop. From this assessment, all ideas with a certain number of votes were selected for development. However, prior to the final selection, the results were revisited collectively by the Value Team to ensure that those selected by the voting process truly represented the best ideas for development. This gave the team the opportunity to down-rate some ideas and to up-rate other ideas based upon team discussion of the ideas.

The criteria used for selection were:

1. The inherent value, benefit and technical appropriateness of the idea

2. The expected magnitude of the potential cost savings, both capital and life cycle

3. The potential for the District acceptance of the idea

Ideas were selected for development as Value Alternatives based on all three criteria.

Not all ideas were developed. This evaluation process is designed to identify those ideas with the greatest potential for value improvement that can be developed into Value Alternatives within the time constraints of the workshop and the production capacity of the team. The remaining ideas were eliminated from further consideration by the team; however, the ideas not developed should also be reviewed, as there may still be other good ideas not developed by the team because of time constraints or other factors. These could be further evaluated or modified to gain the maximum benefit for the project.

To further ensure the Value Team is focused on developing the best ideas, a mid-point review meeting is conducted with the Value Team Leader and the District representatives. This mid-point review allowed the District to identify any fatal flaws in the ideas that were not apparent to the Value Team but were apparent to the District project team because of their greater institutional knowledge of the project. These fatal flaws may be technical, operational, political, etc.

Development Phase

During the Development Phase of the workshop, each idea was expanded into a workable alternative to the original project concept. Development consisted of preparing a description of the value alternative, evaluating advantages and disadvantages, and making cost comparisons.

Each alternative is presented with a brief narrative to compare the original concept and the alternative concept. Sketches and brief calculations were also developed, if needed, to clarify and support the alternative. The value alternatives developed during the workshop are presented in Section 4 – Value Improvement Alternatives.

The Value Team Leader and, to the extent possible, other team members reviewed each alternative to improve completeness and accuracy.

Redesign costs are not included in the cost comparison of alternatives. the District will be responsible for determining these costs.

Presentation Phase

The last phase of this workshop was the presentation of the Value Alternatives. The presentation was made by the Value Team on January 21, 2011 to representatives of the District's project team. The Value Team described each Value Alternative and the rationale that went into the development. This was followed by answering the audience's questions. The acceptability of the Value Alternatives was deferred pending the District's review of our Preliminary Report.

From this presentation, the following key points of discussion were noted:

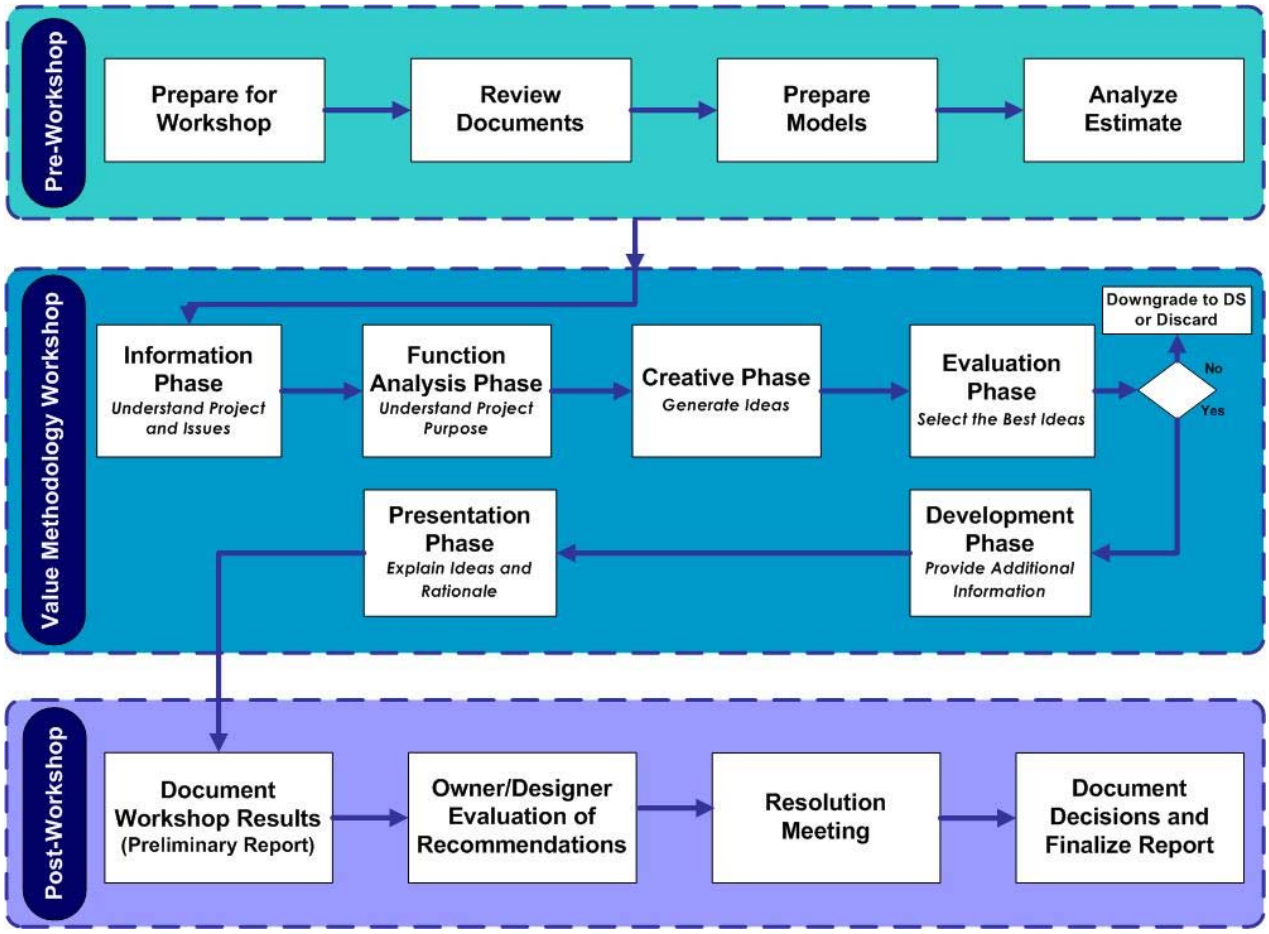
- The importance of providing appropriate drainage for any potential barrier was stressed. While permeable berms are attractive, the addition of drop structures will be required.

- Land acquisition is likely to be problematic and will strongly influence selection of the preferred option. Specifically the team was not able to readily identify acreage suitable for storage on a large enough scale to materially influence flood levels.

POST-WORKSHOP

The Post-Workshop activities of this Value Study consisted of preparing the Value Study Reports. Shortly after the conclusion of the workshop, our Preliminary Report was submitted to the District for review. This report contained the raw workshop product. This Final Value Study Report includes documentation of the Value process, as well as, the Value Alternatives developed during the workshop. The decisions regarding implementation of the alternatives are documented outside this report.

Figure 3-2
Value Engineering Process Diagram



SECTION 4

VALUE ALTERNATIVES

SECTION 4
VALUE ALTERNATIVES

The results of this Value Study represent the value improvement opportunities that can be realized on this project. They are presented as individual alternatives for specific changes to the current plan.

Each alternative includes:

- A summary of the original concept
- A description of the alternative concept
- A brief narrative comparing the original plan and the recommended change
- Sketches, where appropriate, to further explain the alternative
- Calculations, where appropriate, to support the technical adequacy of the alternative
- A capital cost comparison
- And a life cycle cost analysis, if appropriate

Cost was the primary resource that was compared to the functions being accomplished in the project. To ensure that costs were compatible within the Value Alternatives proposed by the team, the project cost estimate was used as the basis of cost.

EVALUATING THE VALUE ALTERNATIVES

Each part of a Value Alternative should be evaluated on its own merit, rather than discarding an entire Value Alternative because of concern over a particular aspect of the proposed change. Furthermore, the District is encouraged to review all of the ideas shown in the creative idea listing in the Appendix. Since the Value Team was constrained by a finite duration for the workshop and the production capacity of the team not all ideas were developed. Therefore there may be other ideas in that list that would provide additional value improvement opportunities for the project.

ORGANIZATION OF ALTERNATIVES

The alternatives presented on the following pages are organized by concept (scenario), that is, alternative solutions to the project objective(s). The project or functional categories used to organize the alternatives and design suggestions are as follows:

Create Barrier (CB)

Separate Basins (SB)

Trap Fish (TF)

General (G)

Ideas Previously Generated By Project Team (Prev)

Handle Ice (HI)

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Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
Prev. B-4

Title:
Rock/Sand Berm Parallel to I-69 w/ Graham-McCulloch Ditch realigned (Baseline)

Description of Proposed Concept:

The alternative concept is to:

- realign the Graham-McCulloch Ditch to the north edge of the Eagle Marsh property from downstream of the wastewater treatment plant to the I-69 roadway fill, and then parallel to the I-69 roadway to the existing I-69 bridge over the railroad and existing Graham-McCulloch Ditch;
- reconstruct confining berm(s) separating the realigned Graham-McCulloch ditch from Eagle Marsh during low flows, but allowing overtopping at select locations at high flows to inundate the wetlands areas. The downstream arm of the confining berm parallel to I-69 would be constructed of permeable materials such as uniformly graded riprap with sand core and an overflow structure near the I-69 Bridge. The berm would block the existing Graham–McCulloch Ditch alignment and tie-in to the existing railroad berm.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☑ Maintained
☐ Decreased	☐ Decreased

Cost Savings Summary

First Cost:	$ 4,273,000

Advantages/Disadvantages

Alternative No.: Prev B-4

Advantages of Alternative Concept

- Creates a barrier to migration of invasive species by separating the watersheds with flow only allowed between basins through the sand/riprap berm, except at extreme high flow events.
- Sand core of berm prevents migration of microscopic and larger organisms and eggs of larger organisms.
- Confining berm separates urban runoff with low water quality from upper Graham-McCulloch watershed from Eagle Marsh during minor flood events.
- Realignment channel passes low flows, preserving the majority of storage in Eagle Marsh for high flow flood events that create backwater flooding from the St. Mary's River across the existing basin divide.
- Potential opportunity to improve Eagle Marsh performance as a wetland.

Disadvantages of Alternative Concept

- Requires coordination with railroad for real estate rights to tie into railroad berm.
- Significantly affects function of existing Eagle Marsh. NRCS has expressed reservations to alternatives affecting Eagle Marsh function.
- Sand filter and/or riprap could potentially "clog" over time with sediment "filtered" from flood waters, requiring periodic maintenance to remove accumulated sediment
- Will likely trap debris and/or ice, requiring periodic removal of debris
- Design of berm to achieve necessary permeability to prevent flooding could be difficult to achieve. Present models suggest about 1800 cfs would be required to pass the 1% flow without surcharge. With a length of about 2000 feet and a height at the 1% flow of about 3 feet, the structure would need to pass flow of about 0.3 ft/sec to avoid a surcharge.

Discussion

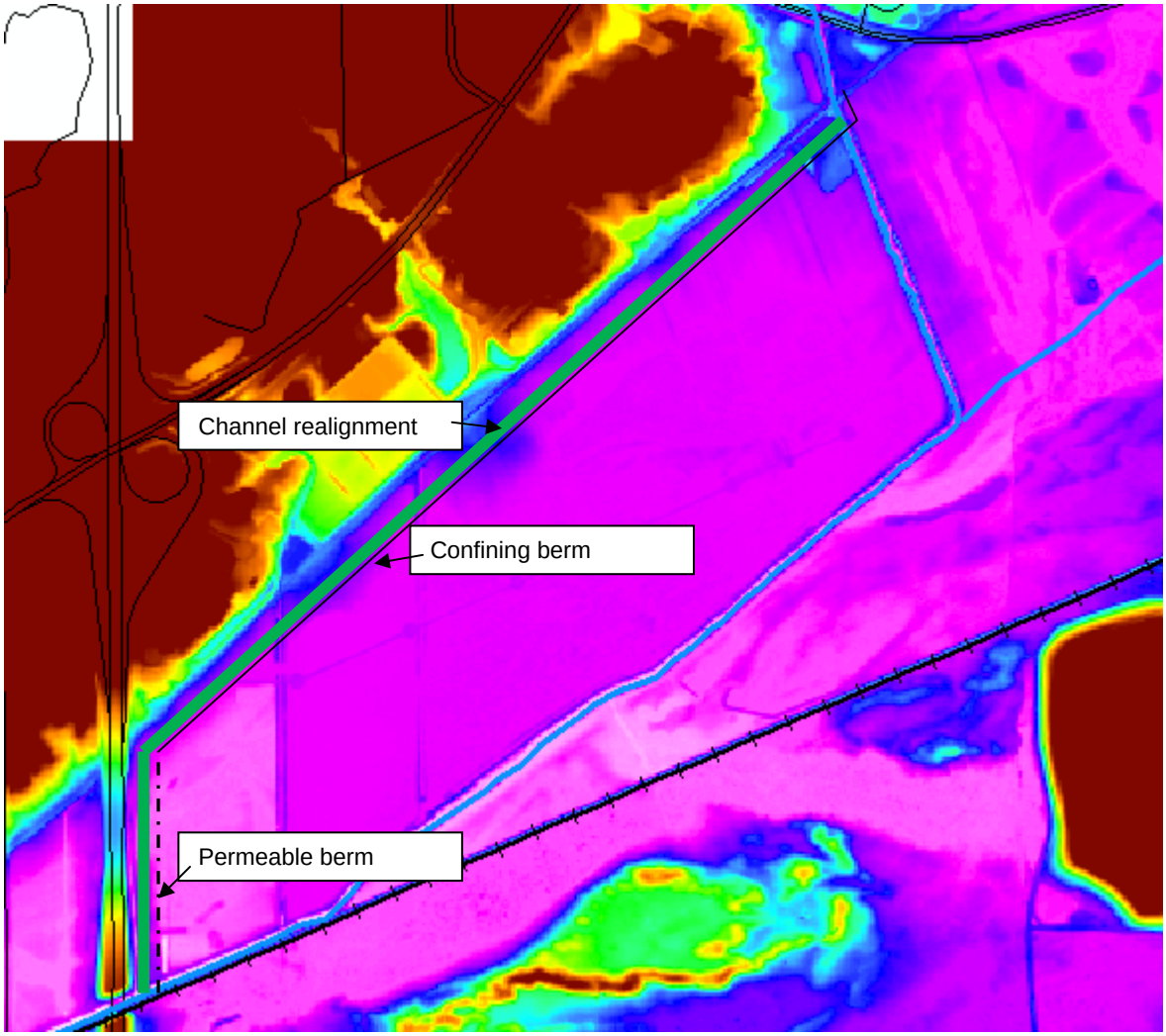
Alternative No.: Prev B-4

This concept creates a barrier to multiple invasive species by establishing a physical structure separating the two basins, while allowing flood flows from backwater flooding on the St. Mary's river to pass through the pervious berm structure. Realigning the Graham-McCulloch Ditch around the Eagle Marsh to downstream of the barrier and isolating it from Eagle Marsh allows passage of daily flows and saves the storage volume within the Eagle Marsh for extreme flood events on the St. Mary's River. Separating daily flows from Eagle Marsh protects the Marsh from regular contamination of low quality urban runoff. An emergency overflow structure would be required to pass extreme flood events.

Sketch

Alternative No.: Prev B-4

☐ Original ☑ Alternative

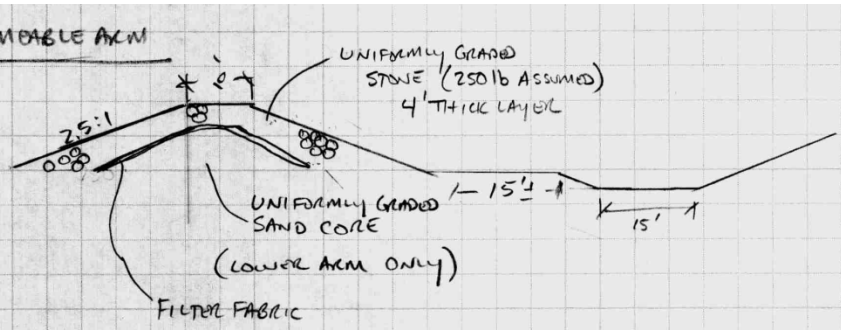


Calculations

Alternative No.: Prev B-4

☐ Original ☑ Alternative

PERMEABLE ARM



VOLUME SAND CORE / LF = $\frac{1}{2}(6' \times 15') \times 2 + (6' \times 2') = 102$ CF/LF

LENGTH SAND CORE / RIPRAP ARM ≈ 1750 LF

VOLUME SAND = 178,590 CF = 6614 CY SAY 6600 CY

VOLUME RIPRAP / LF ≈ $\frac{1}{2}(10 \times 25) \times 2 + (10 \times 10) - 102$ CF/LF (VOL. SAND)

≈ 350 CF/LF − 102 CF/LF = 248 CF/LF

VOLUME RIPRAP ≈ 248 × 1750 = 434,000 CF = 16,074 CY

SAY 16,100 CY

STANDARD BERM:

ASSUME VOLUME BERM ≈ 350 CF/LF PER ABOVE

VOLUME RIPRAP ONLY ON REALIGNED DITCH SIDE ≈ 125 CF/LF

LENGTH = $(4.8/3.5 \times 5280) = 7241$ SAY 7250

↑ Measured on Map

VOLUME COMPACTED SOIL = $(350 - 125) \times 7250 = 1{,}631{,}250$ CF = $60{,}416.\overline{6}$ CY

VOLUME RIPRAP = 125 × 7250 = 906,250 CF = 33564.8 SAY 60,400 CY

SAY 33,560 CY

FILTER FABRIC ENTIRE LENGTH = 7250 + 1750 = 9000 LF × 1.1 = 9900 LF

Calculations

Alternative No.: Prev B-4

☐ Original ☑ Alternative

SA/LF FILTER FABRIC = $\left(\sqrt{6^2 + 15^2}\right) \times 2 + 10 = 42.3$ SAY 45 SF/LF

SA FILTER FABRIC = 45 SF/LF × 9900 LF = 445,500 SF

EXCAVATION DITCH REALIGNMENT

ASSUME 75% EX GROUND ELEVATION AVERAGE

LENGTH ≈ 9000 LF

VOLUME EXCAVATION/LF ≈ $\frac{1}{2}(4 \times 10) \times 2 + 15 \times 4 = 100$ CF/LF

VOLUME ≈ 900,000 CF = 33,333 CY

CONCRETE OVERFLOW STRUCTURE

ASSUME 200 CY CONCRETE

Construction Cost Estimate

Alternative No.: B-4

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Uniformly Graded Sand	CY	$30	6600	$198,000		
Uniformly Graded Riprap (250 Lb)	T	$37	67,041	$2,480,517		
Embankment	CY	$12.45	60,400	$751,980		
Filter Fabric	SY	$2.45	49,500	$121,275		
Excavation	CY	17.85	33,333	$594,994		
Concrete for Overflow Structure	CY	$200	200	$40,000		
Seed and Straw	SF	$0.10	445,500	$44,550		
Remove store and replace topsoil	cy	$5	8,250	$41,250		
TOTALS				$4,272,566		

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SCENARIO 1

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
CB-2

Title:
Create a vertical drop structure

Description of Original Concept:

Realign the Graham-McCulloch ditch and construct a confining berm that provides overflow in select locations and will allow seepage in others. The berm will act as a physical barrier for migration of invasive species. (See Alternative B-4 for details.)

Description of Alternative Concept:

The alternative concept is to utilize the Homestead Road embankment as an impermeable earthen levee that would block all low flow in the Graham-McCulloch Ditch except through a vertical drop structure similar to drop inlet structures on lakes to control water levels. Flows would be controlled by multiple vertical risers. Low flow would be maintained by small diameter openings at low levels of the drop inlet with the inlet ends buried in open graded gravel. Storm water from the Maumee Basin discharging through Eagle Marsh would be temporarily stored in the areas upstream of Homestead Road and discharge through the drop inlet structures. A short section of levee would need to be constructed between the railroad and the Homestead Road embankment. Assume the levee height would be 10 feet above existing ground with 3H:1V side slopes and 75 feet in length. Drop inlets would be constructed along the length of Homestead Road with pipe jacked under Homestead Road. The drop structures would be designed to pass 500 cfs for up to 5 days.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased

Cost Savings Summary

Prev B-4 First Cost:	$ 4,273,000
CB-2 First Cost:	$ 493,000
CB-28 First Cost:	$ 1,023,000
Cost Savings:	$ 2,757,000

Advantages/Disadvantages

Alternative No.: CB-2

Advantages of Alternative Concept

- Significantly reduces risk of invasive species moving towards Lake Erie. Intake screens would reduce risk of gobi and other species migrating into the Wabash Basin depending on screen size. Vertical drop would be sufficient to stop Asian Carp from migrating upstream.
- Maintains hydraulic characteristics of area. No increase in flooding. May reduce peak flooding downstream slightly.
- Can utilize existing Homestead Road embankment with some modifications reducing construction work and schedule.
- Would allow removal of the fence barrier in Eagle Marsh and eliminate any long term impacts to the Marsh. Would cause longer periods of inundation of Eagle Marsh which would be a positive.
- Would increase upper drainage area wetlands by about 400 acres with land between Homestead and I-69.

Disadvantages of Alternative Concept

- Maintenance cost after each significant rainfall event
- Risk of debris, sedimentation and ice blocking the inlet structures
- Increased risk of inducing flooding in Ft Wayne if outlet structure is partially or fully blocked. Could cause inundation of Homestead and Ellison Road. Overtopping of Homestead Road would increase risk of ANS from the Maumee Basin to migrate into the Wabash Basin.
- Requires a long term sponsor which has not been identified.
- Would require periodic inspections and removal of debris from inlet structures
- Some Maumee Basin species would be able to pass through drop structure into the Little River
- Requires easement or purchase of land between I-69 and Homestead Road. Most likely this would be a cost to NRCS. The land in question is frequently flooded agricultural property and several landowners have approached NRCS expressing a desire to enter the Conservation Reserve Program.

- Would retain some floodwater longer than current condition which may be perceived negatively by the public.

Discussion

Alternative No.: CB-2

The alternative concept is to utilize the Homestead Road embankment as an impermeable earthen levee and install drop inlet structures. Low flow would be maintained by several small diameter inlets into the drop structure buried in open graded gravel. A short section of levee would need to be constructed between the railroad and the Homestead Road embankment. This alternative assumes the levee height would be 10 feet above existing ground with 3H on 1V side slopes and 75 feet in length. Flow rates are estimated at 500 cfs for up to 5 days. Outlet headwalls and channels back to the Graham-McCulloch Ditch would need to be constructed.

Both faces of the Homestead Road embankment may need wave action erosion protection. The west face would also serve as a physical deterrent for snakehead.

Maintenance and inspection would likely be required after each flood event. Debris would need to be removed periodically from the inlet structure area.

Advantages of this alternative are reduced operating costs associated with pumping water, creation of additional wetlands, ability to leverage with NRCS wetland funds. Little River Wetlands is a potential administrator of the additional wetlands and construction would be confined within a small area outside of the sensitive Eagle Marsh area. This alternative allows removal of the temporary fence barrier at Eagle Marsh and risk of Asian carp and snakehead migrating from the Wabash to the Maumee Basin through this pathway is greatly reduced, migration of goby and species in the Great Lakes/Maumee Basin to the Wabash is somewhat to greatly reduced.

This alternative would require the owner to inspect, monitor, maintain, operate and repair the facilities. Operation cost will be incurred for inspection and periodic debris removal.

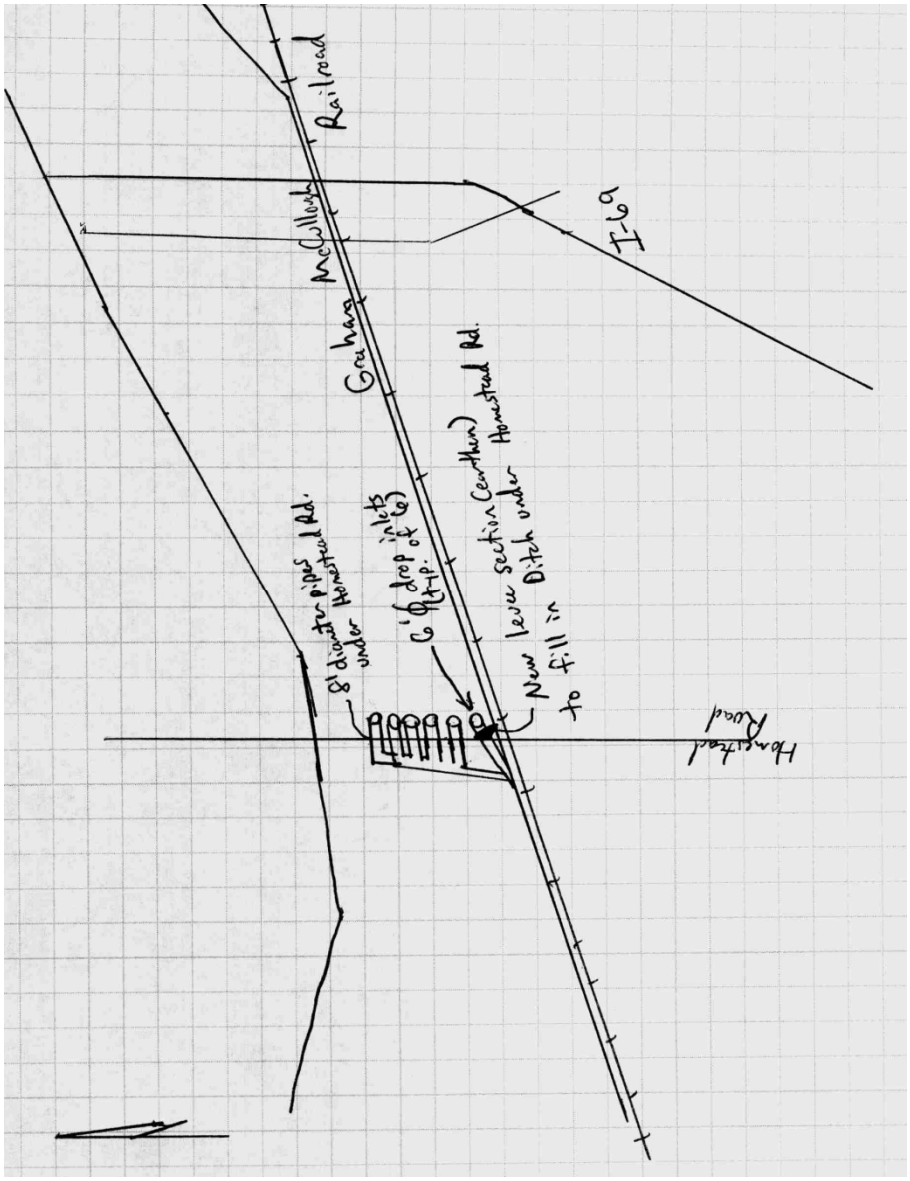
The levee would be approximately 75’ in length beginning at the railroad embankment and tie into the highway embankment. Six new 6 foot diameter PVC or concrete riser pipe or box inlets would be constructed on the east side of Homestead Road at locations across the length of Homestead Road. Each structure would carry approximately 92 cfs at 1.3 ft of head on the inlet structure. Total maximum design flow of 500 cfs would be met. An eight foot diameter horizontal pipe, each 100 feet in length will carry storm water from the drop inlets from the east side of Homestead Road under the road to discharge on the west side of the road. Excavation depth would be approximately 10 feet. Some earthwork would be needed to construct ditches from the end of each outlet pipe back to the Graham-McCulloch Ditch.

Redundant water level sensors located on the east and west side of Homestead Road would send information to the project owner. The inlet structures would be designed to minimize collection of debris, handle ice and potential to block flow with the use of grating.

Sketch

Alternative No.: CB-2

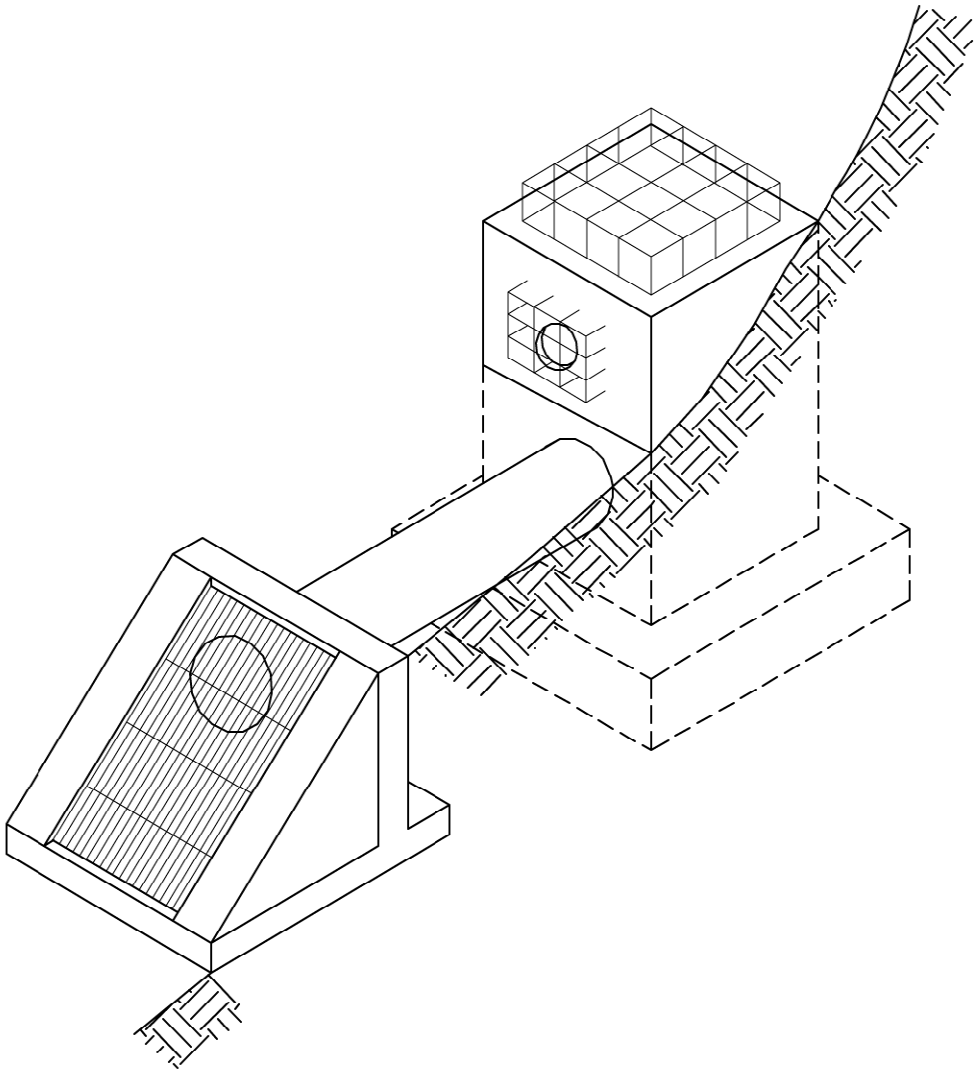
☐ Original ☑ Alternative



Sketch

Alternative No.: CB-2

☐ Original ☑ Alternative



Calculations

Alternative No.: CB-2

☐ Original ☑ Alternative

H=(.3225xQ/L)^2/3 for a broadcrested weir

H=Head on weir (FT), Q=Weir flow (CFS), L=Weir Length (FT)

Assumed 6'diameter inlet, 92 cfs results in 1.3 feet of head.

500 cfs flow rate

(Flow rate provide by project Hydraulic Engineer.)

Calculations

Alternative No.: CB-2

☐ Original ☑ Alternative

Levee earthwork

Assume levee is 10 feet tall, 5 feet wide at top and 3/1 slopes, 75 feet long

2x1/2x30x10=300 10x5=50 Total cross-sectional volume is 350 sq ft.

350x 75= 26250 cu ft =973 cu yds

Outlet channel excavation

Assume outlet pipes are 50 feet apart. Total length of outlet channel would be

50+100+150+200+250= 750 LF

Assume cross-section is 10 ft bottom with 3/1 slopes, 6 ft deep

Cross-section is 10x6+3x6x6=168 sq ft

Volume 168x750/27=4667 cu yds

Aggregate on Homestead Road slopes, assume 1 ft deep

2x1600x10=32,000 sq ft x 1 ft = 1185 cy

1185 cy x 1.35 T/cy = 1600 T

Construction Cost Estimate

Alternative No.: CB-2

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
75' earthen berm 10' high, 3/1 slopes.	CY	$30.30			973	$29,500
8' diameter PVC pipe	LF	$375			600	$225,000
6' diameter Concrete pipe	LF	$250			60	$15,000
Concrete inlet with grated structure	EA	$2,500			6	$15,000
Outlet earthwork	CY	$30.30			4,667	$141,410
Road cuts (5 cuts @ 10 ft deep)	Ea	$1,500			5	$7,500
Aggregate on embankment slope 1 ft deep	T	$37			1,600	$59,200
TOTALS						$492,610

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Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
CB-28

Title:
Berm (permeable) with underdrains

Description of Original Concept:

Realign the Graham-McCulloch ditch and construct a confining berm that provides overflow in select locations and will allow seepage in others. The berm will act as a physical barrier for migration of invasive species. (See Alternative B-4 for details.)

Description of Alternative Concept:

The alternative concept is to install a berm at a specific location which creates a barrier to fish and other aquatic species. The foundation of the berm would contain buried perforated piping surrounded by pervious materials which would capture water and transport under the berm in the direction of flow, while still maintaining a permanent cutoff for fish. The berm itself could also be constructed of pervious material to help pass additional water.

Locations:

Downstream (Graham McCulloch)- within Eagle Marsh, Ellison Road, Homestead Rd, or somewhere between running from high ground, south to the railroad

Upstream (Junk Ditch)- along Junk Ditch within the valley northeast of Engle Rd.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☑ Increased	☐ Increased
☐ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Advantages/Disadvantages

Alternative No.: CB-28

Advantages of Alternative Concept

- Provides cutoff to all fish species
- Allows passage of some/most water to reduce additional flooding
- No utility costs, low maintenance
- No human error – structure functions as constructed
- Intakes cover wide area, reduced concern with debris
- If placed downstream of I-69, small effect on frequency of water levels of flood events in populated areas

Disadvantages of Alternative Concept

- Likely not to address normal flow conditions of Graham McCulloch or Junk Ditch without additional flow structure or rerouting.
- Maintenance issues- siltation of underdrain piping, aggregate berm, and pervious materials around piping. Cleaning of piping, potential replacement of pervious materials.
- If placed at Junk Ditch, reduced flows through/under the berm may cause increase in elevation during storm events
- Difficulty/uncertainty in modeling flow rates through/under the berm
- Groundwater levels could limit lengths/depths/effectiveness of underdrains
- Would require buyout/easement for constructed area, potentially for affected inundation areas

Discussion

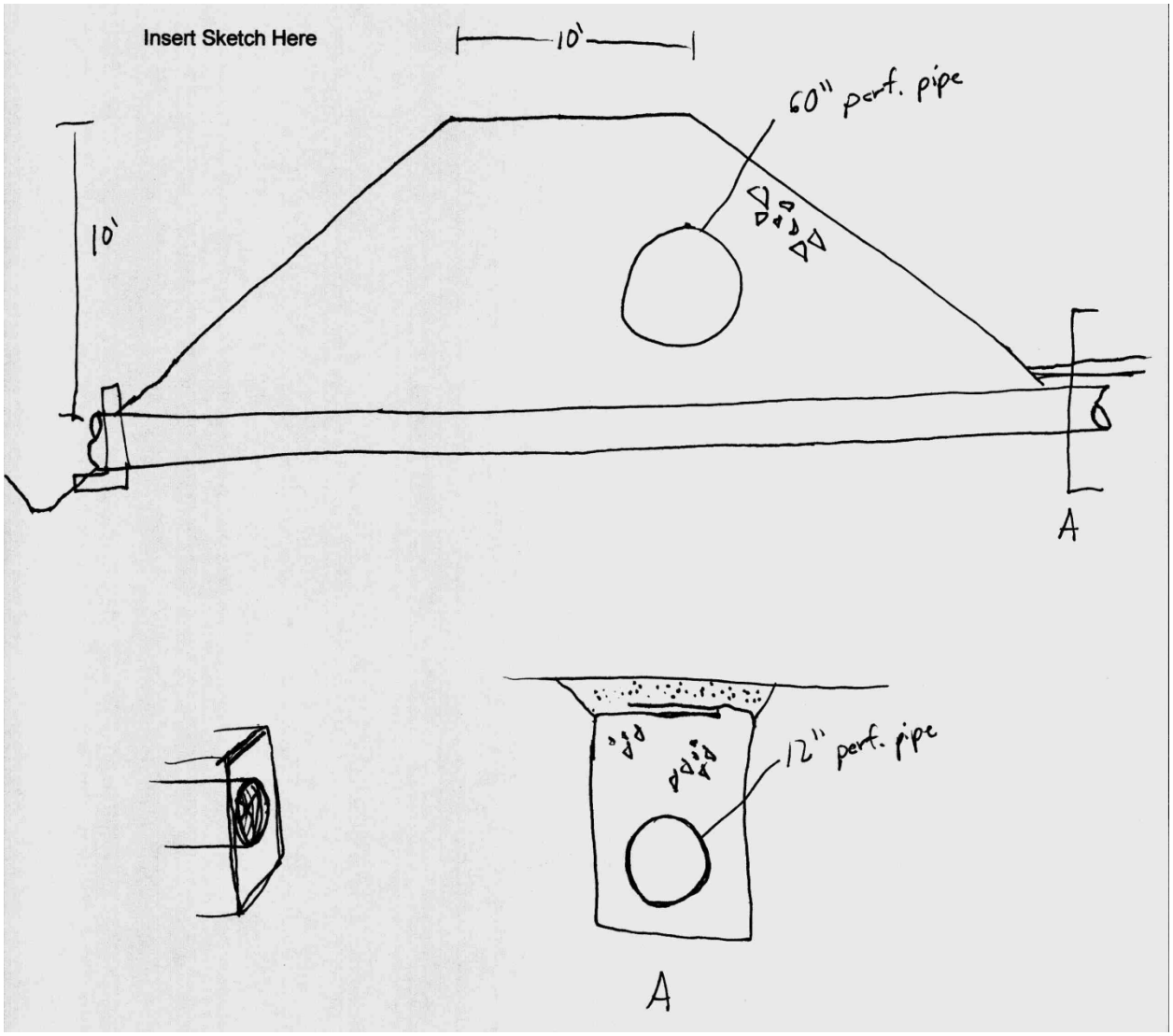
Alternative No.: CB-28

A well designed berm and underdrain system that passes water efficiently is a very feasible option. The berm would essentially exist for cutoff purposes yet have minimal effects on flood levels due to its ability to pass water through the other side, all the while maintaining the cutoff for fish. The berm could exist with minimal maintenance and concern. As the underdrain system would intake from a wide area, buildup of debris and ice would be less of a concern as with other flow structures.

Sketch

Alternative No.: CB-28

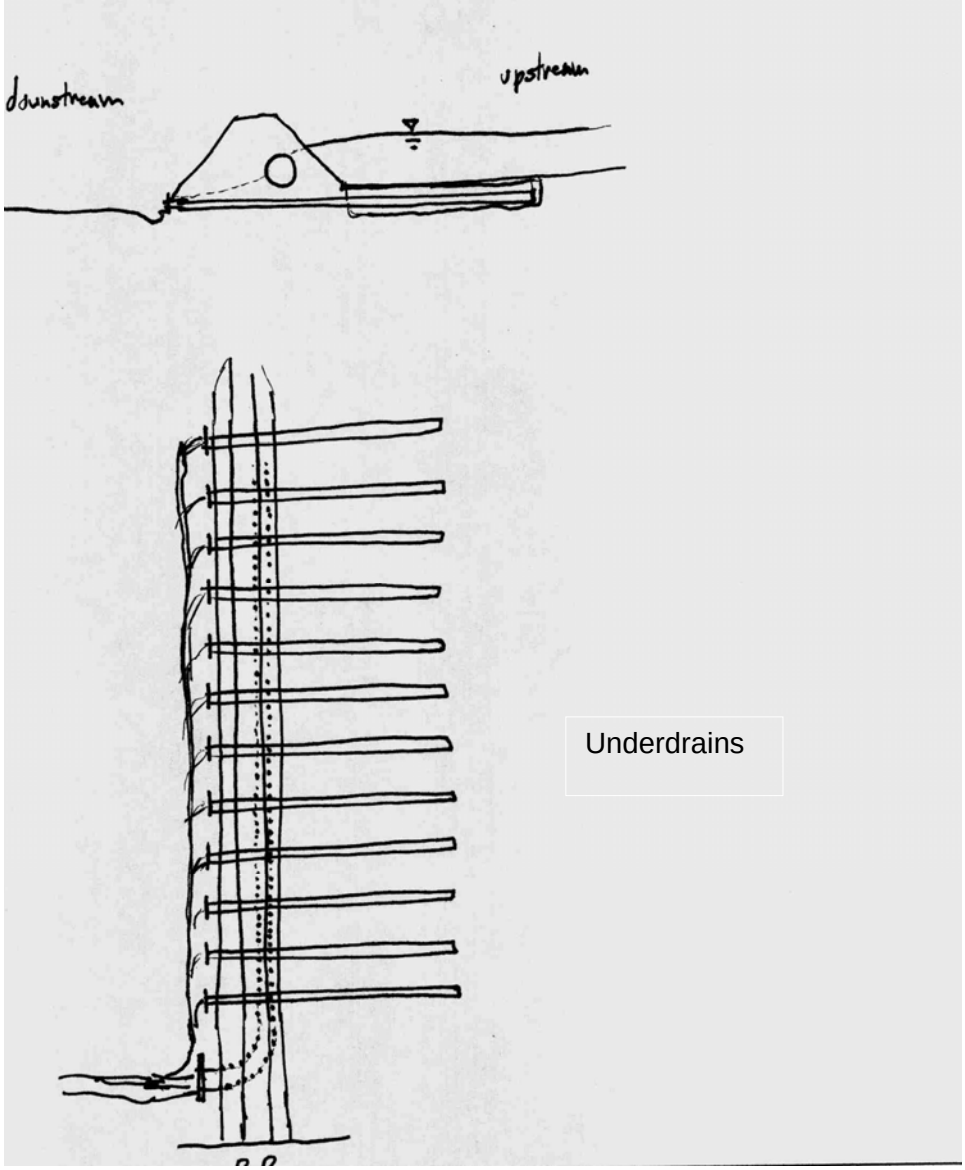
☐ Original ☑ Alternative



Sketch

Alternative No.: CB-28

☐ Original ☑ Alternative



Calculations

Alternative No.: CB-28

☐ Original ☑ Alternative

Berm

2H:1V side slopes

10 ft crown

10 ft Height

2 x ½(10 x 10) + (10 x 10) = (200 sf x 1200 lf)/27cf/cy = 8900 cy

Piping

12" dia. pipe – 16 ea. @ 80 ft long = 1,280 LF

Pervious Material

(2 ft x 3 ft x 1,280 lf)/27cf/cy = 285 CY

Excavation

(2 ft x 3 ft x 1,280 lf)/27 cf/cy = 285 CY

Filter Fabric

(10 ft x 1,280 LF)/9 sf/sy = 1500 sy

Construction Cost Estimate

Alternative No.: CB-28

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Berm	CY	30.30			8,900	$269,670
Rockfill	T	37.00			14,230	$526,510
60” Perforated piping –within berm	LF	120.00			850	$102,000
12" Perforated Piping	LF	26.00			1280	$33,280
Pervious material	CY	51.25			285	$14,606
IN 23 Sand	T	20.00			150	$3,000
Excavation	CY	17.85			285	$5,087
Filter fabric	SY	2.45			1,500	$3,675
Excavation for outlet ditch	CY	28.95			1,100	$31,845
Concrete Headwalls						
12” dia.	EA	$1,000			16	$16,000
60” dia	EA	$8,575			2	$17,150
TOTALS						$1,023,000

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SCENARIO 2

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
CB-3

Title:
Enhance the fence

Description of Original Concept:

Realign the Graham-McCulloch ditch and construct a confining berm that provides overflow in select locations and will allow seepage in others. The berm will act as a physical barrier for migration of invasive species. (See Alternative B-4 for details.)

Description of Alternative Concept:

This concept is to enhance the present fence site to allow for extended use of the system beyond the current schedule of summer 2015.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

Prev B-4 First Cost:	$ 4,273,000
CB-3 First Cost:	$ 1,764,000
Cost Savings:	$ 2,509,000

Advantages/Disadvantages

Alternative No.: CB-3

Advantages of Alternative Concept

- Minor, definable regulatory issues
- Easily constructible
- Real estate in control of partners
- Provides for >20 year service life for blocking present ANS threat

Disadvantages of Alternative Concept

- Powerlines conflict
- Needs railroad agreement
- NRCS Compatible use agreements
- Blocks only the present AIS threat, ie, adult Asian Carp

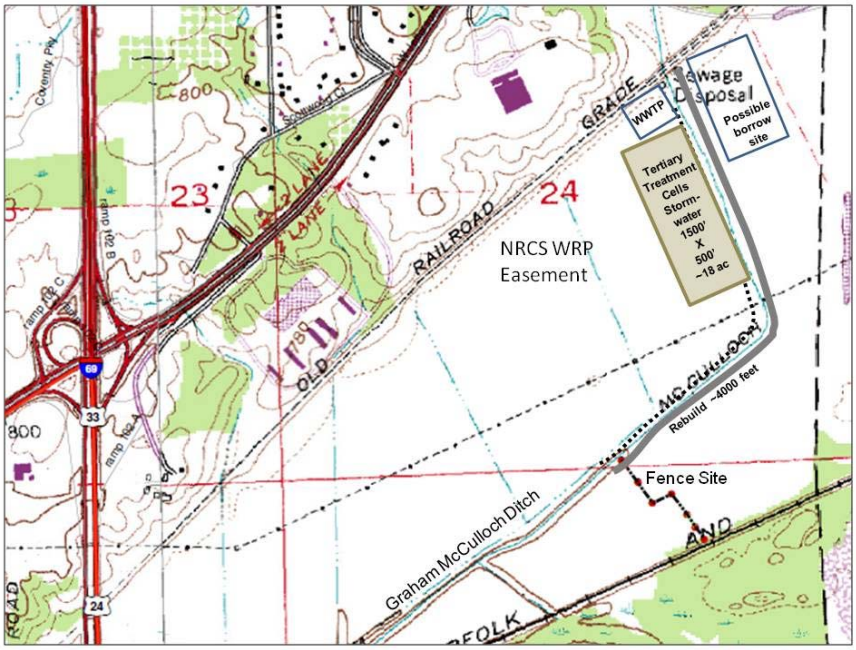
Discussion

Alternative No.: CB-3

This alternate will provide mechanisms to meet regulatory compliance issues including the local compensatory storage. The construction is relatively standard and simple providing for ease of design, estimating, bidding, and construction.

Main design components:

Use the present fence as constructed October 2010, including rockfill end closures, without modification.



Rebuild the left (east) bank of the Graham-McCulloch Ditch berm from the present fence site to the access road leading to the WWTP.

Remove much of the right (west) bank of the Graham-McCulloch Ditch berm to be used as borrow for the left bank rebuild (Compensatory Storage).

Construct a multi-cell wetland for pretreatment of urban storm water discharges from the Graham-McCulloch ditch and combine WWTP effluent discharge at an appropriate location in the design. For this example, an area of 18 acres was chosen. The stream will be located inside the wetland and therefore the containment levee would decrease. The additional soil volume would be for interior structures.

Source additional borrow from areas on the near north side of the site, near the WWTP.

There would be an increase in wetland area and a water quality improvement for the total discharge from the urban stream. Except for the foot-print of the existing stream, mostly incorporated in the treatment wetland, there should not be any wetland impacts, thus easing the regulatory aspects associated with the USACE 404 and IDEM 401 permits.

The section of the Graham-McCulloch under consideration is eroding both banks and thus is eroding the training berms. Eventually these berms will fail and discharge directly into the Eagle Marsh area. This project will address that aspect and thus provide a side benefit locally, helping the perception of the project and potential local support.

Discussion

Alternative No.: CB-3

The existing fence remains in service with little or no modifications. Details of the berm rebuild near the fence would be defined. Sufficient distance currently exists to provide for this fill upon removal or relocation of the present rockfill.

The fence as it presently exists will need to formally go through the IDNR construction in the floodway permit. The fence has multiple features to decrease the potential for surcharge. However, an Emergency Operation Plan or EAP would need to be prepared to fully address this aspect as well as some provision to provide for long term stage monitoring by the USGS.

The present fence location has already been scrutinized by local officials, land holding agency staff, and design staff as the best overall site for such barrier. One primary residual concern was the long term integrity of the 4000 foot berm on the Graham McCulloch. The berm is a spoil structure intended to train the flows from the Graham McCulloch out of the agriculture area.

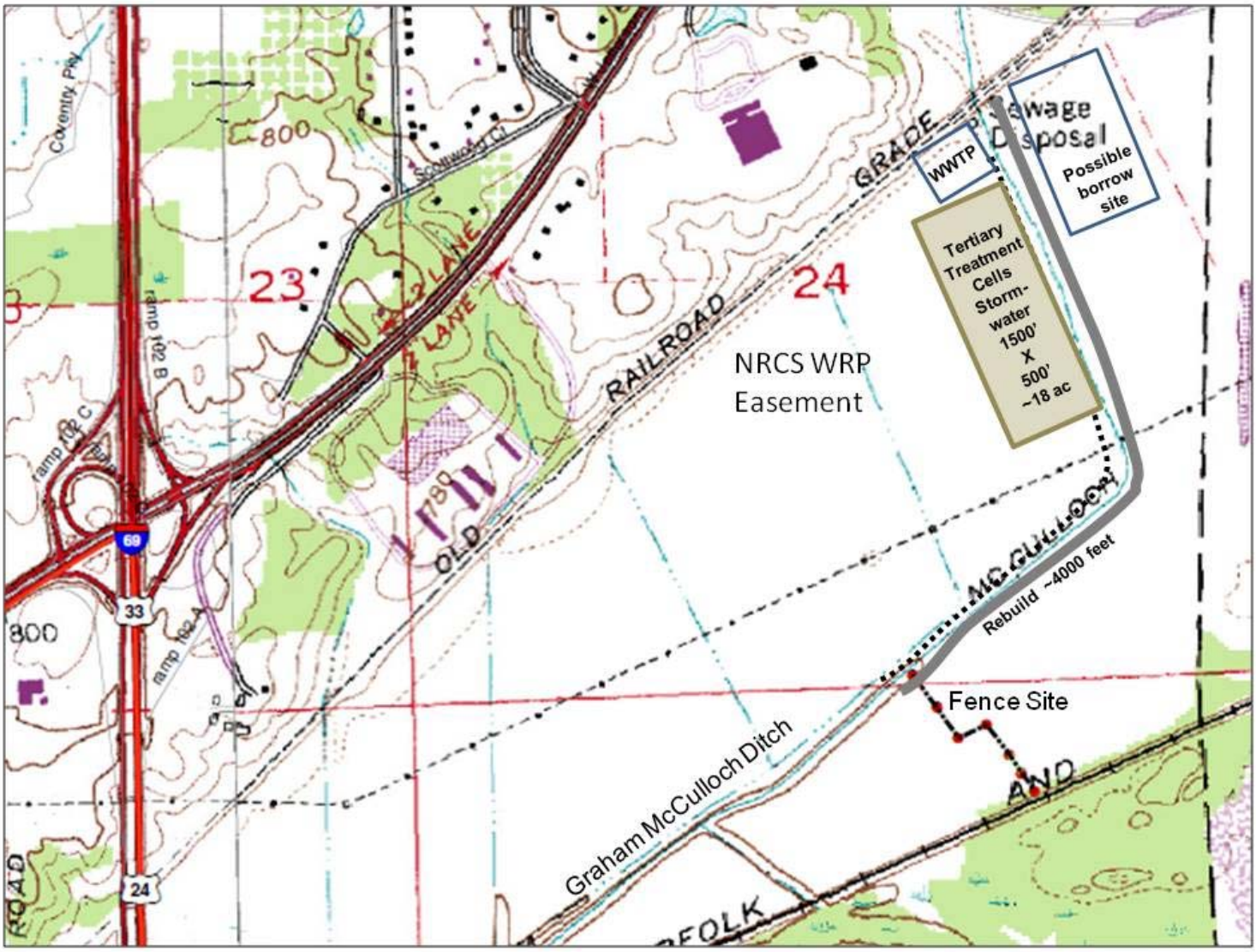
The soil in this general area should be silt and clay based with lower organics than other areas on the site. This is due to the alluvial fan that developed at the discharge of the historic natural drainage into the glacial drainage system. Modification, through ditching, of this alluvial fan resulted in this segment of the Graham McCulloch Ditch.

In design, care should be taken to address the access needs of the utility company for the high-tension electric power lines. In addition, the Norfolk-Southern Railroad will need to provide for some type of easement allowance for the rockfill on the south limit of the fence.

Sketch

Alternative No.: CB-3

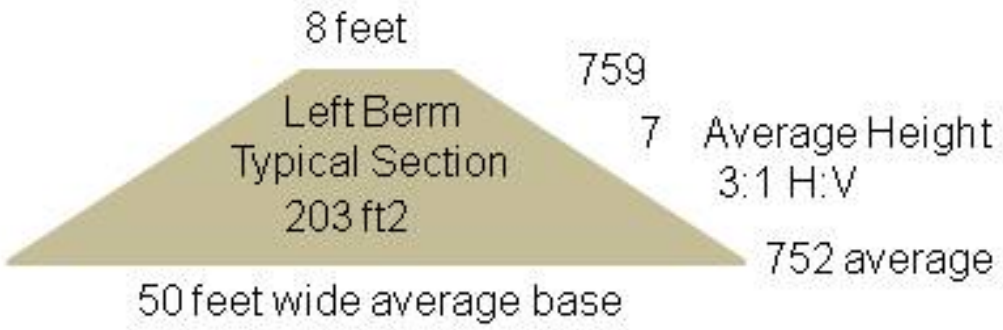
☐ Original ☑ Alternative



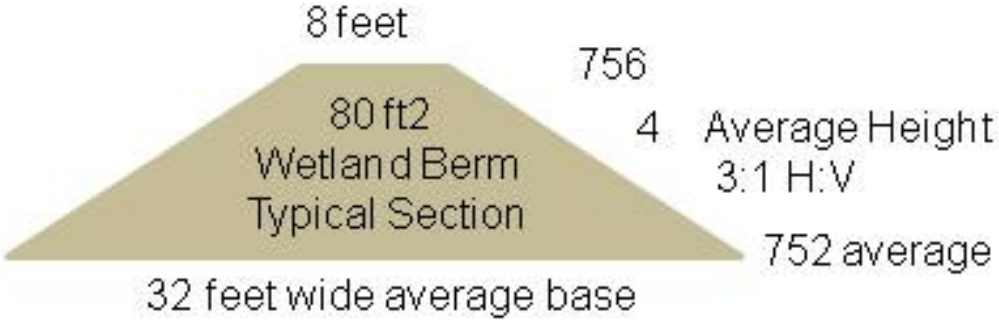
Sketch

Alternative No.: CB-3

☐ Original ☑ Alternative



203 ft2 X 4000 ft./27ft3/cy= ~30000 CY



80 ft2 X 4000 ft./27ft3/cy= ~12000 CY

Calculations

Alternative No.: CB-3

☐ Original ☑ Alternative

Wetland Cells construction ~18 acres

Construction Cost Estimate

Alternative No.: CB-3

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Embankment – barrier berm	Cy	$12.45			30,000	$373,500
Embankment – wetland berm	Cy	$12.45			12,000	$149,500
Excavation – barrier berm	Cy	$17.85			30,000	$535,500
Borrow – wetland berm	Cy	$17.85			12,000	$214,200
Remove and replace topsoil	Cy	$5.00			15,000	$75,000
Straw and seed	Sf	$0.10			800,000	$80,000
Treatment wetland construction/ planting	ac	$10,000			18	$180,000
Land acquisition, barrier berm	ac	$5,000			5	$23,000
Land acquisition, wetland berm	ac	$5,000			18	$90,000
Land acquisition, borrow	ac	$5,000			5	$23,000
Regulatory	Hr	$100			40	$4,000
Rule 5, ESC	hr	$100			80	$8,000
EAP Development	hr	$100			80	$8,000
TOTALS						$1,763,700

SCENARIO 3

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
CB-4

Title:
Construct berm fence combination

Description of Original Concept:

The original concept is to construct an earthen berm and chain link fence structure to block the movement of Asian carp into the Great Lakes via Eagle Marsh. The structure would replace the existing temporary fence and be constructed in its footprint

Description of Alternative Concept:

The alternative concept is to construct a 4 foot tall berm around the base of the existing chain link fence to block the movement of Asian carp into the Great Lakes via Eagle Marsh. This permanent alternative would be constructed around of the existing fence. The existing Jersey Barriers would be removed and reinstalled on top of the berm. Repairs would need to be conducted on the existing berms that the existing chain link fence ties into. The berm would be on a 3H to 1V slope with a 12 foot wide flat top to allow for attachment of the fence.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

Prev B-4 First Cost:	$ 4.273,000
CB-4 First Cost:	$ 332,000
Cost Savings:	$ 3,941,000

Advantages/Disadvantages

Alternative No.: CB-4

Advantages of Alternative Concept

- Provides for reuse of existing, temporary barrier
- Simplifies real estate issues

Disadvantages of Alternative Concept

- Will require extensive interagency coordination and regulatory processes.
- May be difficult to construct the berm around the existing fence
- May be damaged by ice
- Remediation to the existing berms along the Graham McColloch required
- Does not prevent small fish from passing through the fence

Discussion

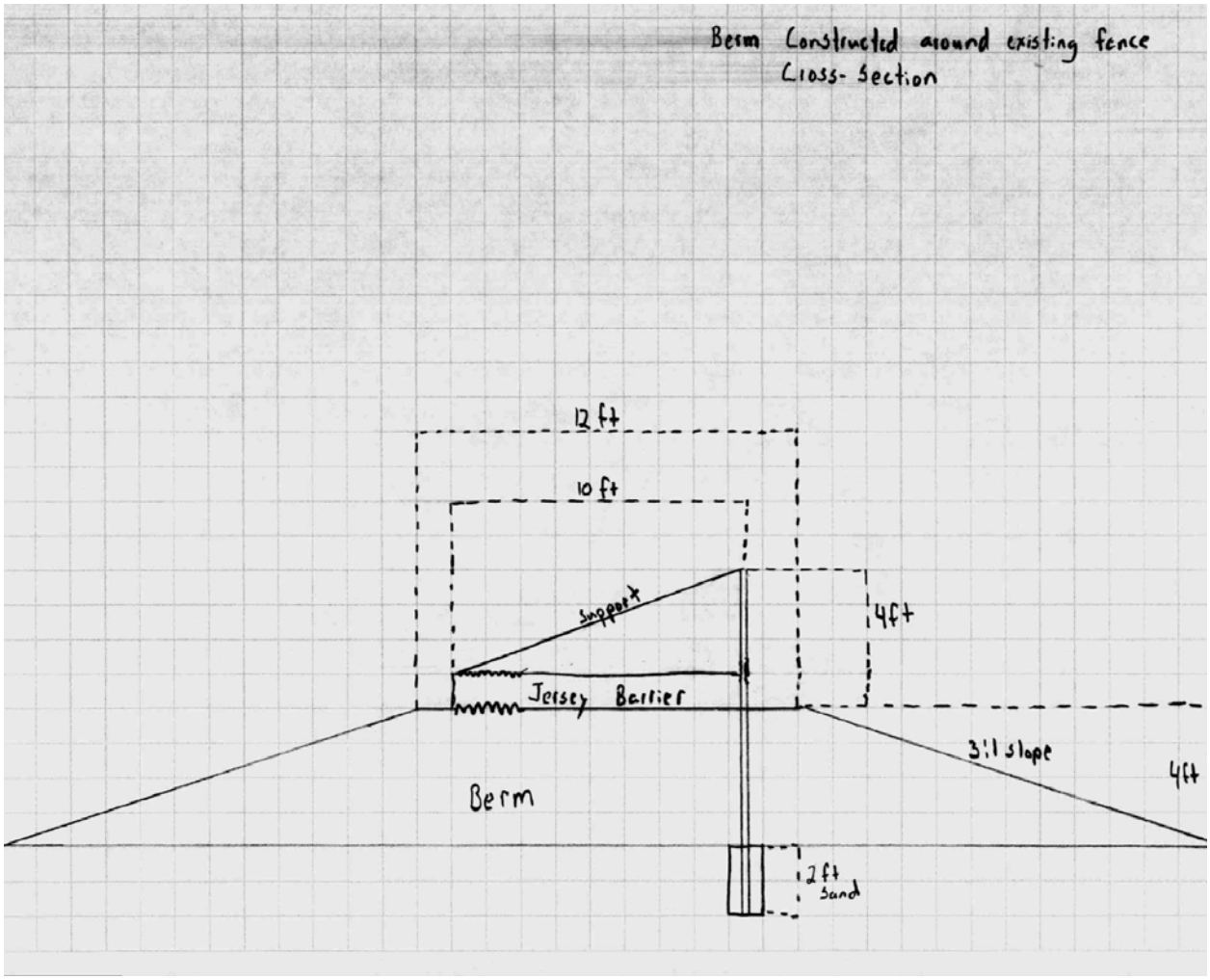
Alternative No.: CB-4

In this concept, the reduced risk of Asian carp migration is achieved by blocking high-frequency flood flows with a berm while allowing low-frequency flows to pass through the fence. It entails constructing an earthen berm and chain link fence structure to block the movement of Asian carp into the Great Lakes via Eagle Marsh. This structure would serve as a permanent alternative to the temporary chain link fence that is currently in place (Figure 1) and would be constructed in the footprint of the existing fence. The berm would be on a 3H to 1V slope with a 12 foot wide flat top to allow for attachment of the fence. The berm would require 4,185 cubic yards of soil. The lowest elevation of the fence crossing area is 749.5 feet with maximum elevation of 753.16 feet. The berm would need to be 4 feet tall to prevent overtopping from the 10 year flood event (elevation 753.3). The fence would serve as additional protection for 100 year flood events (elevation 755.3) and need to be 4 feet tall. The fence would be constructed of chain link, buried 2 feet into the top of the berm and attached to 10 feet long Jersey barriers. The fence would allow water to pass through, cause no increase in flood damage to the surrounding areas, and prevent the passage of migrating adult Asian carp. Tree planting in front of the structure would reduce the impacts of ice on the fence. The total length of the structure would be 1,200 linear feet. The earthen berm would replace and expand existing berms in the area that the existing fence ties into. The existing berms are currently in a state of disrepair.

Sketch

Alternative No.: CB-4

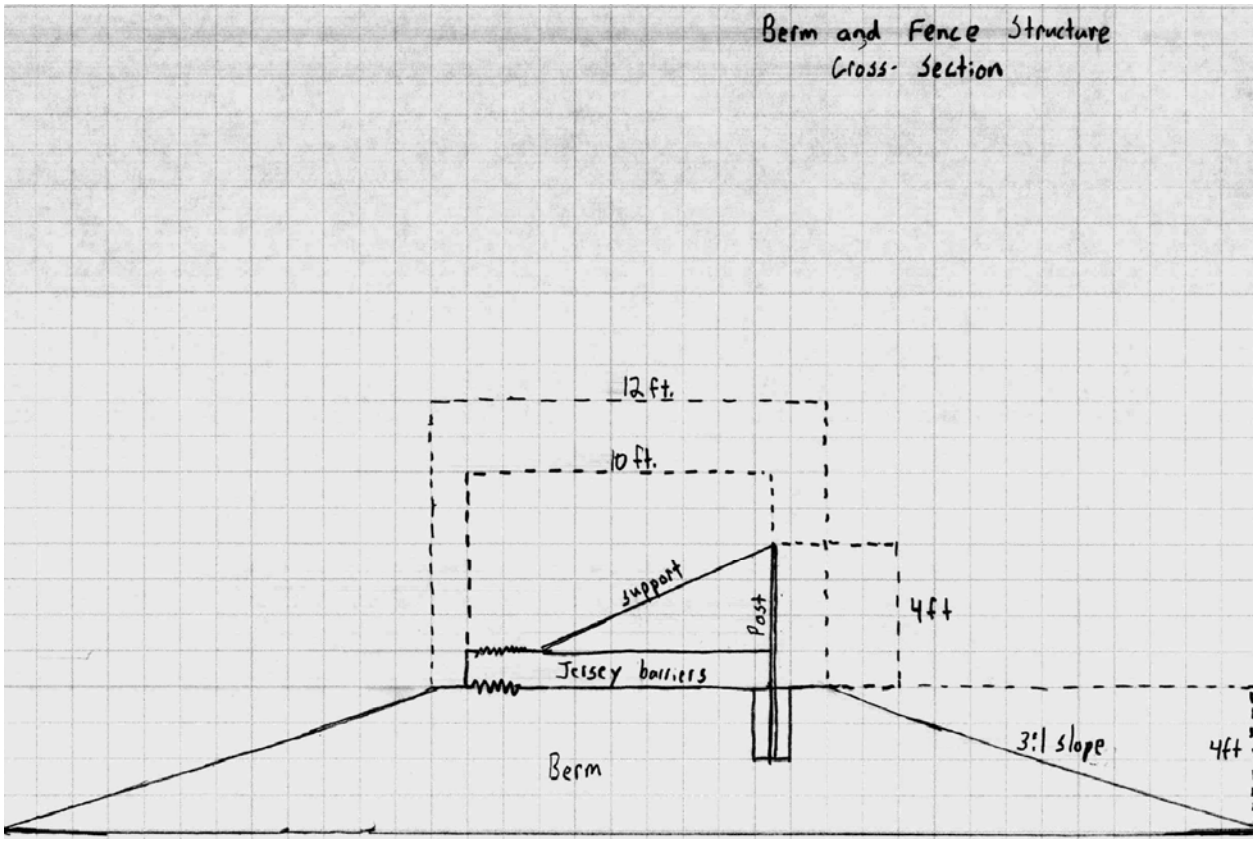
☐ Original ☑ Alternative



Sketch

Alternative No.: CB-4

☐ Original ☑ Alternative



Sketch

Alternative No.: CB-4

☐ Original ☑ Alternative

Calculations

Alternative No.: CB-4

☐ Original ☑ Alternative

4185 cubic yards of soil for berm construction

1177 linear feet of chain link fence

120 10-foot long 32-inch tall Jersey barriers

120 6 foot steel pipe for fence braces

Construction Cost Estimate

Alternative No.: CB-4

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Borrow material – clay	BCY	$17.85			4,185	$74,702
Strip store and place topsoil back	BCY	$5			2,300	$11,500
Place and compact clay material	LCY	$12.45			5020	$62,499
Seed and straw	SF	$0.10			90,000	$9,000
6’ high chain link fence	LF	$95.71			1,200	$114,852
6’ long support posts	EA	$56			120	$6720
10’ long – 32” Jersey barriers	EA	$440			120	$52,800
TOTALS						$332,000

SCENARIO 4

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
CB-2

Title:
Create a vertical drop structure

Description of Original Concept:

Realign the Graham-McCulloch ditch and construct a confining berm that provides overflow in select locations and will allow seepage in others. The berm will act as a physical barrier for migration of invasive species. (See Alternative B-4 for details.)

Description of Alternative Concept:

The alternative concept is to utilize the Homestead Road embankment as an impermeable earthen levee that would block all low flow in the Graham-McCulloch Ditch except through a vertical drop structure similar to drop inlet structures on lakes to control water levels. Flows would be controlled by multiple vertical risers. Low flow would be maintained by small diameter openings at low levels of the drop inlet with the inlet ends buried in open graded gravel. Storm water from the Maumee Basin discharging through Eagle Marsh would be temporarily stored in the areas upstream of Homestead Road and discharge through the drop inlet structures. A short section of levee would need to be constructed between the railroad and the Homestead Road embankment. Assume the levee height would be 10 feet above existing ground with 3/1 side slopes and 75 feet in length. Drop inlets would be constructed along the length of Homestead Road with pipe jacked under Homestead Road. The drop structures would be designed to pass 500 cfs for up to 5 days.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☑ Increased	☐ Increased
☐ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

Prev B-4 First Cost:	$ 4.273,000
CB-2 First Cost:	$ 493,000
CB-9 First Cost	$ 531,000
Cost Savings:	$ 3,249,000

Advantages/Disadvantages

Alternative No.: CB-2

Advantages of Alternative Concept

- Significantly reduces risk of ANS moving upstream. With intake screens would reduce risk of gobi and other species downstream depending on screen size. Vertical drop would be sufficient to stop Asian Carp from migrating upstream.
- Maintains hydraulic characteristics of area. No increase in flooding. May reduce peak flooding downstream slightly.
- Can utilize existing Homestead Road embankment with some modifications reducing construction work and schedule.
- Would allow removal of the fence barrier in Eagle Marsh and eliminate any long term impacts to the Marsh. Would cause longer periods of inundation of Eagle Marsh which would be a positive.
- Would increase upper drainage area wetlands by about 400 acres with land between Homestead and I-69.

Disadvantages of Alternative Concept

- Maintenance cost after each significant rainfall event
- Risk of debris, sedimentation and ice blocking the inlet structures
- Increased risk of inducing flooding in Ft Wayne if outlet structure is partially or fully blocked. Could cause inundation of Homestead and Ellison Road. Overtopping of Homestead Road would increase risk of ANS from the Maumee Basin to migrate into the Wabash Basin.
- Requires a long term sponsor which has not been identified.
- Would require periodic inspections and removal of debris from inlet structures
- Some Maumee Basin species would be able to pass through drop structure into the Little River
- Requires easement or purchase of land between I-69 and Homestead Road. Land is farm land that is frequently flooded.
- Would retain some floodwater longer than current condition which may be perceived negatively by the public.

Discussion

Alternative No.: CB-2

The alternative concept is to utilize the Homestead Road embankment as an impermeable earthen levee and install drop inlet structures. Low flow would be maintained by several small diameter inlets into the drop structure buried in open graded gravel. A short section of levee would need to be constructed between the railroad and the Homestead Road embankment. Assume the levee height would be 10 feet above existing ground with 3 on 1 side slopes and 75 feet in length. Flow rates are estimated at 500 cfs for up to 5 days. Outlet headwalls and channels back to the Graham-McCulloch Ditch would need to be constructed.

Both faces of the Homestead Road embankment may need wave action erosion protection. The west face would also serve as a physical deterrent for snakehead.

Maintenance and inspection would likely be required after each flood event. Debris would need to be removed periodically from the inlet structure area.

Advantages of this alternative are operational costs are less than pumping water, creation of additional wetlands, funding can be leveraged with NRCS wetland funds, Little River Wetlands is a potential administrator of the additional wetlands, construction would be confined within a small area outside of the sensitive Eagle Marsh area, temporary fence barrier at Eagle Marsh can be removed, risk of Asian Carp and snakehead migrating from the Wabash to the Maumee Basin through this pathway is greatly reduced, migration of goby and species in the Great Lakes/Maumee Basin to the Wabash is somewhat to greatly reduced.

This alternative would require the owner to inspect, monitor, maintain, operate and repair the facilities. Operation cost will be incurred for inspection and periodic debris removal.

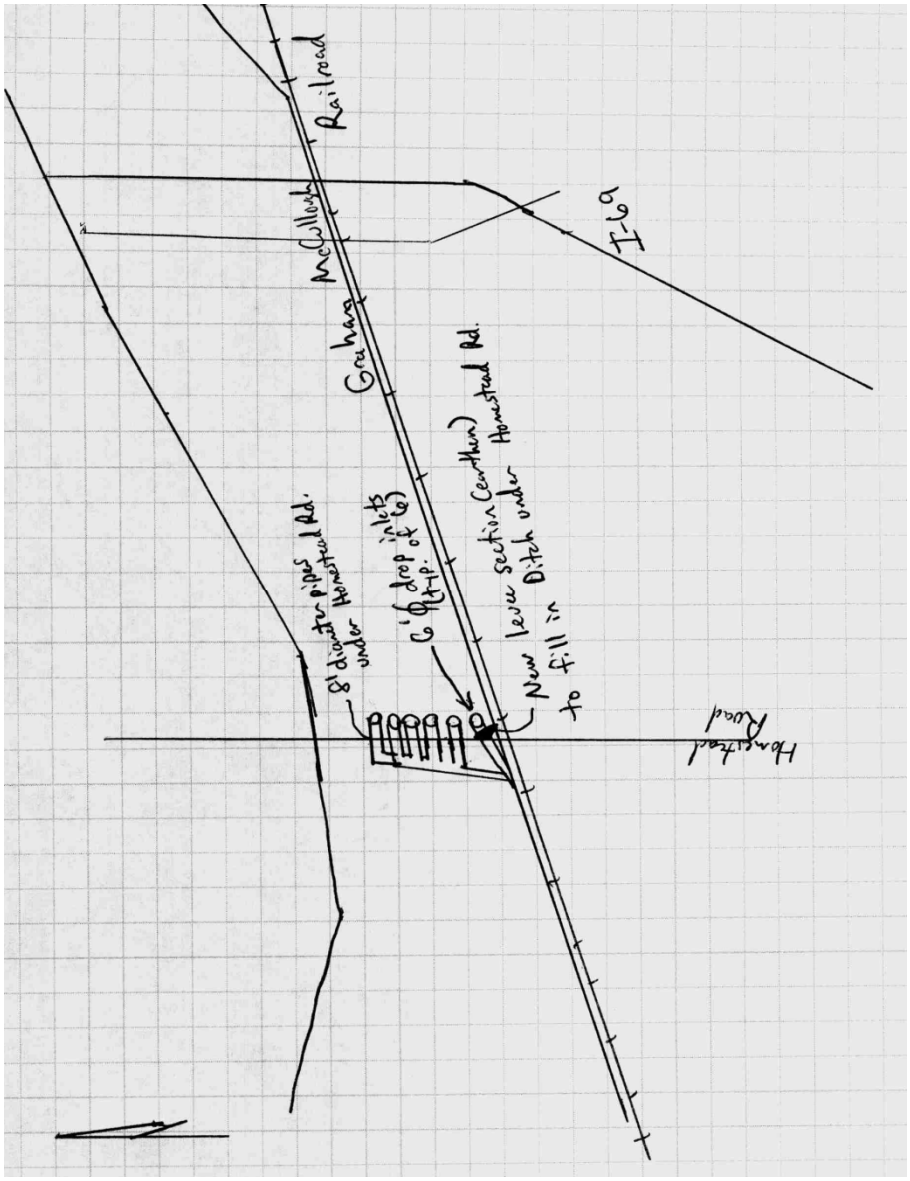
The levee would be approximately 75’ in length beginning at the railroad embankment and tie into the highway embankment. Six new 6 foot diameter PVC or concrete riser pipe or box inlets would be constructed on the east side of Homestead Road at locations across the length of Homestead Road. Each structure would carry approximately 92 cfs at 1.3 ft of head on the inlet structure. Total maximum design flow of 500 cfs would be met. An eight foot diameter horizontal pipe, each 100 feet in length will carry storm water from the drop inlets from the east side of Homestead Road under the road to discharge on the west side of the road. Excavation depth would be approximately 10 feet. Some earthwork would be needed to construct ditches from the end of each outlet pipe back to the Graham-McCulloch Ditch.

Redundant water level sensors located on the east and west side of Homestead Road would send information to the project owner. The inlet structures would be designed to minimize collection of debris, handle ice and potential to block flow with the use of grating.

Sketch

Alternative No.: CB-2

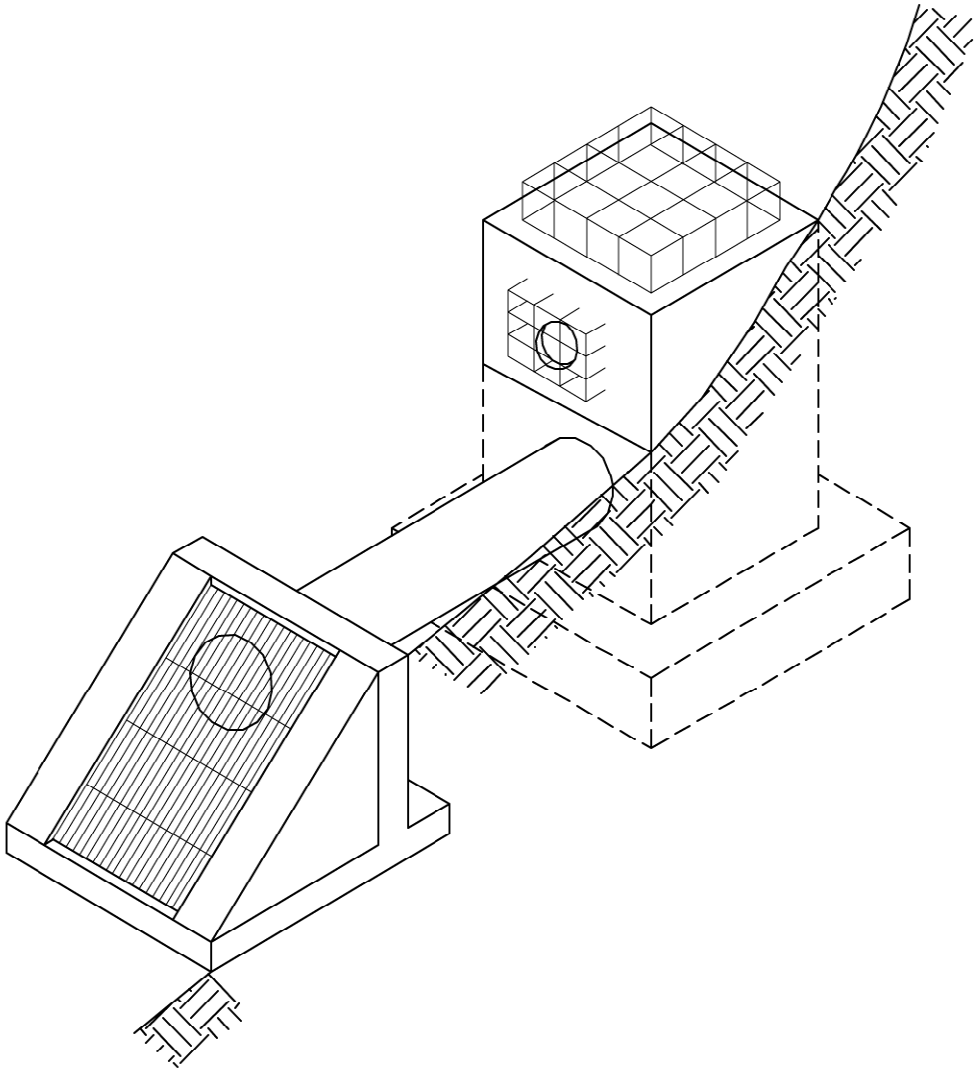
☐ Original ☑ Alternative



Sketch

Alternative No.: CB-2

☐ Original ☑ Alternative



Calculations

Alternative No.: CB-2

☐ Original ☑ Alternative

H=(.3225xQ/L)^2/3 for a broadcrested weir

H=Head on weir (FT), Q=Weir flow (CFS), L=Weir Length (FT)

Assumed 6'diameter inlet, 92 cfs results in 1.3 feet of head.

500 cfs flow rate

(Flow rate provide by project Hydraulic Engineer.)

Calculations

Alternative No.: CB-2

☐ Original ☑ Alternative

Levee earthwork

Assume levee is 10 feet tall, 5 feet wide at top and 3/1 slopes, 75 feet long

2x1/2x30x10=300 10x5=50 Total cross-sectional volume is 350 sq ft.

350x 75= 26250 cu ft =973 cu yds

Outlet channel excavation

Assume outlet pipes are 50 feet apart. Total length of outlet channel would be

50+100+150+200+250= 750 LF

Assume cross-section is 10 ft bottom with 3/1 slopes, 6 ft deep

Cross-section is 10x6+3x6x6=168 sq ft

Volume 168x750/27=4667 cu yds

Aggregate on Homestead Road slopes, assume 1 ft deep

2x1600x10=32,000 sq ft x 1 ft = 1185 cy

1185 cy x 1.35 T/cy = 1600 T

Construction Cost Estimate

Alternative No.: CB-2

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
75' earthen berm 10' high, 3/1 slopes.	CY	$30.30			973	$29,500
8' diameter PVC pipe	LF	$375			600	$225,000
6' diameter Concrete pipe	LF	$250			60	$15,000
Concrete inlet with grated structure	EA	$2,500			6	$15,000
Outlet earthwork	CY	$30.30			4,667	$141,410
Road cuts (5 cuts @ 10 ft deep)	Ea	$1,500			5	$7,500
Aggregate on embankment slope 1 ft deep	T	$37			1,600	$59,200
TOTALS						$492,610

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
CB-9

Title:
Build permeable barrier (riprap)

Description of Original Concept:

Realign the Graham-McCulloch ditch and construct a confining berm that provides overflow in select locations and will allow seepage in others. The berm will act as a physical barrier for migration of invasive species. (See Alternative B-4 for details.)

Description of Alternative Concept:

Construct barrier with rip-rap. The barrier will be approximately 5 feet high with 3H:1V slope and will vary in length depending on the location. Assume a length of 1,200 linear feet for this alternative and comparison. One approach to managing the Graham-McCulloch flows is to add a grated culvert.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☑ Increased	☐ Increased
☐ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Advantages/Disadvantages

Alternative No.: CB-9

Advantages of Alternative Concept

- Construction duration would be short
- Would not retain water
- Construction materials are readily available
- Construction is simple
- Easy to maintain

Disadvantages of Alternative Concept

- Does not retain water
- Not aesthetically pleasing
- Cause debris to collect
- Will need to be maintained (replace riprap as needed)
- Could become impermeable due to debris filling voids and cause damming of water.
- Existing berm is not an engineered structure

Discussion

Alternative No.: CB-9

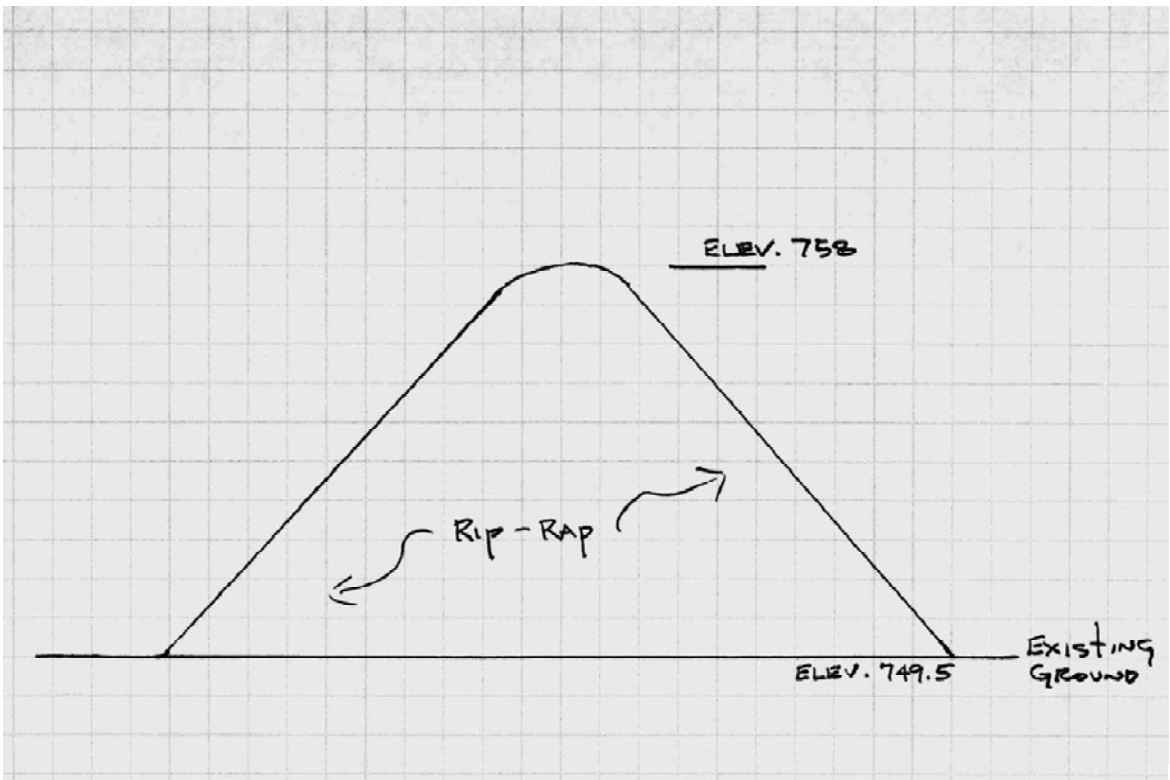
The idea of this alternative is to create a permeable berm from rip-rap. The ground elevation of 749.5' and the flood elevation of 755.6 plus 2' and rounded is 758. This was used to determine the height of the rip-rap barrier. This is what was used with the existing fence and rip-rap that is at the site currently. The barrier will be constructed on a 2H to 1V slope. The barrier will be tied into an existing berm. The existing berm will not be reconstructed. Eight inches of topsoil will be removed then a geotextile fabric will be placed prior to the rip-rap being installed.

The design must include measures to accommodate flows so that no additional flooding to upstream areas occurs.

Sketch

Alternative No.: CB-9

☐ Original ☑ Alternative



Calculations

Alternative No.: CB-9

☐ Original ☑ Alternative

A. REMOVE top SOIL

55′ x 8″/12 x 1,200 = 44,000 CF / 1,630 BCYDS

B. HAUL top SOIL OFF

1,630 BCYDS x 1.20 = 1,960 LCYDS

C. GEOTEXTILE FABRIC

55′ x 1,200′ = 66,000 SF / 7,335 SYDS.

D. RIP-RAP

[½ (8.5′ x 25.5′) x 2] x 1,200′ = 260,100 CF
9,635 CYDS
13,500 TONS

Construction Cost Estimate

Alternative No.: CB-9

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Remove topsoil	BCY.	$1.41			1630	$2,300
Geotextile fabric	SY.	$2.45			7335	$17,970
Rip-rap	T	$36.50			13500	$492,750
Haul off topsoil	LCY	$9.12			1960	$17,875
TOTALS						$530,895

SCENARIO 5

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
CB-25

Title:
Build structure and pump around

Description of Original Concept:

Realign the Graham-McCulloch ditch and construct a confining berm that provides overflow in select locations and will allow seepage in others. The berm will act as a physical barrier for migration of invasive species. (See Alternative B-4 for details.)

Description of Alternative Concept:

The alternative concept is to utilize the Homestead Road embankment as an impermeable earthen levee that would block all low flow in the Graham McCulloch Ditch and provide a pump station that would pump water over the levee back into the Graham McCulloch Ditch. Low flow would be maintained by small diameter PVC pipe with the inlet ends buried in open graded gravel. Stormwater from the Maumee Basin discharging through Eagle Marsh would be pumped from the created storage area into the Wabash Basin. A short section of levee would need to be constructed between the railroad and the pump station. Assume the levee height would be 10 feet above existing ground with 3H:1V side slopes and 75 feet in length. The pump station would consist of three pumps sized at 60% of the peak flow each constructed immediately adjacent to the existing Graham McCulloch Ditch. Estimate is 500 cfs for up to 5 days.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☑ Increased	☐ Increased
☐ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

Prev B-4 First Cost	$ 4,273,000
CB-25 First Cost:	$ 863,500
Cost Savings:	$ 3,409,500

Advantages/Disadvantages

Alternative No.: CB-25

Advantages of Alternative Concept

- Significantly reduces risk of ANS moving upstream. With intake screens would reduce risk of gobi and other species downstream. Pumping would also kill some species. Head differential would stop Asian Carp.
- Maintains hydraulic characteristics of area. No increase in flooding east of I-69. May reduce peak flooding downstream slightly.
- Can utilize existing Homestead Road embankment with some modifications reducing construction work and schedule.
- Would allow removal of the fence barrier in Eagle Marsh and eliminate any long term impacts to the Marsh. Would cause longer periods of inundation of Eagle Marsh which would be a positive.
- Would increase upper drainage area wetlands by about 400 acres with land between Homestead and I-69.

Disadvantages of Alternative Concept

- Cost of pumps, both initial and operational. Would require monitoring, testing, inspection after event, utility costs and future replacements.
- Requires a long term sponsor which has not been identified.
- Some species would be able to pass through low flow drainage or survive pumping from the Maumee Basin into the Little River.
- Requires easement or purchase of land between I-69 and Homestead Road. Land is farm land that is frequently flooded.
- Would retain some floodwater longer than current condition which may be perceived negatively by the public.

Discussion

Alternative No.: CB-25

The alternative concept is to utilize the Homestead Road embankment as an impermeable earthen levee that would block all low flow in the Graham McCulloch Ditch and provide a pump station that would pump water over the levee back into the Graham McCulloch Ditch. Low flow would be maintained by several small diameter PVC pipe with the inlet ends buried in open graded gravel. Storm water from the Maumee Basin discharging through Eagle Marsh would be pumped from the created storage area into the Wabash Basin. A short section of levee would need to be constructed between the railroad and the pump station. Assume the levee height would be 10 feet above existing ground with 3:1 side slopes and 75 feet in length. The pump station would consist of three pumps sized at 60% of the peak flow each constructed immediately adjacent to the existing Graham McCulloch Ditch. Estimate is 500 cfs for up to 5 days. Controls would be automatic with redundant water level sensors located on the east side of Homestead Road. Total maximum flow for the pump station is 500 cfs with an assumed head of 10' including system losses requires each pump to be 600 hp (very large pumps). The pump station will be 100 feet wide by 50 feet deep with the pumps enclosed in the pump house and protected from freezing. Controls would allow remote monitoring of the system including upstream and downstream water levels. A stilling basin would need to be constructed at the outlet end of the discharge piping directing flow back into the Graham McCulloch Ditch.

Operation of the flood station would be automatic with 2 pumps starting in sequence once the available storage reaches about 50%. All pumps would cycle automatically. Notification would be sent to the project owner of pump operations. A pump operator should be dispatched to ensure proper operation of equipment. Remote monitoring could be use to identify problems and dispatch repairman.

Both faces of the Homestead Road embankment may need wave action erosion protection. The west face would also serve as a physical deterrent for snakehead.

Maintenance and inspection would likely be needed after each pumping event. Debris would need to be removed periodically from the pump station area.

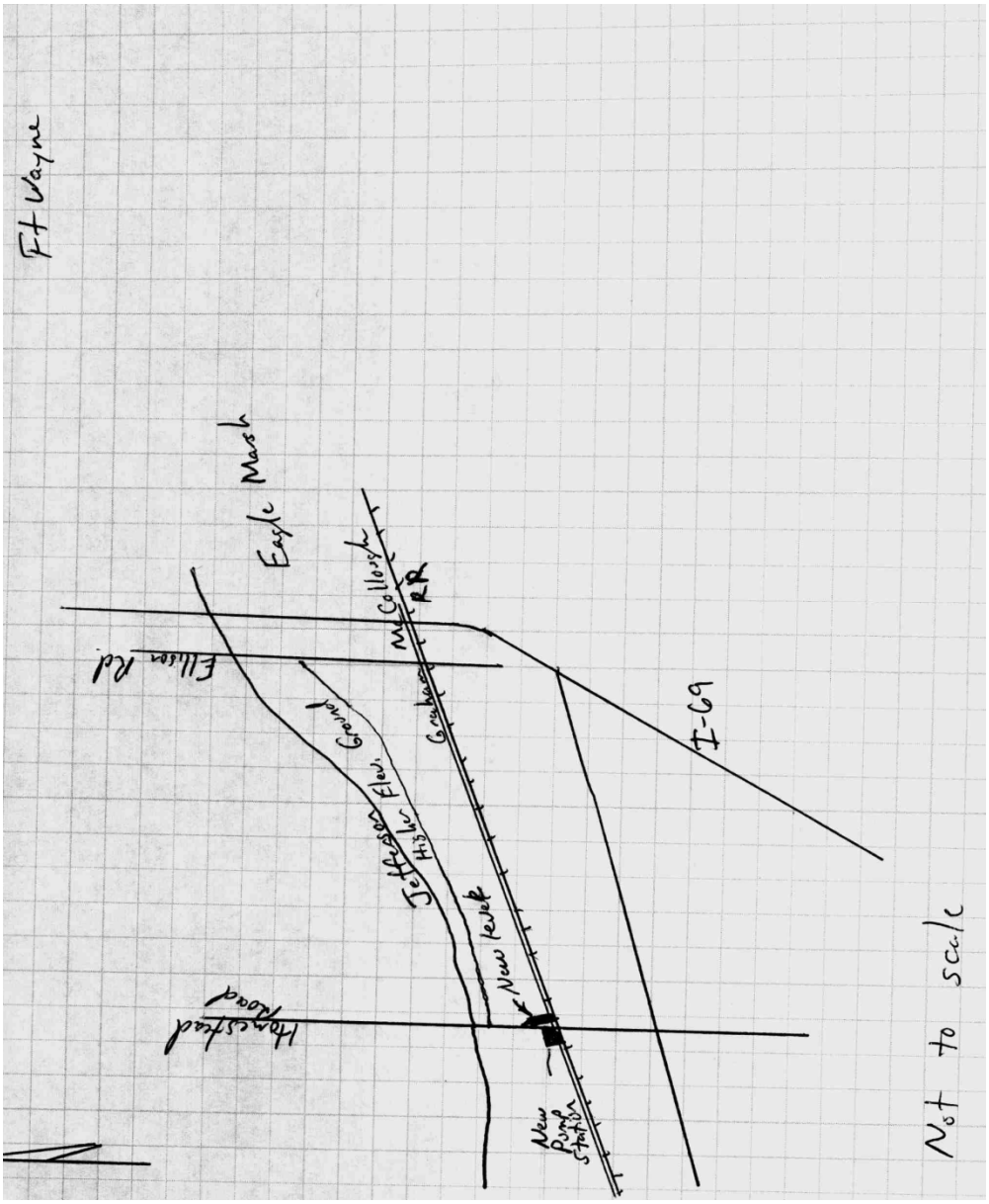
Advantages of this alternative are creation of additional wetlands, funding can be leveraged with NRCS wetland funds, Little River Wetlands is a potential administrator of the additional wetlands, construction would be confined within a small area outside of the sensitive Eagle Marsh area, temporary fence barrier at Eagle Marsh can be removed, risk of Asian Carp and snakehead migrating from the Wabash to the Maumee Basin through this pathway is greatly reduced, migration of gobi and species in the Great Lakes/Maumee Basin to the Wabash is somewhat to greatly reduced.

This alternative would require the owner to inspect, monitor, maintain, operate and repair the facilities. Operation cost will also be incurred for utilities and periodic debris removal.

Sketch

Alternative No.: CB-25

☐ Original ☑ Alternative



Calculations

Alternative No.: CB-25

☐ Original ☑ Alternative

Flow rate provide by project Hydraulic Engineer. Pump information was provided by LRL Mechanical Engineer given the following criteria:

10 feet of head max, 500 cfs flow rate by two pumps for 4-5 days.

Construction Cost Estimate

Alternative No.: CB-25

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Pump Station Building – masonry	SF	$64			5,000	$320,000
Pumps – 600 hp	EA	$170,000			3	$510,000
Clay levee 3:1 slope, 10' high, 16' wide						
Borrow material – clay	BCY	$17.85			1,000	$17,850
Strip store and place topsoil back	BCY	$5			70	$350
Place and compact clay material	LCY	$12.45			1,200	$14,940
Seed and straw	SF	$0.10			3,750	$375
TOTALS						$863,515

SCENARIO 6

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
CB-31

Title:
Reroute Graham McCulloch Ditch into Junk Ditch and create barrier downstream

Description of Original Concept:

Realign the Graham-McCulloch ditch and construct a confining berm that provides overflow in select locations and will allow seepage in others. The berm will act as a physical barrier for migration of invasive species. (See Alternative B-4 for details.)

Description of Alternative Concept:

The alternative concept is two parts; Rerouting of Graham McCulloch Ditch into Junk Ditch which drains to the Maumee watershed, and then building a berm west of I-69 to serve as the cutoff to aquatic nuisance fish. The rerouting of Graham McCulloch into Junk Ditch eliminates having the berm to deal with normal flows from Graham McCulloch. The berm would create a detention basin and would likely require a release structure(s). The berm could be constructed of a variety of materials or methods, the most economical likely being available onsite soils. However, a concrete wall or sheet piling wall could serve the same purpose.

Locations:

Rerouting of Graham McCulloch would likely have to occur starting near it's crossing of Engle Rd, and then along Engle Rd to the Junk Ditch drainage channel located near the intersection of Smith Rd and Engle Rd. Two options are available; piping or an open channel cut.

The berm could be installed anywhere across the valley within the Wabash basin. However, to eliminate higher water levels, areas beyond I-69 are more feasible. The berm would need to provide positive cutoff yet allow for release of collected floodwaters. The berm could be in combination with one of the roadways downstream including Ellison, Homestead, and Aboite. The drainage structure of the berm could be multiple different options, including a vertical drop structure(s), pervious aggregate berm, section of fish screen fence, etc. which would pass the water accumulated upstream of the berm.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☑ Increased	☑ Increased
☐ Maintained	☐ Maintained
☐ Decreased	☐ Decreased

Cost Savings Summary

Prev B-4 First Cost:	$ 4,273,000
CB-31 First Cost:	$ 5,027,000
Cost Savings:	($ 754,000)

Advantages/Disadvantages

Alternative No.: CB-31

Advantages of Alternative Concept

- Provides appropriate cutoff to all fish species
- Eliminates debris concerns from Graham McCulloch flows
- Simplifies other berm issues by eliminating constant flows from Graham McCulloch
- no utility costs, low maintenance
- no human error – structure functions as constructed
- If berm placed downstream of I-69, small effect on frequency of water levels of flood events in populated areas

Disadvantages of Alternative Concept

- Increased flows into Junk Ditch drainage from the Graham McCulloch will cause increased high water events and will likely increase flood elevations downstream.
- Outflow of WWTP will also need to be rerouted or addressed.
- Real estate by Engle Road is limited; modifications to Engle Road are likely.
- Would require buyout/easement for constructed area, potentially for affected inundation areas.

Discussion

Alternative No.: CB-31

If we can eliminate Graham McCulloch flows under the I-69 corridor and beyond, designing and constructing a berm becomes much easier. This eliminates concerns with passing flows from the Graham McCulloch, debris associated with this flow, and additional water that would have to be stored. The berm could store water that occurs from Junk Ditch backwater events, and could release in a controlled manner. There would be no worry of a large influx from a rain event on the Graham McCulloch watershed during this storage period. The berm could be designed or incorporated into existing road crossings north of the railroad

Sketch

Alternative No.: CB-31

☐ Original ☐ Alternative

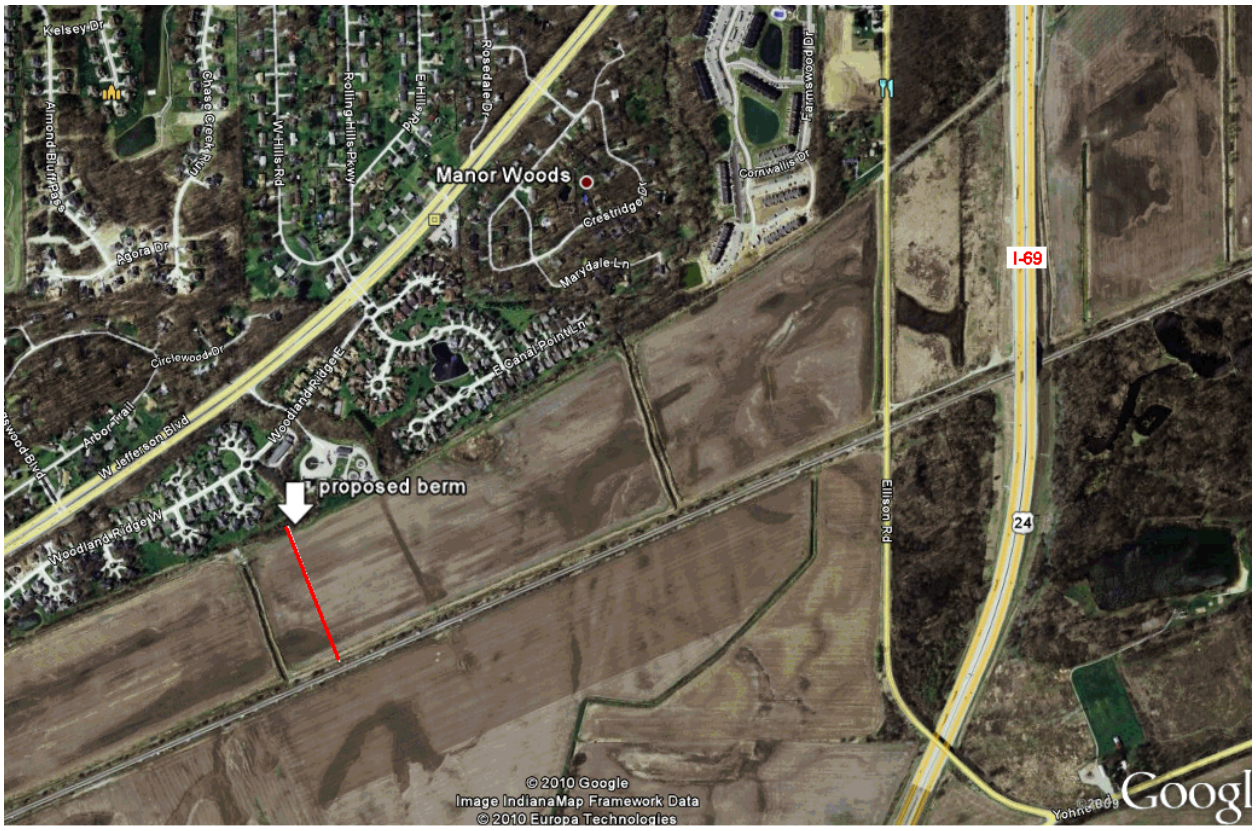
Figure 1. Rerouting of Graham McCulloch along Engle Road

Sketch

Alternative No.: CB-31

☐ Original ☐ Alternative

Figure 2. Proposed Berm location west of I-69



Calculations

Alternative No.: CB-31

☐ Original ☑ Alternative

Reroute Graham McCulloch into Junk Ditch watershed, install Berm downtream of I-69				
BERM				
berm, excavate, haul, place and place	1200	lf	8,888.89	CY
2H:1V side slopes				
10' crown				
10' height				
berm drainage structure(s)			1.00	LS
JUNK DITCH REALIGNMENT				
excavation				
10'deep, 15' wide, 3H:1V side slopes by 7,500 ft long			166,666.67	CY
haul off/placement of excavation in floodplain			166,666.67	CY
stone protection			500.00	ton

Construction Cost Estimate

Alternative No.: CB-31

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Berm Excavate and haul - 800 lf	cyd	30.3			8,900	$269,670
Drainage Structure	ea	15,000.00			1	$15,000
Excavate 10' deep x 15' wide, 7,500 lf - 3:1	bcyd	17.85			166,700	$2,975,595
Haul off material and spread	lcyd	9.12			191,700	$1,748,304
Stone Protection	ton	37			500	$18,500
TOTALS						$5,027,000

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SCENARIO 7

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
CB-35

Title:
Build barrier for the longest economical crest with lowest flow depth

Description of Original Concept:

Realign the Graham-McCulloch ditch and construct a confining berm that provides overflow in select locations and will allow seepage in others. The berm will act as a physical barrier for migration of invasive species. (See Alternative B-4 for details.)

Description of Alternative Concept:

The alternative concept is to build a short barrier that will raise the drainage divide elevation to an elevation at which flow depth is minimized, but will offset the reduction in conveyance by provided additional conveyance by increasing the weir length in order to pass more extreme flood flows. The allowable depth of flow is anticipated to be on the order of 6 inches or less, such that it is inadequate or inhospitable for fish (primarily adult carp) to swim through. Concept is envisioned as a concrete control sill constructed along a saw-tooth or serpentine alignment near the existing basin divide, embedded approximately 3.5 feet into existing ground. The ground would slope from there on a long, gradual slope to maintain minimal depth for a distance of approximately 100 feet on the Graham – McCulloch side, to significantly reduce the risk of a carp or similar species from jumping the barrier or surviving attempts to push through the shallow depth.

For the purposes of costing, a 5000 ft length was assumed.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☑ Maintained
☐ Decreased	☐ Decreased

Cost Savings Summary

Prev B-4 First Cost:

CB-35 First Cost: **No Cost Developed**

First Cost Savings:

Advantages/Disadvantages

Alternative No.: CB-35

Advantages of Alternative Concept

- Reduces frequency of hydraulic connection, thereby blocking passage of Asian Carp species and similar nuisance species from passing to the Great Lakes basin except at extreme events
- Construction should be generally simple
- Minimal real estate acquisition likely
- Minimal aesthetic impact, and could be blended into the landscapes
- Proximity to Eagle Marsh and other wetlands provides opportunities to use weir as a walkway
- Traversable by native terrestrial species
- Minimal impacts to Eagle Marsh (depending upon length required)
- Could potentially be designed to avoid involving railroad property

Disadvantages of Alternative Concept

- Does not satisfy perception of creating an absolute barrier for Asian Carp
- Does not prevent passage of all aquatic nuisance species
- Does not stop transfer of nuisance species from Great Lakes side
- Increases water surface elevations in Junk Ditch floodplain at more frequent events, requiring mitigation.
- Location would have to consider affects on wetlands to reduce impacts and required mitigation

Discussion

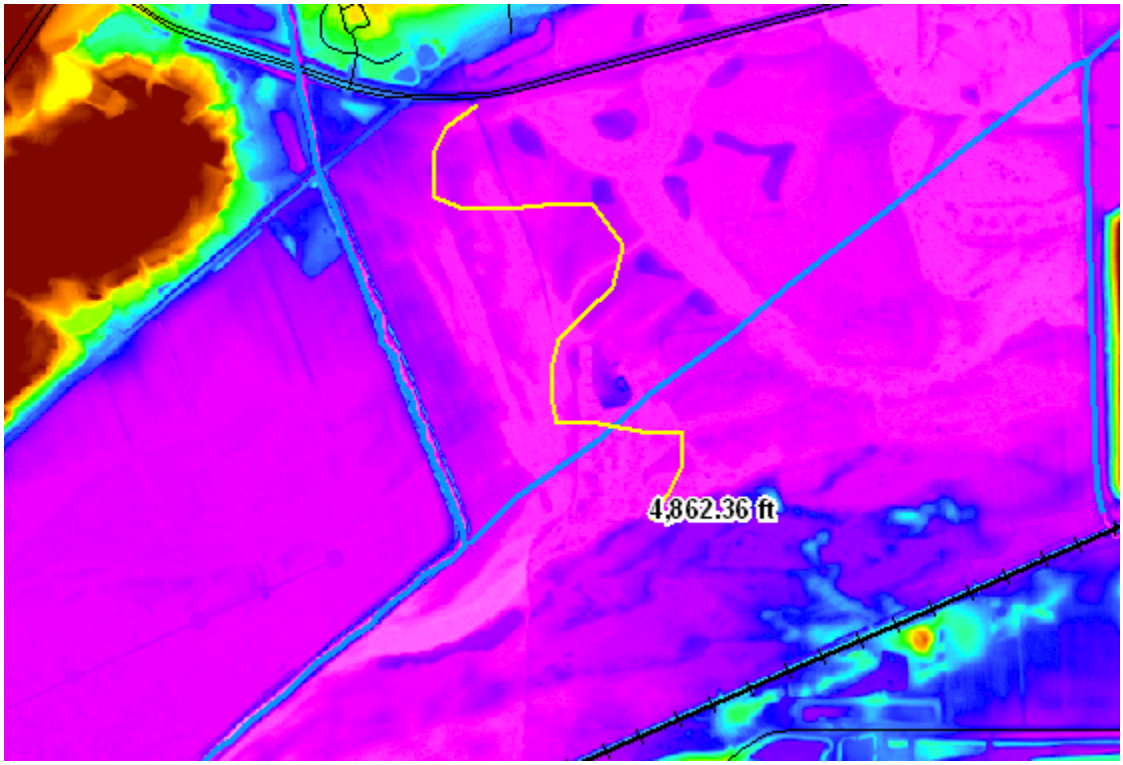
Alternative No.: CB-35

This alternative generally is easy to construct and could be designed to work into the surrounding landscapes with minimal aesthetic impacts. This concept would reduce the frequency of hydraulic connection, thus reducing the risk of species transfer to more extreme events, particularly for the Asian Carp and similar species, which would be reduced to events greater than a 1% chance exceedence event. The area would be traversable to local terrestrial species. The lower elevation would allow for tie in at a lower elevation, therefore it is likely that the weir could end on Eagle Marsh property and not require coordination with the railroad or additional significant real estate acquisition.

Sketch

Alternative No.: CB-35

☐ Original ☑ Alternative



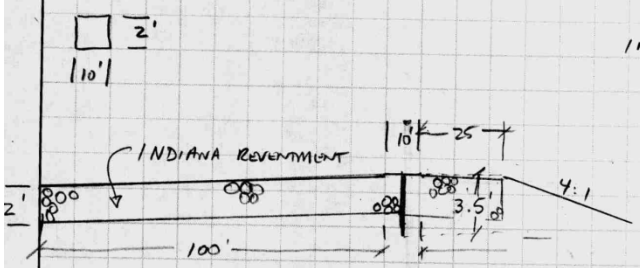
Alignment in yellow for conceptual purposes only to demonstrate approximate footprint of assumed 5000 ft length.

Calculations

Alternative No.: CB-35

☐ Original

TYPICAL SECTION



INDIANA REVETMENT = 18" STONE
$D_{50} \approx 8''$

QUANTITIES:

CONCRETE

$V = 12' \times 3.5' = 7$ CF/LF

$\times$ 5000 LF = 35,000 CF = 1296.3 CY SAY 1300 CY

RIPRAP BLANKET

$V = (2' \times 104') + 2' \times 29' = 208 + 58 = 266$ CF/LF

$\times$5000 LF = 1330000 CF = 49,259 CY

SAY 49,250

MODEL STUDY TRIALS WERE INCONCLUSIVE IN DETERMINING AN APPROXIMATE WEIR LENGTH NECESSARY. FOR PURPOSES OF COST, AN ESTIMATED 5000 LF WEIR IS ASSUMED, BUT IS VERY QUESTIONABLE, SINCE WIDTH OF FLOWAGE IS APPROXIMATELY 4100 FT.

FILL QUANTITIES:

ASSUME AVERAGE FILL DEPTH OF 3', LESS ROCK FILL.

ESTIMATED AVERAGE

VOLUME OF FILL $= \frac{1}{2}(4 \times 3.5) + 1' \times 100' + 1' \times 35' = 142$ CF/LF

$\times$ 5000 LF = 710,000 CF

= 26,296 CY

SAY 26,300 CY

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SCENARIO 8

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
SB-2

Title:
Create storage in both basins

Description of Original Concept:

Realign the Graham-McCulloch ditch and construct a confining berm that provides overflow in select locations and will allow seepage in others. The berm will act as a physical barrier for migration of invasive species. (See Alternative B-4 for details.)

Description of Alternative Concept:

By creating more storage in both basins, rain water will be discharged more slowly into the Little River-Graham-McCulloch Ditch and St. Mary's-St. Joseph's-Maumee Rivers. This will reduce the WSEL thus allowing flood waters to drain without backing over the divide. If water does not back over the divide, no NAS can transfer either way between basins.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☑ Increased	☐ Increased
☐ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

Prev B-4 First Cost:	$ 4.273,000
SB-2 First Cost:	$ 2,361,500
First Cost Savings:	$ 1,911,500

Advantages/Disadvantages

Alternative No.: SB-2

Advantages of Alternative Concept

- Hydraulically separates basins
- Eliminates ANS threat to both basins
- Can be completed in phases
- Reduces flooding as storage is added

Disadvantages of Alternative Concept

- Requires substantial purchase of land affecting many property owners
- Real estate near Ft. Wayne may be difficult and costly to acquire
- May require an extended timeline to achieve meaningful protection

Discussion

Alternative No.: SB-2

By creating more storage in both basins, rain water will be discharged more slowly into the Little River-Graham-McCulloch Ditch and St. Mary's-St. Joseph's-Maumee Rivers. This will reduce the WSEL thus allowing flood waters to drain without backing over the divide. If water does not back over the divide, no NAS can transfer either way between basins.

Additional storage would take two forms: constructed detention basins and rehabilitated natural wetlands. Returning ditches to their historical meandering courses would also add storage albeit at the cost of taking crop land out of production or changing the crops grown and strategy to grow them. (What used to be large monocultural blocks of, say, corn could instead be managed for multiple crops grown in smaller plots.)

Construction of detention basins, although a rather straight forward from an engineering perspective, would require considerable effort in obtaining easements. The NRCS would be the lead agency in obtaining these easements possibly under the Wetland Reserve Program or other applicable programs. Approximately 7,700 acre-feet of storage for a 1% event will be required on the western side of the divide. Over-topping of the divide from the Wabash Basin to the Maumee Basin to a depth that will allow passage of the Asian carp is not known, but is expected to be at less than the 1% event.

On the eastern side of the divide, construction of detention basins could be difficult due the presence of residential and commercial structures. Another approach may be to rehabilitate the historic wetlands to increase their capacity and detention times. Approximately 7,700 acre-feet of storage for a 1% event will be needed on the Fort Wayne side of the divide. The function of the increased storage and detention times is to reduce the WSEL in principally the St Mary's River. This reduced WSEL will allow flood waters from Junk Ditch to drain away from the divide as opposed to crossing the divide and forming a path for NAS. Increased conveyance of Trier Ditch and discharge downstream of New Haven (SB12), and improved conveyance of the Maumee River below Fort Wayne would reduce the detention requirements on the St. Mary's.

Improved storage on the Fort Wayne side of the divide is critical to eliminating the flow into the Wabash Basin. With the flow of water eliminated, the threat of movement of Asian carp into the Maumee Basin is eliminated. Over-topping the divide to a depth that will allow passage by Asian carp will occur during a 10% event.

Given that the probability of water flowing from the Maumee Basin to the Wabash Basin is much greater than the probability of water flowing from the Wabash Basin to the Maumee basin, the priority of effort should go to improved detention in the Maumee Basin. Separation of the basins at the historic divide and rehabilitation of the St. Mary's and St. Joseph's wetlands will probably be the most acceptable alternative to the Eagle Marsh stakeholders.

Sketch

Alternative No.: SB-2

☐ Original ☐ Alternative

The identification of specific storage basins has not occurred. Generally, in the Maumee basin, the shorage basins should be between 10-20 acres and 1-2 feet deep holding from 10-40 acre-feet of water. Approximately 770 basins or rehabilitated wetlands holding 10 acre-feet each would be required.

Construction Cost Estimate

Alternative No.: SB-2

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Uniformly Graded Riprap (250 Lb) 18"	T	$37			3,465	$128,205
Embankment	CY	$12.45			71,230	$886,813
Excavation - Borrow	CY	17.85			71,230	$1,271,456
Seed and Straw	SF	$0.10			250,000	$25,000
Remove store and replace topsoil	CY	$5			5,400	$27,000
Land acquisition	AC	$5,000			5	$23,000
TOTALS						$2,361,474

SCENARIO 9

Value Alternative

Project: Wabash-Maumee River Basin Connection Study
Location: Fort Wayne, IN

Alternative No:
Prev B-12

Title:
Create a barrier at the Huntington Dam as shown on the map below:

Description of Original Concept:

Not applicable.

Description of Alternative Concept:

This alternative can be developed into other sub-alternatives.

1. Install permanent electric barrier at Huntington Dam.
2. Install a barricade on the Huntington Dam and install a trash and debris boom upstream

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

Prev B-4 First Cost:	$ 4.273,000
Prev B-12 First Cost: Alternative 3	$2,982,000
First Cost Savings:	$1,291,000

Advantages/Disadvantages

Alternative No.: Prev B-12

Advantages of Alternative Concept

- This alternative moves the solution away from the Fort Wayne Area which will avoid any negative perceptions from the public.
- Alternative does not negatively impact Eagle Marsh or any other wetland areas which are environmentally sensitive.
- Alternative is constructed at an area where carp is last known to be found. This alternative appears to be more preventative than having an alternative constructed closer to the basin divide.
- Acquisition of real estate is minimal compared to most other alternatives. Huntington Dam area has already been identified constructed and access has already been established. Our project would need to upgrade and improve the access road.

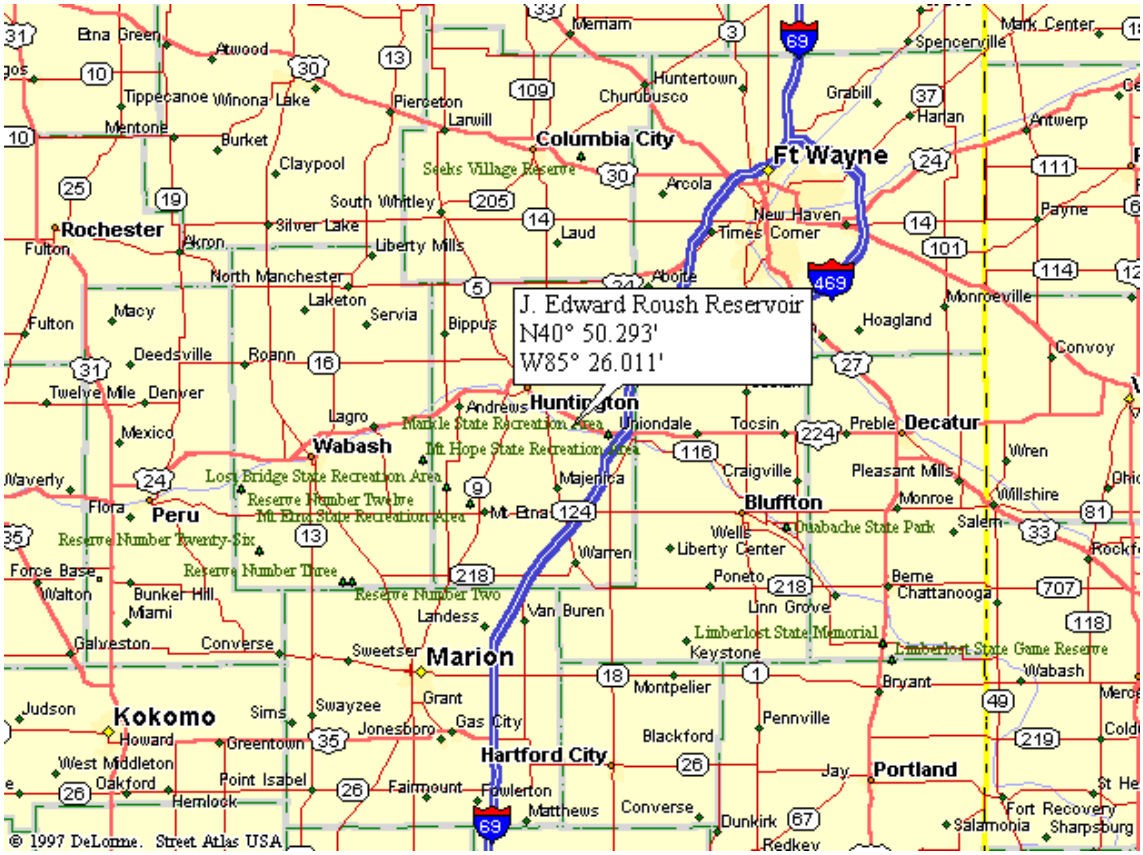
Disadvantages of Alternative Concept

- Huntington Dam would need rehabilitation work completed . Also, a sponsor would need to be identified.
- Monthly electric bills may be costly unless an alternative power source can be identified and utilitized. The electric fence concept is the least intrusive and visual to the public.
- This alternative does not address the Goby migration.
- Failure of the project may imply Corps of Engineers failed to prevent migration of the carp. Public may assume Corps did not properly maintain the project.
- A build up of fish may occur downstream of the fish barrier. It may be necessary for removal of this fish at some time. Since this is a farming area, can the idea of using the fish as a product to fertilizer farms be promoted?
- Debris from the trash boom will need to be removed on a routine basis. This removal schedule will be dependent on how much builds up and flooding.
- A solution would need to be determined how to handle ice break up or melting of the ice.

Discussion

Alternative No.: Prev B-12

The Huntington Dam is an approximate 200 foot wide dam which is approximately six to eight feet high. It is located west of South Jefferson Street in Huntington, Indiana and is approximately 20 miles southwest from Eagle Marsh and is north of the J. Edward Roush Reservoir. See map below.



To the north of the dam is the railroad. Access to the site would be made by a dirt road off of South Lafoniane Street which is west of the dam. Based on aerial photography, it appears an existing dirt road already exists. This dirt road is at the base of the railroad embankment and goes to the existing Huntington Dam Site.

Currently it is believed that no one claims ownership to the Huntington Dam. It is not owned or maintained by anyone or any company/facility. And it is currently in need of repair. Acquisition of the access road and of the Huntington Dam area would be necessary for the construction, operation, and maintenance of this project.

Discussion

Alternative No.: Prev B-12

Photo 1: Huntington Dam upstream.

CONSTRUCTION: It is assumed water must continue to flow during the construction phase. There are several options for construction. For this VE Study, assume water can be diverted to one side while construction of the posts are in the dry. Then once posts construction are completed. Diversion is then re-routed to the other side. This method is currently being used for construction of a Gate Structure in the Indianapolis Water Works Canal.

Several alternatives can be considered at this site in order to keep the carp from migrating toward the Eagle Marsh area.

This alternative can be developed into other sub-alternatives.

1. Install permanent electric barrier at Huntington Dam. It is proposed that during a dry time of the year a trench be constructed across the dam for the placement of a conduit which will contain electric cabling producing an electric current which will deter the fish from migrating. Upstream. A small permanent block structure of approximately 8' x 8' would need to be constructed that would hold the electrical panel and any controls for the electric fence. From the aerial photograph, it appears electric is available.

Alternative sources of energy can also be used at this site in lieu of electric which may be costly. Other energy sources may be solar power. Also, is hydro-power a possibility. See Photo 1 above and Sketch 1 and Sketch 2.

Discussion

Alternative No.: Prev B-12

2. Install a barricade on the Huntington Dam and install a trash and debris boom upstream. From the aerial photograph, it appears debris may be a problem. It is recommended that a trash boom be installed across the upstream portion of the river to collect floating materials. The purpose of the trash boom is to catch debris before it reaches the barricade. The trash debris is to be approximately 300 feet in length. An example of the trash boom is shown on Photo 2 below.

There are several types of barricades which can be constructed on the Huntington Dam. The one which comes to my mind would be shapes similar to the anti-climb barriers seen at prisons. An example of this is shown on Photo 3 below. The height of the barrier is to be determined by hydraulic studies. However, for this VE Study, we will propose the barrier to be 3 meters in height. The material to be used shall be strong enough to withstand water and ice loads.

The width of the slats to be used shall be sufficient to keep out carp. For the sake of this study we will use 2" width since this is the approximate mesh size used on the IDNR fence located at the Eagle Marsh site.

3. Construct a Ice and Fish Barrier Weir Wall. It is proposed to demolish the existing Homestead Dam structure and to reconstruct a new weir wall that is approximately one foot below the existing dam elevation. The center of the proposed weir will be an additional two feet lower to maintain a constant flow during the extremely cold weather. The constant flow will minimize the ice barrier issues. See Photo 4 below. Also see Sketch 3.

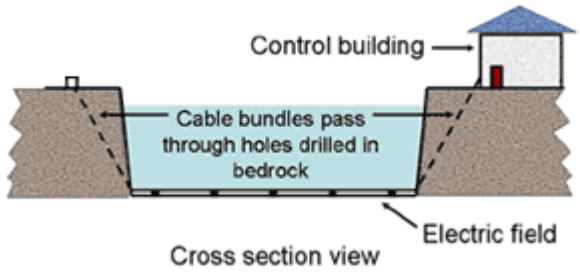
This alternative does move the solution away from the city of Fort Wayne which will avoid the negative perception of construction and blame for any future flooding issues. Also, this alternative required minimal real estate acquisition and is proposed to be constructed at a location which is already used for flood control. An access road has already been constructed by the Huntington Dam owners. While the access road will need improving, it is minimal. No change to the existing alignment for the access road will be necessary. This solution is also unobtrusive. The alternative does not bypass any existing wetland areas and will not require any large property acquisition for detention. There is little to no environmental issues with this alternative.

Sketch

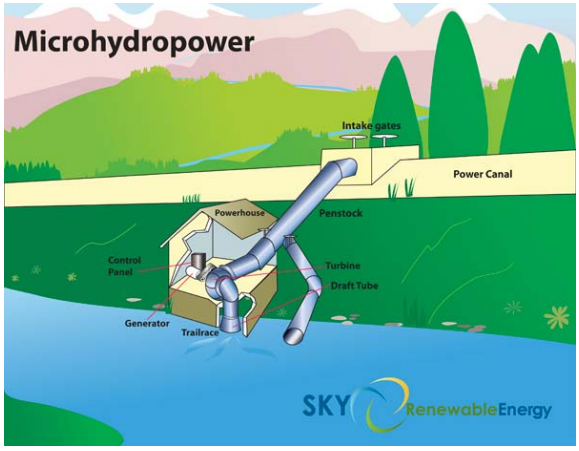
Alternative No.: Prev B-12

☐ Original ☑ Alternative

Alternative 1: Install Permanent Electric Barrier at Huntington Dam.



Sketch 1: typical section of the electric field at Huntington Dam.



Sketch 2: small hydropower plant.

Sketch

Alternative No.: Prev B-12

☐ Original ☑ Alternative

Alternative 2: Install a barricade at the downstream spillway area

Photo 2: Example of a trash boom proposed to be used upstream of Huntington Dam.

Photo 3: Example of Fish Barrier proposed at Huntington Dam.

Sketch

Alternative No.: Prev B-12

☐ Original ☑ Alternative

Alternative 3: Ice and Fish Barrier Weir Wall

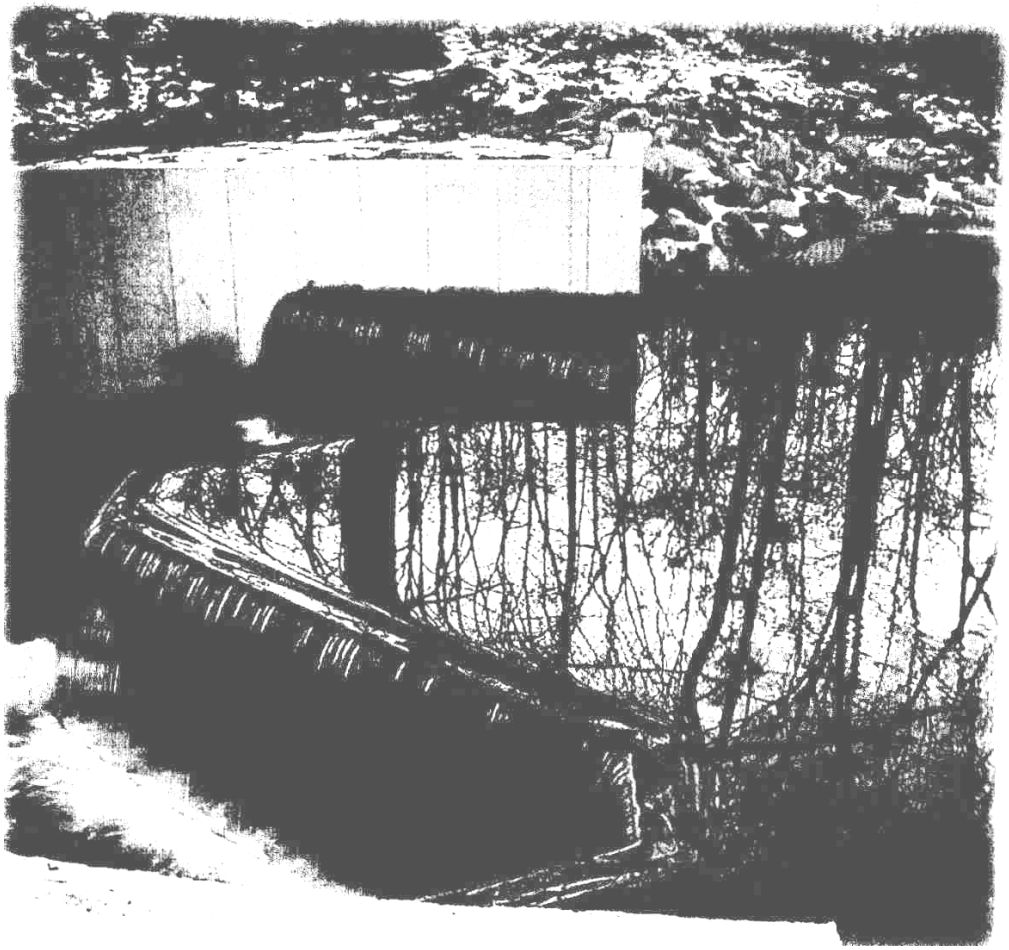


Photo 4: Example of multiple weir to be proposed.

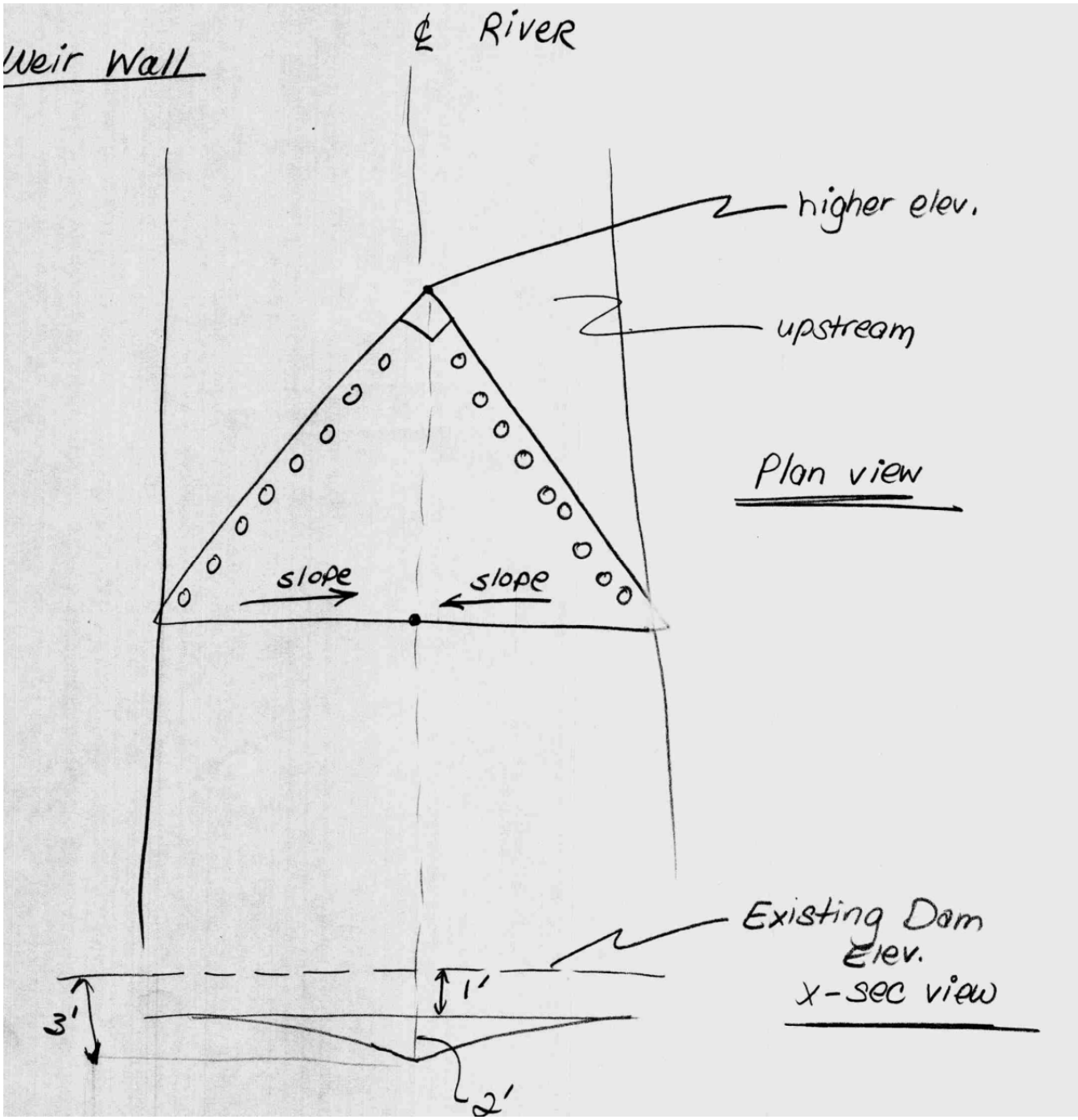
Sketch

Alternative No.: Prev B-12

☐ Original ☑ Alternative

Sketch 4: Proposed weir and slopes.

Trash boom on upstream end of Huntington Inland Dam.



Construction Cost Estimate

Alternative No.: Prev B-12

			Original Concept		Alternative Concept	
			(Deletions)		(Additions)	
Item	**Unit of Meas.**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Alternative 1						
Conduit and electric cabling across lake bottom	LF				200	
8'x8' block building,	EA				1	
Electric panel box	EA				1	
Conduit and cabling	LF				250	
Trenching	LF				250	
Access Road, 10' width , 200 feet length, and parking area	CY				45	
Electric Service Hook-up	EA				1	
Alternative 2						
Barrier—Railing with curved top, 3 meter pale length	LF				225	
Posts, every 8 feet, length 11 feet	EA				28	
Upstream trash boom	LF				300	
Concrete for posts, 28 holes, 3 feet concrete, 1 foot diameter posts holes,	CY				2.5	
28 posts holes to be dug 3 feet in depth, 1 foot diameter. Will be accomplished during low water.						
Divert flow operation during construction	EA				1	
Alternative 3						
Ice Barrier and Fish Weir Wall Design	EA				1	
TOTALS						

Section 5

Design Suggestions

SECTION 5
DESIGN SUGGESTIONS

In addition to the Value Alternatives in the previous section, the team generated several other ideas that we have termed design suggestions. These are presented to bring attention to areas of the plan which, in the opinion of the team, should be changed. In general these ideas were designated as design suggestions rather than Value Alternatives for one of two reasons:

1. The value improvement opportunity is relatively small
2. The concept could not be adequately evaluated or developed within the constraints of the workshop resources

Design suggestions typically are associated with issues such as:

Improved operation

Ease of maintenance

Easier construction

Reduced risk of construction claims

Clarification of construction documents

Or safer working conditions

CB-43 Build wall, separate basins and buy-out flood-prone structures

The value engineering team identified the idea of physically separating the basins and buying out flood-prone structures. The advantage of a large physical structure is that it prevents all aquatic transfer across the divide from either basin. The structure could be constructed to blend into the surrounding landscape.

This alternative is generally believed to be the most expensive and disruptive to the community because of relocation. This would also be a time consuming inter-agency endeavor.

TF Trapping of Aquatic Nuisance Fish

The value engineering team identified the idea of creating methods of trapping, monitoring, eradicating, and deterring aquatic nuisance species as potential areas of further evaluation. These included fish attractors and traps, government incentives for commercial fisheries, eradication of fish eggs or breeding habitat, a reward/bounty system for caught fish, poisoning of the fish, introduction of pathogens or diseases harmful to the nuisance species, and traps for jumping carp near low-head structures. It is possible that by one or more of these methods, the risk of nuisance species migrating between basins can be largely reduced.

Locations or areas which these methods might take place are species dependent. For Asian carp and snakehead species, these methods would need to take place on the Little

River/Wabash system. For goby species, these methods would need to take place along the Maumee/St Mary's system. Methods used in the Pacific Northwest to keep salmon out of intakes might be considered.

G-5 Monitoring of Aquatic Nuisance Fish

The value engineering team identified the idea of extensively monitoring and studying the advancement of aquatic nuisance species within both the St Mary's and Little River basins to identify risks. This stemmed mainly from questions regarding why in particular the Asian carp have not successfully migrated upstream into the Little River system. The study would need to address many factors that could influence movement of this species. These factors would include hydraulic parameters including flow history, water temperature, sediment load, and possible chemistry variables. One USGS gage does exist in the stream section for historic flow data. Additional parameters may be added to the existing gage. Literature research should be extensively researched to aid in identifying flow, chemistry, and temperature triggers that would influence movement to aid in the focus of the data collection.

Images from Google-Earth, March 2005, at the confluence of Little River and the Wabash River in Huntington show a distinct difference in sediment load with a long mixing zone, possibly associated with temperature differences. It does provide evidence of distinct differences in the two streams. In addition, during flood flow the Little River would have a considerable urban runoff factor in the water chemistry. The possibility exist that a trace compound in the discharge acts as a deterrent to movement.

This would need to be a longer term data collecting and monitoring research effort and is therefore outside the boundaries of this study. University research resources do exist in the area, thus grant programs should target the need. Knowledge gained through an improved understanding of species specific movement at this site would be applicable to other areas on the basin boundary. Currently some Asian Carp monitoring for movement tracking is planned. Expanding this study in combination with other parameters would be prudent at this time.

G-10 Generate Separate Solutions by Species

The VE team discussed the list of invasive species that had been previously generated prior to this workshop. The species on the list (see attached) were generally grouped into the following categories: swimmers, floaters, and parasites. A lengthy discussion occurred as to what the scope was for this project and what could reasonably be stopped. Some of these species are microscopic that could be transported as easily via a fishing rod and reel as could be transported hydraulically within a stream bed, therefore this project has chosen to focus on the macro level species more associated with the swimmers. The team quickly analyzed the risk associated with the swimmers as well as the threat timeline and determined the Goby, Asian Carp, Snakehead and the Ruffe to be the most critical within the 50 year life of this project.

<u>Mississippi to the Great Lakes</u>:

The only species currently documented near the site or known to be moving to the site are the Silver and Bighead Asian Carp. Black Carp movement is expected to be similar to the Silver and Bighead with similar barrier function. Snakeheads are expected to require a dry-barrier or separate basin approach.

Great Lakes to Mississippi:

At the present time knowledge of Gobi migration is not documented that closely. Some options may exist to block Gobi at distance, even near Lake Erie. The Ruffe currently exists in the Great Lakes but the participants of this study aren't aware , at this time, of what information is available on the Ruffe migration.

This idea suggests considering a solution to address the function of STOP TRANSPORT by species rather than a one size fits all solution. Each one of these species has different characteristics which may require different solutions; a species specific solution could be installed at different locations.

The Asian Carp (Bighead & Silver Carp):

The Fish

- Once they reach sexual maturity they seek to move upstream, against flow, to spawn
- A sexual mature Asian carp is expected to be approximately 21.5" inches in size which has the capability to swim against very strong flows
- They have been known to jump 10' vertically which could translate into nearly twice that diagonally

The Eggs

- They must have water flow in order to survive: 0.6- 1.8 m/s
-
- The eggs prefer hard water because soft water is said to allow moisture to penetrate

Temperature Tolerance:

Bighead Carp

Bighead Carp can tolerate extremes in water temperature, from cold temperate to tropical. In their native range in China, Bighead Carp spawn at different temperatures: in the Yangtze River, from 26 to 30°C in 1957 to a range of 18.3 to 23.5°C in 1953 and 1954 and as low as 18°C in the Han River. Their critical thermal maximum is 38.8ºC, and a preferred temperature range of 25.0 to 26.9ºC.

Silver Carp

As with Bighead Carp, the water temperature range at which larval Silver Carp can exist is broad: 16-40°C, with optimum temperature experiments reporting ranges from 26-39°C. The upper lethal temperature of larval Silver Carp (aged 3 to 28 days) was 43.5- 46.5°C. Although no lethal minimum temperature has been

documented, it is common for silver carp to survive over-winter in ice-capped water bodies that are near 0°C. Some research suggest that the silver carp may be more cold tolerant that the bighead carp.

Salinity Tolerance

The ability of bighead carp fry to osmoregulate increased with age and 6% appears to be the critical maximum salinity. Studies have indicated that silver carp can survive in water up to 12% salinity.

Sexual Maturity and Spawning Behavior

Bighead Carp

Age at maturity varies significantly with environmental and climatic conditions. The average age of bighead carp at first maturity in temperate climates is 6 to 8 years. In these dame temperate climates, bighead carp matured at an average weight of 5 to 10 kg and 70 to 80 cm.

Mating activity of bighead carp generally takes place at the surface with males actively chasing females and sometimes leaping out of the water. Usually more than two males follow one female; like other carps, the Bighead Carp is promiscuous.

Silver Carp

Like male bighead carp, male silver carp usually mature one year earlier than females, and the age at which this species reaches sexual maturity was variable across systems (2-5 kg, age 3-6). When silver carp are ready to spawn, ripples have been seen on the water surface from spawners chasing each other. About 40 to 80 minutes later, males and females ascended close to the water surface, chasing each other and shedding eggs and sperm

Feeding Habits

Bighead Carp

Most literature cites the Bighead Carp as being predominantly zooplanktivorous, particularly when zooplankton biomass is high. The youngest larvae (7-9 mm) have been found to eat primarily protozoa and zooplankton, including rotifers, the cladocerans Bosima and young Moina, and copepod nauplii and copepodites. At lengths between 18 and 23 mm, larvae began to eat phytoplankton (mainly diatoms), and at 24 to 30 mm they readily consumed zooplankton and phytoplankton.

Silver Carp

Many studies have found Silver Carp to feed primarily on phytoplankton. They consume plankton and other particles that are harvested by filtration, but can effectively filter and consume smaller particles than Bighead Carp (Table 3). They are thought to be pump filter feeders. Silver Carp have been found to be ineffective at removing nannoplankton and picoplankton from the water. Studies have consistently shown that filter feeding by Silver Carp shifts the species composition of the phytoplankton community to smaller species.

Response to Stimuli

Bighead Carp

U.S. Fish and Wildlife Service (2003) reported that Bighead Carp submerged at the sound of an outboard motor in the Missouri River below Gavins Point Dam, South Dakota and Nebraska. It has observed that bighead and silver carps are susceptible to being driven by a boat or other noise-generating methods useful in their capture. Nevertheless, Bighead Carp are more lethargic than Silver Carp and do not often jump from the water.

Silver Carp

Silver Carp is a pelagic, schooling species. Unlike bighead carp, silver carp in the Missouri River or its tributaries are rarely observed on the surface until disturbed. DCC has observed that once disturbed, Silver Carp often swim rapidly near the surface creating a characteristic large wake. Silver Carp regularly jump out of the water when disturbed, particularly in response to outboard motors. It's been stated that this response is more pronounced with higher RPMs and greater motor noise.

Tubenose Goby:

The species was introduced via ballast water into the St. Clair River, Michigan sometime before 1990.

Habitat Preferences

The usual habitat for this species is shallow bays, offshore banks, or flowing water of streams. However, it also can be found in ponds and canals overgrown with vegetation. When current is strong, it hides under boulders. It is often found under stone or among weeds, to which it retreats rapidly if disturbed. The preferred conditions probably restrict its probable range of suitable habitat to shallow waters.

Feeding

Tubenose goby do not feed on zebra mussels, as do round gobies. Tubenose gobies feed on various aquatic invertebrates and have been shown to have a significant overlap in diet preference with rainbow darters, Etheostoma caeruleum, and may compete with these native fish for food.

Spawning

Male tubenose gobies guard their nesting sites defending the eggs and young. They spawn multiple times during the warmer months of the year and as a result are rather prolific. Their eggs have adhesive properties that attach to vegetation or to whatever is nearby.

Sexual Maturity

Tubenose gobies are typically 2-3 inches in total length at sexual maturity. Adults can reach 4 inches

The Snakehead:

The Northern Snake Head (Channa argus) can exceed 33 inches in total length. It is a veracious predator with teeth capable of inflicting injuries to anglers. The northern snakehead can tolerate water temperatures from 0-30 degrees Celsius. Its upper salinity limit has been reported at 18 parts per thousand. The northern snake head

reaches sexual maturity at 2 to 3 years. Snakeheads form monogamous pair that remain throughout the spawning season. They build nest from vegetation. Snakeheads practice parental protection of the nest until the fry absorb their yolk sacs. At this time the fry are usually 8mm in length. Adult females can produce 22,000-51,000 eggs per spawn and can spawn 1 to 5 times per year. Adult snakeheads feed mostly on other fish. Young northern snakeheads eat a wider variety of food items. In optimal conditions the northern snakehead can survive out of water for up to 4 days. It can survive buried in mud for much longer periods of time. It can also travel short distances across land in moist conditions. The northern snakehead prefers stagnant, shallow, weedy, waterways with mud bottoms. However, they can survive and reproduce in a variety of habitats.

Snakeheads are popular food items in Asia. Some introductions into the United States have been traced to this source. They are also kept in the aquarium trade. The northern snake head resembles the bowfin (Amia calva), a native fish species. The most obvious difference is the larger anal fin and prominent teeth of the snakehead when compared to the bowfin. Measures to control the Northern snakehead include the use of chemicals such as Rotenone.

The northern snakehead was first detected in the United States at Silverwood Lake, California in 1997. They have also been reported from Maryland, North Carolina, Arkansas, Massachusetts, Illinois, New York, Virginia, and Pennsylvania. Several of these areas have reported reproduction. This species has the potential to spread aggressively from these areas. The northern snakehead has also invaded popular culture including made for TV movies (see below).

The Ruffe:

The ruffe (Gymnocephalus cernuus) reaches an adult length of 4 to 6 inches. It is highly aggressive and can survive a wide variety of environmental conditions from deep cold lakes to shallow warm bodies of water. The optimal temperature for growth is between 25 and 30 degrees Celsius. The upper lethal temperature for juveniles is between 30 and 34 degrees Celsius. It can tolerate murky, polluted, nutrient rich waters and salinities ranging from fresh to brackish (salinities up to 12%). It is most often found in areas free of vegetation with a soft bottom. The ruffe spends its days in deeper water to avoid predation. It has sharp spines on its fins and gill covers to detour predators. At night it moves into shallow water to hunt. It has anatomical features that make it a very effective nocturnal hunter at all stages of its life. The ruffe matures quickly, typically reaching sexually maturity at 2-3 years but in warmer water it can reach sexual maturity in as little as 1 year. A single female can produce up to 20,000 eggs per year. Newly hatched embryos are 3.5-4.4 mm in size.

The ruffe was first detected in the St. Louis River in the early 1986. Genetic research indicates that ruffe populations in the Great Lakes originated from southern Europe. It is currently found in Lakes Superior, Huron, and Michigan. Additionally, it is found in several tributaries to these lakes.

In Lake Superior attempts to control growth of ruffe populations was attempted by stocking predators including walleye and northern pike; this did not work. Based on examination of stomach contents of several predatory fish species, the only fish species that appears to consume ruffe regularly is the bullhead catfish. The predatory fish that were stocked preferred native fish that lacked the sharp spines the ruffe possesses.

Recent research has examined using alarm pheromones and reproductive pheromones to manage ruffe. Chemical control has also been considered. Chemicals may be effective but if a small number of fish survive they can repopulate the area.

Invasive Species				
Taxa	**Species**	**Common Name**	**Basin Est.**	**Inter Basin Dispersal Mech.**
algae	*Bangia atropupurea*	red macro-algae	GL	ballast / rec. boating
algae	*Cyclotella cryptica*	algae	GL	unknown / any water
algae	*Cyclotella pseudostelligera*	algae	GL	unknown / any water
algae	*Enteromorpha flexuosa*	grass kelp	GL	ballast / rec. boating
algae	*Stephanodiscus binderanus*	diatom	GL	ballast water
annelid	*Branchuris sowerbyi*	tubificid worm	GL	sediment transport
bryozoan	*Lophopodella carteri*	bryozoans	GL	with aquatic plants
copepod	*Neoergasilus japonicus*	a parasitic copepod	GL	parasite to fish
crustacean	*Apocorophium lacustre*	a scud	MS	ballast water
crustacean	*Bythotrephes longimanus*	spiny waterflea	GL	ballast water / sediment transport
crustacean	*Cercopagis pengoi*	fish-hook water flea	GL	ballast / rec. boating
crustacean	*Daphnia galeata galeata*	water flea	GL	ballast water
crustacean	*Echinogammarus ischnus*	a European amphipod	GL	ballast water
crustacean	*Hemimysis anomala*	bloody red shrimp	GL	ballast water
crustacean	*Schizopera borutzkyi*	copepod	GL	ballast water
fish	*Alosa aestivalis*	blueback herring	GL	swimmer
fish	*Alosa chrysochloris*	skipjack herring	MS	swimmer
fish	*Alosa psuedoharengus*	alewife	GL	swimmer
fish	***Channa argus***	**northern snakehead**	**GL**	**swimmer**
fish	*Gasterosteus aculeatus*	threespine stickleback	GL	swimmer
fish	***Gymnochephalus cernnus***	**ruffe**	**GL**	**swimmer**
fish	***Hypophthalmichthys molitrix***	**silver carp**	**MS**	**swimmer**
fish	***Hypophthalmichthys nobilis***	**bighead carp**	**MS**	**swimmer**
fish	*Menidia beryllina*	inland silverside	MS	swimmer
fish	***Mylopharyngodon piceus***	**black carp**	**MS**	**swimmer**
fish	*Petromyzon marinus*	sea lamprey	GL	swimmer
fish	***Proterorhinus marmoratus***	**tubenose goby**	**GL**	**swimmer**
mollusk	*Pisidium amnicum*	European pea clam	GL	ballast water
mollusk	*Potamopyrgus antipodarum*	New Zealand mudsnail	GL	ballast water
mollusk	*Sphaerium corneum*	European fingernail clam	GL	ballast water
mollusk	*Valvata piscinalis*	European stream valvata	GL	ships
plant	*Carex acutiformis*	swamp sedge	GL	recreational boating & trailers
plant	*Glyceria maxima*	reed sweetgrass	GL	recreational boating & trailers

Invasive Species				
Taxa	**Species**	**Common Name**	**Basin Est.**	**Inter Basin Dispersal Mech.**
plant	*Landoltia (Spirodela) punctata*	dotted duckweed	MS	recreational boating & trailers
plant	*Murdannia keisak*	marsh dewflower	MS	recreational boating & trailers
plant	*Oxycaryum cubense*	Cuban bulrush	MS	recreational boating & trailers
plant	*Trapa natans*	water chestnut	GL	recreational boating & trailers

HI-1-7

The value engineering team identified a functional need to HANDLE ICE (HI) for any alternative solution that is developed. The topic of accommodating ice is a secondary function to this project but may be critical to the long term operations and success of the project. Several methods were brainstormed on how to prevent or at least minimize the opportunity for ice formation:

- H1: Melt Ice
- HI2: Break Up Ice
- HI3: Minimize surface for ice formation
- HI4: Minimize standing water
- HI5: Check need for ice load
- HI6: Build forest to block ice
- HI7: Design for appropriate ice event reoccurrence
- HI8: Use chemicals to melt ice and discourage fish

A quick review of historical data from http://www.weather.gov/climate/ yields an expected window of potential ice formation from December – February. The temperatures appear to remain at or below freezing majority of the time thus further supporting the concerns raised by the team. The probability/risk of substantial ice formation may warrant further investigation but for the purpose of this activity, no information could be obtained to discredit the need/concern. It would be prudent for the final design to account for and accommodate ice formation.

Historical Climate for Lafayette Indiana					
	Jan-10	Feb-10	Mar-10	Nov-10	Dec-10
Average High Temperature (F)	29.3	32.7	55.1	55.2	30.9
Average Low Temperature (F)	17.8	19.1	34.5	31.9	17
Highest Temperature (F)	54	41	78	76	60
Lowest Temperature (F)	-2	2	21	21	-2
Heavy Snow (# Days)	0	0	0	0	0
Snow	2	2	0	0	3
Light Snow (# Days)	11	13	0	1	18
Freezing Rain (# Days)	0	0	0	0	0

APPENDICES

APPENDIX
A – PARTICIPANTS

(

Wabash-Maumee River Basin Connection Study
Fort Wayne, IN
January 19 – 21, 2011

Name:	Company:	Phone:	Email:	Introduction	Mid-Point Review	VE Presentation
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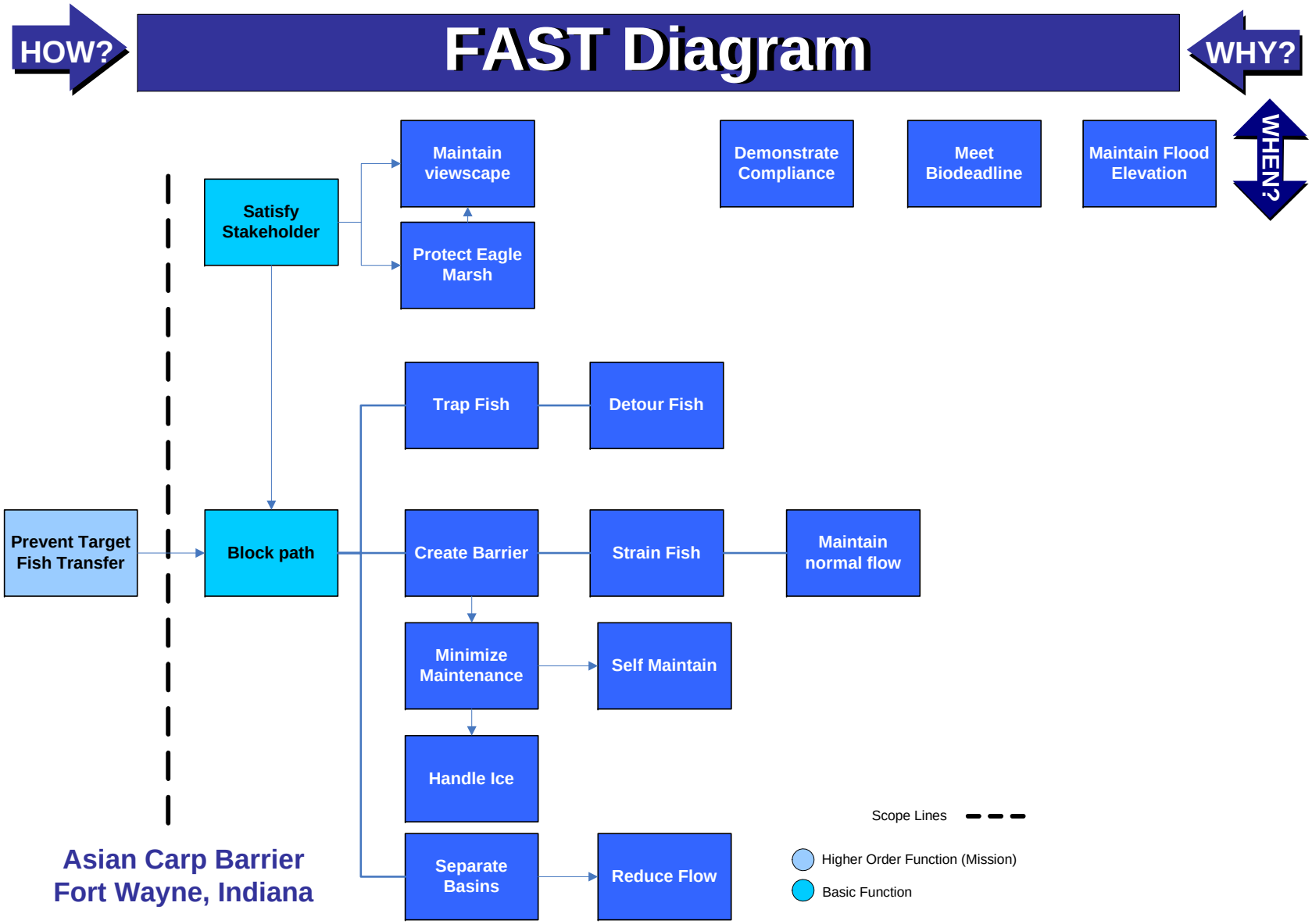
APPENDIX
B – FUNCTION ANALYSIS

FAST Diagram



Asian Carp Barrier
Fort Wayne, Indiana

APPENDIX
C – CREATIVE IDEA LISTING

CREATIVE IDEA LISTING

Idea No.	Description	Votes
Create Barrier (CB)		
CB-1	Build a berm	4
CB-2	Create a vertical drop structure	5
CB-3	Enhance the fence	5
CB-4	Create a fence berm combination	6
CB-5	Build a jersey barrier wall	0
CB-6	Build a fence in one location and a berm in another	RR
CB-7	Create channel or swale as a barrier	1
CB-8	Constuct barrier as path through wetland	1
CB-9	build a permeable barrier (riprap)	7
CB-10	Use bubble barrier	0
CB-11	Use electric barrier	0
CB-12	Use a dead zone	0
CB-13	Create extremely turbulent flow zone	2
CB-14	Build a dam and siphon spillway	1
CB-15	Build a labyrinth to lengthen flow path	1
CB-16	Build an "S" shaped spillway	2
CB-17	Use disposable net	0
CB-18	Use fuse-plug section	0
CB-19	Reshape wetland a multi-cell long path	1
CB-20	Use cable-type barrier to reduce maintenance	0
CB-21	Build a vegetative barrier that will lay down under emergency flows	DS
CB-22	Build berm where Graham McCulloch crosses railroad	1
CB-23	Use inflatable dam	1
CB-24	Use partial barrier with closure for predicted flood	1
CB-25	Build structure and pump around	5
CB-26	Build a dam with traditional fish screens	4
CB-27	Fix screen full height at I-69	0
CB-28	Berm with underdrains	7
CB-29	Berm with jump barrier	0
CB-30	Use existing topo and structure while lowering tailwater	0
CB-31	Create barrier and reroute Graham-McCullom Ditch to Junk ditch and build floodwall	5
CB-32	Create flood wall enclosure at the mouth of Junk Ditch	0
CB-33	Replace existing low head dams and build Amberson Dam with bar screens to foil jumping carp	2

Idea No.	Description	Votes
CB-34	Build angled bar screen	0
CB-35	Build barrier for the longest economic crest for lowest head difference and lower velocity	6
CB-36	Add or build a new structure with self-regulating gates bottom hinged with bar screens	2
CB-37	Move fence to immediately downstream of a road and use the road as an ice filter	2
CB-38	At a road, install self-regulating tide gates to control water surface elevation with a low sill for gobi and screen for carp	1
CB-39	Add sufficient bar screens and culverts to maintain adequate flow	0
CB-40	Add a large trash rack in front of other structures and use bar screens for carp	2
CB-41	Do CB-39 with trash bypass such as stop logs or similar	3
CB-42	Build long weir for 1% flood and screen culvert for 10% flood	1
CB-43	Build wall, separate basin and buy out flood-prone structures	DS
CB-44	Create dry barrier for snakehead	0
CB-45	Create low vertical sill to block gobi	1
Separate Basins (SB)		
Sb-1	Raise elevation of the divide	4
Sb-2	Create storage in both basins	9
Sb-3	Create a pump storage detention south of the railroad and west of I-69	0
Sb-4	Create wetland detention	4
Sb-5	Use quarries for storage	2
Sb-6	Construct depressed wetland below water table and pump	4
Sb-7	Do SB-6 and use renewable energy	2
Sb-8	Enhance conveyance of the Maumee and Wabash Rivers	3
Sb-9	Use stormwater BMPs in St. Mary's and St. Joseph watersheds	4
Sb-10	Create storage in Junk Ditch	RR
Sb-11	Increase conveyance on the Trier Ditch up stream of New Haven	0
Sb-12	Do SB-11 and reroute to discharge downstream of New Haven	2
Sb-13	Divert flow to reservoir at Roush dam	2
SB-14	Lower water surface elevation as part of the design approach	0
Trap Fish (TF)		DS
TF-1	Build a carp trap for jumping fish at low head dams	2
TF-2	Create incentives for commercial fishery	4
TF-3	Create a bounty system	0
TF-4	Skim for snakehead eggs	0
TF-5	Attract fish to trap areas	0

Idea No.	Description	Votes
TF-6	Build side channel reservoir with upstream screen and preferred path for fish	1
TF-7	Poison fish	1
TF-8	Bait area to attract	0
TF-9	Create sport	0
TF-10	Kill with overpressure	0
General (G)		
G-1	Invite TNC to maintain wetland	0
G-2	Create stakeholder group by information campagn regarding threat and opportunity	2
G-3	Generate funding source for 35% cost share	1
G-4	generate funding source for long term maintenance	1
G-5	Extensively monitor and study the Little River to determine why the carp has not migrated	DS
G-6	Find and stock native competitor	1
G-7	Create a moderated, technical blog on carp biology and management practices	1
G-8	Have free conferences offering CEUs focused on carp control	1
G-9	Move solutions away from flood areas	2
G-10	Separate solutions by species (goby in one place, carp in another	DS
G-11	Use adaptive management and build additional measures as necessary - get adequate land, etc.	1
G-12	Encourage Predation	0
G-13	Find pathogens or disease to which carp are susceptible	1
G-14	Research Asian literature	1
G-15	Do nothing	5
Ideas previously generated by project team (Prev)		
prev B-1	Construct Barrier Fence	2
Prev-B-2	physical barrier at headwaters of Junk Ditch east of Eagle Marsh near theoretical basin divide	3
Prev-B-3	Barrier upstream of I-69	0
Prev-B-4	Rock/sand berm parallel to I-69 combined with realignment of Graham McCullogh Ditch - variations include sand core berm w/ rock cover; excavation of ditch realignment material used for berm; one or series of innovative release structures	5
Prev-B-5	Barrier at Homestead Road	4
Prev-B-6	Barrier at Ellison Road	0
Prev-B-7	Barrier at Aboite Road	0
Prev-B-8	System combining multiple areas with a chain of small ponds	4

Idea No.	Description	Votes
Prev-B-9	Barrier at current fence site	1
Prev-B-10	Barrier at I-69 bridge	0
Prev-B-11	Extend levee across Junk Ditch and add pump station	0
Prev D - 1	Fox Island Diversion (create more storage south of RR)	1
Prev D - 2	Divert Graham-McCulloch Ditch to Maumee watershed	0
Prev D - 3	Divert south side of Engle Road, channel parallel to Engle Road	0
Prev D - 4	Reduce flood elevations/Backflow in Junk Ditch	1
Prev D - 5	Add detention basins on St. Marys/St. Josephs watershed	4
Prev D - 6	Reroute Little River to Lake Roush	0
Prev T/K	Prevent passage of carp by electricity, "dead zone", or non-toxic repellent such as fruit juice. Maybe a leaky structure. If G-M Ditch is rerouted to the Maumee, then requirement for low water (normal) flow through the dam is eliminated.	0
Prev B 12	Create a fence or barrier at Huntington Dam	6
Prev B 13	Wicket dam barrier - floating overflow structure	2
Handle Ice (HI)		DS
HI	Melt ice	0
HI-1	Break up ice	1
HI-2	Minimize surface for ice formation	0
HI-3	Minimize standing water	0
HI-4	Check need for ice load	2
HI-5	Build forest to block ice	4
HI-6	Design for appropriate ice event reoccurance	1

DS – Indicates the Idea was selected to be written as a Design Suggestion and is included in the Design Suggestion Section of this report

RR – Indicates the Idea received enough votes by the Value Team to be developed. However, during the Development Phase the team found that the Idea was not feasible. Therefore, it has been designated RR indicating that it was Reviewed and Rejected by the Value Team.

APPENDIX
D – MATERIALS PROVIDED

MATERIALS PROVIDED

Document	Prepared by	Date
Paper map of Eagle Marsh habitat	Little River Wetlands Project	2011
Waterlines: Newsletter of IDNR describing current carp project	IDNR	Winter 2011
Topo sheets, maps and aerial photograph of Eagle Marsh & environs	IDNR	undated
Draft Alien Species White Paper (adobe and WP format)	Frank M. Veraldi, et al	November 2010
Alternatives Analysis, Parts 1&2	USACE	January 2011
Wabash-Maumee Field Report	Tetratech EM, Chicago, IL for USEPA	July 27, 2010

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APPENDIX E
Real Estate

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1.0 General

This Real Estate summary will accompany the report developed by the United States Army Corps of Engineers (USACE) entitled Aquatic Nuisance Species Controls Report, Wabash-Maumee Basin Connection, Fort Wayne, Indiana. The purpose of this report is to present the results of a USACE investigation to provide a range of options and technologies to prevent the spread of aquatic nuisance species (ANS) between the Mississippi River Basin and the Great Lakes Basin at the headwaters of the Wabash and Maumee Rivers near Fort Wayne, Indiana. The ANS Controls Report includes information on no-action, non-structural alternatives and structural alternatives. This Real Estate summary only applies to the nine structural alternatives analyzed in Section 3.5 of the ANS Controls Report. The structural alternatives will require the acquisition of private or State-owned real estate interests. A detailed description of each structural alternative is also included in Section 1.5 of Appendix F.

2.0 Project Area

The project area is defined as the headwaters of the Wabash and Maumee Rivers, primarily situated within Allen County in northwest Indiana, near the city of Fort Wayne. The area extends southwest along the Little Wabash River to the city of Huntington, Indiana. The principle area of concern is Eagle Marsh, a major unit of the Little River Wetlands Project (LRWP). Eagle Marsh is an urban natural area used primarily for conservation, education, and recreation. The property is owned by the State of Indiana and managed by the LRWP. The area downstream from Eagle Marsh is primarily agricultural in nature. Some structures associated with agricultural practices are present in this area, but substantial commercial and residential development is not present. The structural alternatives would be located on lands bordered by the I-69 corridor to the east, the Norfolk and Southern Railroad to the south, Aboite Road to the west and U.S. Highway 24 to the north.

3.0 Standard Estates

The following standard estates would most likely be required to support the various structural alternatives identified in Section 3.5 of the ANS Controls Report.

3.1 Temporary Work Area Easement (RWTWE)

A temporary easement and right-of-way in, on, over, and across the subject lands for a period not to exceed 3 years. The possession of the land is granted to the Grantee for use by its representatives, agents, and contractors as a work area, including the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to

perform any other work necessary and incident to the construction of the aforementioned project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving; however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.2 Road Easement (RWRDE)

A perpetual and assignable easement and right-of-way in, on, over and across the subject lands for the location, construction, operation, maintenance, alteration and replacement of a road and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way; subject however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

4.0 Non-Standard Estates

There are several structural alternatives presented in this report that require the construction of an earthen levee, I-wall, and/or fence to inhibit the movement of ANS. The real estate interest traditionally used to support the construction of a levee or I-wall is the Flood Protection Levee Easement (RWLVE). The Flood Protection Levee Easement is defined as “a perpetual and assignable right and easement in the subject lands to construct, maintain, repair, operate, patrol and replace a flood protection levee [or wall], including all appurtenances thereto…” However, the project alternatives considered in this report utilize traditional flood protection structures to inhibit the movement of ANS, not for flood protection purposes. As a result, the standard estate language would need to be modified to meet the needs of the project. Fences would be considered appurtenant structures, and would be covered under a modified levee easement.

If the final recommended alternative requires the use of a non-standard estate, the estate’s description will be included in the Real Estate Plan of a feasibility report or other decision document that would be reviewed and approved by HQUSACE prior to the commencement of acquisition activities.

5.0 Valuation of Real Estate Interests

Screening-level land value estimates have been prepared for each structural alternative by USACE for the purpose of this Real Estate summary. The estimates yielded a per acre value of $7,500, based on recent agricultural land sales within the main project area. Alternative F is located within the city of Huntington; a per acre value of $50,000 is used for this alternative only. A summary of conceptual Real Estate costs is provided in the Section 6.0, Table E-1.

Pending the execution of a Project Partnership Agreement (PPA) and prior to any acquisition activities, a market value appraisal report will be required to be provided by the non-Federal sponsor. The appraisal report will be reviewed by USACE for compliance with the Uniform Appraisal Standards for Federal Land Acquisition (UASFLA) and the Uniform Standards of Professional Appraisal Practice (USPAP). All acquisitions will be performed in accordance with Public Law 91-646, as amended.

6.0 Real Estate Costs

The following table indicates conceptual Real Estate costs for each structural alternative:

Alternative	Description	Permanent Acres	Temporary Acres	Total Lands	Total Costs
Alternative A	Construct I-wall	6.53	21.26	$95,000	$119,000
Alternative B	Construct Fence and Reconstruct Left Descending Graham-McCulloch Berm	12.76	26.64	$151,000	$189,000
Alternative C	Construct Earthen Berm and Pump Station	2.80	3.10	$27,000	$34,000
Alternative D	Construct Permeable Berm with Telemetered Sluice Gates	14.90	7.60	$125,000	$157,000
Alternative E	Construct Fence / Earthen Berm Combination	15.51	22.15	$161,000	$202,000
Alternative F	Construct Bar Screen Barrier at Existing Weir (Huntington Dam)	1.20	0.70	$68,000	$85,000
Alternative G	Construct Vertical Drop Structures with Telemetered Sluice Gate	2.30	1.50	$20,000	$25,000
Alternative H	Reconstruct Left Descending Graham McCulloch Berm	16.29	30.23	$184,000	$230,000
Alternative I	Reconstruct Left Descending Berm, Demolish Right Descending Berm, Construct Vegetation Filter Strip	24.31	32.95	$248,000	$310,000

*Temporary Work Area Easements are estimated at 3 years in duration. **Total Costs include a 25% contingency

Table E-1. Summary of Conceptual Real Estate Costs of Structural Alternatives

Preliminary Right-of-Way Plans have been developed for the purpose of the ANS Controls Report and are included in Appendix G, Sheets RW101 through RW114. When a final alternative is recommended and final Right-of-Way plans are available, a formal Real Estate tract register will be developed to include owner, estate, and acreage data. The tract register and a detailed Real Estate Project Map will be included in the Real Estate Plan of an approved feasibility report or other decision document.

7.0 Navigational Servitude

Navigational Servitude does not apply to this project.

8.0 Induced Flooding

As a result of the preliminary analysis conducted for the ANS Controls Report, it has been determined that induced flooding will be a likely consequence of constructing many of the structural alternatives identified. Further calculations will be conducted during the design phase of the project following the recommendation of a final alternative. If it is determined that permanent or occasional flowage easements will be required to support the project, a Physical Takings Analysis will be prepared by USACE in accordance with Federal and State laws regarding just compensation payment requirements.

Reference Section 3.5 of the ANS Controls Report for discussion of the structural alternatives and their respective flooding impacts. Section 5.0 of the ANS Controls Report provides a summary discussion regarding potential mitigation requirements relative to the potential to induce flooding for each of the nine structural alternatives considered.

9.0 Environmental Mitigation

Environmental mitigation requirements will be determined when a final alternative is selected.

10.0 Mineral/Timber/Landfill Activity

The project area substantially consists of agricultural lands. No timber activity is present or anticipated that could affect the project. An active landfill is located east of Eagle Marsh within the headwaters area. The landfill is owned and operated by United Refuse Company, Inc. The operation of the landfill is not anticipated to interfere with any of the alternatives identified in the ANS Controls Report.

11.0 Public/Landowner Concerns

The potentially affected private landowners have not been contacted. When the timing is appropriate, the USACE and non-Federal sponsor will maintain communications with all stakeholders including private landowners and State and local government officials. The State of Indiana through the Indiana DNR is the majority landowner in the study area and has expressed their support for the project and lent their expertise during the production of this report. However, Indiana DNR leadership has communicated their unwillingness to participate as a non-Federal cost-sharing partner citing the issue of ANS migration as having national implications. Reference Section 7.2 of the ANS Controls Report for more discussion regarding interagency cooperation.

12.0 Cooperation with Others

The U.S.D.A., National Resources Conservation Service (NRCS) is currently seeking applicants within the ANS Controls Report study area to participate in their Wetlands Reserve Program (WRP). Through the purchase of an easement, the WRP gives landowners an opportunity to protect, restore, and enhance wetlands on their property[1]. The USACE has participated in discussions with Indiana NRCS staff to ensure that once an alternative is recommended, the project will not conflict with WRP efforts being conducted in the area. Generally, WRP Compatible Use Permits are authorized by the NRCS for activities that further both the long-term protection and enhancement of the wetland and other natural areas of the [easement area][2]. If any alternatives are constructed, they will have a positive effect on the development of wetlands within the project area. In general, the NRCS has expressed support for an ANS Controls construction project.

In the event that the NRCS purchases a WRP easement on lands needed to support the recommended alternative, the required interests would be acquired by the non-Federal sponsor subject to the existing WRP easement. Alternatively, if the USACE identifies a recommended plan and the required real estate interests are identified prior to NRCS's purchase of a WRP easement, the NRCS has agreed to exclude the required portion from their program.

[1] "Wetlands Reserve Program – NRCS." 20 April 2011. http://www.nrcs.usda.gov/programs/wrp

[2] USDA National Office - WRP Compatible Use Guidance (WRP Manual 514.20 and 21)

13.0 Existing Federal Interests and Rights

The NRCS currently has an interest in the majority of what is referred to as Eagle Marsh through the Wetlands Reserve Program easement. The WRP easement was granted by the State of Indiana and the LRWP in return for contributing a percentage of the funds used to purchase the

property from a private owner. No other Federal interests are known to exist within the project area.

14.0 Public Law 91-646 Relocation Assistance Benefits

P.L. 91-646 Relocation Assistance will be addressed when a final alternative is recommended. However, no relocation benefits are anticipated.

15.0 Outstanding Conditions

There are many outstanding conditions at this conceptual level of the project. When a final alternative is recommended issues such as identifying a non-Federal Sponsor, borrow and/or disposal sites and necessary utility relocations will be addressed.

16.0 Facility, Utility and Cemetery Relocations

Any conclusion or categorization contained in this appendix, or elsewhere in this report, that an item is a utility or facility relocation to be performed by the Public Sponsor as part of its LERRD responsibilities is preliminary only. The Government will make a final determination of the relocations necessary for the construction, operation and maintenance of the project after further analysis, and completion and approval of a Final Attorney's Opinion of Compensability for each of the impacted utilities and facilities.

16.1 Facility, Utility and Road Relocations

Facility, utility and road relocations are indicated on the Plan Sheets located in Appendix G, Sheets CS101 through CS114.

If relocations are required to support the final recommended alternative, Attorney's Opinions of Compensability will be prepared to determine whether the owners have compensable interests in the land on which the impacted portion of the facility or utility is located. The non-Federal sponsor will be responsible for ensuring the performance of all relocations. A more detailed analysis of relocations requirements will be developed as part of an approved Real Estate Plan.

16.2 Cemeteries

No cemeteries are believed to exist within the project area. A thorough investigation will be performed when a final alternative is recommended.

17.0 Hazardous, Toxic, and Radioactive Waste (HTRW) Impacts

HTRW impacts will be determined when a final alternative is recommended.

18.0 Environmental and Historical Preservation Considerations

Compliance with the National Environmental Policy Act (NEPA) and the National Historical Preservation Act (NHPA) will be met prior to selection of a final plan.

19.0 Non-Federal Sponsor

A viable non-Federal sponsor has not been identified. Upon the execution of a Project Partnership Agreement, the non-Federal sponsor will be required to provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material.

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Fort Wayne, Indiana

APPENDIX F
Engineering

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AQUATIC NUISANCE SPECIES CONTROLS REPORT
WABASH-MAUMEE BASIN CONNECTION STUDY
FORT WAYNE, INDIANA

APPENDIX F

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APPENDIX F

SECTION 1
GENERAL

1.1. INTRODUCTION

Based on the U.S. Army Corps of Engineers document Great Lakes and Mississippi River Interbasin Study (GLMRIS), Other Pathways Preliminary Risk Characterization, dated 9 November 2010, thirty-one surface water pathways were identified outside of the Chicago Area Waterway System (CAWS) for which risk characterizations were deemed necessary to evaluate the risk of aquatic nuisance species (ANS) crossing the drainage divide between the Great Lakes and the Mississippi River basins. In order to carry out the risk characterization, teams of experts in hydrology and invasive species were formed. The teams included members of the United States Geological Survey (USGS), United States Fish and Wildlife Service (USFWS), Natural Resources Conservation Service (NRCS), National Oceanic and Atmospheric Administration (NOAA), the Departments for Natural Resources from Minnesota, Wisconsin, Indiana, Ohio, the New York Department of Environmental Conservation, and the Great Lakes Fishery Commission.

Each ANS expert assigned hydrologic risk ratings (Ideal, Very Favorable, Favorable, Possible, Unlikely, or Highly Unlikely) to each of the thirty-one water surface pathways for ANS movement in both directions (into the Great Lakes and out of the Great Lakes.) The Highly Unlikely rating was defined as insignificant risk and was a basis for no further consideration. One site was singled out as the greatest concern, the Eagle Marsh site in Fort Wayne, Indiana. A 2009 Flood Insurance Study indicated that significant backflow from the St. Marys and St. Joseph Rivers at the confluence with the Maumee River occurs through Junk Ditch. The USGS representatives that studied the Eagle Marsh pathway indicated that a 10% frequency storm was likely to provide a water column depth across the drainage divide sufficient for large fish, such as the Asian carp, to traverse.

Eagle Marsh, a 716 acre wetland preserve located on the southwest border of Fort Wayne, Indiana, straddles a natural geographic divide created by the last glacial movement approximately 10,000 years ago. The site is operated by the private Little River Wetlands Project and is co-owned by the Indiana Department of Natural Resources (DNR). The broad wetland marsh extends across the divide and is flanked by two drainage ditches, the Graham-McCulloch Ditch and Junk Ditch. The Graham-McCulloch Ditch drains west into the Little River and eventually the Wabash River near Huntington,

while Junk Ditch drains northeast into the St. Marys River and then the Maumee River. Under normal conditions, there is no direct hydraulic link between the Wabash River and the Maumee River. However, the tributaries and drainage ditches near Eagle Marsh provide a potential hydraulic connection under certain flooding situations.

Photo 1.1: Eagle Marsh in Fort Wayne

Asian carp, one of the ANS, have been present in the Wabash River for over fifteen years. Indiana DNR biologists first discovered them in 1996 during a survey at Hovey Lake Fish & Wildlife Area at the southwest tip of Indiana. Since then, Asian carp have been detected in spot locations on the Wabash River as far upstream as the tailwater area below J. Edward Roush Lake in Huntington County, which is downstream of Eagle Marsh. The 91 foot high concrete and earth dam at J. Edward Roush Lake is an impassible barrier to further upstream movement through the Wabash River. However, where the Little River enters the Wabash River downstream of the Roush Lake Dam there are no significant barriers in place to prevent fish movement or other ANS movement through the Little River toward the basin divide at Eagle Marsh.

Asian carp are currently known to exist near the mouth of the Little River, approximately 20 miles southwest from Eagle Marsh. During flooding conditions, there is concern these and other ANS can move upstream through the Little River and the Graham-McCulloch Ditch and cross the divide to the Maumee River Basin, giving them direct access to Lake Erie.

With assistance from the Indiana Department of Natural Resources fisheries biologists, 247 water samples were collected in October 2010 in ditches and streams in the vicinity of Eagle Marsh. The largest sampling to date of Indiana waterways for environmental DNA (eDNA) evidence of Asian carp yielded negative results on either side of Eagle Marsh. Supplemental sampling in the summer of 2011 also yielded negative results.

1.2. OBJECTIVES

The main objectives of Appendix F are to:

- Identify structural barriers which provide a single point of defense to a multi-tiered defense to prevent or reduce the possibilities of the movement of ANS. Work is to be at a screening level of design effort;
- Conceptually illustrate the structural barrier alternatives on plans;
- Identify potential hurdles;
- Explain why other structural alternatives were eliminated from further study; and
- Provide open communication with local stakeholders for their contribution.

1.3. EXISTING TEMPORARY BARRIER

As an immediate preventative measure, in October 2010, the Indiana DNR constructed a temporary 1,177 foot long, eight foot high chain link fence and a supplemental 494 foot debris catch fence at Eagle Marsh. The chain link fence is bolstered by approximately 120 concrete New Jersey type barriers weighing 2.5 tons each. For stability purposes and to prevent undermining, the fence fabric extends 24 inches below grade and is covered with a compacted granular fill. The fence posts were filled with concrete for stability.

Photo 1.2: Indiana DNR fence construction

Photo 1.3: Indiana DNR fence at north abutment

Rip rap stone was placed at the north abutment of the fence at the Graham-McCulloch Ditch earthen embankment and at the south abutment at the Norfolk Southern Railroad embankment. The fence was constructed in accordance with the Wetland Reserve Program Compatible Use Authorization which expires on 24 August 2014. At that time, either the fence will need to be removed or the agreement extended.

1.4. VALUE ENGINEERING STUDY

Value Engineering (VE) is a structured facilitated process that identifies the key functions that must be provided to assure project success and to verify optimum project value. As per ER 11-1-321, change 1 "Army Programs, Value Engineering" U.S. Army Corps of Engineers, dated 01 January 2011, a VE study for this project was conducted 19-21 January 2011 in Louisville, Kentucky and was facilitated by Strategic Value Solutions, Inc.

A multi-disciplinary team comprised primarily of the Project Delivery Team (PDT) from the Army Corps of Engineers and personnel from the Indiana DNR and NRCS attended the three day integrated value based design VE workshop. One of the goals of the workshop was to confirm a full understanding of the project scope by allowing the multi-disciplinary team to participate as a group in an open dialogue to assure open project communication. The second goal was to utilize the team collaboration to brainstorm as many solutions as possible and formulate measures that warranted further investigation with the objective of finding the best solution to meet the project purpose and need. Emphasis was placed on preserving the important ecological and aesthetic significance of the Fort Wayne, Indiana area.

During the creativity phase of the workshop, over 100 measures were generated regardless of feasibility. During the evaluation phase, the VE team selected measures with the most merit for further development. The criteria used for selection were inherent value, benefit, acceptance of the measure, life cycle cost savings, and technical appropriateness of the measure. The measures were narrowed down to twelve and were expanded during the development phase, which consisted of preparing a description of the measure, evaluating advantages and disadvantages, preparing a brief narrative, and making cost comparisons.

The presentation phase primarily consisted of the final written report, however the charrette participants wrapped up the workshop with an informal discussion of the developed ideas and the next steps for the team. The project manager utilized the information learned during the workshop to prepare a briefing to Corps personnel and key stakeholders on the project. Of the twelve measures developed at the workshop, seven were developed into alternatives and are included in this report for further development below. The other five measures were eliminated for various reasons as explained in Section 1.6, Eliminated Structural Measures. Two new alternatives, Alternatives H and I, were generated by the PDT after the VE study concluded and additional survey data was obtained of the area. All nine alternatives are explained in Section 1.5, Structural Alternatives, below.

A copy of the Value Engineering Study dated February 2011 is included as supporting documentation only. Reference Appendix D.

1.5. STRUCTURAL ALTERNATIVES

1.5.1. Construct an I-Wall, Alternative A, (Eagle Marsh, Basin Divide)

The drainage basin divide for the Maumee River basin and the Wabash River basin is located northeast of Eagle Marsh and Engle Road, runs in a north-south direction and is identified and located on the map below. In order to prevent any movement of ANS from one basin to another, Alternative A proposes construction of a permanent structure at the approximate location of the hydraulic basin divide. Reference is made to Alternative A Site Plan CS101 in Appendix G.

Two types of structural barriers were considered: an earthen levee and an I-wall. The advantages and dis-advantages of each barrier type were discussed. The footprint of an earthen levee would be larger than that of an I- wall; therefore, real estate acquisition for construction of an I-wall would be less and would consequently reduce overall project costs.

Photo 1.4: Location of the drainage basin divide

The larger footprint of an earthen levee would also impose a greater impact to the Eagle Marsh wetland preserve. In addition, an earthen levee would require importing material from a nearby borrow site which would need to be identified. Transportation costs for material hauling from the borrow site would be high. An earthen levee would also need routine mowing which will increase the long-term operation and maintenance costs of this project. After consideration of these factors, an I-wall is proposed. In an effort to preserve the character of Eagle Marsh and public acceptance of this project, it is also proposed that an environmentally themed concrete form liner be used on the I-wall.

This alternative provides a hydraulic separation between basins and will raise floodwater crest elevations for Junk Ditch, which will affect structures within the area. The I-wall will traverse along the hydraulic divide at an elevation varying from 760 to 762 feet to provide protection from over topping for a 1% annual chance event. Using a low berm with an elevation of 762 feet on the south side of Engle Road, the berm will tie the I-wall into the left abutment of the Engle Road Bridge.

Minimal operation and maintenance will be required for this alternative.

The baseline cost estimate for Alternative A is approximately $12.8 million.

1.5.2. Construct a Fence and Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative B, (Eagle Marsh, Basin Divide)

Construct a permanent fence east of the location of the existing Indiana DNR fence located in Eagle Marsh. The fence will run in a north-south direction and will include rip rap stone abutments at the Graham-McCulloch Ditch berm and at the Norfolk Southern Railroad embankment. Reference is made to Alternative B Site Plan CS102 in Appendix G. Based upon visual inspection during a site reconnaissance trip in November 2010, it appears the Graham-McCulloch Ditch berm is eroding in several areas and is in poor

condition. A portion of the berm would serve as part of the barrier, and thus should be reconstructed in accordance with appropriate USACE standards to protect against failure

Photo 1.5: Left descending bank of Graham-McCulloch Ditch shown on left

during a high water event. From the tie in point with the fence, the berm along the left descending (east) bank of the Graham-McCulloch Ditch is to be demolished and reconstructed to an elevation to prevent overtopping by the 1% annual chance event and will tie into high ground at the wastewater treatment plant. The earthen berm will be rebuilt up to an elevation of 762 along the south side of the wasterwater treatment plant access road to Engle Road, and along Engle Road to the left (looking downstream) abutment for the Engle Road bridge over the Graham-McCulloch Ditch. Most of the existing material in the left berm will be available for reuse. However, additional borrow material will be needed to construct a reliable cross section. Multiple permits and regulations will be required to acquire a borrow site. A sacrificial drift/ice fence will be located on the east side of the primary barrier to prevent or reduce possible damage or clogging of the primary fence.

An option of this alternative would be to use the temporary barrier fence constructed by Indiana DNR, and rebuild the additional section of berm down to the location of the existing fence. Assuming the existing fence is constructed to adequate hydrologic and structural requirements, it likely has a sufficient service life left to be considered for this alternative.

This alternative will require routine maintenance and inspection after each rain event to ensure the fence is not damaged and to remove debris. If damage does occur, the fence will need to be repaired or replaced.

The baseline cost estimate for Alternative B is approximately $2.4 million.

1.5.3. Construct an Earthen Berm and Pump Station, Alternative C, (Homestead Road)

For this alternative, a pump station and earthen berm is proposed downstream of the basin divide on the Graham-McCulloch Ditch just downstream of Homestead Road. Reference is made to Alternative C Site Plan CS103 in Appendix G. This alternative consists of constructing a large pump station to control all flow of the Graham-McCulloch. The pump station would pump the flows through the earthen berm, which

creates a complete cutoff of the existing Graham-McCulloch flow. The berm would tie into the Norfolk Southern Railroad on the southern end and into Homestead Road on the northern end.

Material for the berm would come from existing loam soils on site excavated for the construction of the pump station. The berm would be compacted to 95% maximum density per ASTM D 698, protected by riprap on the upstream side, and constructed to an elevation exceeding the 1% annual chance event. An overflow spillway section may be constructed within the portion of the berm through the original channel. This spillway would account for extreme flows and keep water levels from overtopping Homestead Road, the railroad, or from causing damage to personal property.

The pump station itself will contain a total of eleven electric pumps. Three pumps will be 150 horsepower, and the other eight 350 horsepower. The intake structure for the pump station is approximately 101 feet by 47 feet. Eight of the pumps will have a 48 inch discharge pipe and the remaining three pumps will have a 30 inch discharge pipe. The discharge pipes will outlet into a 52 foot by 15 foot discharge well. The discharge well will outlet by two 10 feet wide by 6 feet tall box culverts that drain into Graham-McCulloch Ditch, downstream of the pump station and berm. Pumps will be electronically controlled by a float system or other electronic water level indicator software.

Each of the eleven discharge pipes will contain a flap gate within the discharge well. This will be the first obstacle for ANS travelling upstream. The second obstacle will be the pump impeller. ANS travelling downstream that are small enough could potentially pass through the pump impellers and be released downstream.

The pump station intake structure and discharge well will be massive concrete structures capable of supporting the heavy loads and turbulent forces of the pumps and flowing water. Deep foundations are anticipated to support the pump station and potentially the discharge well.

During normal to low flow conditions, it is anticipated one or two of the smaller pumps will need to run to continuously pass flow on the Graham-McCulloch Ditch. Electricity costs for this alternative will be high. The pump station will require regular maintenance and inspection to ensure systems are operating as intended.

The baseline cost estimate for Alternative C is approximately $20.2 million.

1.5.4. Construct a Permeable Berm with Telemetered Sluice Gates, Alternative D, (Amber Road)

This alternative consists of constructing a permeable berm that would pass flow during a potential connection high water condition. Reference is made to Alternative D Site Plan CS105 in Appendix G. A permeable berm is an embankment made up of opened graded rip rap surrounding a perforated pipe system that will capture the water as it passes

through the stone. The berm, proposed just upstream of Amber Road, will run north-northeast adjacent to the road and tie into high ground approximately 200 yards east of Amber Road. The southern end of the permeable berm would tie into the embankment of the Norfolk Southern Railroad. The system will drain south to the Graham-McCulloch Ditch and the pipe system with collector channels will empty into the existing channel downstream of the berm.

The berm will contain sluice gates with automated closure mechanisms that will close the gates to a nominal opening height of 3 inches when gages on the Graham-McCulloch Ditch, Junk Ditch and/or within Eagle Marsh near the drainage divide indicate that flow conditions are imminent that could support transfer of ANS. During normal low flow conditions the gates would be open to allow normal drainage of the Graham-McCulloch watershed. Gages at the sluice gate would allow the gate to reopen once adequate head differential across the berm was developed such that velocities through the sluice gate would be unsuitable to support ANS transfer in the upstream direction (toward the Great Lakes watershed). These gages at the structure would also trigger closure of the gate when other scenarios such as backwater flooding or headwater flooding of the Graham-McCulloch Ditch might support movement of ANS upstream. When the velocity of flow through the gates decreases below threshold values preventing ANS transfer, the gates will close and ponded water will be released by infiltration through the permeable berm.

The berm would be designed so that the entire length would be equally submerged during a high water condition. This would allow the berm to pass maximum flows. Water levels are expected to rise on the berm during an event, and would inundate a large area upstream of the berm. Debris and sediment buildup onto and within the berm is a concern for this alternative. A vegetated filter strip should be planted upstream from the permeable berm to filter debris and sediment. It is important to the performance of the system that debris and sediment do not collect on or in the stone matrix of the berm as this could reduce flows through the system. This system would require periodic maintenance and testing of automated systems to assure functionality of the system.

The baseline cost estimate for Alternative D is approximately $8.3 million.

1.5.5. Construct a Fence/Earthen Berm Combination, Alternative E, (Eagle Marsh, Basin Divide)

An earthen berm will be constructed to an elevation exceeding a 4% annual chance event on the Graham-McCulloch Ditch, with a fence on the crown of the berm constructed to an elevation equal to the 1% annual chance event on either watershed. A 4% annual chance storm on the Graham-McCulloch Ditch was selected based on professional judgment to reduce high frequency flooding without increasing water surface elevations on Junk Ditch. This corresponds to approximately a 99% annual chance event on the St. Marys River. Reference is made to Alternative E Site Plan CS107 in Appendix G.

This alternative will serve as a permanent alternative to the temporary fence constructed by Indiana DNR in 2010. This alternative reduces the frequency that flood flows will

allow transfer of ANS species but permits flow across the divide during less frequent events. The fence component of the barrier would prevent movement of adult swimming species of ANS. The design of the fence is generally based upon the Indiana DNR fence concept.

The southern portion of the fence/berm alignment follows the general location of the basin divide. At the intersection of the Eagle Marsh access road and the fence/berm alignment, the fence and the berm separate. It is proposed the Eagle Marsh access road would be located on the crown of the berm. The south abutment of the fence/berm combination ties into the Norfolk Southern Railroad embankment. This alternative will require routine maintenance and inspection after each rain event to ensure the fence is not damaged. If damage does occur, the fence will need to be repaired or replaced.

The conceptual cost estimate for Alternative E is approximately $3.8 million.

1.5.6. Construct Bar Screen Barrier at Existing Weir, Alternative F, (Huntington Dam)

Huntington Dam is a concrete, fixed crest weir located on the Little River (sometimes also referred to as the Little Wabash River) in Huntington, Indiana, at roughly stream mile 2.4, about 20 miles downstream of the drainage divide. The crest of the dam is at approximately elevation 720.6 (NAVD88), nominally providing a six foot head differential at low water. Reference is made to Alternative F Site Plan CS108 in Appendix G.

The weir component of the existing Huntington Dam would provide a hydraulic drop over the structure which would hinder the leaping ability of some of the ANS, such as the Asian carp, during low flow conditions. In conjunction with the vertical drop, a bar screen and supporting superstructure is proposed to be constructed across the Little River.

The bar screen would be angled to allow debris and ice to pass over the top of the screen during high flows and reduce the possibility of blockage of the screen.

Top Photo 1.6: Huntington Dam is estimated to be 150 feet wide
Bottom Photo 1.7: An example of a heavy-duty debris boom

To reduce debris or ice from collecting or damaging the bar screen barrier, a heavy-duty floating boom made for controlling and diverting heavier items, such as logs, would be placed upstream of the existing weir. The floating boom would be placed at a 45 degree angle across Little River and would divert debris to the right descending bank where it would accumulate until removed. Access to Little River can be made easily from East State Street for debris removal.

This alternative will require routine maintenance after each rain event to clean the bar screens and to remove trees and limbs from the debris boom.

The baseline cost estimate for Alternative F is approximately $2.8 million.

1.5.7. Construct Vertical Drop Structures with Telemetered Sluice Gate, Alternative G, (Homestead Road)

For this alternative, a series of vertical drop structures would be constructed integral to a berm upstream of Homestead Road. Reference is made to Alternative G Site Plan CS109 in Appendix G. The drop structures, ten in all, are preliminarily sized as 24-foot diameter circular concrete structures, mimicking the construction of silos commonly used for grain storage. Each drop structure would empty using a 6 foot by 3 foot box culvert traveling through the berm and exiting downstream. A trash fence/jumping fish fence would be placed around the rim of the circular drop structure. This would prevent debris from entering the drop structure from upstream, and prevent fish from jumping out of the drop structure that traveled through the box culvert from downstream. This alternative creates a vertical drop of flow from upstream to downstream, limiting the passage of ANS from downstream to upstream. A sluice gate structure is proposed to be constructed on the Graham-McCulloch Ditch which will be telemetered similar to the concept in Alternative D. The sluice gate will contain an automated closure mechanism that will close such gates to a nominal opening height of 3 inches when gages on the Graham-McCulloch Ditch, Junk Ditch and/or within Eagle Marsh near the drainage divide indicate that flow conditions are imminent that could support transfer of ANS. During normal low flow conditions the gates would be open to allow normal drainage of the Graham-McCulloch watershed.

This alternative will require routine maintenance and inspection after each rain event to ensure debris is not blocking the trash fence on the drop structures and the sluice gate.

The baseline cost estimate for Alternative G is approximately $4.7 million.

1.5.8. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative H, (Eagle Marsh, Basin Divide)

The Graham-McCulloch Ditch at Eagle Marsh is located east of the wastewater treatment plant and passes under the Towpath Trail and wastewater treatment plant access road bridge. Reference is made to Alternative H Site Plan CS111 and CS112 in Appendix G. From there, berms exist on either side of Graham-McCulloch Ditch as it traverses

downstream through the Eagle Marsh Area. This section is approximately 8,700 feet long and ties into the Norfolk Southern Corporation Railroad embankment approximately 1,700 feet east of I-69. The existing Indiana DNR fence temporary barrier is tied into the left descending berm of Graham-McCulloch Ditch at Eagle Marsh. From visual inspection of the existing berm in November 2010 and March 2011, it was found to be in deteriorating condition. Unless the berms of the Graham-McCulloch Ditch are repaired in the near future, they will eventually fail. This alternative addresses that aspect and has the potential to provide additional benefits to Eagle Marsh.

Left Photo 1.8: Graham-McCulloch Ditch located east of wastewater treatment plant which is shown on the right in the photo
Right Photo 1.9: Visual inspection of the Graham-McCulloch Ditch reveals voids in the embankment

This alternative proposes to separate the waters from the Maumee and the Wabash River basins by reconstructing the left berm to a higher elevation and to higher construction standards.

This alternative would require demolishing the left descending berm of the Graham-McCulloch Ditch from the water treatment plant access road to the Norfolk Southern Railroad embankment. A new berm will be constructed along the same alignment to prevent overflows of the Graham-McCulloch Ditch into Eagle Marsh during storm events. This new berm will be the hydraulic separation between the basins and would prevent the movement of ANS. In some locations, the new berm will be 2-3 feet higher, and most sections will have a wider footprint than the existing. It is proposed the slopes of the berm will be 3H:1V to accommodate mowing equipment and the berm will have a ten foot crown to facilitate access of operation and maintenance vehicles. The berm would be compacted to 95% maximum dry density per ASTM D 698, and covered with topsoil. The berm itself would be seeded with native grasses, and some type of erosion control measure applied to the berm side slopes and crown following construction. Portions of the berm on the ditch side may need to be lined with rip rap or other means for channel protection.

The Graham-McCulloch Ditch right descending berm would remain as is and would function in the same manner as it does now. Any water which overflows the top of the right descending berm would flow into the north area of Eagle Marsh. A spillway section could be constructed within the right descending berm with this alternative. This spillway would control any overtopping and likely prolong the life of the right descending berm.

Borrow material will need to be acquired for this alternative. While most of the material can be reused from the existing left descending berm, additional material will be needed to build the new berm to a reliable cross section. Regulatory permits would be required for construction of this alternative.

Eliminating overflow of flood waters from the Graham-McCulloch Ditch into storage areas behind the left bank berm will result in increases in peak water surface elevations downstream. The increases in water surface elevations above existing conditions are estimated to be approximately 0.4 foot upstream of I-69 and 0.3 feet upstream of Aboite Road, based upon preliminary modeling. Flowage easements may be necessary for some overbank areas upstream of Aboite Road, but it does not appear any structures are affected. Downstream of Aboite, water surfaces appear to be generally contained within the channel banks.

This alternative will require minimal maintenance and inspection to ensure erosion is not occurring on the berms. Yearly inspections should be anticipated.

The baseline cost estimate for Alternative H is approximately $5.5 million.

1.5.9. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Demolish Right Descending Berm, and Construct Multi-Cell Wetland Area, Alternative I, (Eagle Marsh, Basin Divide)

This alternative is similar to the previous Alternative H, as it includes reconstruction of the left descending berm. Reference is made to Alternative I Site Plan CS113 and CS114 in Appendix G. The difference is this alternative also includes removal of the right descending berm from the wastewater treatment plant to the point where the Graham-McCulloch Ditch turns at the Norfolk Southern Railroad embankment, a distance of approximately 8,700 feet. Material from the right descending berm would then be used to reconstruct the left descending berm. This would provide a substantial amount of additional material, and would likely delete the need for a borrow site.

Alternative I proposes to separate the waters from the Maumee and the Wabash River basins by reconstructing the left berm to a higher elevation and to higher construction standards. Once the right descending berm is removed, stormwater flows from the Graham-McCulloch will flood the north section of Eagle Marsh with a higher frequency. A multi-cell wetland area is proposed along the previous alignment of the right descending berm of the Graham-McCulloch Ditch. The multi-cell wetland area would begin at the wastewater treatment plant and run approximately 1,800 feet downstream to

where the ditch turns and flows in a southwesterly direction. The multi-cell wetland area will pre-treat the urban stormwater from the Graham-McCulloch Ditch by slowing runoff and allowing sediment and attached pollutants to settle and/or be filtered by vegetation.

In Alternative H, water which overtops the right descending berm during a storm event is retained until water levels in the Graham-McCulloch Ditch recede. With Alternative I, as the right descending berm has been removed, there is no water retained by it. This will cause an increase in peak water surface elevations for the Graham-McCulloch Ditch during a storm event that previously would have overtopped the right descending berm, because peak flows are not reduced through detention behind the right bank berm. Anticipated increases over Alternative H elevations are approximately 0.6 foot near I-69, and 0.3 foot downstream at Aboite Road for the 1% annual chance event As discussed above for Alternative H, these increases may require flowage easements upstream of Aboite Road, but do not appear to impact any structures. Downstream of Aboite Road, the water surfaces still appear to remain within the channel banks.

This alternative will require minimal maintenance and inspection to ensure erosion is not occurring on the berms. Yearly inspections will be required.

The baseline cost estimate for Alternative I is approximately $7.7 million.

1.6. ELIMINATED STRUCTURAL MEASURES

As noted in the Value Engineering discussion, five measures were eliminated prior to being developed into alternatives. These five measures are discussed in the following paragraphs along with a few other measures that were initially discussed. These measures are detailed in the following paragraphs including reasoning for elimination.

1.6.1. Create Storage in Both Basins

This measure would require construction of large detention areas within the St. Marys River and Graham-McCulloch Ditch watersheds in order to reduce water surface elevations enough that a hydraulic connection does not occur. Areas along the Junk Ditch corridor and the Graham-McCulloch Ditch upstream of Engle Road were reviewed for potential sites. The Junk Ditch watershed is well-developed with both residential and light industrial and commercial development along both banks. The Graham-McCulloch Ditch watershed is largely residential areas. To significantly reduce the likelihood of a hydraulic connection, i.e., prevent water passing the natural drainage divide for the 1% annual chance event, approximately 990 acre-feet of storage will be required on the Junk Ditch side of the watershed divide and 285 acre-feet of storage on the Graham-McCulloch Ditch side assuming that flow is permitted to be stored in the Eagle Marsh and Fox Island areas without passing the drainage divide. To prevent flow from passing the Graham-McCulloch left bank berm, approximately 585 acre-feet of storage would need to be created.

Based on review of the watershed and an attempt to identify potential detention basin sites, areas large enough to provide adequate storage volumes were not available. Depths of excavation for detention areas would be limited due to the flat topography or expected shallow depths to ground water surface. Therefore, large surface areas would be required to achieve the necessary storage volumes.

This measure was considered not feasible due to the amount of real estate acquisition that would be necessary to achieve the necessary storage volumes. The length of time it would take to acquire the real estate required for this measure was also considered. The real estate process for this amount of acquisition would be lengthy; due to the urgency to prevent movement, this measure was eliminated.

1.6.2. Keep the Temporary Barrier Fence at Eagle Marsh

The current location of the Indiana DNR fence at Eagle Marsh was not without controversy. After all, the fence was constructed in the midst of a wetland restoration project at Eagle Marsh. However, the completion of the temporary barrier was a substantial accomplishment in preventing the movement of ANS, particularly mature Asian carp, across the basin divide until a permanent solution can be designed and constructed.

The incorporation of the existing fence measure was eliminated for multiple reasons. The main reason is due to the condition of the left descending Graham-McCulloch Ditch berm which the north abutment of the fence ties into. As stated earlier in previous alternatives, upon visual inspection, the Graham-McCulloch Ditch berms are in a deteriorated condition, with unknown methods of construction and level of compaction. This raises concerns about the long-term integrity of the Graham-McCulloch Ditch berms. If the left descending berm fails upstream of the current fence during a flood event, the ANS will have a hydraulic path around the fence to migrate between drainage basins. For this reason, a fence/berm combination such as Alternative B is more desirable as it significantly reduces the risk of a berm failure.

Another reason the temporary fence barrier design was eliminated is the barrier not only stops the passage of some ANS, but it also stops native wildlife movement as indicated by local environmental agencies. Additionally, the 2 inch mesh size of the current chain link fence does not prevent the transfer of smaller ANS when submerged.

1.6.3. Electric Dispersal Barrier

An electric dispersal barrier operates by creating an electrical field in the water of the stream/ditch, which either will immobilize the ANS or create sufficient discomfort to deter them from attempting to pass through the area. The electrical field is created by running direct electrical current through steel cables secured to the bottom of the stream/ditch. The electrodes are connected to a raceway, consisting of electrical connections to a control building. Equipment in the control building generates a direct current pulse through the electrodes, creating an electric field in the water. To ensure the

barrier is always operational during power outages, back-up generators that automatically activate are essential if a complete or partial power loss occurs.

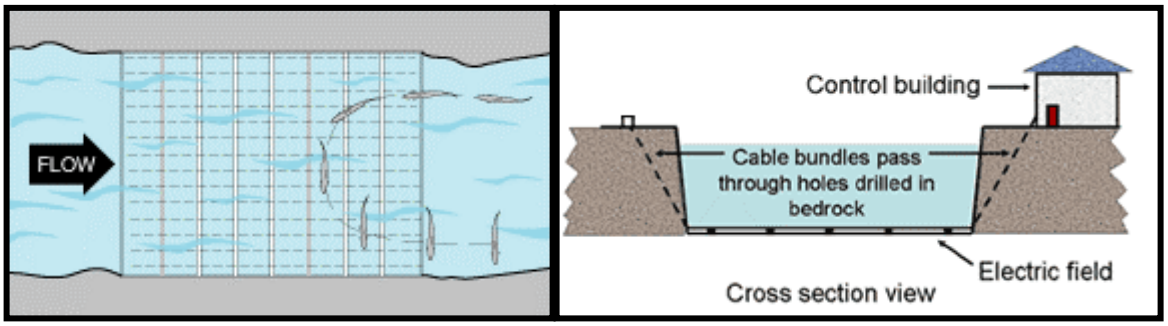

Figure 1.1: Schematic of typical electrical dispersal barrier across waterway. As fish advances into the electric field, they feel discomfort and are unable to advance further. The fish turns and swims in the opposite direction.

There were several reasons why this measure was eliminated. First and foremost were the long-term operation and maintenance requirements for the electric dispersal barrier. Depending on the location of the electrical dispersal barrier, the electric field may or may not be running continuously. But there will be monthly utility bills associated with this barrier which will be significant during months in which rainfall events occur.

Field effectiveness of the electrical barrier is also a concern. In a recent memorandum for record prepared by the Corps of Engineers, Great Lakes and Ohio River Division, dated 24 March 2011, Subject "Operational Protocols for Electrical Barriers on the Chicago Sanitary and Ship Canal: Influence of Electrical Characteristics, Water Conductivity, Fish Behavior, and Water Velocity on Risk for Breach by Small Silver and Bighead Carp" a study has shown that reactions of ANS to electrical exposure are influenced by fish length. Longer fish are repelled earlier in the electric field than short fish. Therefore, there is no guarantee the electrical barrier can prevent movement across the hydraulic basin divide.

Another factor that influenced the elimination of this measure was the evaluation of human safety versus the electric barrier. Eagle Marsh is a popular attraction for outdoor activities; the proximity of the electric barrier could be a danger to hikers and others using this area.

1.6.4. Rotating Drums, Traveling Curtains, Floating Curtains

Rotating drum screens and traveling screens operate very similarly. Both barriers continuously rotate to pass debris over the top of the drum to the downstream side while deterring ANS from migrating past the screen. Continuous exposure to wet weather during extremely low temperatures will cause ice to form on the rotating drums and traveling/floating curtains. When this occurs, they are inoperable and ineffective to preventing the movement of ANS.

Both barriers are good for small, well-defined channels. However, for this particular study, movement of the ANS only occurs when the two drainage basins connect, which is during flooding conditions and water is outside the channel, spread across the wide valley. Therefore, these barriers were determined not to be feasible.

Floating curtains consist of a system of floats attached with a cable that stretch across the channel. Attached to the cable below the water surface are nets, made of nylon or chains. Floating curtains are best used in channels with low velocities and little debris and do not prevent movement of ANS species which may jump over the floating curtain to the other side.

1.6.5. Utilize Local Quarry as a Storage Area

This measure considers the use of one of the existing quarries to store excess floodwaters and prevent a hydraulic connection. Two quarries, owned by Hanson Aggregates, are located southeast and south of Eagle Marsh. The southern quarry on Lower Huntington Road is no longer active and was considered for this measure.

The concept of this measure is that floodwaters from Junk Ditch could be channeled or piped to the quarry, thus reducing floodwaters in the Eagle Marsh area so that there would not be a hydraulic connection. This is similar to the eliminated measure in Section 1.6.1, Create Storage in Both Basins, as previously discussed. The existing quarry pit would serve as the storage area for the Junk Ditch basin.

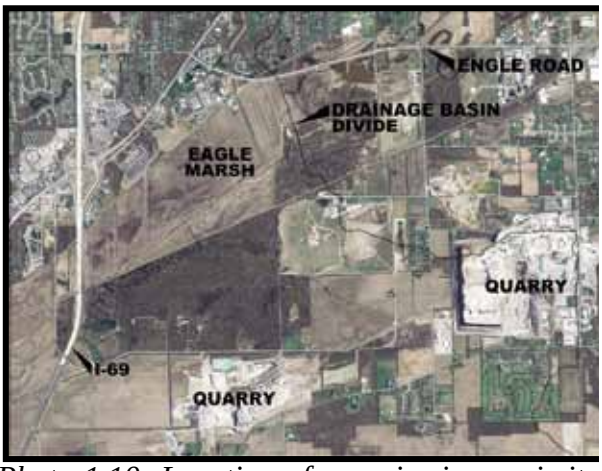

Photo 1.10: Location of quarries in proximity to project area

To use this quarry for storage would require purchasing or acquiring an easement on the quarry itself, as well as multiple acres to construct the channel or pipeline. Extensive earthwork and the creation of over a mile of drainage channel or pipeline to the quarry would also be necessary. Piping the water to the quarry does not appear cost effective. Existing channels are not large enough to convey the volume of water, and are potentially subject to floodwaters from overflow of the Graham-McCulloch Ditch.

Therefore substantial excavation and grading would need to be accomplished. The anticipated operation and maintenance of pumping of the stored water back to the proper watershed after each flood event would also be costly. Therefore, acquisition of this property combined with construction of the drainageway and pumping operations is expected to far exceed the cost of other alternatives.

1.6.6. Bar Screens

Angled bar screens are proposed in Alternative F in Section 1.5.6 above in combination with a vertical drop. This eliminated measure is for vertical bar screens as a standalone measure.

Bar screens are devices which allow unrestricted passage of water and small debris, but prevents passage of ANS of a specified size. The size of the opening on the bar screen can vary depending on the size of the ANS targeted for cross contamination. The bar screen would be attached to a vertical support post which would span the entire width of the stream. Since some of the ANS are excellent jumpers, the barrier height of the bar screen would extend above the water level to prevent movement. Bar screens are often found on intakes to pump stations, and often have a mechanical debris removal system.

Bar screens were eliminated from consideration for several reasons. First, bar screens can dramatically reduce the flow rate depending on the opening sizes. Second, to use bar screens on this project, a large length or area of screen would be required to pass the needed flow. Third, the effect of bar screens is comparable to fencing, yet is a much more expensive option. Finally, debris buildup on the bar screens would be a maintenance issue and would require regular cleanup. Due to these reasons, bar screens are not intended in areas that need to allow a large or constant amount of flow.

1.6.7. Wetlands Storage

This measure is similar to the eliminated measure in Section 1.6.1, Create Storage in Both Basins, as previously discussed. The wetlands storage alternative considers the use of the existing wetland areas at Eagle Marsh and Homestead Road to store excess floodwaters and prevent a hydraulic connection. Based on review of the watershed and the areas of the available existing wetland areas, adequate storage volumes did not appear achievable. Depths of excavation for detention areas would be limited due to the flat topography or expected shallow depths to ground water surface. Therefore, large surface areas would be required to achieve the necessary storage volumes.

This measure was considered not feasible due to the amount of real estate acquisition that would be necessary to achieve the necessary storage volumes. The length of time it would take to acquire the real estate required for this measure would be prohibitive. Due to the real estate costs and the urgency to prevent movement, this measure was eliminated.

1.6.8. Enhance Conveyance of Maumee and Wabash Rivers

This measuree would develop a plan for enhancing conveyance of the existing channels, or creating new channels in order to reduce peak water surface elevations, eliminating or significantly reducing the frequency of a hydraulic connection between the basins. This typically would take the form of channel clearing, channel widening, lowering the

thalweg of the channel, or a combination of these measures. Channel improvements in the Maumee River and St. Marys River channels could likely reduce water surface elevations to prevent flow across the left descending bank berm of the Graham-McCulloch Ditch, but real estate acquisition along these rivers in downtown Fort Wayne would likely take significant time. Besides real estate acquisition costs and delays, the Graham-McCulloch Ditch overflows the left descending bank berm in Eagle Marsh for flows greater than a 10% annual chance event or approximately 1300 cubic feet per second (cfs). Expanding the channel to pass additional flows in excess of 1900 cfs for the 1% annual chance event to prevent overtopping of the left bank berm was not deemed feasible.

1.6.9. Removable Fence/Barrier

This measure would require a removable fence/barrier erected only when flood waters threaten to create a hydraulic connection of the Maumee and Wabash Rivers at Eagle Marsh. Once the floodwaters recede, the fence/barrier would be removed and packed neatly away, leaving an unobstructed view of Eagle Marsh. An example of a removable barrier is shown below in Photo 1.11. Vertical supports anchor into the concrete foundation and aluminum planks are stacked between the vertical supports. The aluminum planks weigh approximately five pounds per foot.

Photo 1.11: Example of a removable barrier

Photo 1.12: Concrete wall foundation, only bolts are visible when barrier is down

Manufacturers of the removable wall estimate one person can erect a 50 foot section of 10 foot high wall in about 2.5- 5 man-hours, depending on the difficulty of the site. Therefore, based on the average height and length of the removable wall at the basin divide which is estimated to be approximately six feet high and 4,800 feet long, the removable wall could take up to 288 man-hours to install.

Based on the accepted hydrograph, as developed by Indiana DNR and reviewed by multiple agencies, the St. Marys River will peak 36 hours after the initial rainfall. For the Graham-McCulloch watershed area, which is considerably smaller than the St. Marys

River watershed, the time to peak is even less. Due to the time of concentration which is estimated to be less than one day, the flashiness of both streams would not allow adequate time to mobilize and erect a temporary barrier. Therefore, this measure was considered not feasible.

1.6.10. Reroute Graham-McCulloch Ditch to Junk Ditch

For any permanent barrier measure that blocks the Graham-McCulloch Ditch, in addition to preventing flows across the divide, it will also block the natural drainage of the Graham-McCulloch watershed, including flows contributed from local groundwater. The Graham-McCulloch Ditch drains an area of approximately twelve square miles upstream of the Towpath Trail (also referred to as the old railroad grade) bridge at the existing wastewater treatment plant. To allow this area to drain without impediment, and thereby reduce the need for a barrier structure to handle the majority of these daily flows, this alternative would intercept the Graham-McCulloch Ditch at Engle Road and create a pathway for flow eastward along Engle Road to near its intersection with Smith Road, where flows would enter Junk Ditch. Two potential alignments were investigated:

1. Construct a channel along the south side of Engle Road to the edge of Little River Wetlands property. To avoid disturbance to existing constructed wetlands area on the United Refuse Company property, this channel would be diverted to the north side of Engle Road via a box culvert and follow eastward adjacent to the roadway to a new confluence with Junk Ditch downstream of the Engle Road bridge near Smith Road.

2. Construct a culvert along the north side of Engle Road to the east side of the property of the existing housing development at Statesmans Way. A culvert would likely be required in order to avoid disturbance of the homes adjacent to Engle Road due to the narrow distance. A channel would then follow along the north side of Engle Road to a junction with Junk Ditch near Smith Road.

This measure was eliminated due to the extremely small slope available between the Graham-McCulloch Ditch at Engle Road and Junk Ditch at Smith Road. In order to handle any significant flows without inundation of Engle Road, the channel would need to be extremely wide and the associated culverts excessively large. A storage basin on the south side of Engle Road was considered to complement these measures, in order to reduce flows and thus reduce the size of the channel, but the basin too would have had to be very large (i.e., past the bend in the Graham-McCulloch Ditch), making draining this area back to the east extremely difficult. Lowering the Junk Ditch thalweg to increase slopes was considered, but this would require channel modification for most of the length of the Junk Ditch, which was considered infeasible due to the length of time required for associated real estate acquisition.

1.6.11. Longest Economical Crest

This concept was proposed based upon the theory that the flow capacity of a weir can be increased by increasing the length of the weir. The weir would serve as a barrier to ANS by creating a vertical water surface differential at the weir, much the same as a drop inlet structure. In order to pass adequate quantities of flow during high flow events, a labyrinthine weir would be constructed to an elevation allowing the 1% annual chance event to pass without increasing water surface elevations in the Junk Ditch and St. Marys River floodplains. The weir would likely be constructed as a concrete and/or sheet pile wall structure. Low flows detained behind this structure would be drained by manual or automated opening of a sluice gate or similar structure. This measure was eliminated because the low topographical relief of the area combined with the high flows of the 1% annual chance event would not create adequate water surface differential across the weir, even with weir lengths several times wider than the valley, without increasing water surface elevations upstream.

1.7. COST ESTIMATE SUMMARY

Table 1.1 gives a summary of structural alternatives and the baseline cost estimates (screening level of design) that prevent or reduce the possibility of movement of ANS.

Alternative	Alternative Description	Location of Proposed Work	Operation and Maintenance*	Baseline Cost Estimate**
A	Construct an I-wall	Eagle Marsh (Basin Divide)	$11k	$12.8M
B	Construct a Fence and Reconstruct the Left Descending Graham-McCulloch Ditch Berm	Eagle Marsh (Basin Divide)	$18k	$2.4M
C	Construct an Earthen Berm and Pump Station	Homestead Road	$600k	$20.2M
D	Construct a Permeable Berm with Telemetered Sluice Gates	Amber Road	$22k	$8.3M
E	Construct Fence/Earthen Berm Combination	Eagle Marsh (Basin Divide)	$22k	$3.8M
F	Construct Bar Screen Barrier at Existing Weir	Huntington Dam	$96k	$2.8M
G	Construct Vertical Drop Structures with Telemetered Sluice Gate	Homestead Road	$26k	$4.7M
H	Reconstruct Left Descending Graham-McCulloch Ditch Berm	Eagle Marsh (Basin Divide)	$14k	$5.5M
I	Reconstruct Left Descending Graham-McCulloch Ditch Berm, Demolish Right Descending Berm, and Construct Multi-Cell Wetland Area	Eagle Marsh (Basin Divide)	$17k	$7.7M

Table 1.1: Summary of Alternatives and Baseline Cost Estimate

Hydrologic Risk Analysis Ratings are to be determined. Reference Appendix A for additional information.
**Reference Section 9 of this Appendix for the Operation and Maintenance schedules.*
***Reference Section 10 of this Appendix for the Cost Estimate.*

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2.1. REFERENCES

1) Fort Wayne History. City of Fort Wayne, Indiana. Viewed on the Internet 19 September 2011 at http://www.cityoffortwayne.org/fort-wayne-history.html.

2) *Wabash-Erie Channel Hydrogeology*. Tony Fleming, LPG (Indiana), January 1996

3) The Great Marsh. Tony Fleming. Viewed on the Internet 27 September 2011 at http://lrwp.org/great_marsh.php.

4) Water Resource Availability in the Maumee River Basin, Indiana - Executive Summary. Indiana Department of Natural Resources, 2006. Viewed on the Internet at http://www.in.gov/dnr/water/files/maumee_basinsums.pdf

5) Flood Insurance Study, Allen County, Indiana and Incorporated Areas, Revised August 3, 2009

6) HEC-RAS River Analysis System User's Manual (Version 4.1), Hydrologic Engineering Center, Davis, CA, January 2010.

7) Surface Water Data, U.S. Geological Survey, Reston, VA

8) Untitled IDNR notes on Junk Ditch Modeling, 13 April 1989. Author unknown.

9) Part 7, Flooding in Other Parts of Indiana, Ohio and Michigan in March 1982, U.S. Geological Survey, Reston, VA. Viewed on the Internet 11/4/2011 at http://www.crh.noaa.gov/images/iwx/Events/FWAFlood1982/Part71982flood.pdf

10) Floods in Indiana: Technical Manual for Estimating Their Magnitude and Frequency (Geological Survey Circular 710), L.G. Davis. U.S. Geological Survey, Reston, VA, 1974. Viewed on the Internet at http://pubs.usgs.gov/circ/1974/0710/report.pdf

11) Coordinated Discharges of Selected Streams in Indiana. Indiana Department of Natural Resources, Division of Water. Originally published November 1996, with updates. Figures available on the Internet at http://www.in.gov/dnr/water/4898.htm

12) Drainage Areas of Indiana Streams - Allen County. Indiana Department of Natural Resources, Division of Water. Originally published in cooperative Agreement with the U.S. Geological Survey, 1975. Viewed on the Internet at http://www.in.gov/dnr/water/files/allen_drainage.pdf

13) Event Record Details, Flood of 05-14 July 2003. National Climatic Data Center. Viewed on the Internet at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~ShowEvent~493671

14) Personal Correspondence. Email from Don Arvin to Ken Lamkin, 6 February 2012 regarding USGS Recorded Peak Measurements at Gages 04182900 and 04182000.

2.2. GENERAL

The city of Fort Wayne is located in northeastern Indiana in Allen County. The city developed at the junction of the St. Marys River and the St. Joseph River, which together form the Maumee River. The headwaters of the St. Marys River begin in northwestern Ohio in the vicinity of the town of St. Marys, and the river generally drains in a northwesterly direction, crossing into northeastern Indiana, before turning northeasterly near its mouth. The St. Joseph River headwaters are located in southeastern Michigan and flows to the southwest, crossing the northwestern tip of Ohio, and joining the St. Marys River in downtown Fort Wayne. The Maumee River drains from this point in Fort Wayne to the northeast and into northwestern Ohio, to its confluence with Lake Erie in Maumee Bay along the Ohio-Michigan state border. Please also reference Figure 2.1 and the Appendix G drawings.

In addition to this river network, a wide valley known as the Wabash-Erie Channel, formed by glacial melt waters, extends from the west side of Fort Wayne to the southwest. The Wabash-Erie Channel formed over time as the natural outlet path for the relatively young St. Marys and St. Joseph Rivers in the wake of retreating glacier, and later as the outlet for "Glacial Lake Maumee", prior to glacial retreat and formation of the Maumee River. Also called the St. Marys Overflow, this valley acts as a "relief valve" for floods on the St. Marys River and Maumee River watersheds, allowing high flows to inundate and reverse flow in Junk Ditch, a tributary near the mouth of the St. Marys River, and cross the natural divide into the Wabash River watershed.

The Wabash-Erie Channel valley was attractive to early Native Americans and European settlers in the area as it provided a short 8-mile portage into the headwaters of the Wabash River, affording access not only to the areas of northern Ohio and inland Michigan by way of the St. Marys, St. Josephs, and Maumee Rivers, but much of current-day Indiana, Illinois and other areas along the Ohio and Mississippi Rivers to the south. Being the lowest elevations in western Allen County, the wide, flat valley generally was composed of a series of interconnected wetlands. Over time, this area became popular for agriculture, and man-made channels were constructed in this valley to promote drain

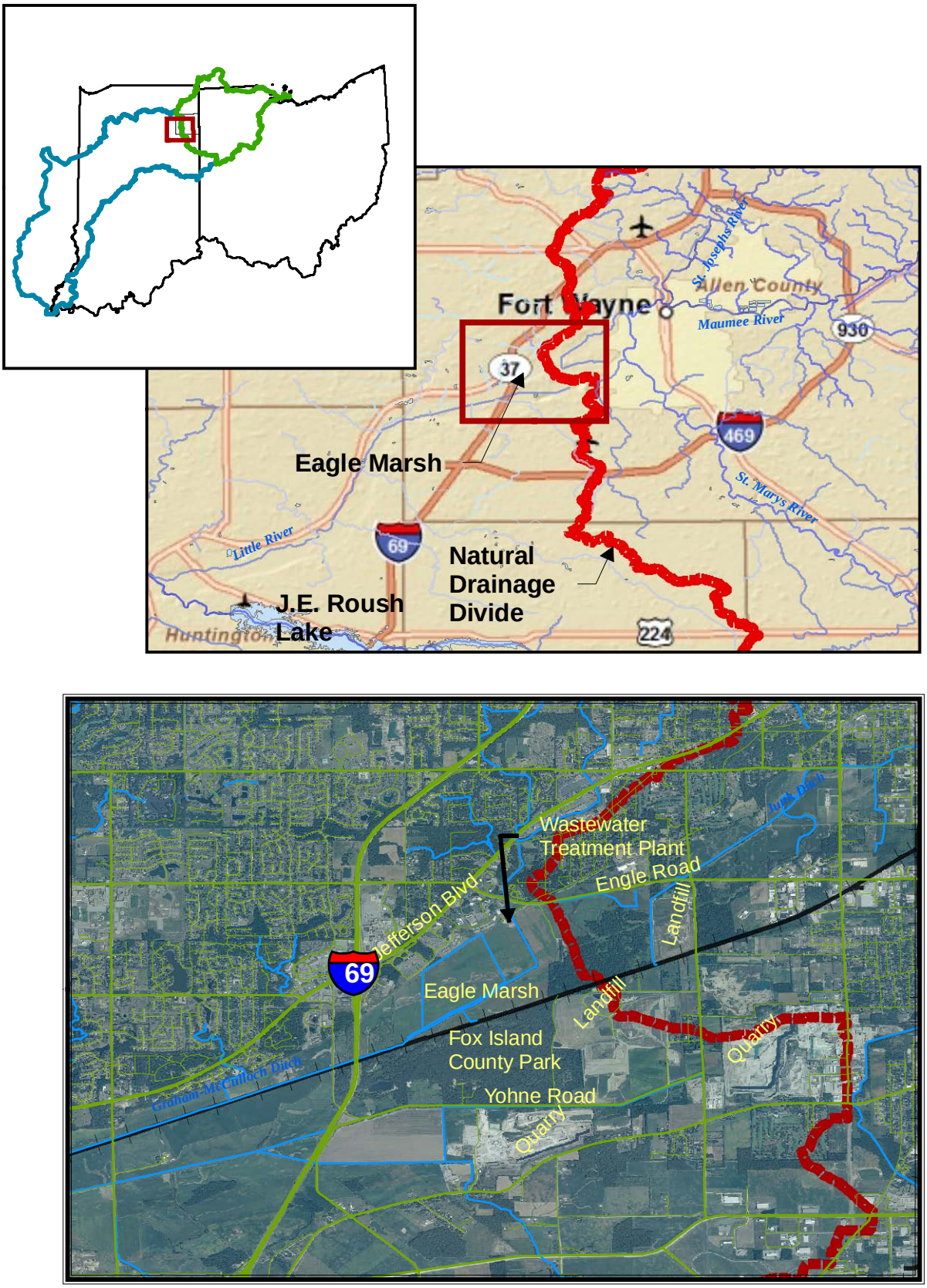


Figure 2.1: Location Map

-age and improve crop production. The stream and upper watershed that was formerly called Cranberry Creek drained into the marsh lands near the current wastewater treatment facility at Engle Road. The Graham-McCulloch Ditch was cut across the marsh from the mouth of Cranberry Creek and the entire watershed was named for this new ditch. Berms isolate the regular floodwaters of the Graham-McCulloch Ditch from the surrounding valley floodplain; these berms were likely constructed from the channel excavation materials and additional soil pushed up from the surrounding valley as it was converted to farm land. Junk Ditch was also constructed through the eastern end of the valley, connecting several isolated meanders with a much smaller existing ditch that drained toward the St. Marys River, effectively reversing the direction of flow for that drainage area and moving the drainage divide from its natural location to a point roughly three miles further west. These channels, combined with systematic tiling of the farm lands, led in large part to the demise of these wetlands within the valley. These former wetlands are gradually being restored through the cooperative efforts of the Little River Wetlands Project, the Natural Resource Conservation Service (NRCS), and the Indiana Department of Natural Resources (IDNR). Eagle Marsh is the first and largest project for this restoration initiative, encompassing approximately 716 acres east of Interstate 69 and south of Engle Road.

Because of the natural connection between the two watersheds by way of the Wabash-Erie Channel valley, the concern is that this location provides adequate hydraulic connection that could support the exchange of invasive species between the Great Lakes and the Mississippi watersheds. As part of this study is to evaluate technologies to prevent the transfer of invasive species, a better understanding of the hydraulic conditions and frequency of flooding was required. This section summarizes the hydrologic and hydraulic analysis performed to date to support this study.

2.3. CLIMATE

Allen County is located within the humid continental climate zone and experiences four distinct seasons per year. Weather patterns in Allen County are influenced by the Great Lakes. The seasonal range of temperature is a daily winter minimum of approximately 20 degrees Fahrenheit (ºF) to a daily summer maximum of approximately 85ºF. Snowfall is prevalent in the winter months, with average cumulative annual snowfall of approximately 33 inches. The average annual precipitation is approximately 36 inches, with annual evapotranspiration of approximately 27 inches.

2.4. PRECIPITATION

Precipitation in the Fort Wayne area is fairly well distributed throughout the year, with the monthly averages ranging from 1.9 inches in August to 4.0 inches in June. Table 2.1 gives the average monthly rainfall based upon the period of 1971-2000 for the Fort Wayne International Airport.

TABLE 2.1
MEAN MONTHLY PRECIPITATION (INCHES)
FOR THE FORT WAYNE, IN AREA

Month	Precipitation (Inches)	Month	Precipitation (Inches)
January	2.1	July	3.6
February	1.9	August	3.6
March	2.9	September	2.8
April	3.5	October	2.6
May	3.8	November	3.0
June	4.0	December	2.8
		Total:	**36.6**

2.5. HISTORIC STORMS AND FLOODS

2.5.1. Discussion of return frequency event terminology

In the past, terminology such as “10-year flood” or “100-year flood” has been used to describe the chances of an event occurring with a statistically-determined peak flow in a given year. This terminology has fallen out of favor because the emphasis is on the period expected to occur between flood events of a given magnitude, and the statistics behind the frequency of the event is lost. For example, it becomes “expected” that the “100-year flood” will only occur once every 100 years, instead of understanding that there is a 1% chance that this event could be equaled or exceeded in any given year. Over time, such a flow may on average occur once every hundred years, but the time between individual events could vary widely. Instead, terminology used in this report will refer to the probability of an event occurring or being exceeded in any given year, e.g., the “1% annual chance event.”

2.5.2. Historic Floods

Flash flooding in the vicinity of Fort Wayne occurs nearly annually to some degree, but based upon review of the floods in Allen County from the National Climatic Data Center storm event database (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms), the majority of these floods occur on minor tributaries with limited areas of damage. Much larger events on the St. Marys watershed have occurred infrequently, with the most

significant occurring in 1913, 1982, 1985, and 1991, and 2003. Significant floods have typically been caused by frontal storms of great intensity, long duration and extending over large areas of the St. Marys and St. Joseph Rivers watersheds.

The 1982 flood is generally the benchmark to which most floods are compared, being nearly the flood of record and superceded by less than 0.2' by the 1913 flood on the Maumee River. Various sources report that the 1982 flood event was the product of a 2.9% - 4% annual chance event on the St. Marys River combined with a 0.7% - 1% chance event on the St. Joseph River peaking approximately 3 days later, and was the result of extended rainfall combined with snowmelt. In 1985, a 4% annual chance event on the St. Marys River combined with a 3.3% annual chance event on the St. Joseph River, peaking only approximately 12 hours apart. The 2003 flood event became the flood of record on the upper St. Marys River after nearly 15 inches of rain fell over the watershed, with the majority falling over a four day period. Flooding was widespread, with additional damage noted along the upper Wabash River near Bluffton. Tables 2.2a and 2.2b list the top ten flood stages at the USGS gages upstream and downstream of the city of Fort Wayne.

TABLE 2.2a
HISTORIC PEAK STAGES
MAUMEE RIVER AT FORT WAYNE
(USGS GAGE 04182900)

Date	Gage Height (feet)	Elevation (NAVD88)	Notes
03/26/1913	26.10	755.66	~ 2% annual chance event
03/17/1982	25.93	755.49	~ 1.25% annual chance event
02/27/1985	24.55	754.11	~ 3.3% annual chance event
01/01/1991	23.90	753.46	
03/24/1978	23.76	753.32	
03/13/2009	23.58	753.14	
02/08/2008	22.93	752.49	
03/08/1908	22.50	752.06	
01/14/2005	22.44	752.00	
01/15/1930	22.40	751.96	

* Historical Peak Elevation. Datum of the gage is 729.56 NAVD88.

TABLE 2.2b
HISTORIC PEAK STAGES
ST. MARYS RIVER NEAR FORT WAYNE
(USGS GAGE 04182000, a.k.a MULDOON BRIDGE)

Date	Gage Height (feet)	Elevation (NAVD88)	Notes
07/09/2003	21.20	769.66	
03/14/1982	19.66	768.12	~ 4% annual chance event
02/11/1959	19.42	767.88	
01/14/2005	19.06	767.52	
5/19/1943	18.79	767.25	
3/21/1978	18.39	766.85	
2/16/1950	18.34	766.80	
02/26/1985	18.33	766.79	
01/01/1991	17.92	766.38	
02/09/2008	17.67	766.13	

* Historical Peak Elevation. Datum of the gage is 748.46 NAVD88.

2.6. HYDROLOGY

2.6.1. Existing Gages

Detailed hydrologic models were not developed for the individual watersheds that contribute to the complex hydrology of the Fort Wayne area; rather, existing data was to be used to the extent possible. Several flow and/or elevation gages exist within the Fort Wayne area, but only a few have been in place for enough time to develop sufficient periods of data for analysis. Table 2.3 lists the gages and their periods of records, and Figure 2.1 depicts their locations. Real-time stages and flows are provisional, available for a period of 120 days prior to the most recent reading. As can be seen, the gages are concentrated on the St. Marys and Maumee Rivers. No gages exist on Junk Ditch or the Wabash side of the natural drainage divide in or near the area of interest; the nearest gage on the Wabash side is on the Littler River at Huntington, Indiana.

TABLE 2.3
STREAM GAGES NEAR ST. MARYS OVERFLOW

USGS Gage No.	Gage Name/Location	Gage Type	Period of Record
03324000	Little River near Huntington, IN	Real-Time Stage, Flow; Mean Daily Discharge	4/1944-Present
03323583	Eagle Marsh East Near Fort Wayne, IN	Real-Time Stage	8/2010-Present
03323584	Eagle Marsh West Near Fort Wayne, IN	Real-Time Stage	8/2010-Present
04180500	St. Joseph River near Fort Wayne, IN	Real-Time Stage, Flow; Mean Daily Discharge	8/1941-Present
04182000	St. Marys River near Fort Wayne, IN (Muldoon Bridge)	Real-Time Stage, Flow; Mean Daily Discharge	11/1930-Present
04182769	St. Marys River At Main St. at Fort Wayne, IN	Real-Time Stage, Flow; Mean Daily Discharge	10/2009-Present
04182808	Spy Run Creek near Park Drive at Fort Wayne, IN	Real-Time Stage, Flow; Mean Daily Discharge	5/2008-Present
04182900	Maumee River at Fort Wayne, IN (Anthony Blvd.)	Real-Time Stage; Daily Stage	10/1997-Present
04182950	Maumee River at Coliseum Blvd. at Fort Wayne, IN	Real-Time Stage, Flow; Mean Daily Discharge	12/2003-Present
04183000	Maumee River at New Haven, IN	Real-Time Stage, Flow; Mean Daily Discharge	10/1956-Present

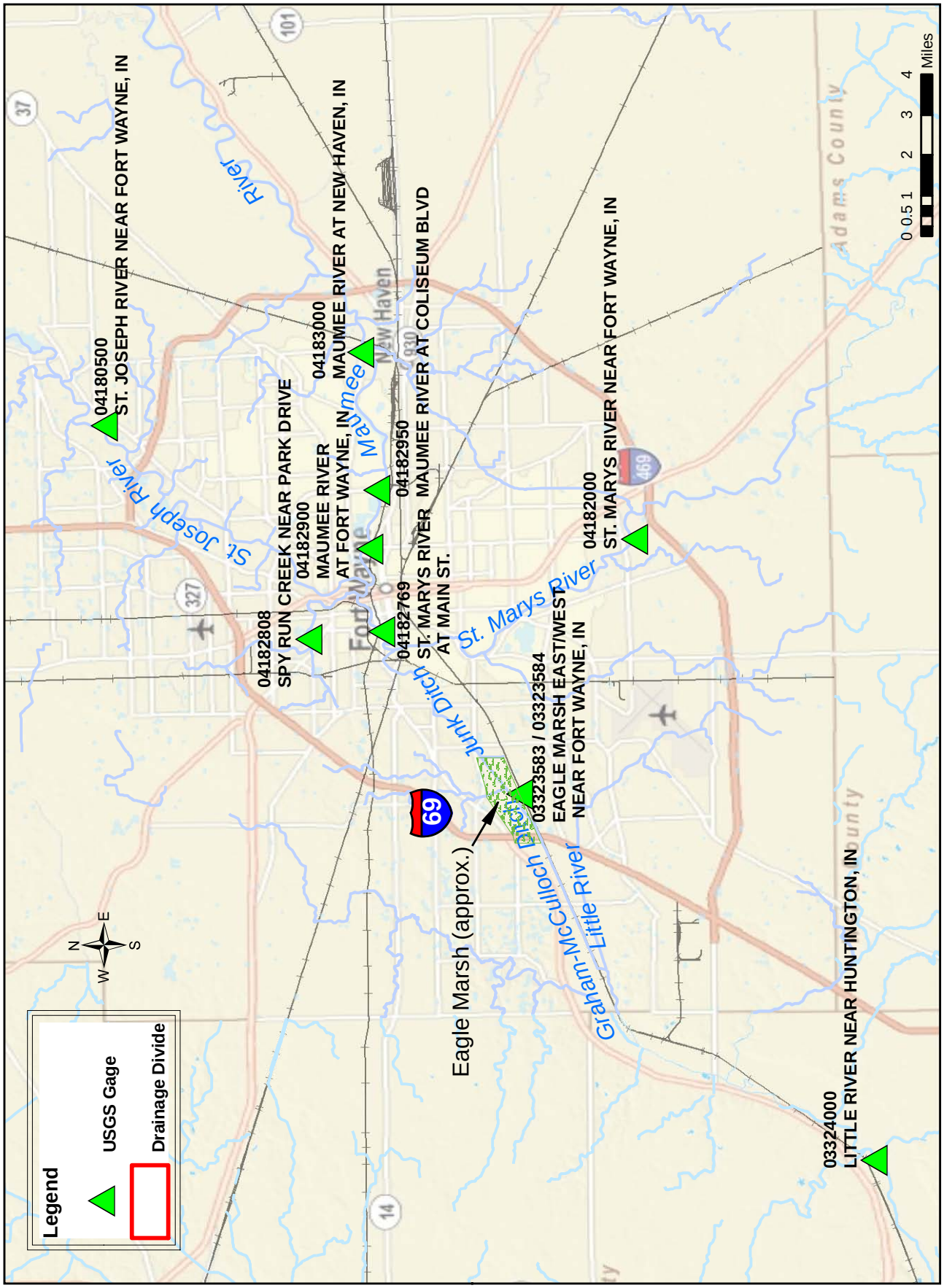


Figure 2.2: Stream Gages Near St. Marys Overflow

2.6.2. Flow Data Used for Hydraulic Modeling

By a Memorandum of Understanding (MOU) of 6 May 1976, the U. S. Soil Conservation Service (now known as the Natural Resources Conservation Service), the U. S. Geological Survey (USGS), the U.S. Army Corps of Engineers (USACE, specifically Louisville, Detroit and Chicago Districts), and the Indiana Department of Natural Resources (IDNR) mutually agreed to coordinate discharge-frequency values for use in water resources investigations and planning activities in the State of Indiana. "Coordinated Discharge" values for only the 10%, 4%, 2%, and 1% annual chance events were determined under this agreement, and were used where available in this study. Flows for other design storm frequency events were interpolated or extrapolated from these values using standard methodologies. Coordinated Discharge graphs for the St. Marys River and the Graham-McCulloch Ditch are included as Figures 2.3a and 2.3b respectively. For the St. Marys River, where an extended period of gage data was available, a partial duration analysis was performed to better establish flows for events more frequent than the 10% annual chance event. The derived discharge-frequency curve for the St. Marys River at the USGS gage is included as Figure 2.4. It should be noted that the Coordinated Discharge values for the Graham-McCulloch Ditch are not specific to this stream, but rather were obtained from the Coordinated Discharges chart "Ungaged Streams in Allen County". Per the MOU, "[w]here adequate stream-flow data is not available, provisional discharge-frequency determinations" will consider USGS Circular 710, *Floods in Indiana: Technical Manual for Estimating Their Magnitude and Frequency*. This circular presents regression equations for estimating flood magnitude and frequency. Due to the absence of any gages on the Graham-McCulloch or any of its tributaries, this was the best existing information available, although regional regression equations are largely discounted as the least accurate of methodologies for determining flow. The accuracy of this information is also questioned given the substantial development that is believed to have occurred in the Graham-McCulloch watershed since Circular 710 (dated 1974) or the Ungaged Streams in Allen County (dated March 1982) was published. A peak discharge value for the 0.2% annual chance event was also published in the 2009 FIS study report. These values were used to derive peak flow values for other design frequency events, as shown in Figure 2.5.

Per files available through IDNR, the hydrograph for the 1% annual chance event was based upon the observed hydrograph for the 1985 flood and the unit hydrograph. It is believed that the 1985 event was chosen instead of the 1982 flood for the basis of this hydrograph because of better available hydrograph information and flow records, and the combination of flooding on the St. Marys and St. Joseph Rivers created a stable backwater for an extended period of time for analysis of Junk Ditch flooding. The hydrograph for the 1985 flood was scaled up to match the 1% annual chance peak flows, as shown in Figure 2.6. This same method of scaling the unit hydrograph was used to create hydrographs for other design frequency events. No information was available to establish a typical hydrograph for floods on the Graham-McCulloch Ditch, so a theoretical hydrograph shape was based upon the St. Marys River unit hydrograph, with the rising and descending limbs of the hydrograph shortened based upon engineering judgment to account for the smaller watershed size (See Figure 2.7).

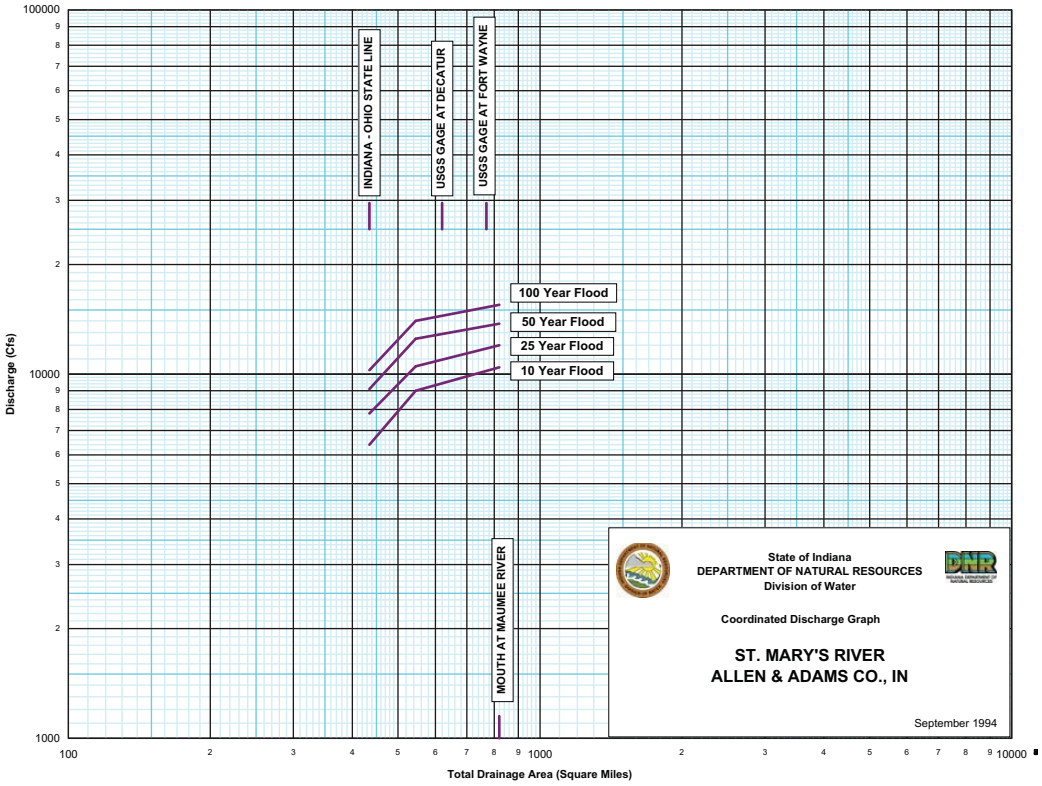


Figure 2.3a: Coordinated Discharges graph for St. Marys River

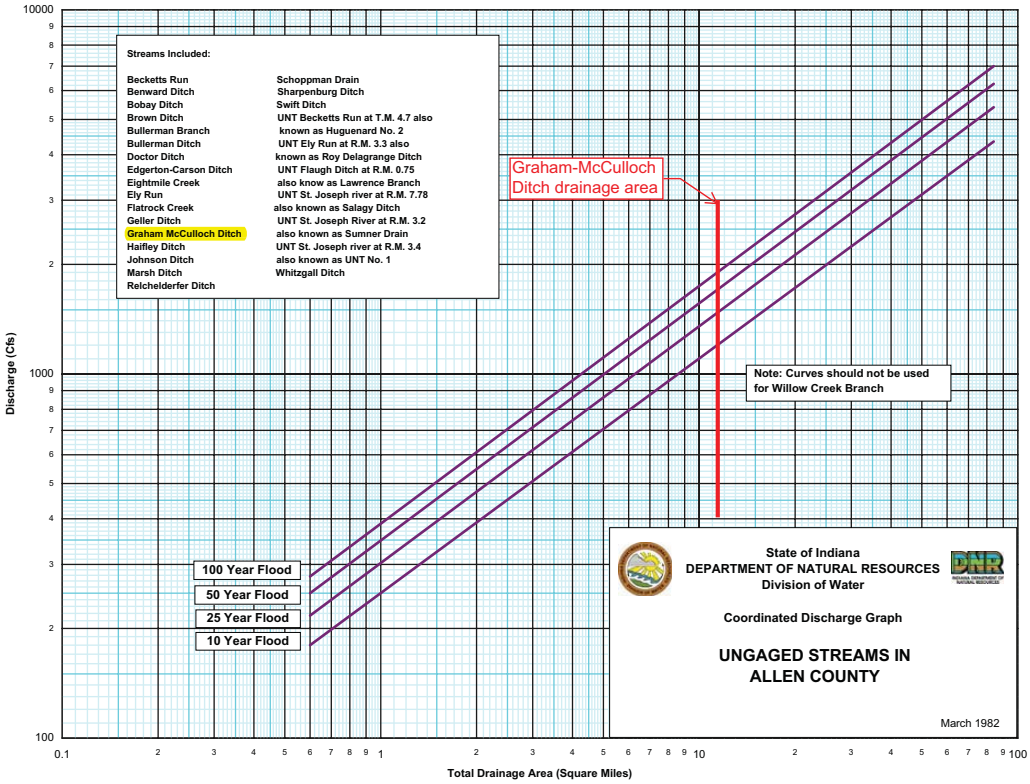


Figure 2.3b: Coordinated Discharges graph for Graham-McCulloch Ditch

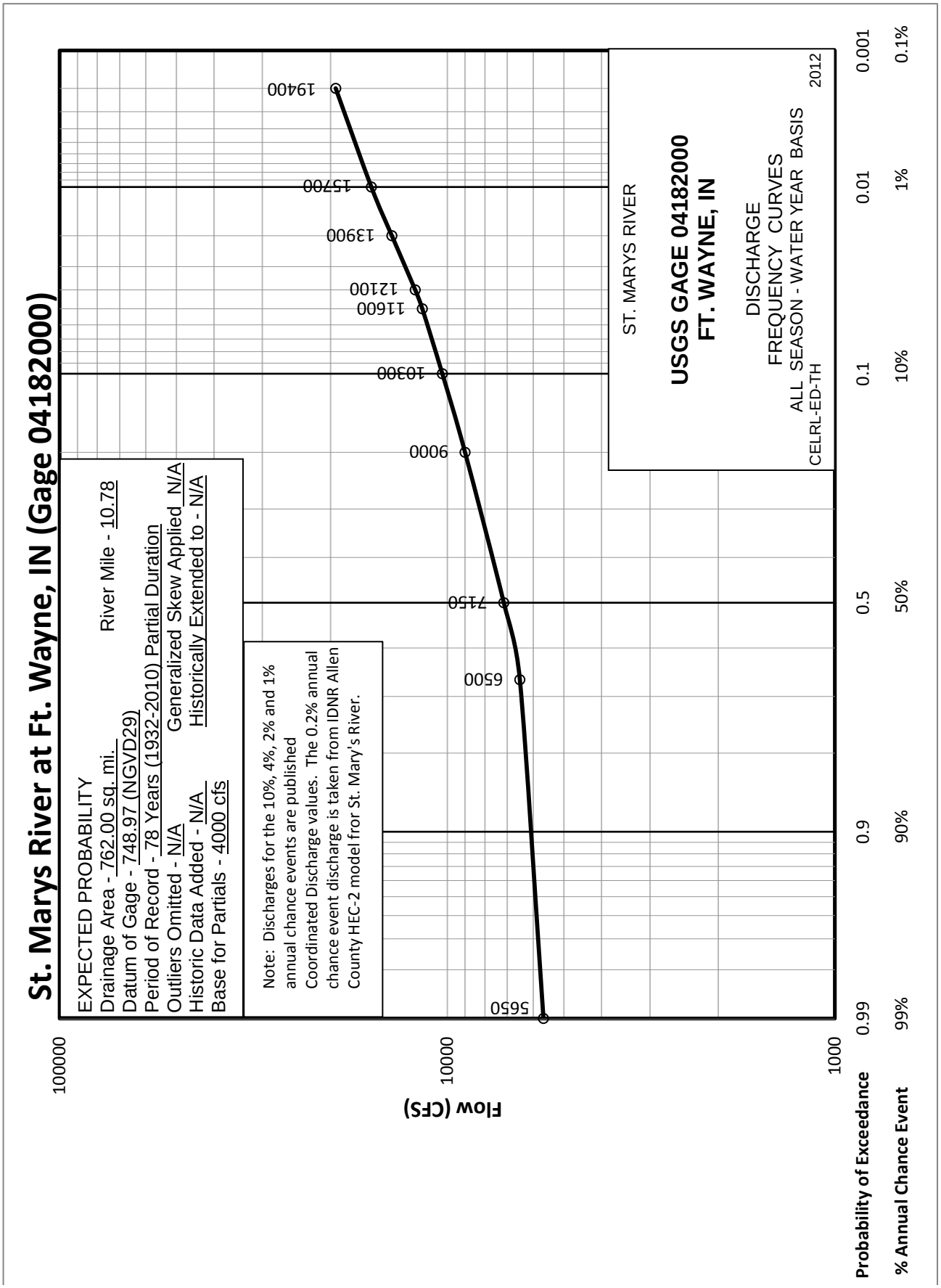


Figure 2.4: Derived flows for St. Marys River at USGS gage

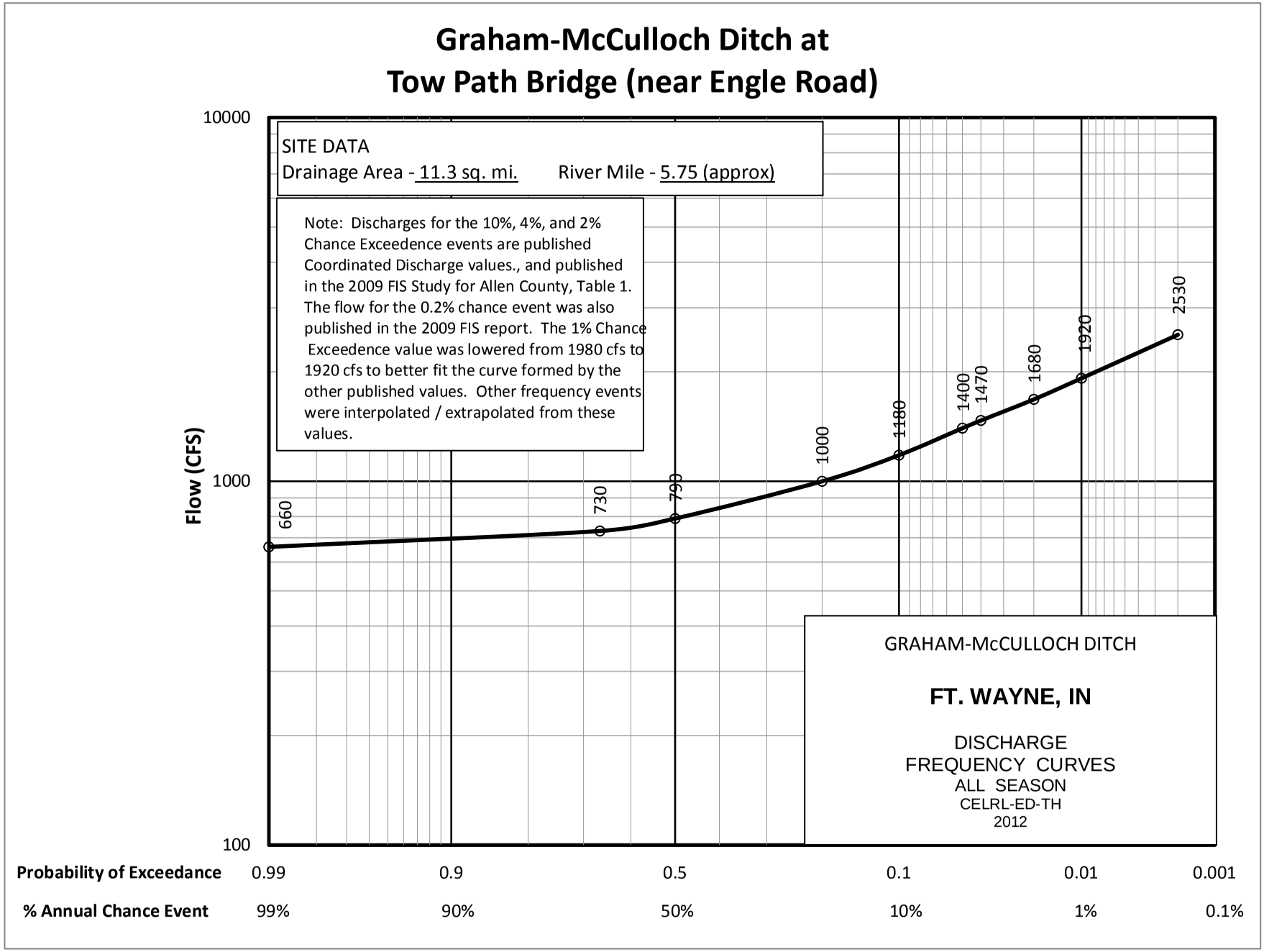


Figure 2.5: Derived flows for Graham-McCulloch Ditch upstream of Eagle Marsh

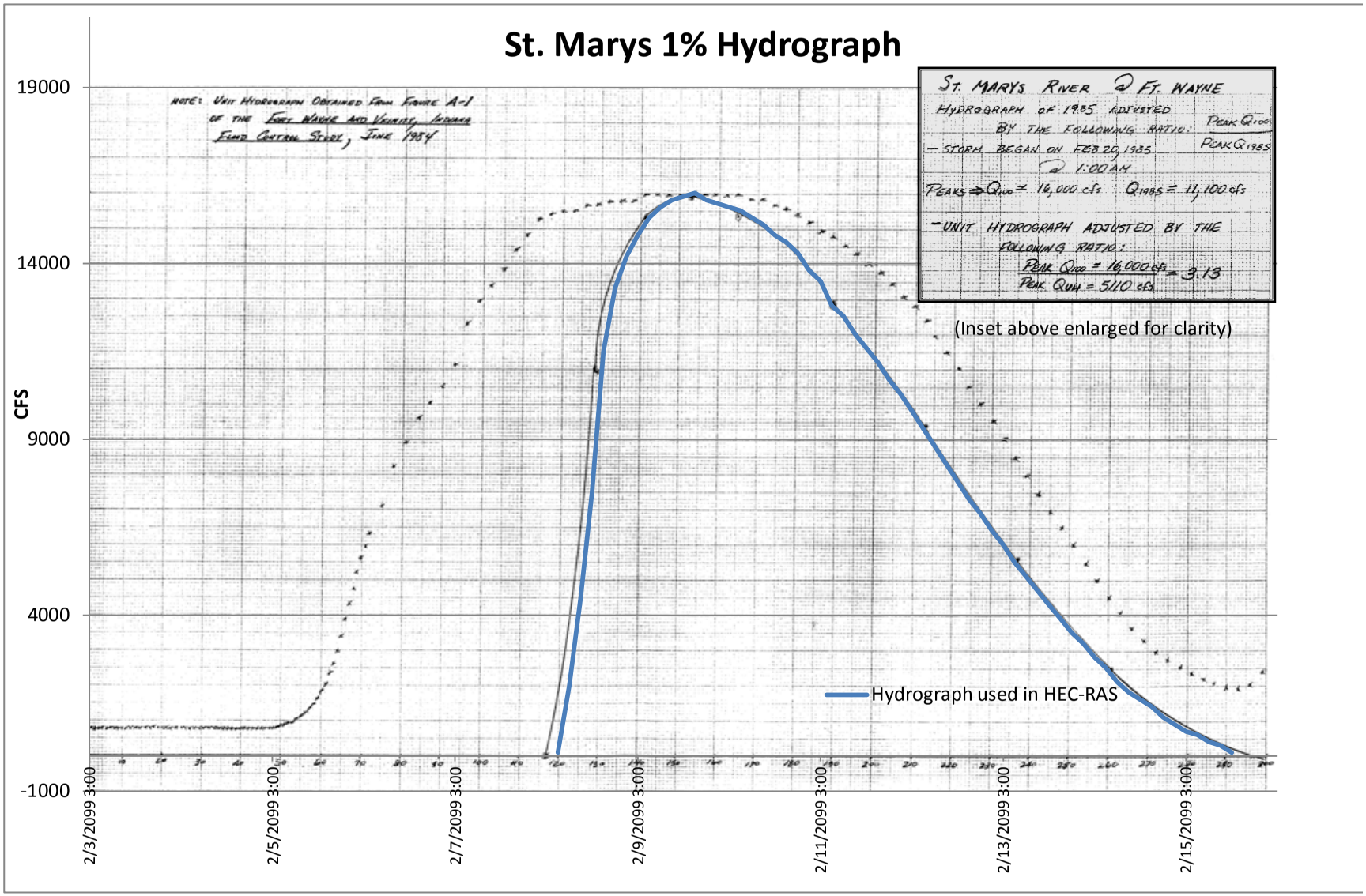


Figure 2.6: Theoretical St. Marys River 1% Annual Chance Event Hydrograph, as modeled per IDNR derivation

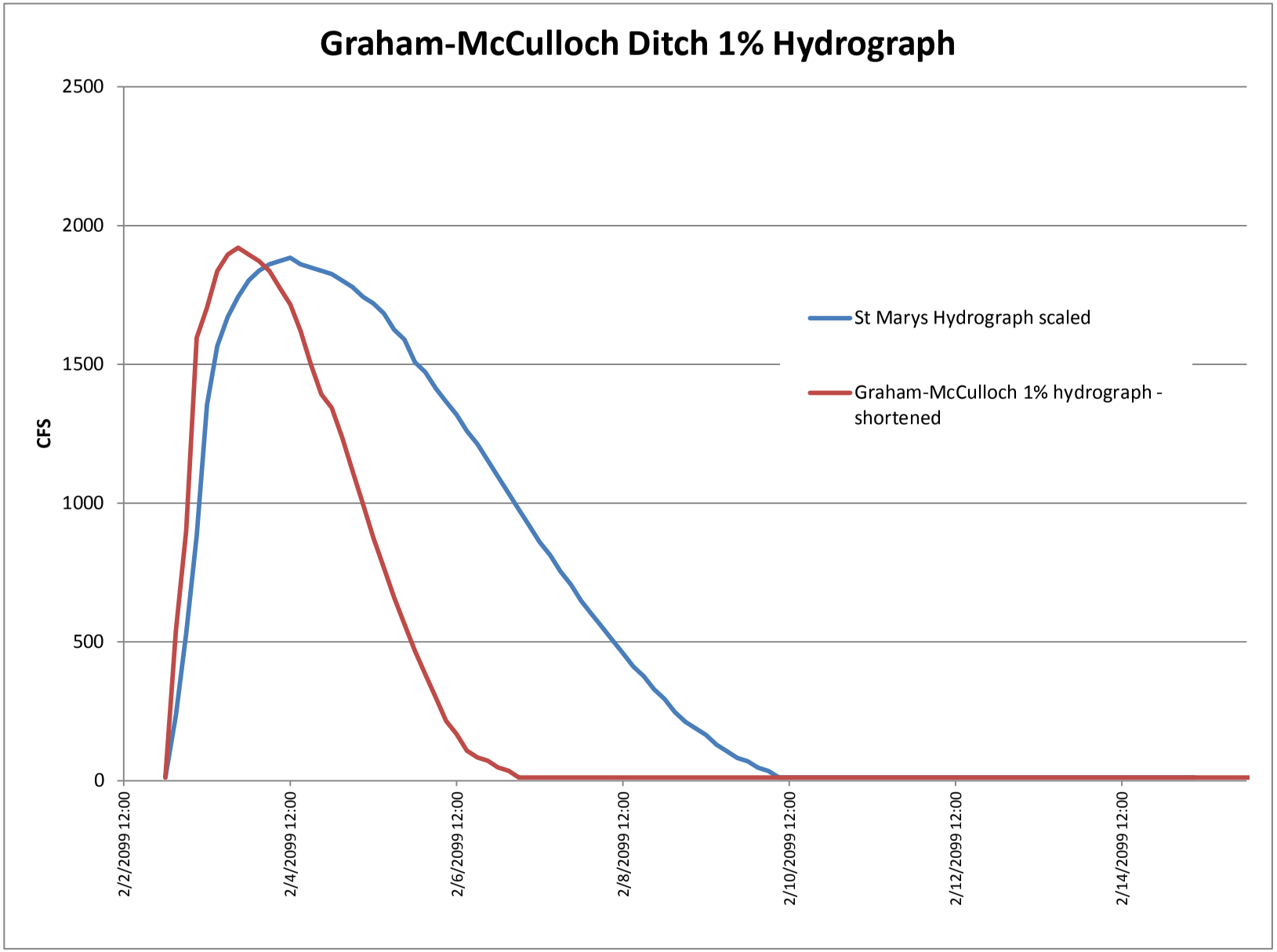


Figure 2.7: Theoretical Graham-McCulloch Ditch 1% Annual Chance Event Hydrograph, as modeled

In the hydraulic model, it was assumed that floods on the St. Marys River, St. Joseph River and the Graham-McCulloch Ditch watersheds will not occur or peak at the same time, due to the significantly different size of the watersheds; the drainage area of the Graham-McCulloch Ditch upstream of Eagle Marsh (near Engle Road) is approximately 12 square miles, whereas the drainage area of the St. Marys River at the confluence of the Junk Ditch is approximately 820 square miles. The St. Joseph River drains approximately 1086 square miles at its mouth. If a large rain event occurred on all of these watersheds, with the event typically progressing from west to east, flooding on the Graham-McCulloch Ditch will peak much sooner than from the same event occurring on the St. Marys and/or St. Joseph watersheds. In the hydraulic model, scenarios were analyzed assuming independent floods on either the St. Marys River or the Graham-McCulloch Ditch. Floods on the St. Josephs River were not modeled because the confluence with the St. Marys River was deemed sufficiently downstream of the mouth of the Junk Ditch that it would not impact backwater elevations as significantly as floods of the same frequency on the St. Marys River.

2.7 HYDRAULICS

2.7.1. Hydraulic Modeling

At the onset of the study, due to the emphasis on use of existing information to the extent possible and the initial accelerated schedule for the study, it was determined that modeling of the St. Marys overflow area would best be accomplished utilizing a HEC-RAS (version 4.1) unsteady flow model. HEC-RAS is a one-dimensional model that can be used to simulate both steady- and unsteady-flow situations. Use of a two-dimensional (2D) model was considered due to the complex flow patterns occurring between the two watersheds, but HEC-RAS was deemed adequate and preferred for the following reasons: 1) the flatness of the area would require a grid size for a 2D model to be small. When combined the large overall area to be modeled, it is expected that this would result in excessively long computation times to analyze a single event or alternative; 2) a number of alternatives were expected to be modeled, each requiring multiple changes to geometry to identify acceptable conditions. Geometry changes are much more difficult to make for each alternative in a 2D grid, requiring additional time for model setup; 3) Existing HEC-2 models were available for the St. Marys, St. Joseph, and Maumee Rivers from IDNR. HEC-RAS is the successor model to HEC-2, therefore it was expected that these models could be imported into HEC-RAS with minimal updates; 4) it was uncertain how typical 2D models would handle the multiple bridges on Junk Ditch that were expected to impact water surface profiles on Junk Ditch and the overflow into the Wabash watershed; and 5) in-house personnel had significant experience with HEC-RAS. A 2-D model would have likely required outsourcing to another District or Center of Expertise, other agency, or engineering firm, requiring significant time for coordination of scopes of work and contract negotiations. For these multiple reasons, modeling of this system with HEC-RAS was deemed the best alternative for this study.

HEC-RAS Model Schematic

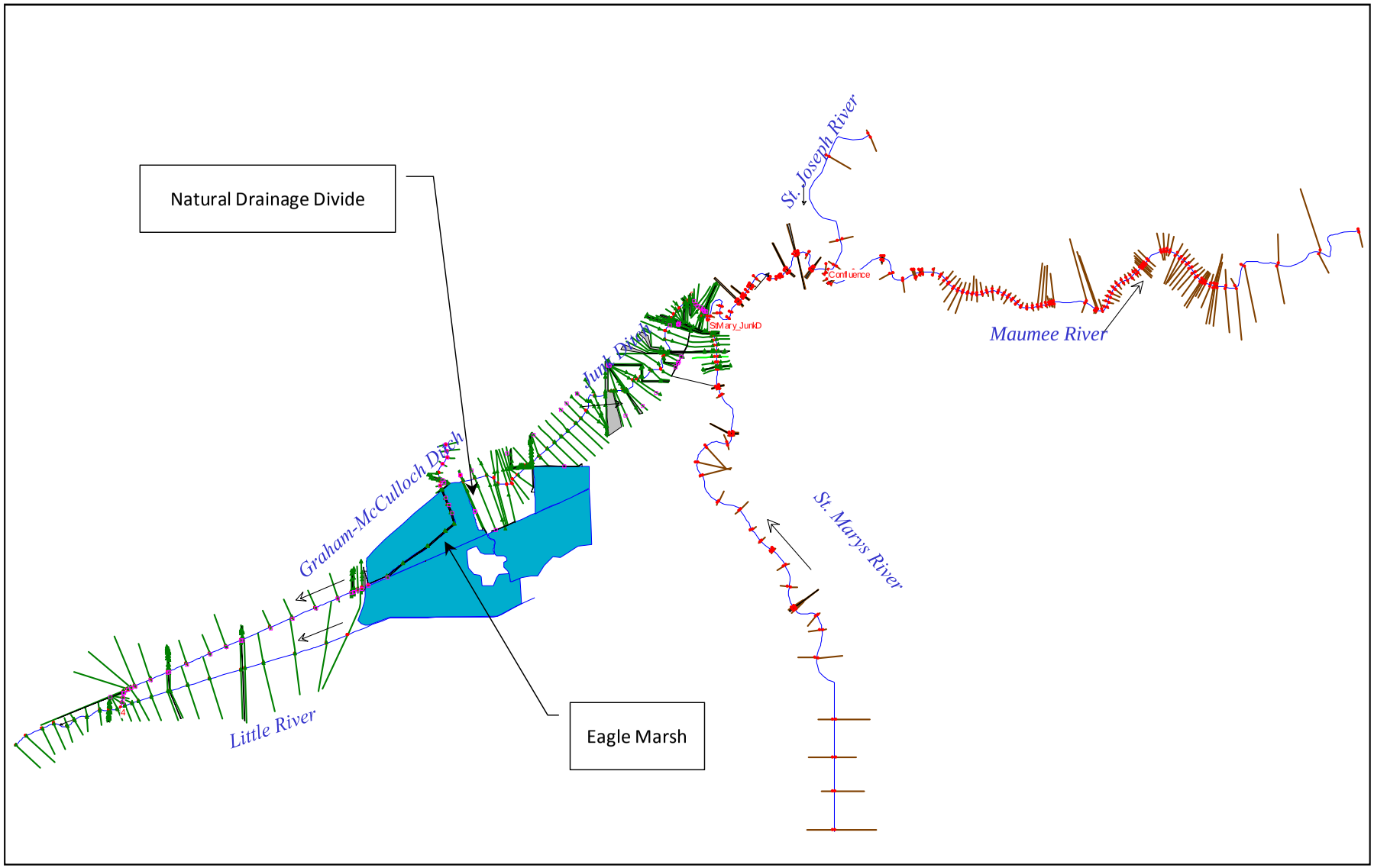


Figure 2.8: HEC-RAS model schematic of St. Marys Overflow and affected streams

The schematic of the stream network represented in the HEC-RAS model is shown in Figure 2.8. The HEC-RAS model that was developed represents the St. Marys River from the USGS gage location at approximately river mile 10.78 to its confluence with the St. Joseph River, and the Maumee River from this confluence to the gage location at river mile 129.08. The cross sections for the St. Marys and Maumee Rivers were imported from existing HEC-2 models developed by IDNR and most recently used in the 2009 Flood Insurance Study (FIS) update for Allen County. Initially, the St. Joseph River HEC-2 model was not available, so minimal required cross sections were cut from the 2009 Allen County LIDAR digital elevation model (DEM) to serve as a place holder representing the location of the St. Joseph confluence. The actual geometry of the St. Joseph River was not deemed crucial for the purposes of this study, but the river was merely included to create the junction point in HEC-RAS so that the St. Marys River and Maumee River stream mileage could be preserved in the model, and to provide a place for flows from the St. Joseph River to be input. The stream centerlines of the St. Marys, St. Joseph, and Maumee Rivers were partially geo-referenced to USGS quad sheets in the HEC-RAS model for visual purposes only, with the exception of the upper end of the St. Marys River beyond the bounds of Fort Wayne West quadrangle, which was not readily available. The data requirements and hydraulic computations for bridges in an HEC-RAS model is different than for HEC-2 models; therefore the bridges had to be re-coded manually after the existing HEC-2 models were imported. The new HEC-RAS model after conversion from HEC-2 produced profiles that closely matched the original HEC-2 calculated water surface elevation profiles. Due to the limited width of the existing HEC-2 model cross sections in reaches above the mouth of the Junk Ditch, it was later determined that the reach between the mouth of the Junk Ditch (St. Marys River mile 2.6) and new river mile 3.285 should be reprogrammed using updated mapping due to questions about the exchange of flow between the St. Marys River and Junk Ditch in the vicinity of Taylor Street; for this section, overbank geometry was cut from the 2009 Allen County LIDAR mapping DEM, and the stream invert ("thalweg") of the channel was approximated by interpolating the elevations and widths from the nearest HEC-2 models cross sections.

No existing geometry data was available for Junk Ditch, the Graham-McCulloch Ditch, or the Little River; therefore HEC-GeoRAS was used to cut overbank geometry from the 2009 LIDAR DEM, which had been augmented with additional survey points obtained from the NRCS survey of the Eagle Marsh property in 2006. As this DEM information stopped at the water surface that occurred at the time of the mapping, thalweg information was surveyed by Louisville District survey crews at most of the bridges on Junk Ditch and the Graham-McCulloch Ditch, and channel inverts were interpolated from this survey information for cross sections located between bridges.

The exchange of flow between the two watersheds is controlled by the elevation of an earthen berm that lines the left descending bank of the Graham-McCulloch Ditch. Please reference Figure 2.9 for a sample cross section of this channel, berm and overbanks. Floods on the St. Marys River and tributaries can cause flow to reverse in Junk Ditch and gradually fill in storage areas along the channel. The Junk Ditch channel will eventually "fill" to the elevation when it reaches a low area or "saddle point" at the head of Junk

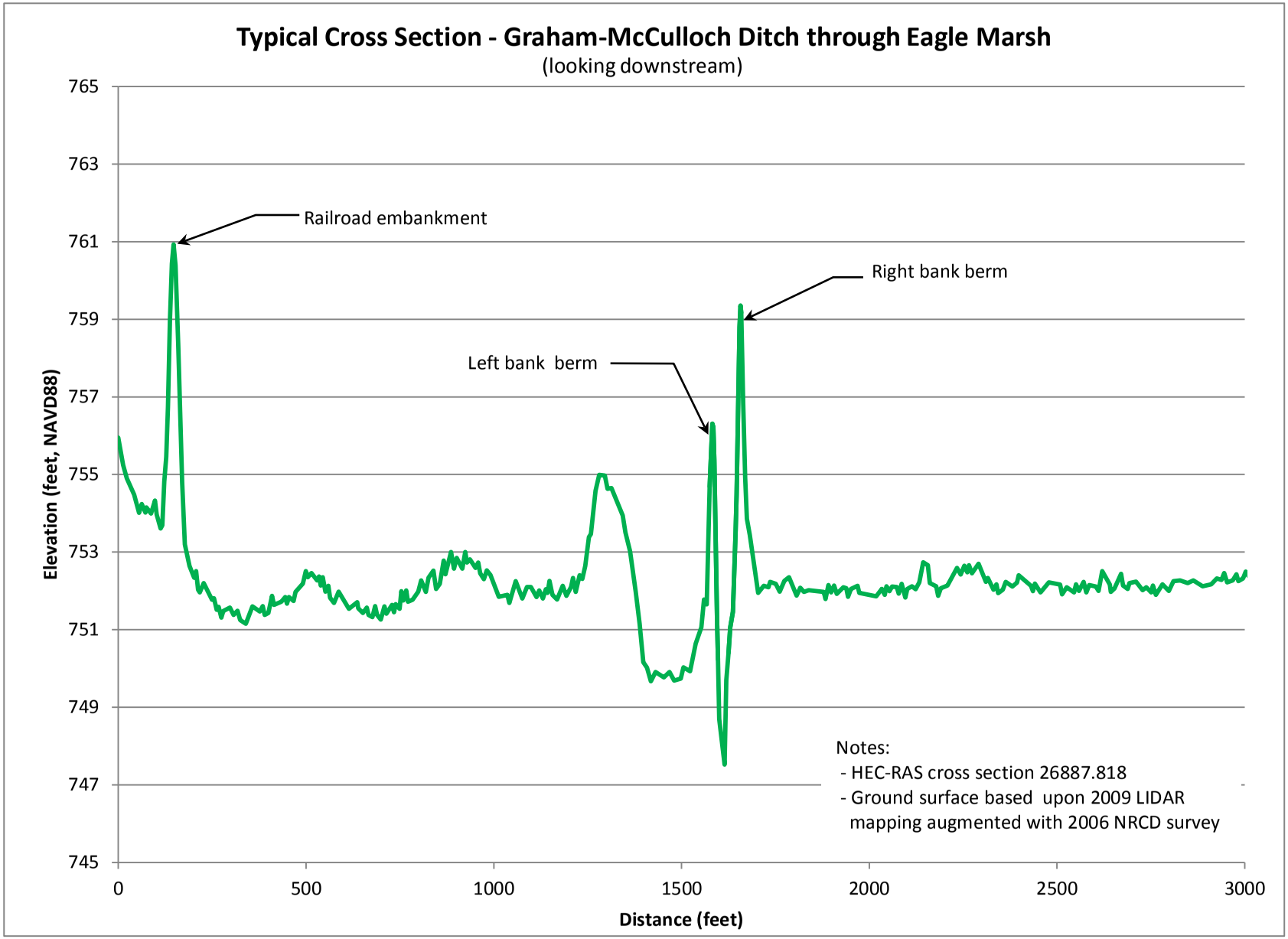


Figure 2.9: Typical Cross Section of Graham-McCulloch Ditch through Eagle Marsh, depicting confining berms on both banks

Ditch, at the east end of Eagle Marsh, which normally serves as the natural watershed divide. The watershed divide then acts as a weir, allowing flow into low areas bounded by the railroad berm to the south and the Graham-McCulloch left bank berm to the north and west, which eventually ties into the railroad berm near the west end of the Eagle Marsh. Conversely, floods on the Graham-McCulloch Watershed must generally overtop the left descending bank berm, fill the low Eagle Marsh south storage (EMSS) areas, and then "overtop" the natural watershed divide to flow into the Junk Ditch. Four known 18" corrugated metal drain tiles exist through the left descending bank berm, which connect the EMSS to the Graham-McCulloch Ditch. One of these pipes to the east of the existing IDNR barrier fence was previously buried in riprap to prevent its use as a conduit for fish species during floods. Due to large head differentials observed during floods in the spring of 2011, the riprap covering the pipe entrance was dislodged due to the high flows through the pipe. At the time of this report, IDNR has stated their plans to plug and fill this pipe in the fall of 2011. Because of the observed poor condition of these pipes, their effectiveness as a conduit for both flow and aquatic species is considered questionable, so the pipes were not included in the HEC-RAS model. Definition of the left bank berm elevations came from survey data by the NRCS from 2006. This data was deemed to be a better representation of the berm elevations than the elevations from the 2009 LIDAR mapping; however, deterioration (e.g., erosion or sloughing) of the left bank berm may have occurred in the interim period, which is thus not captured in the model. In the HEC-RAS model, this berm is a lateral weir structure with a weir coefficient (C_d) of 2.0, a value lower than normal, as defined by engineering judgment, to represent the reduced efficiency of flow in a lateral direction. Due to the lack of gage data on the Graham-McCulloch Ditch, further refinement of this value through calibration could not be performed. In HEC-RAS, the natural watershed divide is also modeled as a lateral weir connected to the last cross section on the Junk Ditch and the EMSS.

Along Junk Ditch and in the vicinity of Eagle Marsh, the railroad and other surface features can act as weirs that allow flow to occur laterally away from the channel, either into isolated areas where storage can occur, or permit the exchange of flow between channels. These lateral weir elevations were taken from the 2009 DEM either using automated tools in HEC-GeoRAS or manually entered from survey information, where available. Storage area elevation-volume curves were computed using HEC-GeoRAS tools within ArcGIS using the 2009 DEM. The existing 4' diameter culvert through the railroad embankment was surveyed and included as the connection between water surface elevations in Eagle Marsh and the Fox Island County Park, which also provides additional storage during floods. There are no apparent connections to the Little River under Yohne Road to the south of the Fox Island County Park.

Initial flows on each stream were set equal to expected low flow values, based upon engineering judgment and preliminary review of flow data, where available. Stability of the numerical model also influenced these minimum values in certain cases. Tables 2.4a and 2.4b summarize the boundary conditions and initial flows for events on the St. Marys River and Graham-McCulloch Ditch respectively. It is assumed that no antecedent storms have reduced the available storage in the storage areas and that they are nearly dry, with the initial ponded elevations set just above the minimum elevation on the

elevation-storage curve. The boundary conditions are defined as constant low flows equal to the initial flows for all streams except for the flood event hydrograph which is introduced on either the St. Marys River or Graham-McCulloch Ditch. Please refer to Section 2.6.2 for further discussion of the flow hydrographs used.

TABLE 2.4a
MODEL BOUNDARY CONDITIONS FOR
FLOOD EVENT ON ST. MARYS RIVER

Reach	Reach Location	Boundary Type	Input Flow (cfs)
Graham-McCulloch Ditch	Upstream	Base Flow hydrograph	25
Junk Ditch	Upstream	Base Flow hydrograph	25
Little River	Upstream	Base Flow hydrograph	10
Little River	Downstream	Normal Depth	-
Maumee River	Downstream	Normal Depth	-
St. Joseph River	Upstream	Base Flow hydrograph	2000
St. Marys River	Upstream	Flow Hydrograph	Varies

TABLE 2.4b
MODEL BOUNDARY CONDITIONS FOR
FLOOD EVENT ON GRAHAM-McCULLOCH DITCH

Reach	Reach Location	Boundary Type	Input Flow (cfs)
Graham-McCulloch Ditch	Upstream	Base Flow hydrograph	Varies
Junk Ditch	Upstream	Base Flow hydrograph	25
Little River	Upstream	Base Flow hydrograph	50
Little River	Downstream	Normal Depth	-
Maumee River	Downstream	Normal Depth	-
St. Joseph River	Upstream	Base Flow hydrograph	200
St. Marys River	Upstream	Flow Hydrograph	2000

2.7.2. Calibration

The 1982 flood event was chosen as a calibration event due to the well documented high water mark information collected by IDNR for this significant flood. An additional high water mark located inside the Little River Wetlands Project (LRWP) maintenance barn at Eagle Marsh for the 1982 flood was surveyed by Louisville District survey personnel. There is some conflicting information on the hydrograph used: a review of IDNR files

TABLE 2.—*Summary of peak stage and discharge data*—Continued

[R, river; nr, near; Cr, creek; mi², square miles; ft, feet; ft³/s, cubic feet per second; (ft³/s)/mi², cubic feet per second per square mile; dashes indicate missing or unknown value]

Site number	Station number	Station name	Contributing drainage area (mi²)	Period of record (water years)	Maximum flood previously recorded: Date	Gage height (ft)	Discharge (ft³/s)	Discharge (ft³/s)/mi²	Maximum during 1982 flood: Date	Gage height (ft)	Discharge (ft³/s)	Discharge (ft³/s)/mi²	Recurrence interval (years)
		St. Joseph River Basin—Continued											
40	04100500	Elkhart R at Goshen, Ind.	594	1932–82	4– 4–50	10.15	5,440	9	3–14	11.94	6,180	10	[1]80
41	04101000	St. Joseph R at Elkhart, Ind.	3,370	1948–82	4– 5–50	27.82	18,400	5	3–21	27.91	18,600	6	[1]45
42	04101500	St. Joseph at Niles, Mich.	3,666	1931–82	4– 5–50	15.10	20,200	6	3–21	14.97	19,900	5	[1]45
43	04101800	Dowagiac R at Sumnerville, Mich.	255	1961–82	6–26–68	8.78	1,280	5	3–17	8.33	1,150	5	15
44	04102320	Paw Paw R nr Paw Paw, Mich.	195	1981–82	5–11–81	5.73	1,230	6	3–14	6.26	1,540	8	---
45	04102420	Paw Paw R nr Hartford, Mich.	311	1981–82	2–21–81	9.76	1,760	6	3–17	10.37	2,500	8	---
46	04102500	Paw Paw R at Riverside, Mich.	390	1952–82	3– 9–79	10.11	2,830	7	3–18	10.11	2,650	7	45
		River Raisin Basin											
47	04176000	River Raisin nr Adrian, Mich.		1933–38									
			463	1954–82	4–30–56	14.87	5,580	12	3–15	15.77	6,660	14	>100
48	04176400	Saline R nr Saline, Mich.	94.6	1966–82	6–26–68	13.37	3,990	42	3–14	11.84	1,990	21	10
49	04176500	River Raisin nr Monroe, Mich.							3–15	11.16	Ice jam		
			1,042	1938–82	9– 6–81	10.22	14,500	14	3–16	---	15,300	15	50
		Maumee River Basin											
50	04177720	Fish Creek at Hamilton, Ind.	37.5	1970–82	3–23–78	10.79	497	13	3–17	11.52	603	16	35
51	04178000	St. Joseph R nr Newville, Ind.	610	1947–82	4– 6–50	17.05	9,710	16	3–17	17.96	9,190	15	[1]50
52	04179000	St. Joseph R at Cedarville, Ind.			3–24–78	18.62	---						
			763	1956–82	5– 1–56	---	10,100	13	3–17	21.94	14,500	19	[1]>100
53	04179500	Cedar Cr at Auburn, Ind.	87.3	1943–82	4– 5–50	9.90	1,520	17	3–14	10.63	2,100	24	[1]>100
54	04179510	Cecil Metcalf ditch nr Auburn, Ind.	.78	1973–82	6–13–81	---	90	115	3–14	10.50	140	179	20
55	04180000	Cedar Cr nr Cedarville, Ind.	270	1947–82	4– 5–50	11.67	4,870	18	3–14	12.98	5,340	20	[1]45
56	04181500	St. Marys R at Decatur, Ind.	621	1947–82	2–10–59	24.22	11,300	18	3–14	24.40	10,900	18	[1]20
57	04182000	St. Marys R nr Fort Wayne, Ind.	762	1931–82	2–11–59	19.42	13,600	18	3–14	19.66	12,600	17	[1]25
58	04182590	Harber ditch at Fort Wayne, Ind.	21.9	1965–82	6–13–81	11.67	916	42	3–14	12.25	900	41	10
59	04182900	Maumee R at Fort Wayne, Ind.	1,926	1907–82	3–26–13	26.10	---	---	3–17	25.93	---	---	---
60	04183000	Maumee R at New Haven, Ind.	1,967	1947–82	3–24–78	23.58	22,400	11	3–17	25.49	26,600	14	[1]80
61	04183500	Maumee R at Antwerp, Ohio	2,129	1922–82	5–20–43	20.29	26,200	12	3–17	21.70	26,100	12	[1]40
62	04185000	Tiffin R at Stryker, Ohio		1922–28									
			410	1941–82	4–25–50	15.45	6,640	16	3–15	18.36	7,760	19	50
63	04186500	Auglaize R nr Fort Jennings, Ohio		1922–36									
			332	1941–82	1–23–59	20.30	12,000	36	3–13	15.05	5,850	18	<5
64	04187500	Ottawa R at Allentown, Ohio		1924–35									
			160	1943–82	1–22–59	10.88	7,740	48	3–12	8.70	3,640	23	<5
65	04189000	Blanchard R nr Findlay, Ohio		1924–36									
			346	1941–82	6–14–81	17.43	13,000	38	3–13	12.35	6,320	18	<5
66	04191500	Auglaize R nr Defiance, Ohio			2–13–59	27.65	Ice jam						
					2–16–50	---	52,500	23					
			2,318	1916–82	2–12–59	---	52,500	23	3–14	27.39	52,300	23	20
67	04192500	Maumee R nr Defiance, Ohio		1925–36									
				1939–75									
			5,545	1979–82	2–16–50	13.70	87,100	16	3–15	15.87	104,000	19	>100
68	04193500	Maumee R at Waterville, Ohio		1900–01									
				1922–36									
			6,330	1939–82	2–16–50	14.52	94,000	15	3–15	17.18	120,000	19	90
		Kankakee River Basin											
69	05515000	Kankakee R nr North Liberty, Ind.			6–27–68	9.04	---						
			116	1951–82	6–14–81	---	780	7	3–17	9.01	908	8	[1]>100
70	05515400	Kingsbury Cr nr LaPorte, Ind.	3.01	1971–82	7–26–81	6.83	73	24	3–13	6.31	63	21	10
71	05515500	Kankakee R at Davis, Ind.							3–17	12.98	---		
			400	1932–82	7–29–81	12.52	1,580	4	3–20	---	1,920	5	[1]>100
72	05516000	Yellow R nr Bremen, Ind.	131	1955–82	5–15–78	17.68	2,750	21	3–16	15.17	2,800	21	[1]>100

Figure 2.10: Excerpt from USGS Water Supply Paper, 1982 Flood

found a hydrograph plotted for this event, but the peak flows on this hydrograph do not match USGS and other IDNR documentation that the flood was created as a result of a 4% annual chance event on the St. Marys River, followed closely by a 1% annual chance event on the St. Joseph River. Figure 2.10 is taken from the USGS Water Supply Paper on the 1982 flood event. This latter combination of floods was chosen for hydraulic modeling of this event based upon better documentation supporting this scenario and the better results obtained in the model. Figures 2.11 and 2.12 show the water surface profiles for the St. Marys River and Junk Ditch respectively, where high water mark information was well documented. This model closely reproduced these high water marks, particularly on the lower Junk Ditch and St. Marys River. At Eagle Marsh, the computed water surface elevation is approximately 0.6' higher than the observed high water mark in the LRWP barn.

Little additional information was available for validation of the model to an additional storm. To that end, documentation of any flood observations was requested of LRWP personnel. Photos were provided for four different events where the entrance road to the

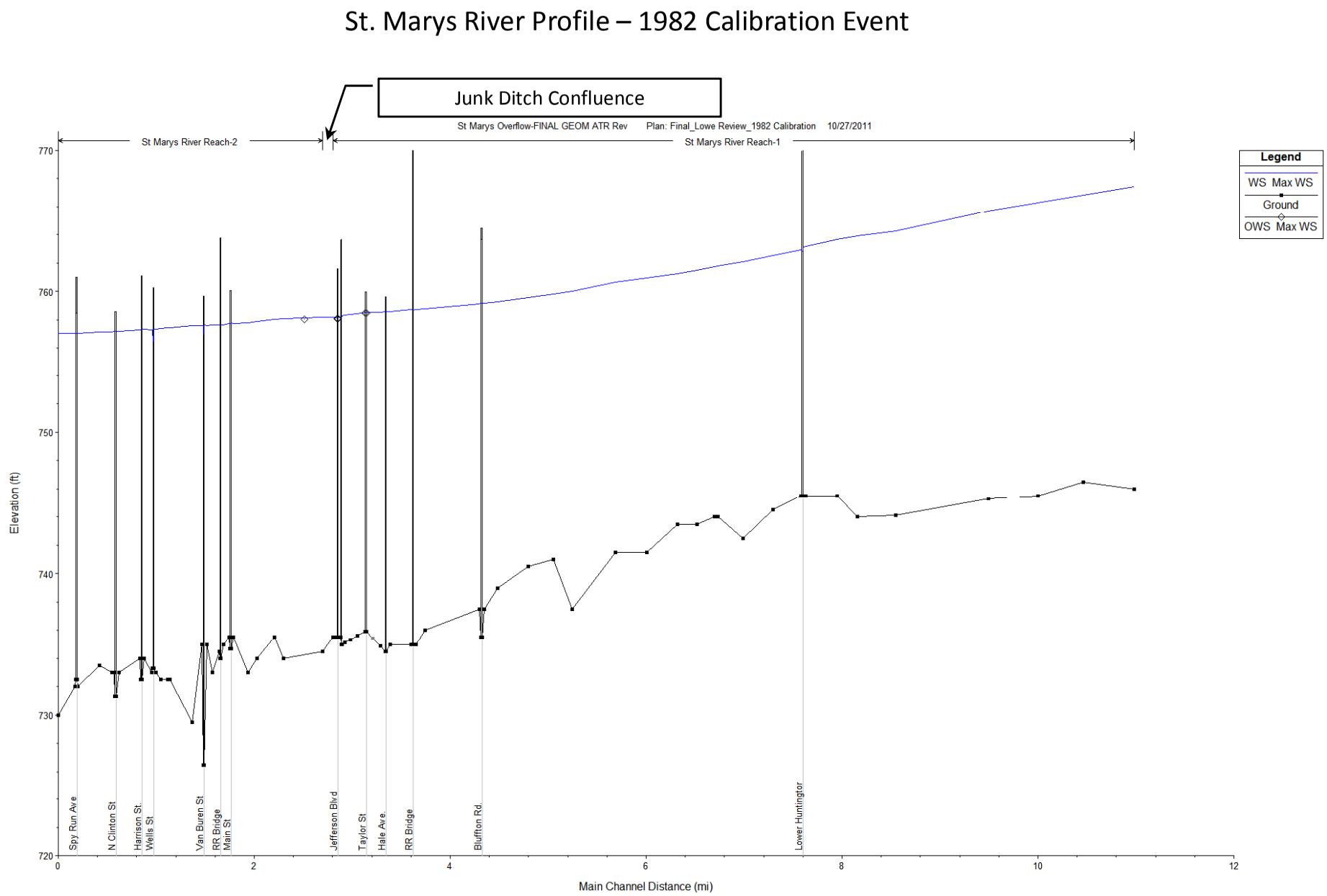


Figure 2.11: Calibration results for 1982 flood event – St. Marys River

Junk Ditch Profile – 1982 Calibration Event

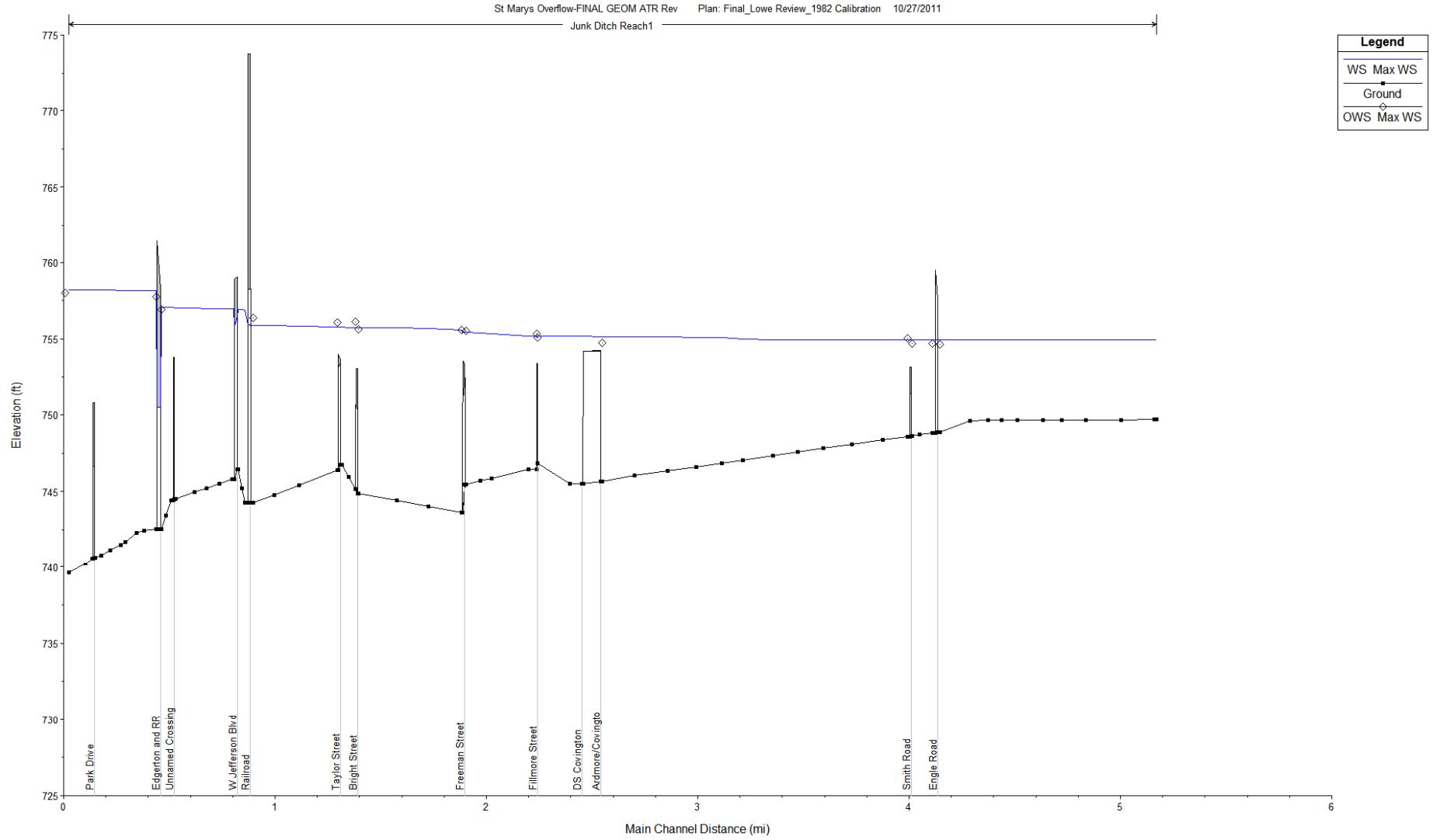


Figure 2.12: Calibration results for 1982 flood event – Junk Ditch

Photo 2.1: Flooding at Eagle Marsh Entrance Road, March 10, 2009. (Photo provided by Betsy Yankowiak, LRWP)

LRWP barn was overtopped and thus prevented access: 21 August 2007; 17 February 2009; 10 March 2009; and 31 March 2010. Based upon review of a new gages on the St. Marys and Maumee Rivers in downtown Fort Wayne, of these events only the 10 March 2009 flood event at Eagle Marsh appeared to be a result of backwater flooding from the St. Marys River (see Photo 2.1). Based upon examination of the DEM, it is estimated that the water surface elevation in the picture is approximately 752.5, referencing NAVD88. Modeling of this event reproduced very closely the peak gage elevation of 753.05 on 13 March 2009 at the Anthony Boulevard gage. At Eagle Marsh, the model predicts a peak elevation of approximately 753.7 several days after the photograph was taken, however it is unknown how water surface elevations reacted at Eagle Marsh during this period. It is also unknown what role, if any, flooding on the Graham-McCulloch may have played during this event; the model does not assume any significant flows on the Graham-McCulloch during this event. Based upon the data available, it is believed that the model generally reproduces the hydraulics of this system for this flood event.

2.7.3. Suggested Model Improvements

As discussed previously, the understanding of flows on the Graham-McCulloch Ditch is limited due to the absence of any gage information and detailed hydrologic analysis performed for this watershed. At a minimum, a detailed hydrologic model such as HEC-HMS should be developed for the watershed, preferably coupled with the installation of one or more flow gages in the vicinity of Eagle Marsh so that the hydrologic model may be calibrated. Ideally two gages would be installed, one upstream of Eagle Marsh to define flows strictly from the Graham-McCulloch headwaters, and a second gage near the I-69 Bridge which, when compared with the first gage upstream, could estimate flows

that may be entering or leaving the Graham-McCulloch watershed by crossing the left bank berm. Other configurations of gages may also provide similar information.

The Taylor Street overflow area which connects of the Junk Ditch and the St. Marys River upstream of the mouth of Junk Ditch, appears to play a significant role in determining the amount of flow that enters the Junk Ditch and utilizes storage within that watershed, thereby affecting the frequency that the Graham-McCulloch left bank berm is overtopped. The current modeling of this area controlled by a lateral weir at the railroad embankment appears to be conservative in that it may allow greater flows in the model to pass to Junk Ditch than may actually occur. Further study and alternative means of modeling this area should be explored.

2.8. BASELINE CONDITIONS

With the model developed to the extent possible given the available information and resources, the model was run for eight standard design flood frequencies: 0.2%, 1%, 2%, 4%, 10%, 20%, 50% and 99% annual chance events. As stated previously, the floods were each run independently on the St. Marys River and the Graham-McCulloch Ditch. Figures 2.13a through 2.13c show the maximum water surface elevation profiles for the St. Marys River, Junk Ditch, and Graham-McCulloch Ditch respectively for these flood events occurring on the St. Marys River. Figures 2.13d through 2.13f depict the same frequency events if the floods occurred on the Graham-McCulloch Ditch. These profiles are considered the baseline conditions to which alternatives for preventing the transfer of aquatic nuisance species will be compared. It should be noted in Figure 2.13c that the water surface profiles on the Graham-McCulloch Ditch are coincident for the 4%, 10%, 20%, 50% and 99% annual chance events on the St. Marys River because the left bank berm is not overtopped until approximately a 3% annual chance event on that watershed. Likewise, the Junk Ditch profiles in Figure 2.13e for the 10%, 20%, 50%, and 99% annual chance events are coincident as a 10% annual chance event on the Graham-McCulloch does not overtop the left bank berm. Figures 2.14a and 2.14b illustrate water surface elevations in the vicinity of the Eagle Marsh for select representative events relative to the Graham-McCulloch Ditch left bank berm. For reference, Figures 2.15a and 2.15b illustrate the approximate depths of flow and extents of inundation in the vicinity of Eagle Marsh for a 1% annual chance event occurring on the St. Marys River or the Graham-McCulloch Ditch. Please note when examining these depth charts that the depths have been broken into classifications for easier interpretation, but this results in a conservative representation; for example, an actual depth of 1.6 feet will appear the same as a depth of 3 feet because they have been classified in the group of depths of 1.5’ – 3’.

It is not assumed that a flood on the St. Joseph River will occur coincident with the St. Marys or Graham-McCulloch events. While the St. Marys and St. Joseph watersheds are similar in size, the geographic areas they encompass are significantly separated; the headwaters of each stream are separated by over 100 miles. It is not believed to be likely that a storm of extreme intensity or duration would encompass both watersheds, producing peaks that would reach the confluence simultaneously. Preliminary analysis

Baseline Water Surface Profiles – St. Marys River Flood Events

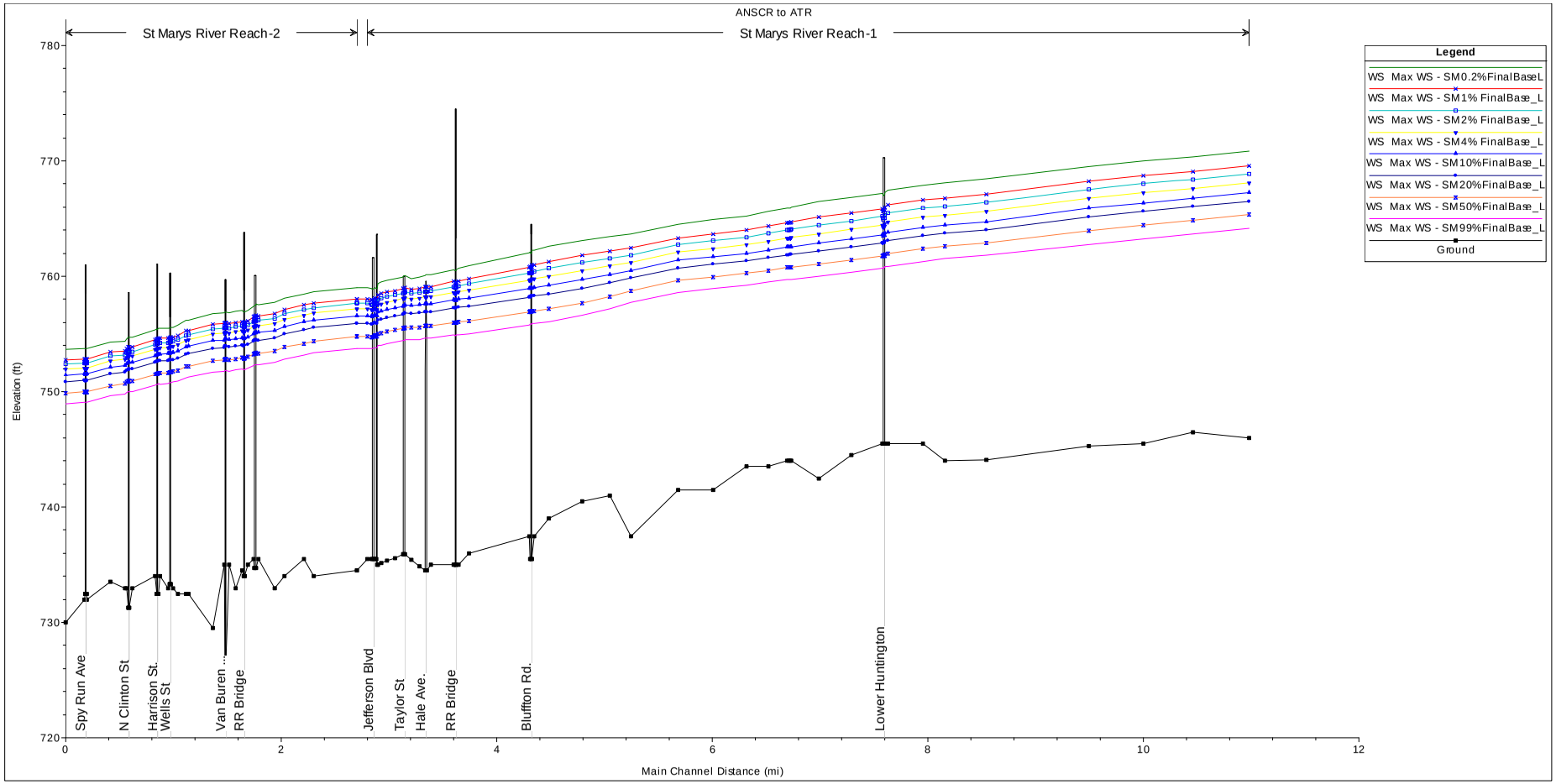


Figure 2.13a: Baseline water surface profiles for floods on the St. Marys River

Baseline Water Surface Profiles – St. Marys River Flood Events

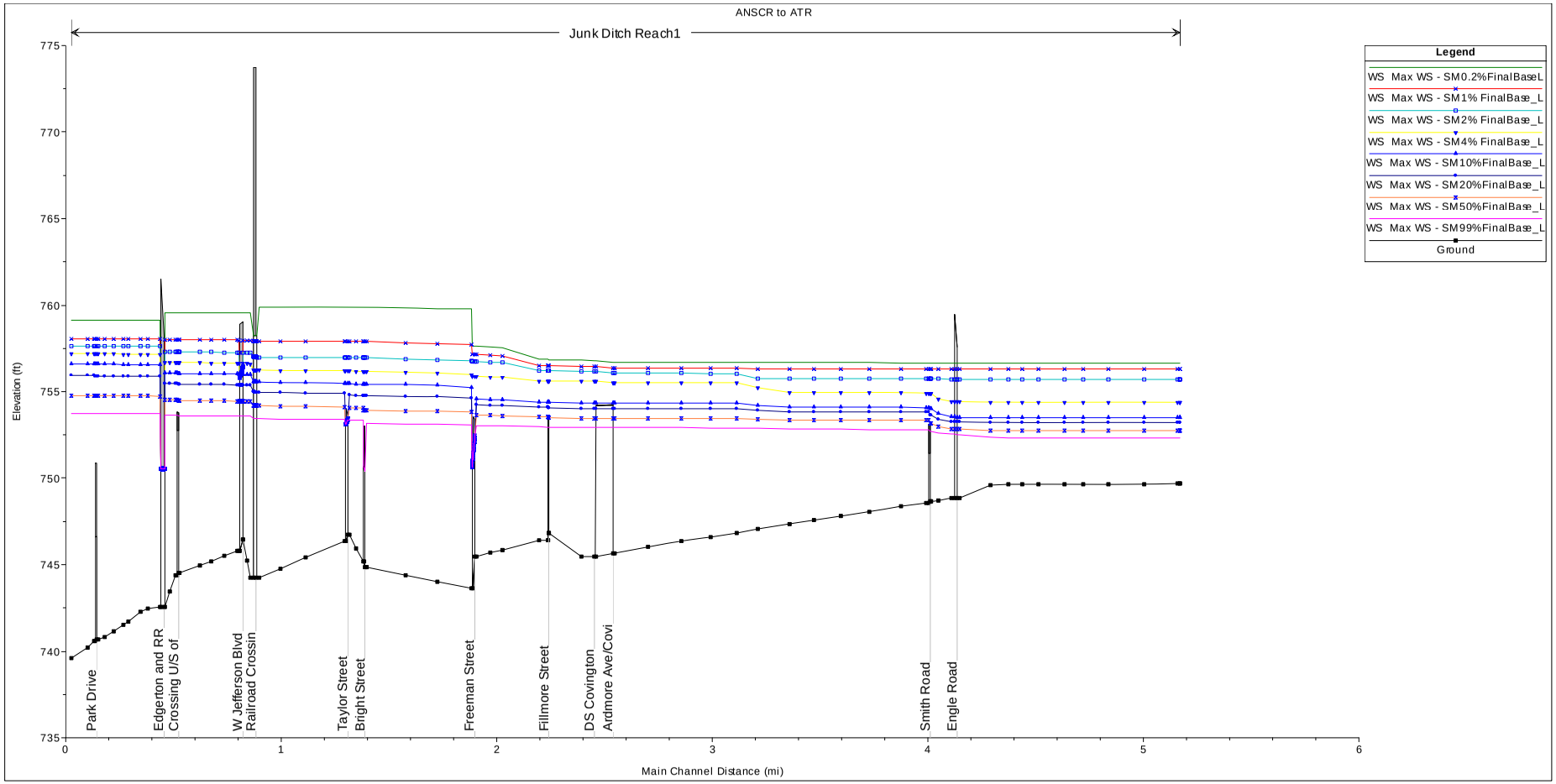


Figure 2.13b: Baseline water surface profiles on Junk Ditch for floods on the St. Marys River

Baseline Water Surface Profiles – St. Marys River Flood Events

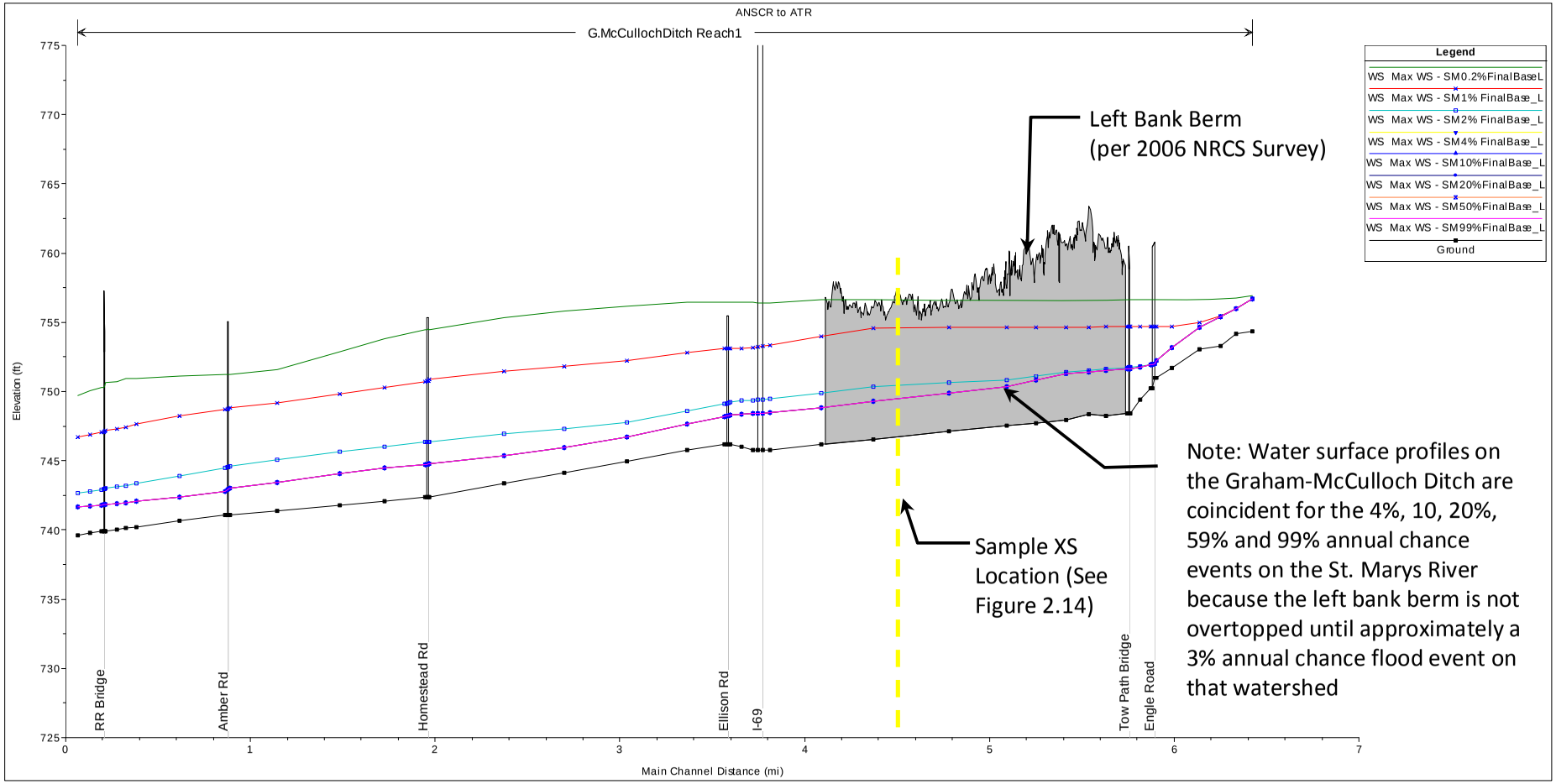


Figure 2.13c: Baseline water surface profiles on Graham-McCulloch Ditch for floods on the St. Marys River

Baseline Water Surface Profiles – Graham-McCulloch Ditch Flood Events

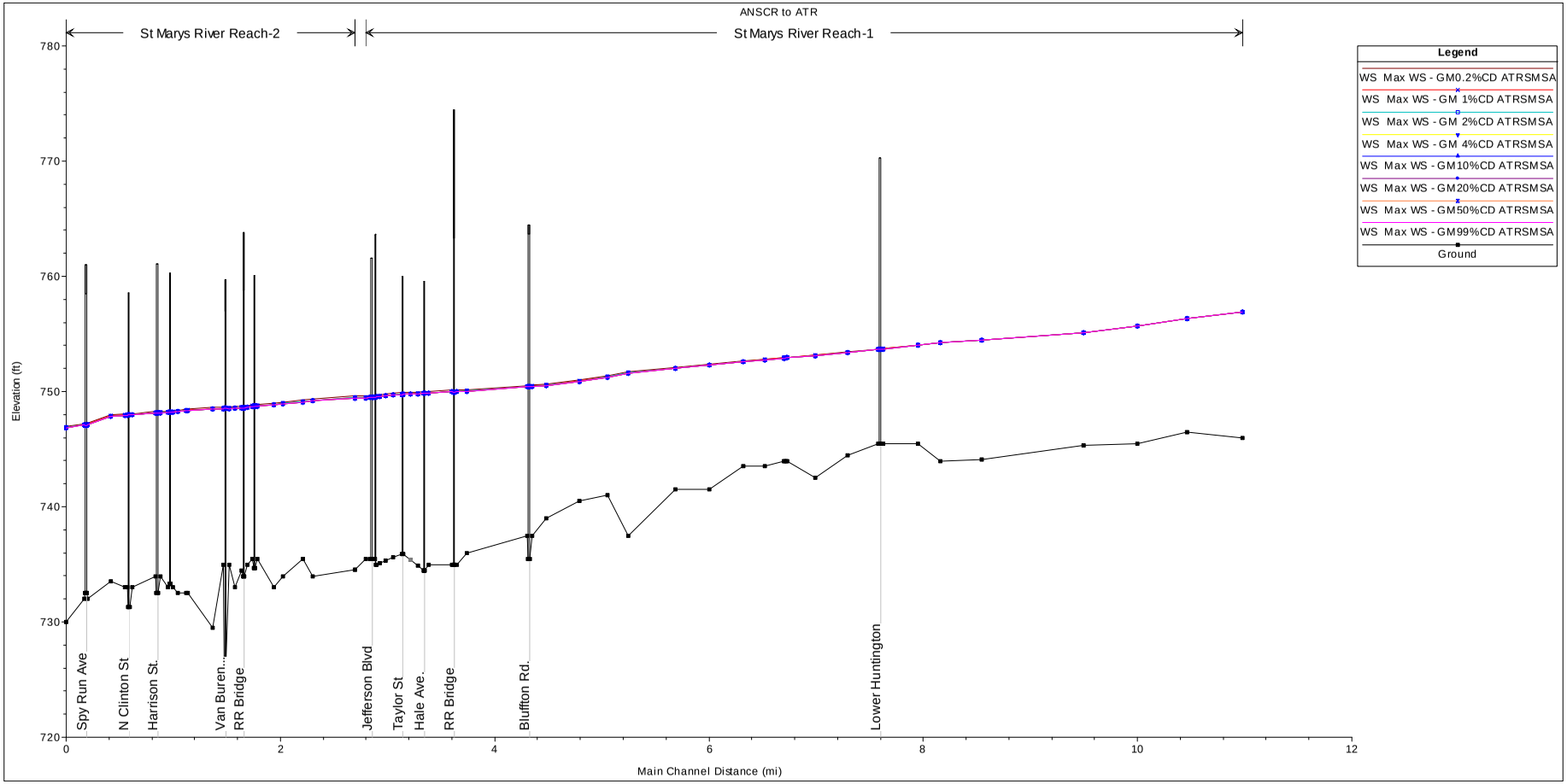


Figure 2.13d: Baseline water surface profiles on the St. Marys River for floods on the Graham-McCulloch Ditch

Baseline Water Surface Profiles – Graham-McCulloch Ditch Flood Events

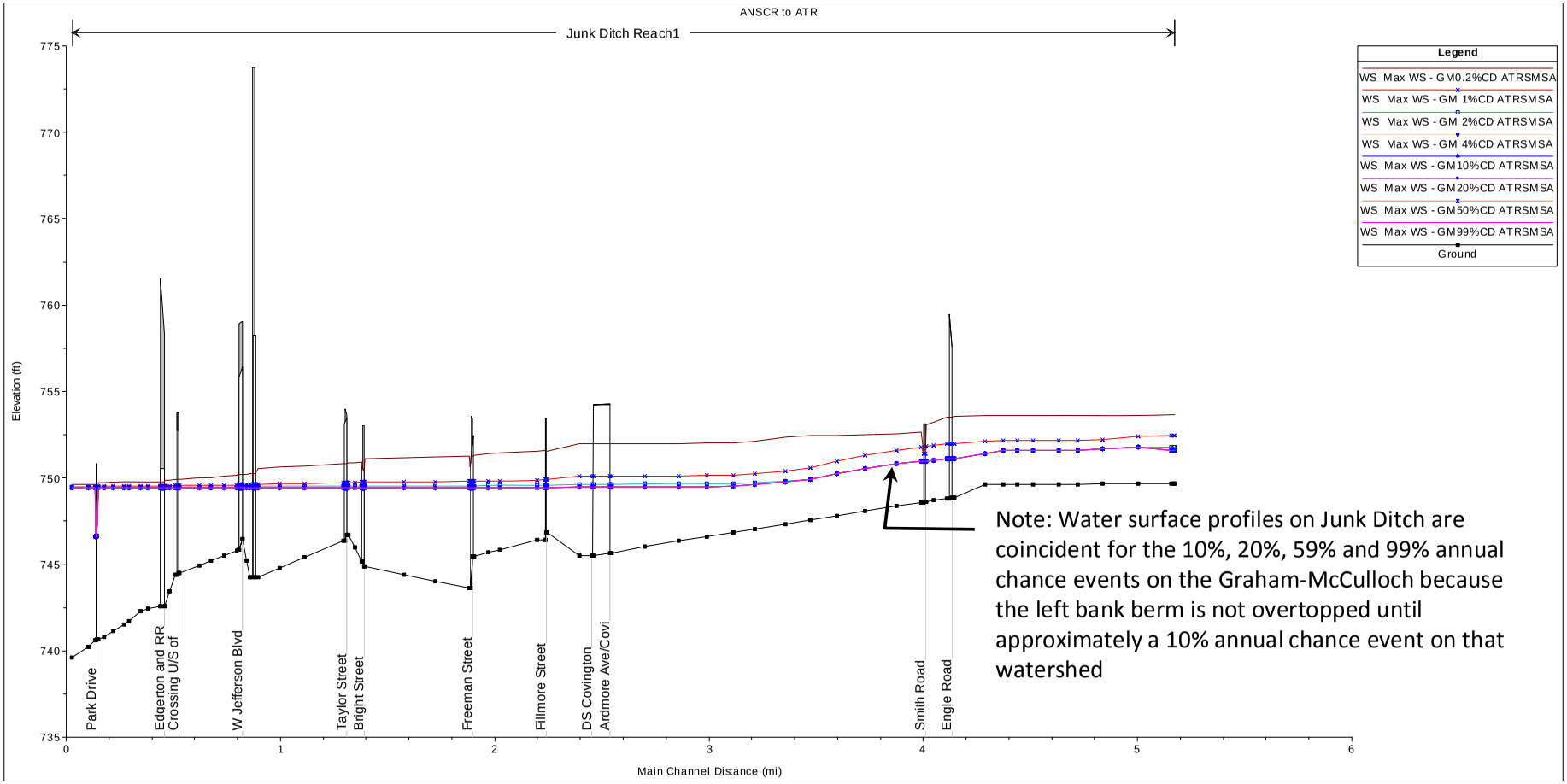


Figure 2.13e: Baseline water surface profiles on Junk Ditch for floods on the Graham-McCulloch Ditch

Baseline Water Surface Profiles – Graham-McCulloch Ditch Flood Events

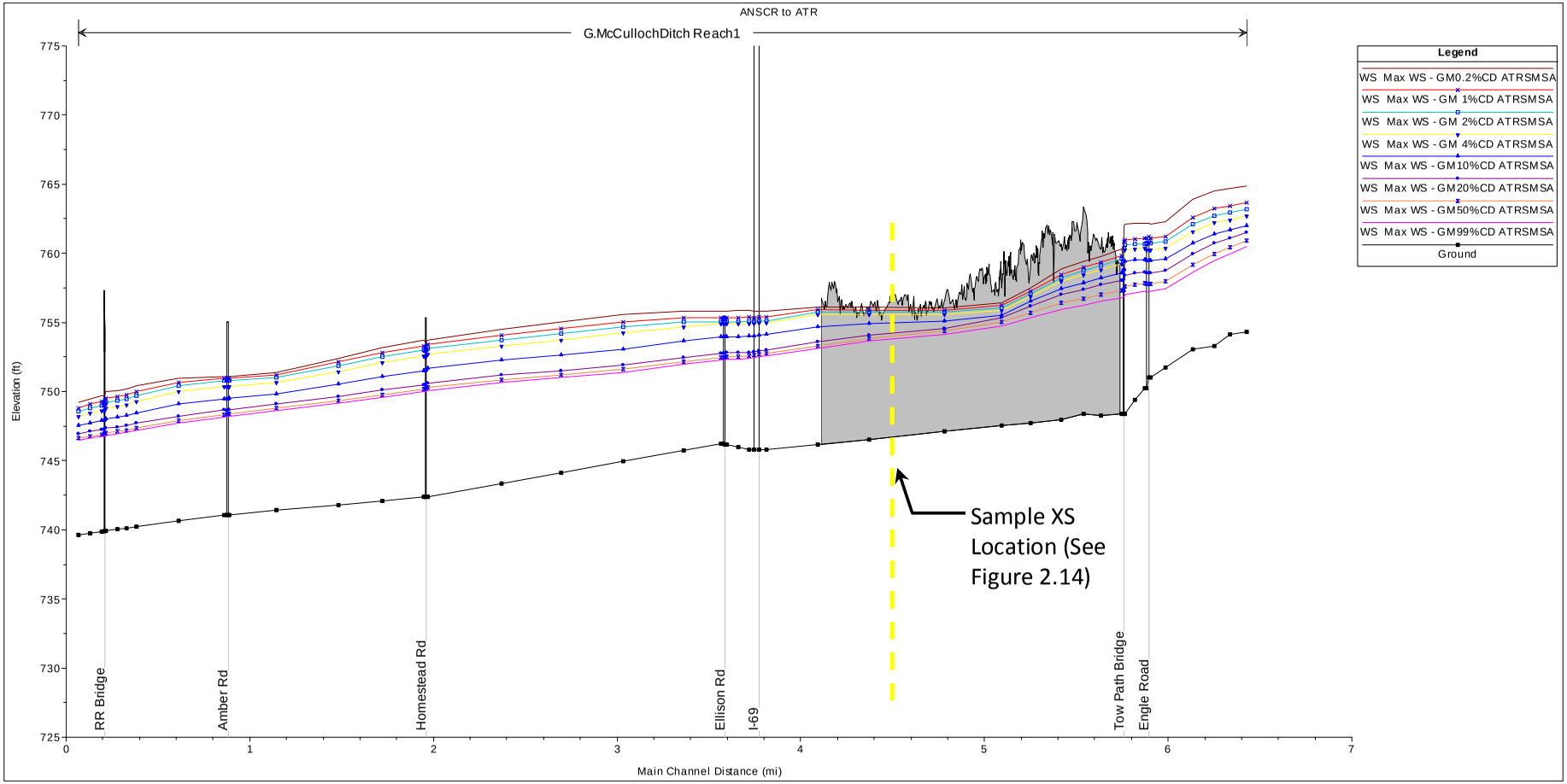
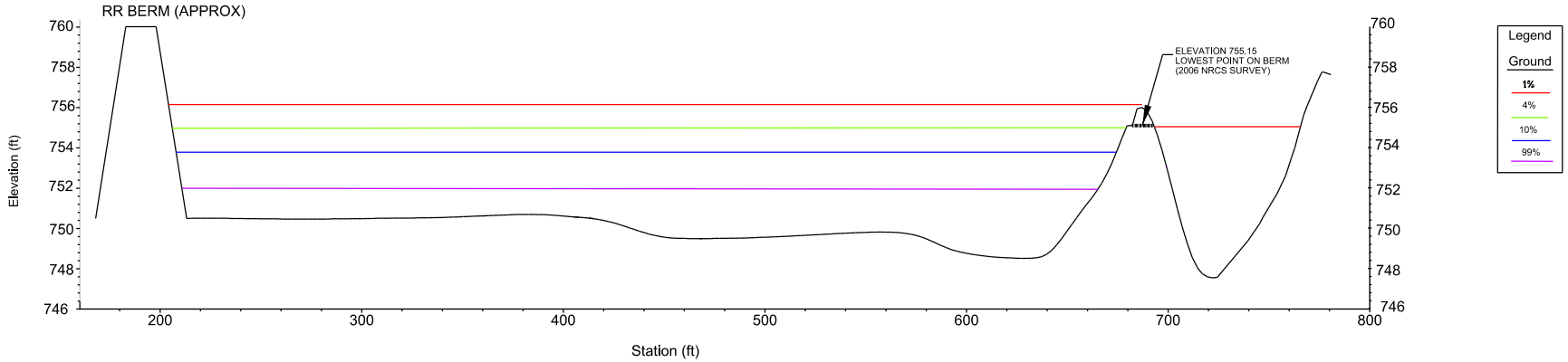
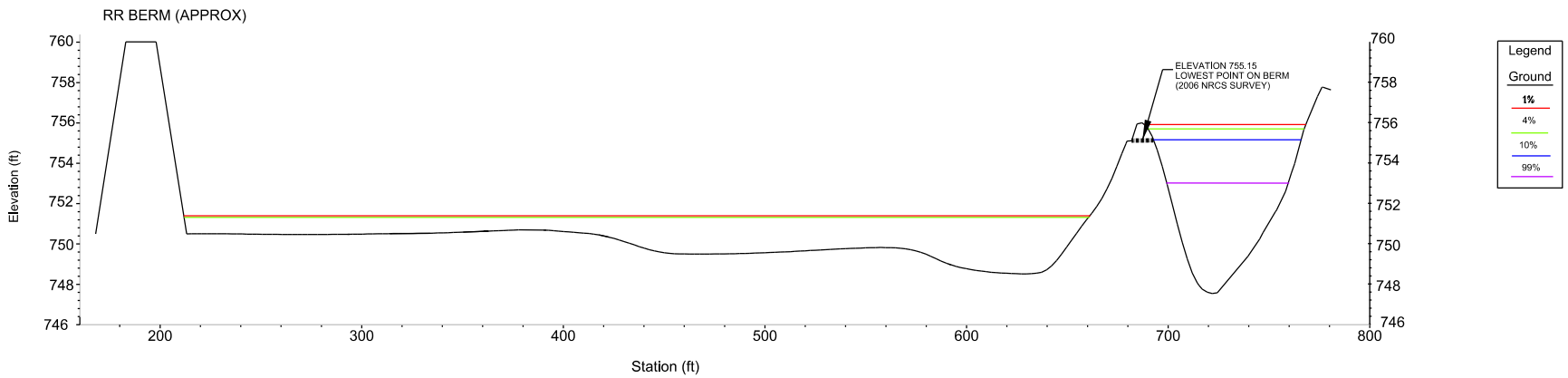


Figure 2.13f: Baseline water surface profiles on Graham-McCulloch Ditch



SAMPLE CROSS SECTION
LEFT OVERBANK GRAHAM-McCULLOCH DITCH
FLOW DEPTH FOR SELECT FLOODS OCCURING
ON ST. MARYS RIVER WATERSHED



SAMPLE CROSS SECTION
LEFT OVERBANK GRAHAM-McCULLOCH DITCH
FLOW DEPTH FOR SELECT FLOODS OCCURING
ON GRAHAM-McCULLOCH DITCH WATERSHED

Figure 2.14a: Sample Cross Section through Eagle Marsh left bank berm and southern storage area

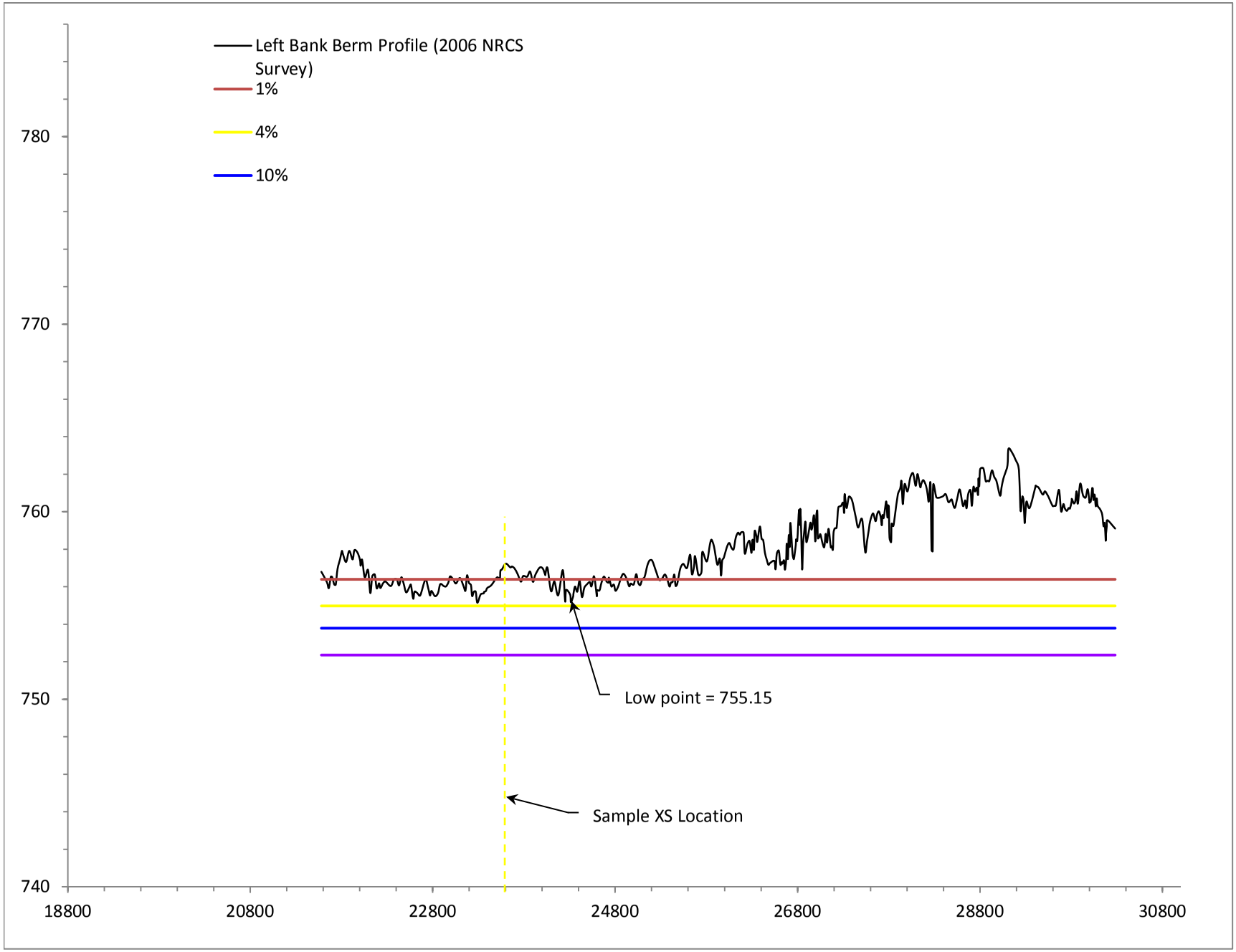


Figure 2.14b: St. Marys Flood water surface elevations behind Graham-McCulloch left bank berm (2006 NRCS survey)

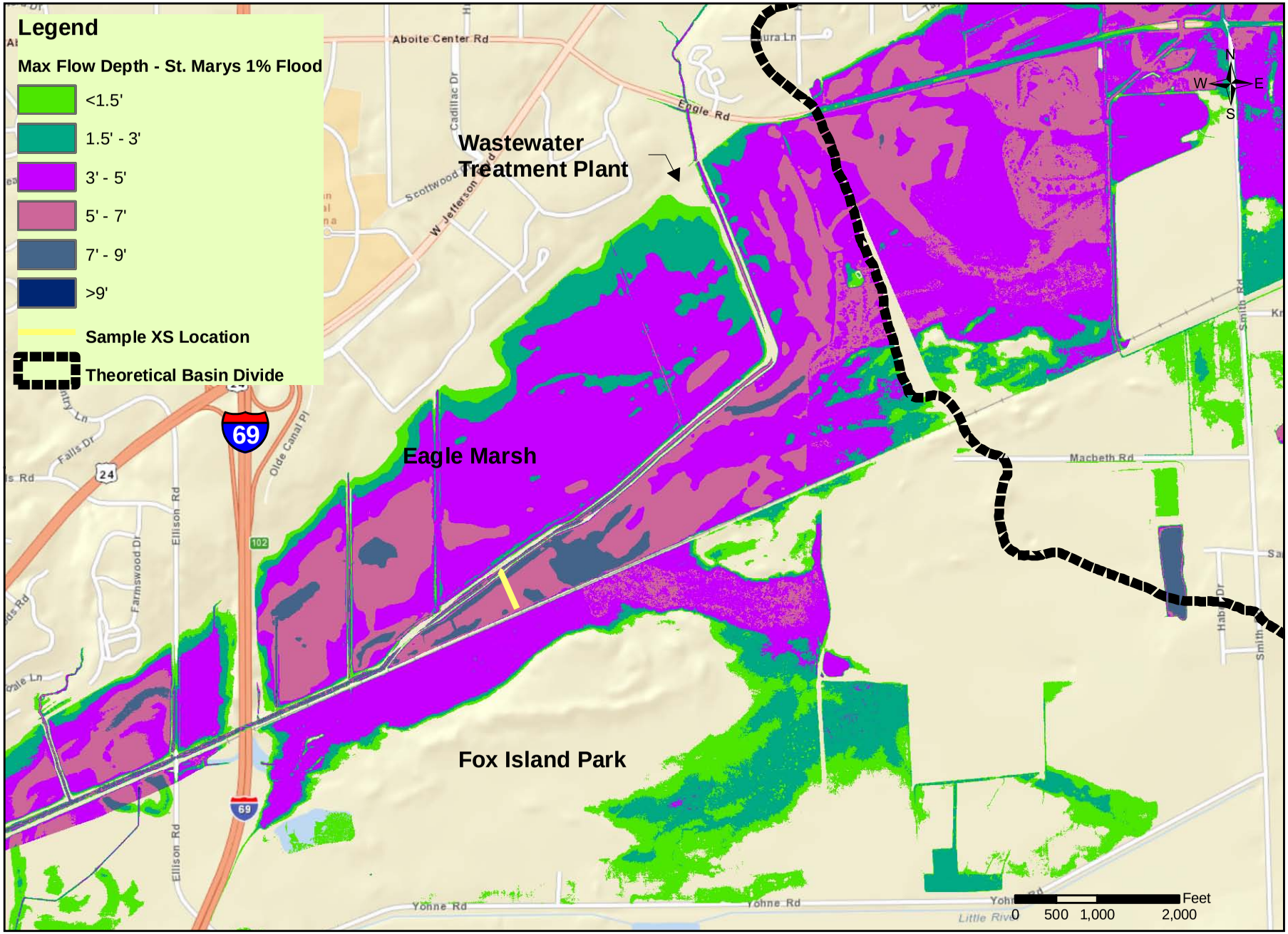


Figure 2.15a: St. Marys River 1% Annual Chance Event Depths at Eagle Marsh

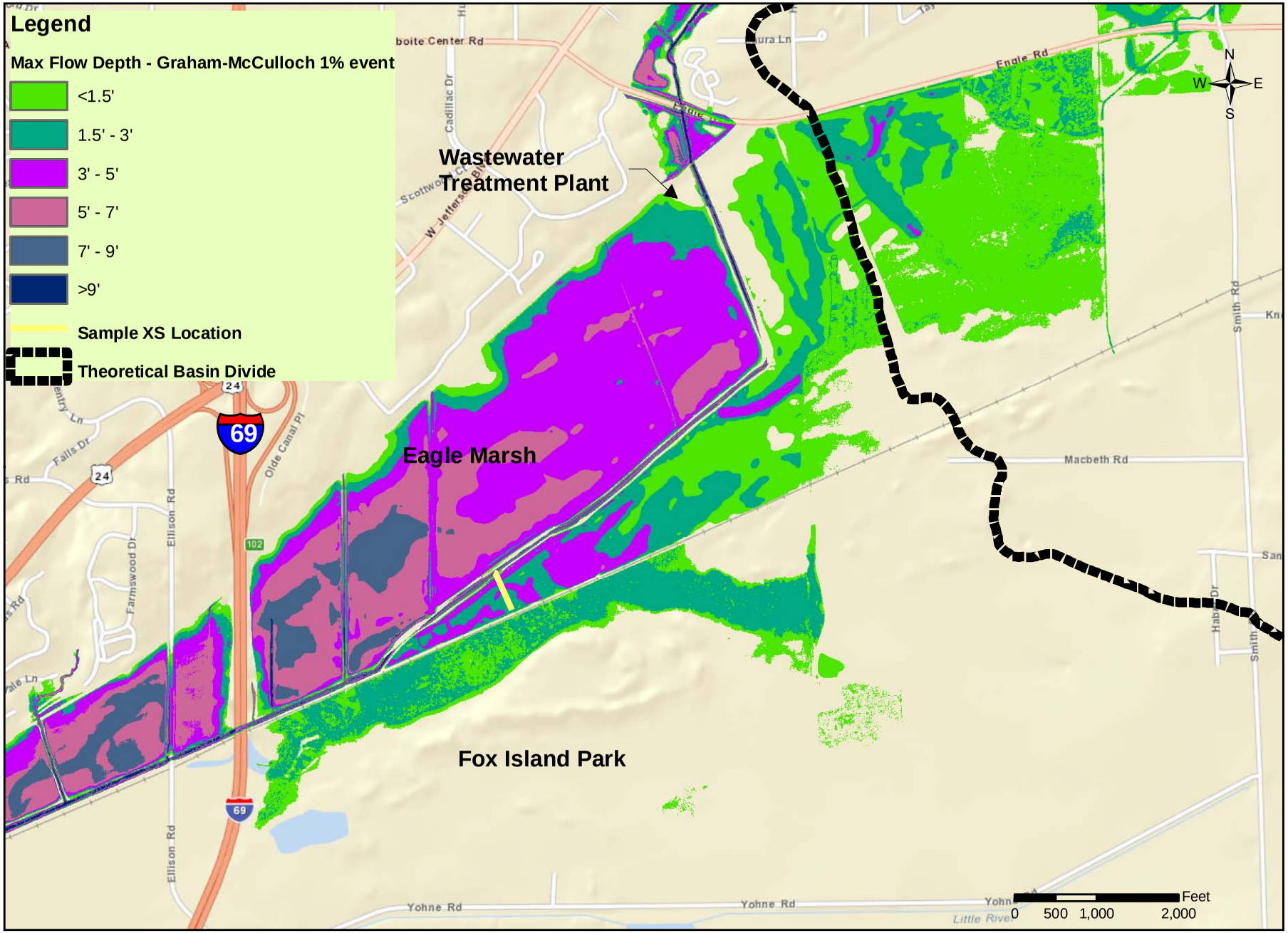


Figure 2.15b: Graham-McCulloch Ditch 1% Annual Chance Event Depths at Eagle Marsh

also showed that backwater effects from flood events on the St. Joseph River do not create significant flooding on Junk Ditch as compared to the same frequency events on the St. Marys River.

Using depth grids and inundation maps like Figures 2.15a and 2.15b, with cooperation from the Maumee River Basin Commission, a preliminary assessment of the existing condition damages were measured, quantifying the number of parcels and structures affected by the 1% annual chance events occurring on each watershed and the classification of the properties affected. The value of the affected properties was also calculated utilizing 2008 Assessment values which were readily available. Please refer to Section 2.3.3 of the main report for a summary of the findings.

2.9. EXISTING FLOOD CONTROL MEASURES

A system of levees and floodwalls has gradually been constructed and improved since the March 1913 flood. In general, the system is intended to protect areas near the lower reaches of Junk Ditch near its mouth, downstream of Main Street; the left bank of the St. Marys River from Junk Ditch to N. Clinton Street and from the Spy Run confluence to the mouth of the St. Marys River; the lower left bank of Spy Run from State Boulevard, to its mouth; the St. Joseph River left bank from near North Anthony Boulevard, and the right bank from State Boulevard to its confluence with the St. Marys River, and the left bank of the Maumee River from the St. Marys and St. Joseph Rivers confluence to a point east of North Anthony Boulevard. Figure 2.16 is extracted from the National Levee Database public map server depicting the locations of these structures. These flood hazard reduction measures are typically constructed to an elevation two feet greater than the1913 flood elevation. Per the 2009 FIS report, not all of these structures meet current FEMA standards for adequate design height, structural stability, and/or adequate operation and maintenance for protection against the 1% annual chance event.

2.10. STRUCTURAL ALTERNATIVES

In the development of the following alternatives, risk and uncertainty in water surface elevations was considered when determining the elevations of barrier components of each alternative. Preliminary calculations were performed based upon the multiple standard frequency events for both the St. Marys River watershed and the Graham-McCulloch Ditch watersheds. The preliminary calculated values were less than the standard 2.0 foot minimum freeboard, so per EC 1110-2-6067, this minimum value was used. These calculations will need to be further refined upon selection of a preferred alternative in accordance with any final design details.

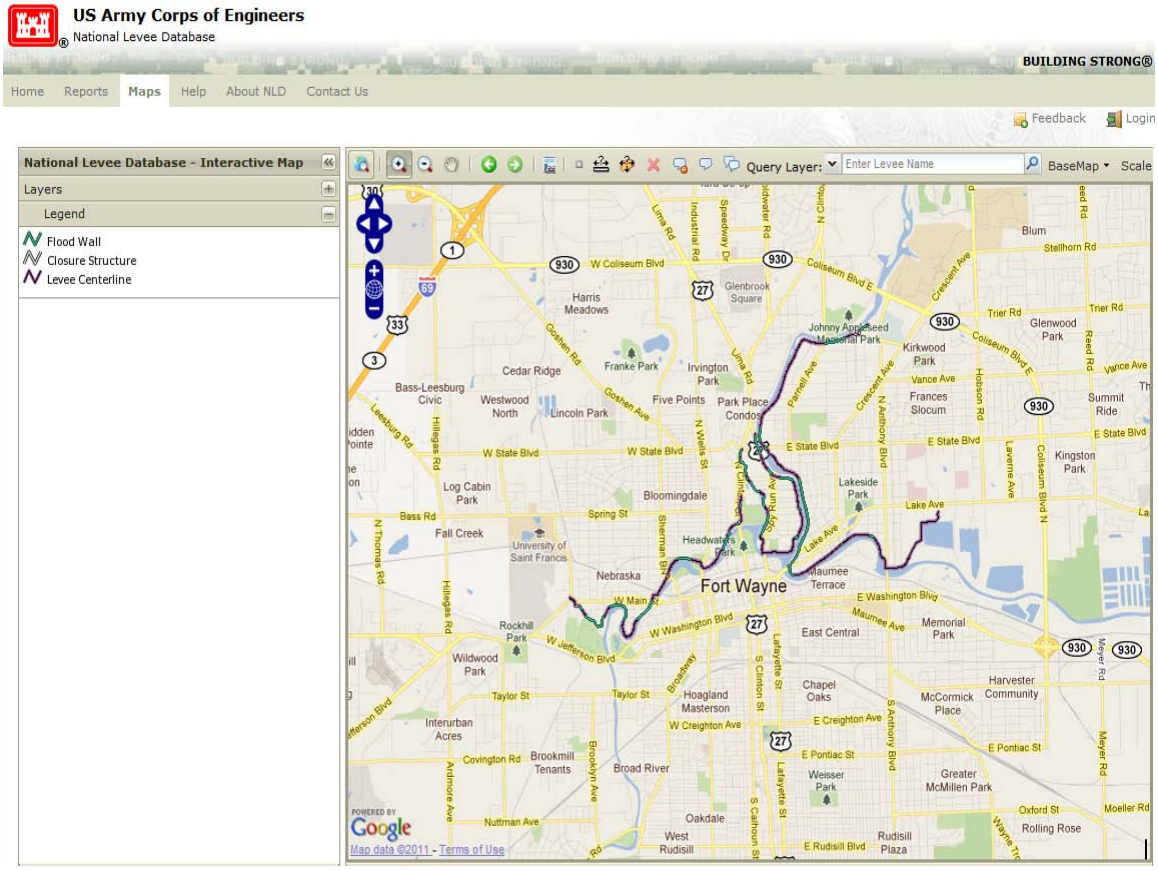


Figure 2.16: National Levee Database levee and floodwall locations in Fort Wayne

Tables 2.5a and 2.5b summarize the changes to calculated water surface elevations at select points of interest within each watershed for the 1% annual chance event on each watershed. Please also refer to Section 3.4.3 for further discussion of each structural alternative, including evaluation of impacts for each concept. As was performed for the existing conditions, preliminary inundation maps and depth grids were compared to 2008 property assessment data for Allen County with the assistance of the Maumee River Basin Commission. For each alternative modeled, it was determined utilizing GIS the number of new parcels and structures that would be affected by increased water surface elevations. The real property values were calculated based on newly inundated structures that fell within these parcels. The property values provided in the main report discussion assume that the entire parcel and structure is completely inundated. In reality, there are places where only the corner of a structure may experience minimal flooding (for example, 1” of water), but in the absence of first floor information and depth-damage curves for these properties, it was assumed that the entire property is completely affected. The real property values reported are very conservative, but are provided as a way to qualitatively evaluate and compare the impacts of each structural alternative relative to potential increased water surface elevations.

TABLE 2.5a
COMPARISON OF CALCULATED WATER SURFACE ELEVATIONS FOR CONSIDERED STRUCTURAL ALTERNATIVES FOR 1% ANNUAL CHANCE EVENT ON THE ST. MARYS RIVER WATERSHED

	Stream	Graham-McCulloch Ditch				Junk Ditch				St. Marys River	
	Bridge	Amber Road		I-69		Ardmore Avenue		W. Jefferson Blvd		Main Street	
Alternative	Description	Max. WSEL (ft NAVD88)		Max. WSEL (ft NAVD88)		Max. WSEL (ft NAVD88)		Max. WSEL (ft NAVD88)		Max. WSEL (ft NAVD88)	
-	Baseline Conditions	748.81		753.28		756.37		757.98		756.61	
		Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)	Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)	Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)	Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)	Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)
A	Construct an I-Wall	742.95	-5.86	748.44	-4.84	757.87	1.5	757.98	0	756.55	-0.06
B	Construct a Fence and Reconstruct Left Descending Graham McCulloch Ditch Berm (2)										
C	Construct an Earthen Berm and Pump Station	749.41	0.6	754.37	1.09	756.45	0.08	757.33	-0.65	756.09	-0.52
D	Construct a Permeable Berm with Telemetered Sluice Gates (3)										
E	Construct a Fence/Earthen Berm Combination	748.82	0.01	753.29	0.01	756.36	-0.01	757.98	0	756.61	0
F	Construct Bar Screen Barrier at Existing Weir (4)										
G	Construct Vertical Drop Structure with Telemetered Sluice Gate	749.38	0.57	754.83	1.55	756.45	0.08	757.33	-0.65	756.15	-0.46
H	Reconstruct Left Descending Graham McCulloch Ditch Berm	742.96	-5.85	748.44	-4.84	757.17	0.8	757.98	0	756.61	0
I	Reconstruct Left Descending Graham McCulloch Ditch Berm, Demolish Right Descending Berm, and Construct Multi-Cell Wetland Area (5)	742.96	-5.85	748.44	-4.84	757.17	0.8	757.98	0	756.61	0

Notes
(1) All calculated elevations taken upstream of bridge (normal flow direction)
(2) Alternative B was not specifically modeled, as the hydraulic conditions will remain essentially the same as the current (baseline) conditions.
(3) Alternative D was not specifically modeled for this flow condition, as the Graham-McCulloch Ditch 1% annual chance event flows will control.
(4) Alternative F was not specifically modeled, as it was assumed that the constraints of minimizing impacts to upstream water surface elevations upstream to at or near Indiana maximum allowable levels of 0.14 feet increases for 1% chance event will dominate the bar screen design
(5) Alternative I was not specifically modeled for this flow condition, as the hydraulic conditions will remain essentially the same as Alternative H.

TABLE 2.5b
COMPARISON OF CALCULATED WATER SURFACE ELEVATIONS FOR CONSIDERED STRUCTURAL ALTERNATIVES FOR 1% ANNUAL CHANCE EVENT ON THEGRAHAM-McCULLOCH DITCH WATERSHED

	Stream	Graham-McCulloch Ditch				Junk Ditch				St. Marys River	
	Bridge	Amber Road		I-69		Ardmore Avenue		W. Jefferson Blvd		Main Street	
Alternative	Description	Max. WSEL (ft NAVD88)		Max. WSEL (ft NAVD88)		Max. WSEL (ft NAVD88)		Max. WSEL (ft NAVD88)		Max. WSEL (ft NAVD88)	
-	Baseline Conditions	750.94		755.35		750.1		749.6		748.77	
		Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)	Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)	Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)	Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)	Calculated WSEL	Increase (+) / Decrease (-) from Baseline (feet)
A	Construct an I-Wall	750.94	0	755.39	0.04	749.69	-0.41	749.51	-0.09	748.75	-0.02
B	Construct a Fence and Reconstruct Left Descending Graham McCulloch Ditch Berm (2)										
C	Construct an Earthen Berm and Pump Station	750.74	-0.2	755.66	0.31	750.27	0.17	749.64	0.04	748.78	0.01
D	Construct a Permeable Berm with Telemetered Sluice Gates	750.88	-0.06	755.63	0.28	750.32	0.22	749.34	-0.26	748.31	-0.46
E	Construct a Fence/Earthen Berm Combination	750.95	0.01	755.46	0.11	750.25	0.15	749.64	0.04	748.78	0.01
F	Construct Bar Screen Barrier at Existing Weir (4)										
G	Construct Vertical Drop Structure with Telemetered Sluice Gate	750.17	-0.77	756.02	0.67	751.32	1.22	749.67	0.07	748.37	-0.4
H	Reconstruct Left Descending Graham McCulloch Ditch Berm	751.1	0.16	755.89	0.54	749.46	-0.64	749.45	-0.15	748.73	-0.04
I	Reconstruct Left Descending Graham McCulloch Ditch Berm, Demolish Right Descending Berm, and Construct Multi-Cell Wetland Area	751.2	0.26	756.47	1.12	749.46	-0.64	749.45	-0.15	748.73	-0.04

Notes
(1) All calculated elevations taken upstream of bridge (normal flow direction)
(2) Alternative B was not specifically modeled, as the hydraulic conditions will remain essentially the same as the current (baseline) conditions.

(4) Alternative F was not specifically modeled, as it was assumed that the constraints of minimizing impacts to upstream water surface elevations upstream to at or near Indiana

2.10.1. Construct an I-Wall, Alternative A, (Eagle Marsh, Basin Divide)

Alternative A was developed for reference to demonstrate the impacts of complete hydraulic separation of the St. Marys and Maumee watersheds from the Wabash River watershed, thus preventing the possibility of any aquatic nuisance species from being transferred via this path through a hydraulic connection in either direction. Including preliminary calculations to account for risk and uncertainty in the modeling and available data, it is estimated that a wall with elevation varying from 760 to 762 would provide protection from overtopping (and thereby a hydraulic connection) for a 1% annual chance event. To tie into high ground, a low berm will be constructed to elevation 762 along the south side of Engle Road connecting this I-wall with the left (looking downstream) abutment for the Engle Road bridge over the Graham-McCulloch Ditch. Figure 2.17 shows the impacts to maximum water surface elevations (WSEL) on Junk Ditch for the 1% annual chance event on the St. Marys River, relative to the baseline WSEL for the same event. As can be seen in these figures, the impacts to maximum water surface profiles would be significant and far reaching. For floods on the St. Marys River, hydraulic separation at the drainage boundary does not allow use of storage that is currently occurring in the Eagle Marsh South Storage area (EMSS) east of the Graham-McCulloch left berm, nor in the Fox Island County Park, and does not allow additional flows to escape into the Graham-McCulloch Ditch. Flows thus are held in the Junk Ditch and thus increases water surface levels in that reach. The increases in WSEL for the 1% annual chance event created by this barrier alternative are anticipated to be approximately 1.5 feet on the Junk Ditch for areas between the barrier and Ardmore Avenue, and gradually decreasing as you continue east toward Taylor Street. Likewise, events on the Graham-McCulloch watershed would not be allowed to discharge excess flows into the St. Marys watershed, resulting in water surface increases on the Eagle Marsh south storage area and Fox Island County Park of approximately 0.6 feet and 0.4 feet respectively for the 1% annual chance event. These elevations are still well below the elevations for the 1% annual chance event on the St. Marys River under existing conditions. Water surface profiles for the 1% annual chance Graham-McCulloch event are not expected to change. Indiana floodplain regulations allow a project to increase the WSEL for the 1% annual chance event by a maximum of 0.14 feet.

Alternative A Water Surface Profiles – St. Marys River 1% Annual Chance Event

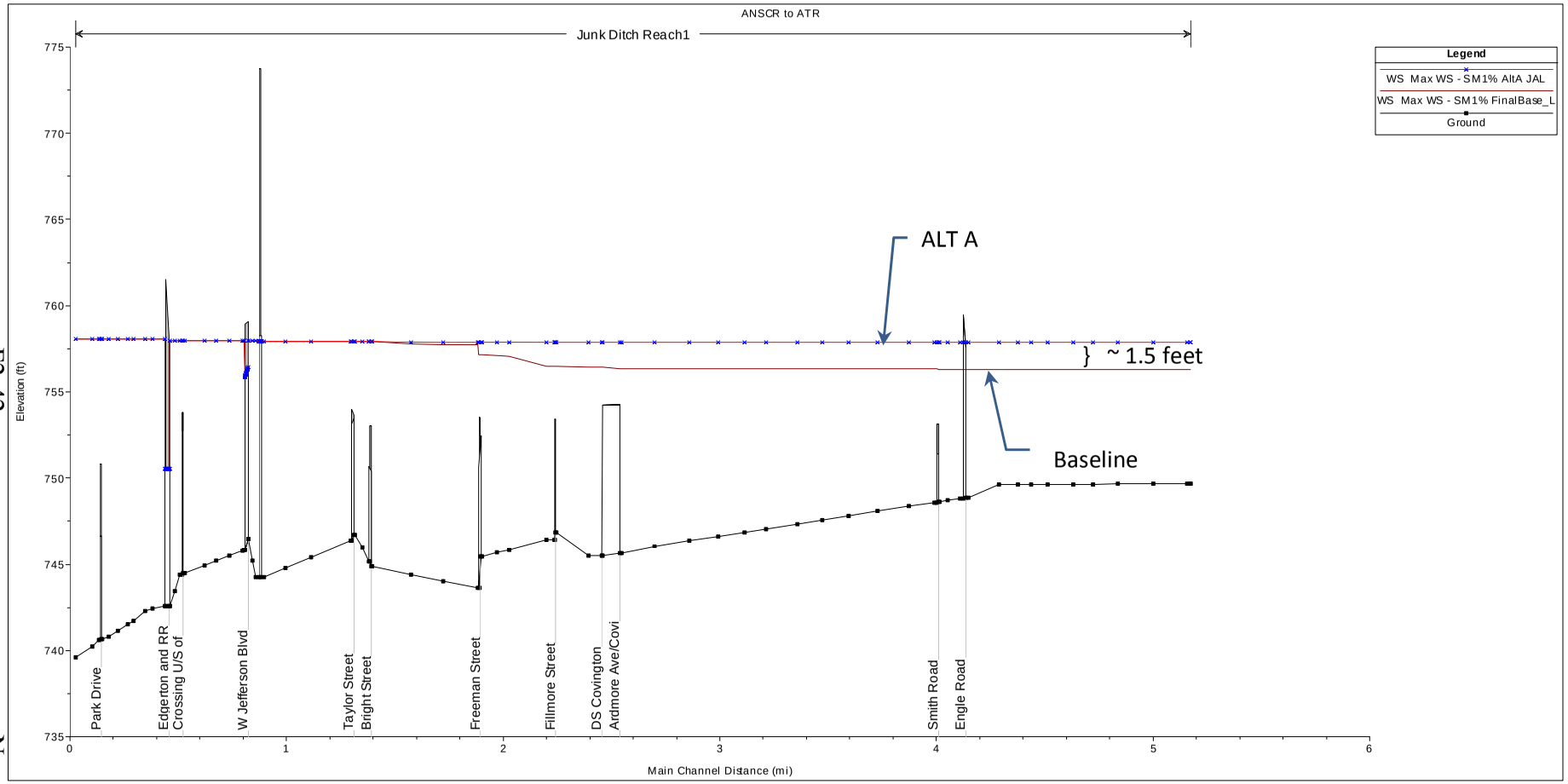


Figure 2.17: Comparison of Baseline and Proposed water surface profiles for Alternative A – Junk Ditch Reach

2.10.2. Construct a Fence and Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative B, (Eagle Marsh, Basin Divide)

As discussed previously in the report, in 2010 IDNR with the cooperation of the NRCS and LRWP constructed a temporary fence between the Graham-McCulloch left berm and the railroad embankment that separates the Eagle Marsh south storage area and the Fox Island County Park. This fence was built primarily to prevent the transfer of adult fish species between basins due to the known presence of Asian carp species in the Wabash River watershed in relatively close proximity to the natural drainage divide. The effectiveness of this fence as a barrier is in part dependent on the integrity of the left bank berm and its ability to separate the Graham-McCulloch ditch from the Eagle Marsh south storage area and thus the watershed divide. As further discussed in Section 4 of Appendix F, the integrity of the left bank berm is deemed to be poor due to poor construction methods, observed slope failures and penetrations by animal burrows and vegetation. The most upstream section of the berm would be reconstructed, starting at the tie-in point with the existing tow path embankment and ending immediately past the westward bend in the Graham-McCulloch Ditch, where the new fence alignment would be constructed. The fence and berm would be constructed to an elevation to prevent overtopping by the 1% annual chance event. The berm would be constructed to an elevation of 762 near the tow-path embankment and sloping to elevation 760 at the fence. To tie into high ground, a low berm will be constructed to elevation 762 along the south side of the wastewater treatment plant access road to Engle Road, and along Engle Road to the left (looking downstream) abutment for the Engle Road bridge over the Graham-McCulloch Ditch. It is anticipated that the remainder of the left bank berm downstream of the fence and reconstructed berm would be left undisturbed. Like the current IDNR fence, this barrier would only prevent the movement of large fish species that can make it to the fence location. To prevent debris buildup and the potential for related swell-heads, the fence would be constructed of standard chain link material, although smaller opening sizes could be investigated. Sacrificial fences would also be positioned on the upstream side of the main barrier fence to catch debris. No modeling specific to this alternative was performed as this condition should not significantly change the hydraulics of the area; this section of berm to be replaced is currently higher in general than other areas, therefore the increase in berm height is not significant.

2.10.3. Construct an Earthen Berm and Pump Station, Alternative C, (Homestead Road)

This alternative would consist of raising the roadway embankment at Homestead Road to elevation 758.0 and constructing a pump station and confining berm (also to elevation 758.0) downstream of the roadway. The confining berm and raised roadway would allow some storage of flood waters upstream, with higher flows being pumped through the berm. The pump station is conceptually designed to handle peak flows of approximately 1100 cfs resulting from the 1% annual chance event on the Graham – McCulloch Ditch,

in order to prevent increasing the transfer of flows across the left bank berm and subsequently water surface elevations on Junk Ditch. This alternative would primarily be a barrier to the passage of aquatic nuisance species from the Wabash River watershed to the St. Marys River watershed, and has little capability to prevent transfer of ANS from the St. Marys River to the Wabash River watershed. Figures 2.18a and 2.18b show the resulting water surface elevations for this alternative compared to baseline conditions for the 1% annual chance event for the Graham-McCulloch Ditch watershed. The resulting increase in water surface elevations on the Junk Ditch is estimated to be 0.2 feet for the Graham-McCulloch 1% annual chance event. While greater than the allowable increase per IDNR floodplain management regulations of 0.14 feet, it is expected that this difference can be mitigated through further detailed modeling of the pump station features. For comparison, the increased WSEL for this alternative on the Junk Ditch is over 4 feet less than the St. Marys 1% annual chance event.

2.10.4. Construct a Permeable Berm with Telemetered Sluice Gates, Alternative D, (Amber Road)

This alternative consists of constructing a permeable berm that would pass flow during a potential connection high water condition. A permeable berm is an embankment made up of opened graded rip rap surrounding a perforated pipe system that will capture the water as it passes through the stone. Please reference Section F4, Geotechnical Engineering, for further discussion of the berm characteristics. The berm is proposed just upstream of Amber Road and ties into high ground to the northeast and into the embankment of the Norfolk Southern Railroad. The system will drain south to the Graham-McCulloch Ditch and the pipe system with collector channels will empty into the existing channel downstream of the berm.

The berm will contain sluice gates with automated closure mechanisms that will close the gates to a nominal opening height of 3 inches when gages on the Graham-McCulloch Ditch, Junk Ditch and/or within Eagle Marsh near the drainage divide indicate that flow conditions are imminent that could support transfer of ANS. Preliminary modeling approximated the 16 gates 5 feet in width and 5 feet in height, although the number and sizes of these gates should be evaluated further to optimize these parameters. During normal low flow conditions, the gates would be open to allow normal drainage of the Graham-McCulloch watershed. Gages at the sluice gate would allow the gate to reopen once adequate head differential across the berm was developed such that velocities through the sluice gate would be unsuitable to support ANS transfer in the upstream direction (toward the Great Lakes watershed). These gages at the structure would also trigger closure of the gate when other scenarios such as backwater flooding or headwater flooding of the Graham-McCulloch ditch might support movement of ANS upstream. Gates could be manipulated individually in order to maximize the amount of flow allowed through the gates while maintaining velocities above minimum acceptable levels. When the velocity of flow through the gates decreases below threshold values preventing ANS transfer, the gates will close and ponded water will be released by infiltration through the permeable berm. Because infiltration through the berm will be slow, this was not modeled in the HEC-RAS analysis of the system, therefore the results are considered

Alternative C Water Surface Profiles – Graham-McCulloch Ditch 1% Annual Chance Event

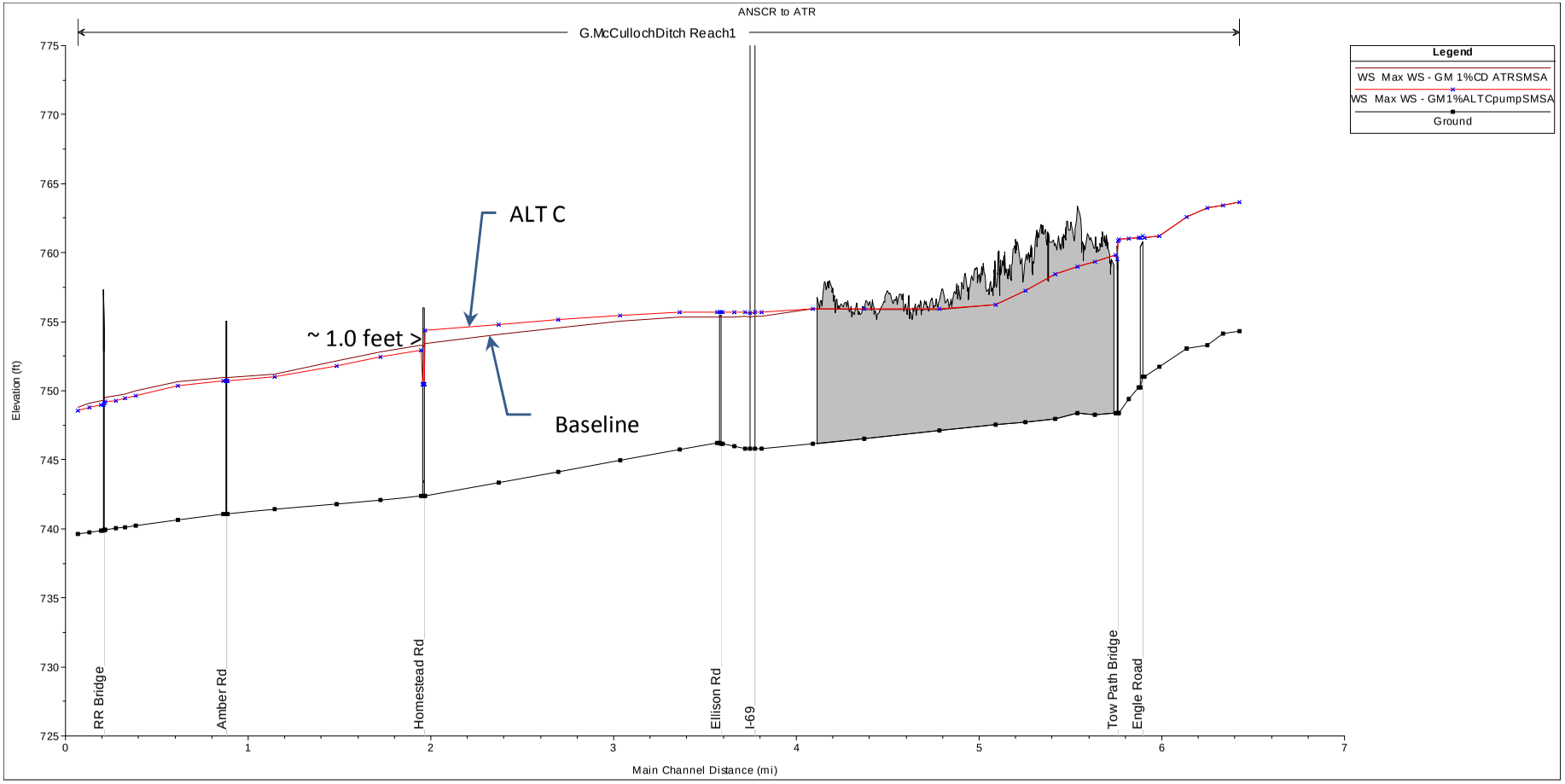


Figure 2.18a: Comparison of Baseline and Proposed water surface profiles for Alternative C – Graham-McCulloch Ditch

Alternative C Water Surface Profiles – Graham-McCulloch Ditch 1% Annual Chance Event

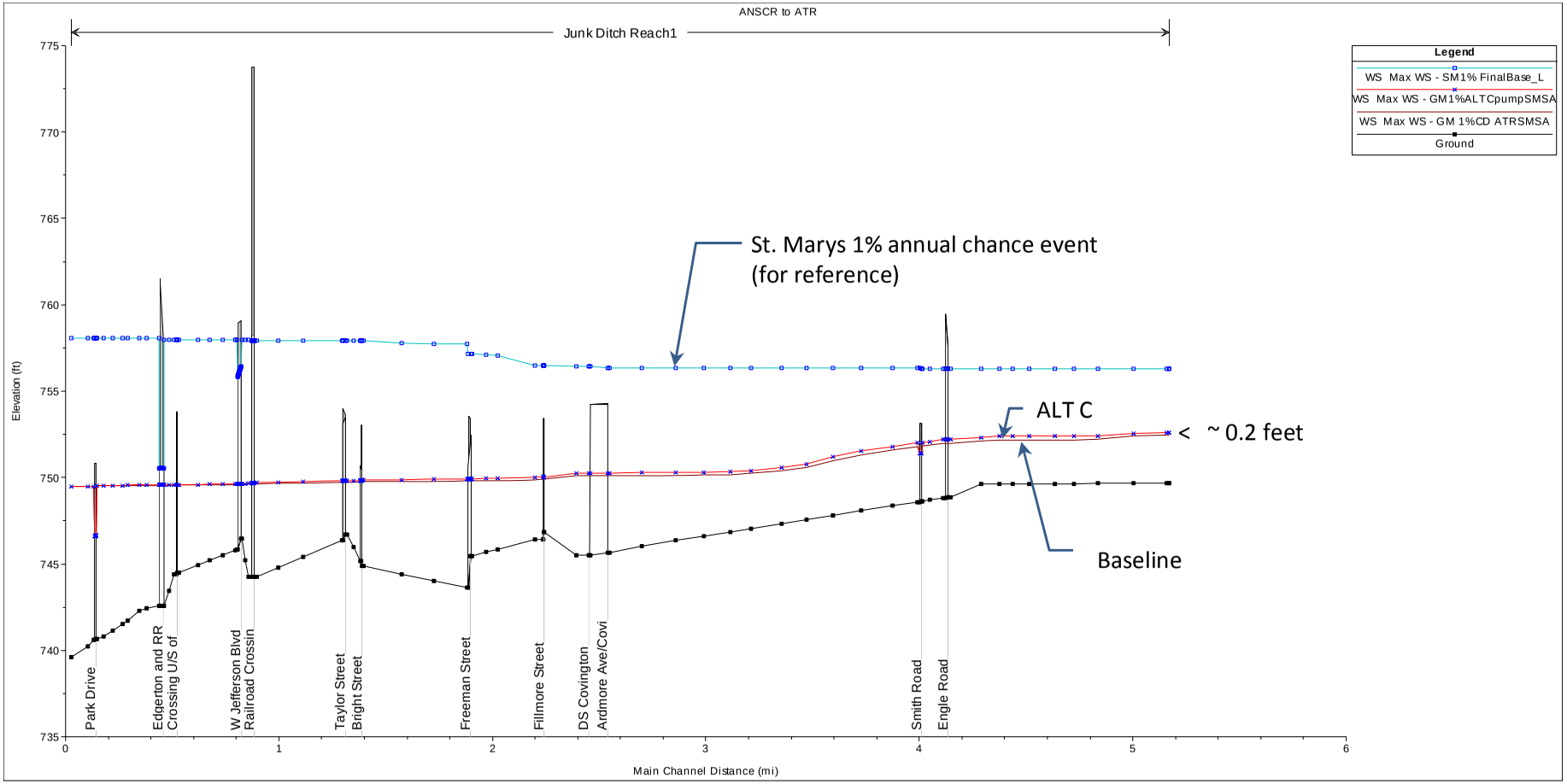


Figure 2.18b: Comparison of Baseline and Proposed water surface profiles for Alternative C – Junk Ditch Reach

conservative. Water surface profiles for this alternative are included as Figures 2.19a and 2.19b. The maximum water surface elevation increases on the Junk Ditch for the 1% annual chance event on the Graham-McCulloch is approximately 0.4 feet, but it is believed that further refinement of the gate operations could reduce this to meet Indiana floodplain limitations of 0.14 feet increase in the 1% annual chance. For reference, this increase is still less than the 1% annual chance elevation for the St. Marys River flood event.

The berm would be designed so that the entire length would be equally submerged during a high water condition. This would allow the berm to pass maximum flows. Water levels are expected to rise on the berm during an event, and would inundate a large area upstream of the berm. Debris and sediment buildup onto and within the berm is a concern for this alternative. A vegetated filter strip should be planted upstream from the permeable berm to filter debris and sediment. It is important to the performance of the system that debris and sediment do not collect on or in the stone matrix of the berm as this could reduce flows through the system. This system would require periodic maintenance and testing of automated systems to assure functionality of the system.

2.10.5. Construct a Fence/Earthen Berm Combination, Alternative E, (Eagle Marsh, Basin Divide)

Alternative E is intended to reduce the annual chance of inter-basin flow by creating a berm to elevation 752.5 that would block flows up to a 4% annual chance event on the Graham-McCulloch Ditch. This event is similar to approximately a 99% annual chance exceedance event on the St. Marys River. A higherberm elevation could not achieve the goal of no induced damages on Junk Ditch. For larger events up to the 1% annual chance event on the St. Marys River, the passage of ANS, primarily larger swimming species, could be blocked by a fence on top of or immediately adjacent to this berm. This alternative is conceptually aligned such that the Eagle Marsh entrance road could be raised to provide better access during frequent flood events and regular inspection of the fence, and allow for ease of removing debris accumulations or fence repairs. Figure 2.20 shows the impacts to the maximum WSEL for the 1% annual chance event on the Junk Ditch for floods on both the Graham-McCulloch Ditch and the St. Marys River. This alternative has no effect on the 1% annual chance event occurring on the St. Marys, and decreases the water surface elevations for the same chance exceedance event on the Graham-McCulloch Ditch. Minor increases of up to 0.15 feet are created on the Graham-McCulloch Ditch by this alternative for the 1% annual chance event on that watershed.

2.10.6. Construct Bar Screen Barrier at Existing Weir, Alternative F, (Huntington Dam)

This alternative is located to the west of the Eagle Marsh site in the town of Huntington, Indiana, at an existing low head, fixed weir dam across the Little River. A bar screen structure would be constructed immediately downstream of the fixed weir to prevent the movement of ANS past this barrier. A floating boom would be constructed upstream of the dam and angled toward the right descending bank to divert floating debris to a

Alternative D Water Surface Profiles – Graham-McCulloch Ditch 1% Annual Chance Event

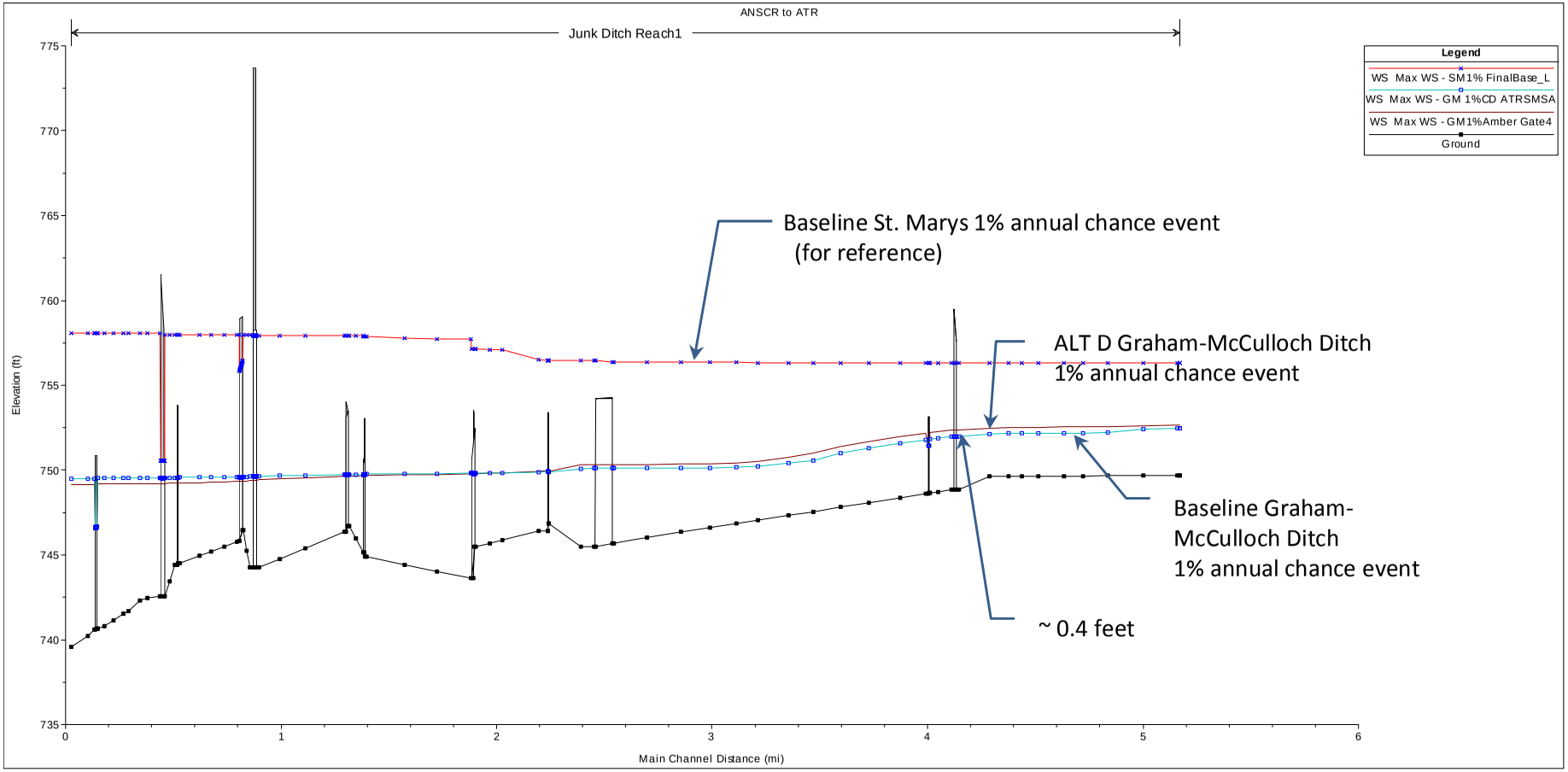


Figure 2.19a: Comparison of Baseline and Proposed water surface profiles for Alternative D – Junk Ditch Reach

Alternative D Water Surface Profiles – Graham-McCulloch Ditch 1% Annual Chance Event

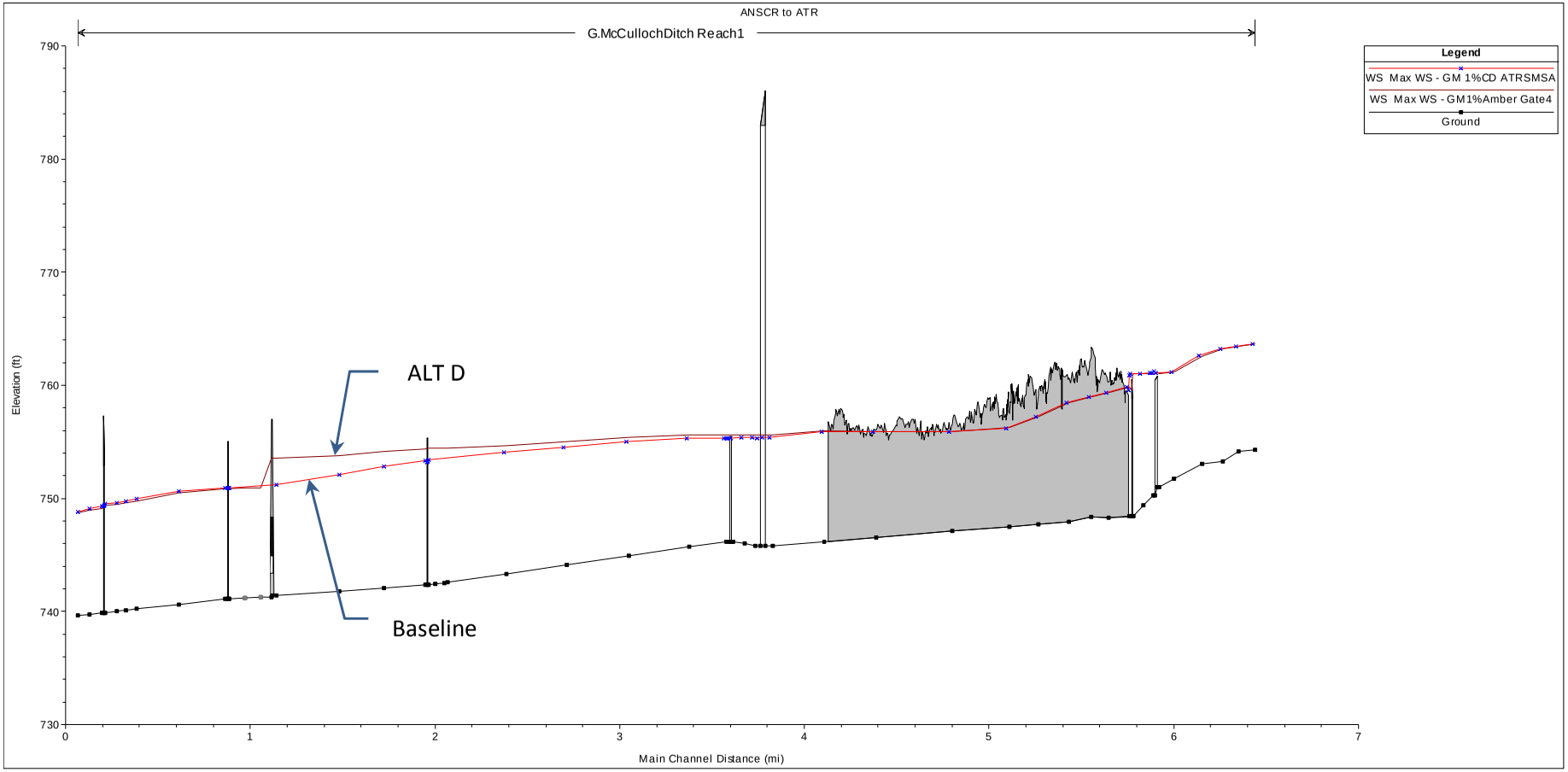


Figure 2.19b: Comparison of Baseline and Proposed water surface profiles for Alternative D – Graham-McCulloch Ditch

Alternative E Water Surface Profiles – Graham-McCulloch Ditch 1% Annual Chance Event

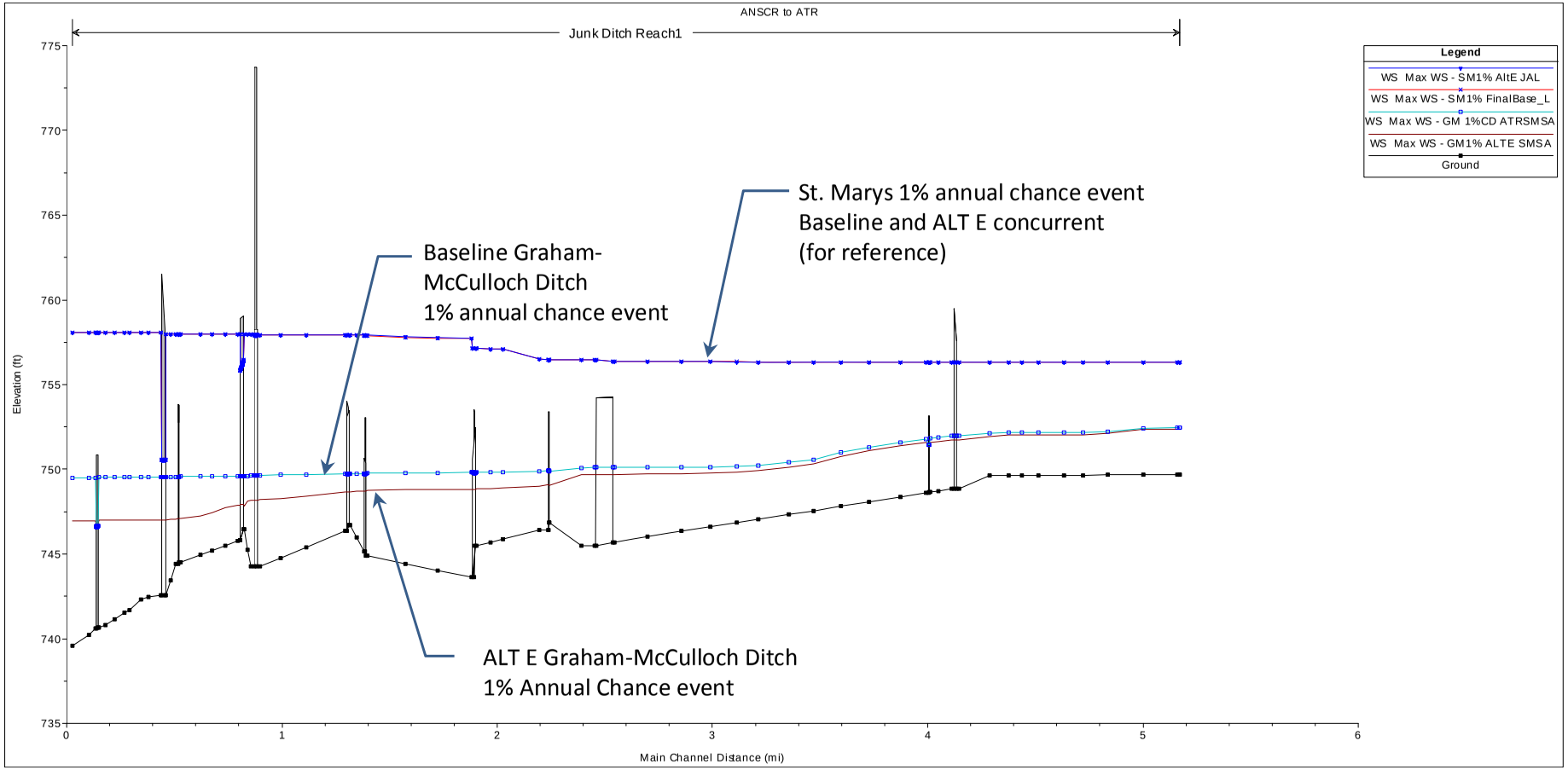


Figure 2.20: Comparison of Baseline and Proposed water surface profiles for Alternative E – Junk Ditch Reach

collection point on that bank. The bar screen would be slanted downstream, both to prevent the ability for certain species of ANS to jump over the screen, and also to allow any floating debris that might get past the floating debris boom to float upward during high flows and potentially be pushed over the bar screen during extreme flood events. This is done to prevent debris from clogging the bar screen and inducing flooding upstream. The top of the screen is set to elevation 727.0 (referencing NAVD88) to equal the 1% annual chance event elevation for the Little River, including preliminary risk and uncertainty considerations. This elevation was determined by conversion of an IDNR HEC-2 model for this reach of the Littler River to HEC-RAS, adjusting elevations to the NAVD88 datum, and incorporating survey information taken at the dam site by Louisville District survey crews. No additional modeling to include the bar screen structure was performed, as the bar screen itself should pose minimal restriction to flows. Piers to support the screen would be small and also should have minimal effect. Additional modeling should be performed in any future design to ensure that the upstream impacts do not exceed Indiana floodplain limitations.

2.10.7. Construct Vertical Drop Structure with Telemetered Sluice Gate, Alternative G, (Homestead Road)

Alternative G relies on the creation of a water surface elevation differential across a barrier to prevent the movement of ANS from the Wabash River basin into the Great Lakes basin. Conceptually located at Homestead Road, a berm would be constructed east (upstream) of Homestead Road. A portion of the berm would be permeable, similar to that described in Alternative D. To pass additional flows, vertical drop structures would act similar to control structures commonly used in lakes, ponds, or detention basins. Low flows would be passed though a sluice gate structure in the main channel of Graham-McCulloch Ditch. The gate would be controlled by gages in a similar fashion to Alternative D, closing when flows increased and threatened to create a hydraulic connection between basins. After the sluice gate closed, the water surface elevation immediately upstream of the barrier would increase and overtop the drop structures. In the model, culverts are used to determine the capacity of flow that the drop structures need to pass past the barrier structure to minimize the impacts to water surface profiles at the left bank berm barrier for the 1% annual chance event for the Graham-McCulloch Ditch. The number and size of the drop structures were then determined for this flow. The drop structures are conceptually 24-foot diameter structures constructed to elevation 754.0, with a debris rack extending to elevation 757.0. Circular structures were conceptually used due to standard computation methods and the diameter sized to be similar to grain silos to facilitate construction. Standard weir and orifice flow equations were used for analysis of the drop structure. It was determined that ten structures of this size would be required. Each drop structure would pass flows through the berm to a receiving channel between the berm and the Homestead Road embankment by way of a concrete box culvert, conceptually sized at 6 feet wide by 3 feet tall. Figures 2.21a and 2.21b depicts the impacts to the maximum WSEL for this alternative for the Graham-McCulloch Ditch 1% annual chance event. Even though the increase to WSEL elevation is less than 0.2 feet at the left bank berm, significant increases of approximately 1 foot or

Alternative G Water Surface Profiles – Graham-McCulloch Ditch 1% Annual Chance Event

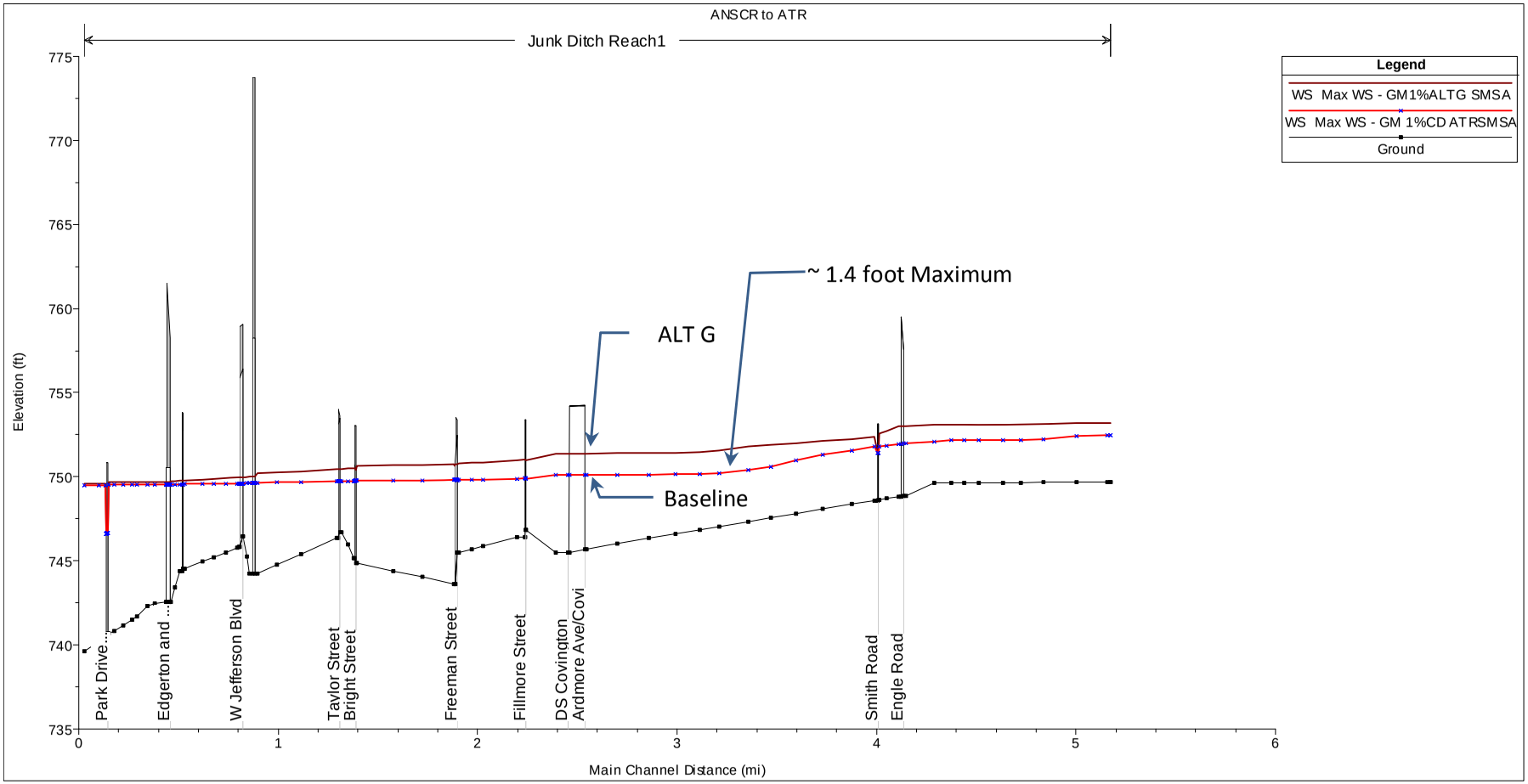


Figure 2.21a: Comparison of Baseline and Proposed water surface profiles for Alternative G – Junk Ditch Reach

Alternative G Water Surface Profiles – Graham-McCulloch Ditch 1% Annual Chance Event

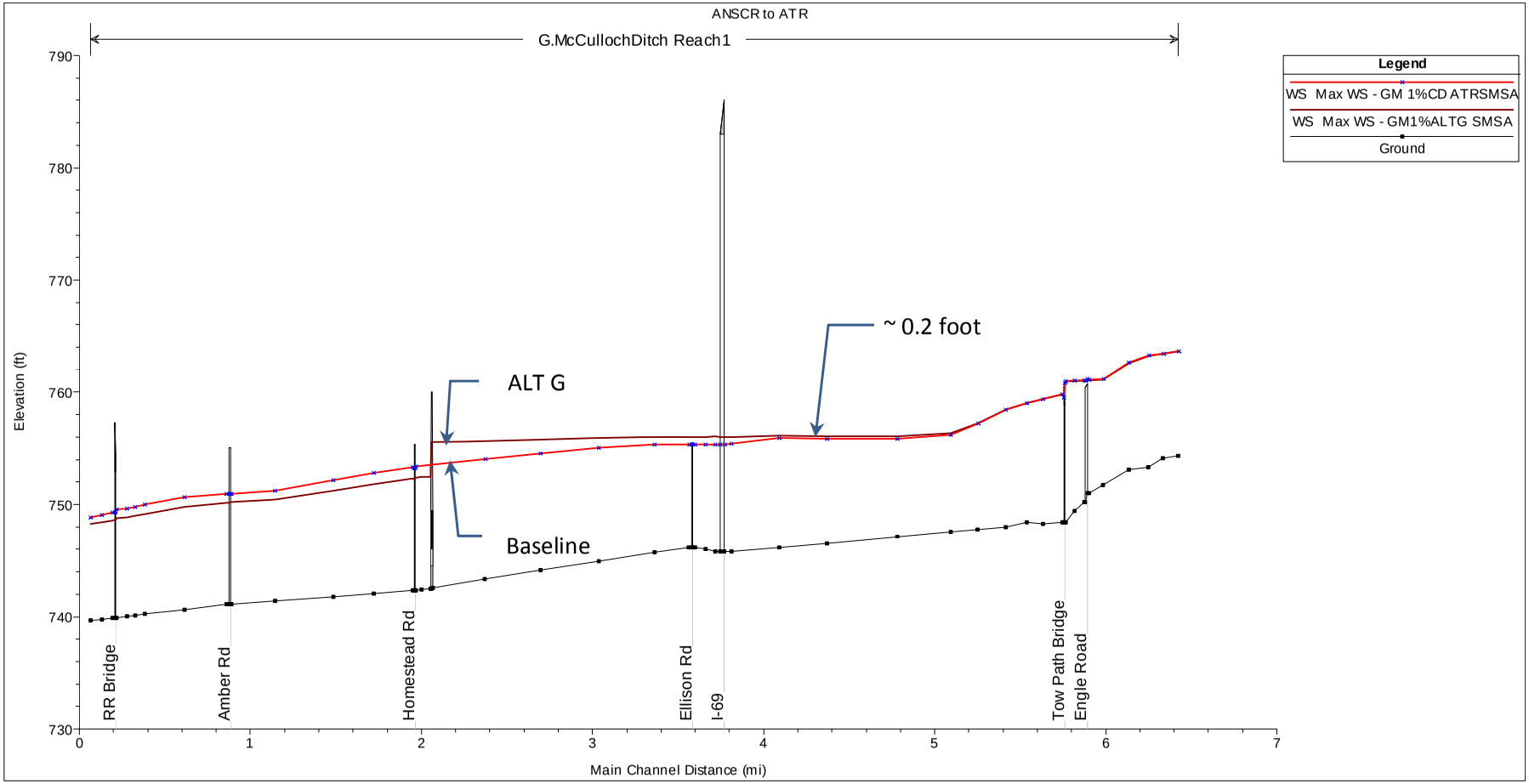


Figure 2.21b: Comparison of Baseline and Proposed water surface profiles for Alternative G – Graham-McCulloch Ditch

more are observed on the Junk Ditch. Even with the number of these structures, due to the flatness of this area and the significant flows that must be transferred across the barrier, the head differential at the barrier during the maximum water surface elevation is only approximately 3 feet.

2.10.8. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative H, (Eagle Marsh, Basin Divide)

As discussed for Alternative B, the Graham-McCulloch Ditch left bank berm is deemed to be in poor condition and currently is overtopped by approximately a 10% annual chance event on the Graham-McCulloch Ditch watershed and approximately a 3% annual chance event on the St. Marys River. This alternative proposes to reconstruct the berm to an elevation that would prevent overtopping by floods on either watershed, and thus create a barrier to ANS movement, up to the 1% annual chance event. Based upon preliminary calculations to account for risk and uncertainty in the design, the elevation of the berm would transition from elevation 762.0 at the existing tow path embankment to elevation 759.0 at the tie-in to the railroad embankment. The berm would be continued along the south side of the WWTP access Road and Engle Road to connect to high ground at the Engle Road Bridge over the Graham-McCulloch Ditch, as previously discussedin Alternative B. All existing drain tiles currently penetrating the existing berm would be removed. This berm would only increase in elevation by approximately 4 feet at the lowest point of the existing berm, and increase on average approximately 2 feet.

Similar to Alternative A, the I-wall barrier at the natural watershed boundary, a barrier completely blocking the exchange of flow will impact water surface elevations in the area exceeding the permissible increases by Indiana floodplain regulations. Figures 2.22a and 2.22b illustrate the impacts to the 1% annual chance elevations with respect to the baseline conditions. Increases to the Graham-McCulloch Ditch 1% annual chance event were approximately 0.5 feet near I-69, and increases of 0.3 feet were observed on the Little River to the end of the model. Increases of up to 0.9 feet were noted on the western end of the Junk Ditch, but no increases were computed east of Freeman Street. It was noted during modeling of this alternative that the Fox Island County Park storage area was not being fully utilized, likely due to the single 4-foot diameter culvert through the railroad embankment that links the area to the Eagle Marsh south storage area. The impacts could potentially be mitigated to a small degree by increasing the number of pipes through the railroad embankment and should be investigated further if this alternative is developed.

2.10.9. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Demolish Right Descending Berm, and Construct Multi-Cell Wetland Area, Alternative I, (Eagle Marsh, Basin Divide)

Alternative I is similar in concept to Alternative H, with the additional features of removing the Graham-McCulloch Ditch right bank berm and the construction of multi-cell wetland areas along the right bank, conceptually in the upper reach near the wastewater treatment area. Removing the right bank berm has the benefit of providing a

nearby source of material for reconstruction of the left bank berm. It has also been expressed by Little River Wetlands Project and NRCS personnel that ideally they would desire to have the Eagle Marsh area inundated more frequently, but the water quality of the Graham-McCulloch Ditch is generally poor due to the fact that it is largely comprised of urban runoff. Construction of the multi-cell wetland would attempt to pre-treat the water and thus improve the water quality before it enters Eagle Marsh.

The northern storage area of Eagle Marsh created by the right bank berm currently functions much like a "side-saddle" detention basin, such that at higher water surface elevations, water overtops a weir structure (the right bank berm) and enters a storage area having a limited means for flow to drain out, reducing peak flows and releasing the detained water over a longer period of time after the peak has passed. As such, removing the right bank berm, which functions as the controlling weir, causes the area to no longer function as a detention area. As a result, peak water surface elevations increase downstream of the Eagle Marsh Area, as seen in Figure 2.23. The 1.0 foot increase in the 1% annual chance event shown by the model may be slightly conservative (i.e., the increase may be less); as with the left bank berm, pipes that drain the north storage area were not included in the model due to a lack of good information about them. The profile of the right bank berm was primarily developed from the 2009 LIDAR information, with the exception of the uppermost adjacent to the wastewater treatment plant, which was surveyed by Louisville District personnel. The LIDAR data was the best available information, but it was observed when compiling the model data that the NRCS survey of the left bank berm resulted in higher elevations in general than the profile cut from the 2009 LIDAR DEM; it may thus be true that the right bank berm is higher than depicted in the model, but in general, by visual inspection at the site, it is confirmed that the right bank berm is generally lower in elevation than the left bank berm. Despite these issues, it is believed that the model generally represents the decreased functionality of the right overbank as a significant means of storing flood water.

Alternative H Water Surface Profiles – St. Marys River 1% Annual Chance Event

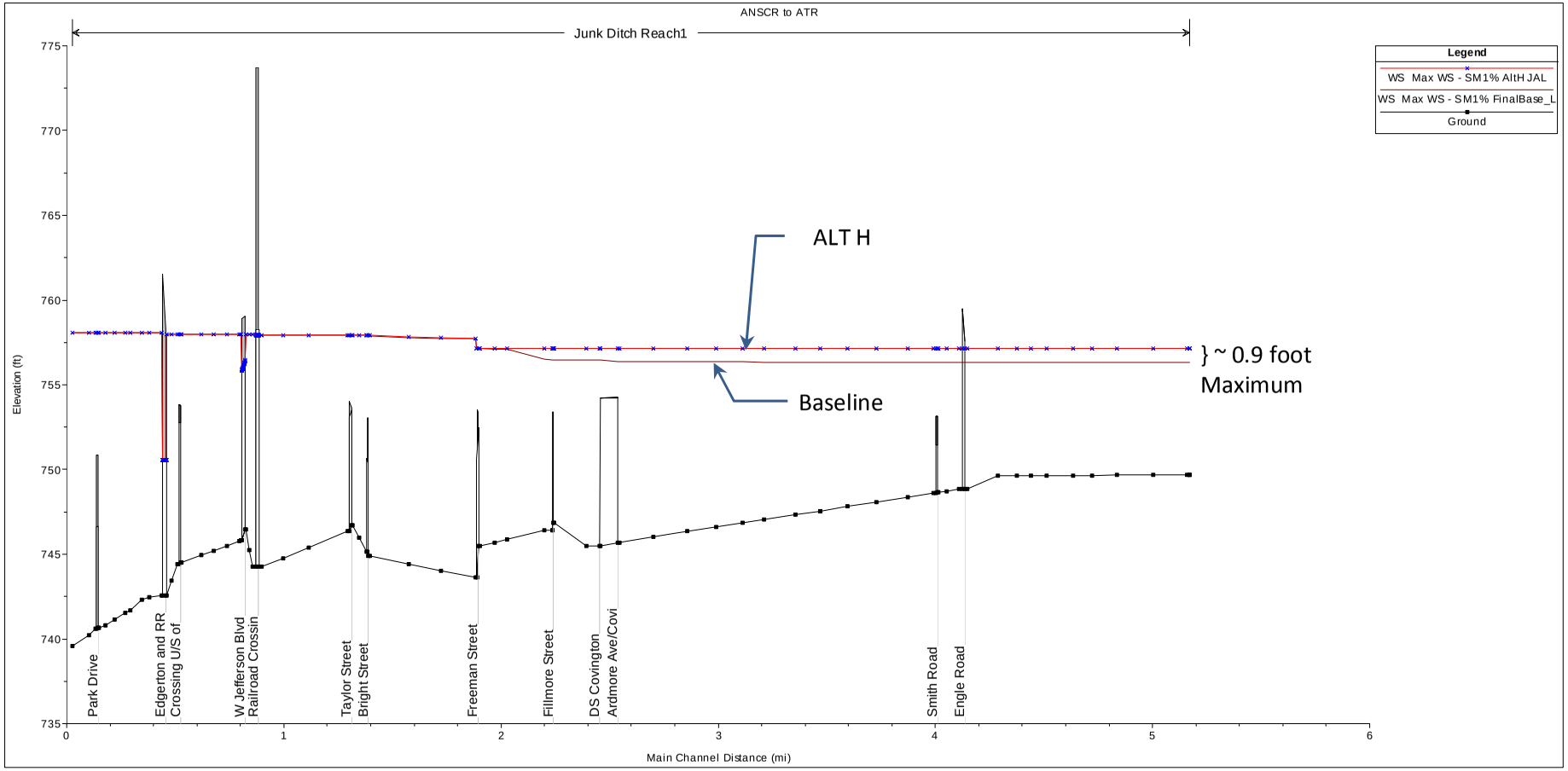


Figure 2.22a: Comparison of Baseline and Proposed water surface profiles for Alternative H – Junk Ditch Reach

Alternative H Water Surface Profiles – Graham-McCulloch Ditch 1% Annual Chance Event

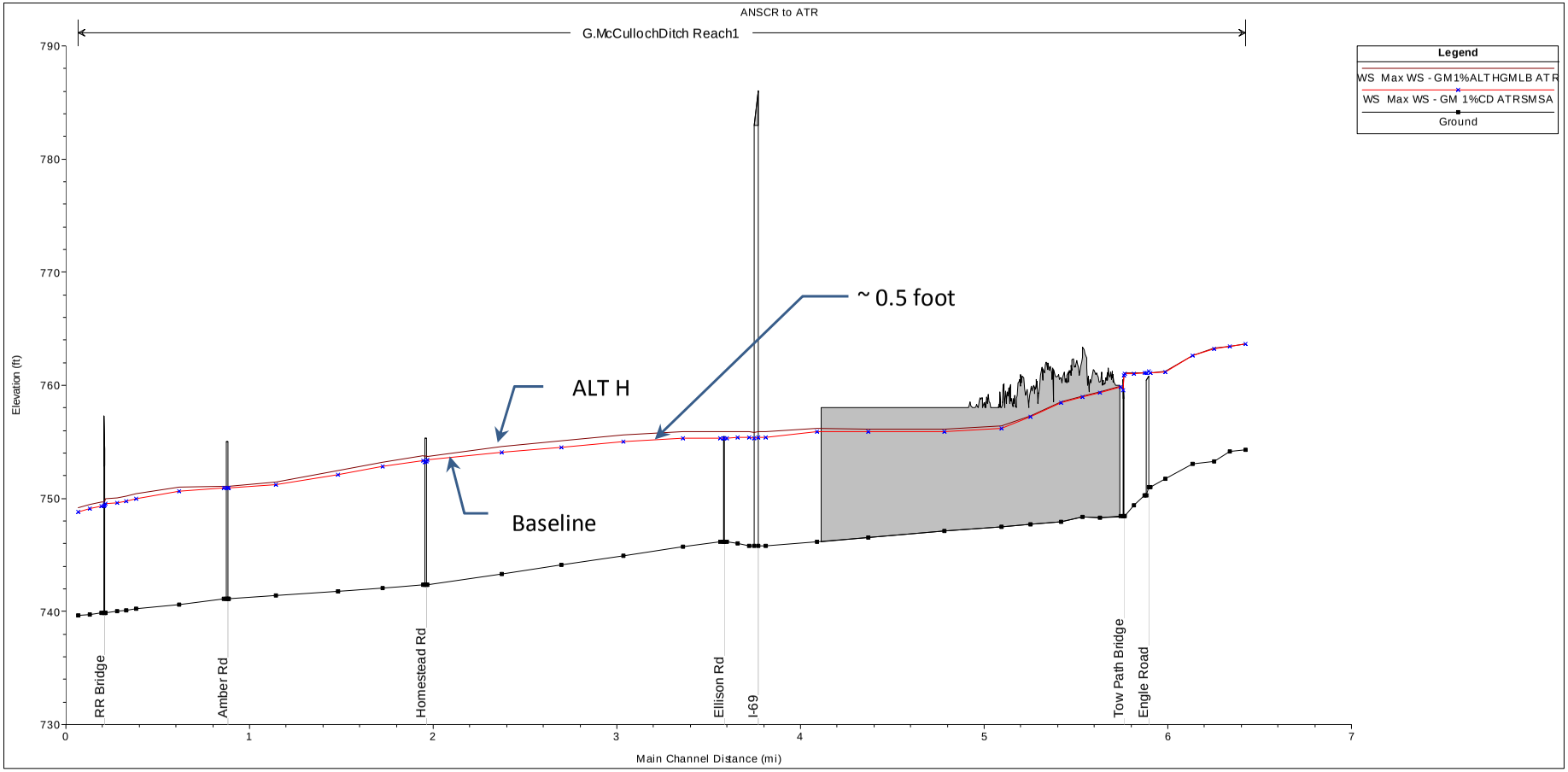


Figure 2.22b: Comparison of Baseline and Proposed water surface profiles for Alternative H – Graham-McCulloch Ditch

Alternative I Water Surface Profiles – Graham-McCulloch Ditch 1% Annual Chance Event

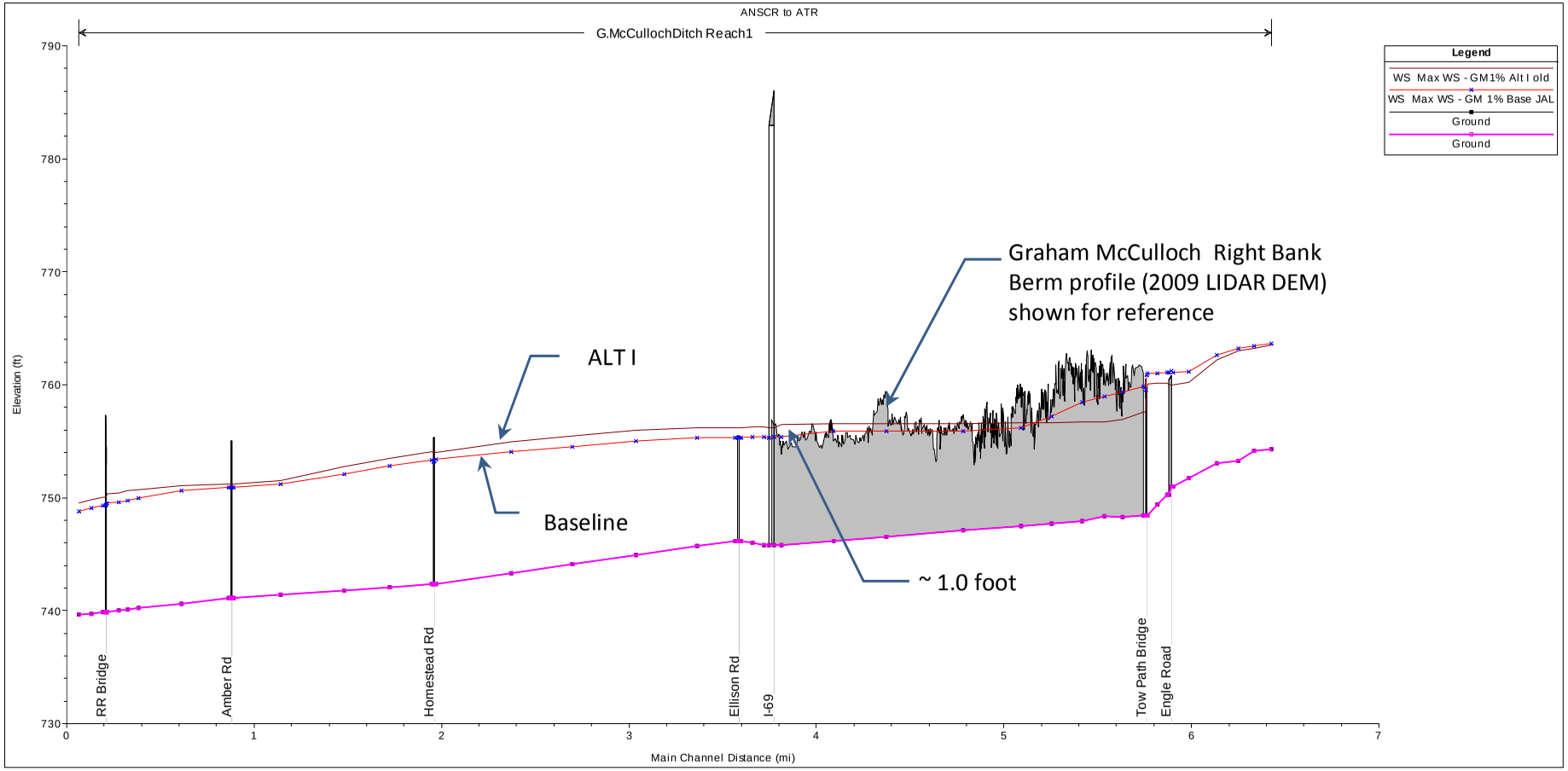


Figure 2.23: Comparison of Baseline and Proposed water surface profiles for Alternative I – Graham-McCulloch Ditch

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SECTION 3
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3.1. EXISTING SURVEY AND MAPPING

The Corps of Engineers obtained various types of data from several sources to be used for the development of the plans for Fort Wayne, Indiana. The Allen County GIS Department provided utility information such as locations of water mains and structures, storm and sanitary sewers and street centerlines. Power and telephone utilities information were not readily available.

The United States Geological Survey (USGS) provided a digital elevation model (DEM) for all of Allen County, Indiana. The DEM was generated from Light Detection and Ranging (LIDAR) data points collected by the Allen County GIS Department in September 2009. The LIDAR data has a vertical precision of 0.116 RMSE (Root Mean Square Error), and horizontal precision of +/- 3.25-ft. The grid cell size of the DEM that was generated from the LIDAR data was 2.5-ft, in an ESRI grid format. Two-ft contours were generated from the DEM for the entire study area in Fort Wayne. All terrain mapping used the horizontal datum NAD83, Indiana State Plane East coordinate system, and a vertical datum of NAVD88.

The National Resources Conservation Service (NRCS) provided surveyed 2-ft contours and spot elevations for the Eagle Marsh area, and surveyed top of berm elevations along the Graham-McCulloch Ditch. This data was used to update the 2.5-ft DEM to create a more precise terrain surface. The data supplied used the horizontal datum NAD83, Indiana State Plane East coordinate system, and a vertical datum of NAVD88.

Aerial photography was downloaded from the Indiana Spatial Data Portal, 2005 Indiana Map Natural Color Orthophotography with 1-ft resolution, and 2008 National Agriculture Imagery Program (NAIP) with 1-meter resolution.

Additional field survey work was required in order to obtain bridge information along Graham-McCulloch and Junk Ditches. This survey work was done by the Corps of Engineers, Louisville District in-house survey team. The bridge information surveyed included cross sections just upstream and/or downstream of the bridge, road profile, low chord, thalweg elevation, width of opening(s), number and size of any piers. The data was surveyed using the horizontal datum NAD83, Indiana State Plane East coordinate system, and a vertical datum of NAVD88.

3.2. FUTURE SURVEY AND MAPPING

Once an alternative is selected, then associated site(s) will need a detailed topographic survey, in accordance with USACE EM 1110-1-1005, Topographic Surveying**.** This reference is available at the following Internet Address http://140.194.76.129/publications/eng-manuals/em1110-1-1005/toc.htm

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SECTION 4
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4.1. REFERENCES

1) *Wabash-Erie Channel Hydrogeology*. Tony Fleming, LPG (Indiana), January 1996

2) State of Indiana Department of Natural Resources, Division of Water. *Water Resource Availability in the Maumee River Basin, Indiana*, 1996

3) EM 1110-2-1913 "*Design and Construction of Levees*" U.S. Army Corps of Engineers, dated 30 April 2000

4) EM 1110-2-2100 "Stability Analysis of Concrete Structures" U.S. Army Corps of Engineers, dated 01 December 2005

5) "Technical Note-Dual Wall HDPE Perforation Patterns". ADS Pipe, January 2010

6) "WSUD Engineering Procedures: Stormwater". Melbourne Water. CSIRO Publishing, 2005

7) *Foundation Design*. Teng, W.C. Prentice Hall, Englewood Cliffs, NJ. 1969

4.2. GEOLOGICAL CONDITIONS

4.2.1. Regional and Site Geology

The channel which extends from Fort Wayne to Huntington is referred to as the Wabash-Erie Channel. Bedrock in the area is composed of lower to mid-Devonian limestone, dolomite, and gypsum of the Traverse and Detroit River formations. These units overlie Silurian age limestone and dolomite. Several glacier events have occurred in the area. The most recent, known as the Late Wisconsin Stage, gives us the current formations. The Trafalgar formation is a dense glacial till, ranging from 35-100 ft thick in and near the Wabash Erie Channel and overlies the bedrock surface. The second formation is represented by the clayey till highlands know as the Lagro Formation which composes most of the walls of the Wabash Erie Channel. The channel was an active glacial drainage way throughout the late Wisconsin glaciation. A spillway event occurred from

glacial melt water when the glacier in the Maumee basin surged, sending a large amount of water down the Wabash Erie Channel, eroding out the Lagro Formation. This event is referred to as the Maumee Torrent. The channel later filled with silt, clay, and sand from river sediment (St. Marys and St. Joseph Rivers flowed through the channel at this time to the Wabash basin) and later organic sediments as it became a wetland due to the Maumee River migrating north and intercepting the St. Joseph and St. Marys Rivers, creating a slack water area in the Channel. A generic profile is shown in Figure 4.1.

Proposed Project sites will generally lie in the silt, sand and clay loam areas of the channel bottom with the potential for organic muck.

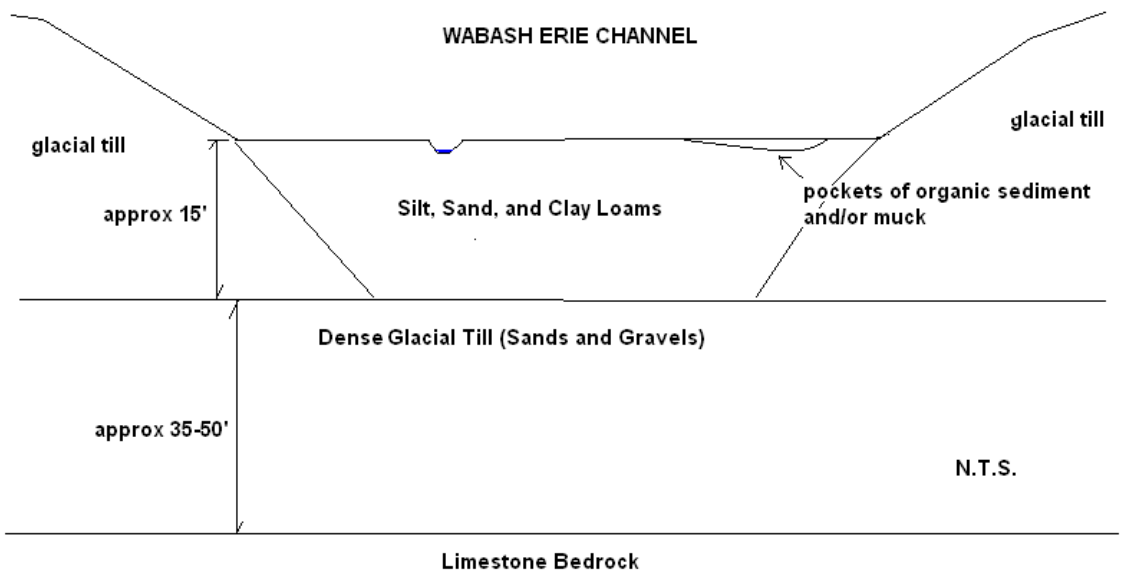


Figure 4.1: General Geologic Cross Section

4.2.2. Seismic Setting

The project site is located in a fairly quiescent region on the periphery of the New Madrid and Western Ohio (Shelby County) region which has the potential to influence ground motions. A site-specific study to determine ground motion parameters was beyond the scope of this report.

The approximate center of the site is found at latitude 41° 1' 49" N and longitude 85° 14' 6" W. For this study, the maximum considered earthquake (MCE) ground motions were represented by the spectral response accelerations for 2 percent probability of exceedance (PE) in 50 years, obtained from the 2009 International Building Code published by the United States Geological Survey (USGS). Using the USGS Java Ground Motion Parameter Calculator - Version 5.1.0**,** the spectral response acceleration parameter Ss (0.2 second period) is 0.149*g*, and the spectral response acceleration parameter S_1 at a period of one second is 0.060*g*.

Due to the high groundwater levels and loose sands and gravels present in the area, the upper soils of the Wabash-Erie Canal likely contain the physical properties required for liquefaction. However, due to the generally quiescent regional seismic activity, it is unlikely that the required ground movement will occur in order to induce liquefaction. A site specific liquefaction study was beyond the scope of this report.

4.2.3. Ground Water and Hydrology

The water table is shallow and often at the surface of the Wabash Erie Channel. The channel floor is the lowest elevation of the surrounding area. Wetlands such as Eagle Marsh exist within the basin, and much of the basin is groundwater fed. The limestone bedrock is the primary aquifer system in the area. This bedrock is often in direct contact with the sands and gravels of the Trafalgar formation, creating a large, transmissive groundwater system in the region. Limestone quarries in the area have diminished the groundwater levels in their surrounding area. Typical groundwater levels downstream likely reflect water levels in the Graham-McCulloch Ditch and Little River drainages. It is anticipated that excavations for foundations will encounter groundwater during construction, and that a pumping/groundwater control plan will be required.

4.3. SITE CONDITIONS

A site reconnaissance was conducted on 2 November 2010 by a geotechnical engineer to observe and document surface conditions at the project site. The information gathered was used to help interpret the surface data and to detect conditions which could affect design and construction recommendations.

The exact project site is not yet known as it is dependent on the selected alternative. The Eagle Marsh area is a potential location for multiple alternatives. The marsh is located just south of Engle Road, east of I-69, and bounded to the south by the railroad. At the time of the reconnaissance, the project site was a wetland area which had been experiencing drought conditions.

The surface cover generally consisted of grasses and aquatic vegetation. The topography of the area is relatively flat with a slight rise to the northwest, and the two berms on either side of the Graham-McCulloch Ditch protrude up dissecting the site from northeast to southwest. Other shallow drainage channels exist on the north side of the ditch. Several shallow ponds are found throughout the site. The Graham-McCulloch Ditch was a shallow creek at the time of the reconnaissance. A sewage treatment plant exists at the northeast corner of the site, and the only structure on site is the Little River Wetland Conservancy shed located on the east end of the property, accessible from Engle Road. The Indiana DNR fence crosses the southern half of the site from north to south. The only visible utilities are a large electrical transmission line which runs down the center of the site from northeast to southwest.

4.4. STRUCTURAL ALTERNATIVES

4.4.1. Construct an I-Wall, Alternative A, (Eagle Marsh, Basin Divide)

This alternative consists of constructing a concrete I-wall founded on sheet piling, which would dissect the divide located near Engle Road. The I-wall would tie into high ground just above Engle Road, and will head south and tie into the railroad ballast. Anticipated soil conditions in this area are loose, sandy loam soils. Sheet piling is driven to a predetermined depth based on multiple factors, including the shear properties of the soil, unit weight of the soil, the height (H) of the wall, design loads, and the bending moment of the piling. From *(7) Teng*, the approximate penetration depth for cantilever sheet piling in loose sand is 1.5H. A thorough wall design including a soil investigation should take place in the design stage.

4.4.2. Construct a Fence and Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative B, (Eagle Marsh, Basin Divide)

This alternative will consist of reconstructing a portion of the Graham-McCulloch Ditch berm and tying it into a fence which would cross the divide and tie into the railroad ballast.

The existing berms on both sides of the Graham-McCulloch Ditch appear to be composed of excavations from the initial construction of the ditch, and potentially from additional cleanout thereafter. NRCS personnel have indicated that the previous landowner who farmed the area had fill material brought in to build up the berm. It is not known to what extent or where the borrow material came from. The crowns of the berms are undulating with variable widths, and the footprints are nonlinear, suggesting the material was dumped adjacent to the ditch. Several low spots appear to have been previously overtopped from Graham-McCulloch Ditch flows. Animal burrows and trees are present throughout (Photo 4.1). Several gravity drainage structures cross through the berms, most consisting of CMP piping. In order to ensure satisfactory performance of the section of berm used in this or other alternatives, it is recommended the berm be reconstructed in order to ensure adequate materials, compaction, and factors of safety are met. Depending on the results of design phase geotechnical investigations, there is the potential the berm may generally be allowed to remain in place and be added to with additional material. However, based on surface conditions and the likelihood of variable materials, this seems unlikely.

Photo 4.1: Graham-McCulloch Ditch and Associated Berms

It is anticipated that the majority of the existing berm will be acceptable material for the reconstruction of the berm. Additional material will likely be needed, which can be obtained from other portions of nearby berms or an offsite borrow area. Potential borrow areas were not identified in this study and would need to be procured in the design stage. Acceptable materials for the berm construction generally depend on the shear strength and permeability of the soil. Typically clayey sands, lean clays, and silts (SC, CL, and ML) are acceptable due to their low permeability and moderate shear strengths. The dimension of the berm will depend on slope and seepage calculations, but would likely consist of a 10 ft crown width with three horizontal to one vertical (3H:1V) side slopes. The berm should be constructed an additional six inches above the design elevation to account for post-construction settlement. Compaction of flood control structures is typically required at 95% of the maximum density per ASTM D 698.

4.4.3. Construct an Earthen Berm and Pump Station, Alternative C, (Homestead Road)

This alternative consists of creating an earthen berm to cutoff the Graham-McCulloch Ditch near Homestead Road. A pump station would be constructed to pump from upstream to downstream.

The pump station will be a large structure with moderate loading. It will house a total of 11 large pumps with associated valves, piping, overhead crane, and controls. Additional to the pump station, a large discharge well will be required. A deep foundation system

such as steel H-piling is anticipated for these structures in order to control potential settlement issues.

The earthen berm will be constructed of nearby excavated materials and will be similar to the berm of the previous alternative. The berm would be required to cut off the Graham-McCulloch Ditch just downstream of Homestead Road and tie into the railroad embankment. Sheet piling may be required through this area. Erosion protection may be required on the upstream face.

4.4.4. Construct a Permeable Berm with Telemetered Sluice Gates, Alternative D, (Amber Road)

The permeable berm alternative is based on the theory of allowing floodwater to pass through the berm, yet restricting ANS. Gradation of the stone and perforations of the piping would be considered the restrictive sizes that would prevent ANS from transferring through the berm. Typical perforation sizes for larger HDPE piping is 10mm. Combined with a bedding stone size of INDOT #2, the 10mm should be considered the restrictive opening size. The amount of water that the berm can pass was estimated for this alternative. Based on seepage calculations and gradation permeability analyses, the estimated maximum flowrate through the berm used was 0.2 cfs per ft of berm. Seepage modeling of the proposed berm cross section was performed to gauge the effectiveness of the structure. The addition of piping to intercept and accelerate the movement of water through the berm was developed based on these results. A spreadsheet was created to determine the flow rates through the pipe perforations, which is considered to be the limiting factor for the flowrate.

Hydraulic modeling of the berm is recommended in the design phase to more accurately determine the design flowrate. It may be an option to special order perforated piping which can contain additional perforations to help pass as much flow as possible. Perforated feeder pipes protruding upstream from the main berm could also add to the flowrate by providing additional infiltration.

The telemetered sluice gates will likely be required in order to pass an additional amount of flow to prevent the berm from overtopping. Anticipated foundation types for the sluice gates are spread footing or mat foundation. A larger sluice gate or series of sluice gates will be installed in the main channel of the Graham-McCulloch Ditch in this alternative. Dewatering and/or pump-around during construction will be required.

Table 4.1 contains the flowrate calculations for the perforated piping. Figure 4.2 labels the piping perforation pattern, and Figure 4.3 contains the general berm cross section seepage model.

Permeable Berm Alternative

04/07/11

Reference: WSUD Engineering Procedures: Stormwater. Melbourne Water 2005, Section 5.3.5.1

Perforations inflow Check

ADS Pipe 36" Corrugated (3 ea) — Circular slot 10mm dia., 12 rows of perf. , 2 holes at every 45 deg. — *water level at top of pipe

perforation config type H — AASHTO Class II

g(cm/s^2)	A (cm^2)	C	B	h (ft)*	h (cm)	Q (cm^3/s)	Q (cfs)		# orifices/ft		Total Q in
981	0.785	0.6	2								
				6	182.88	141.06638	0.004982		4		0.019927
				5.56	169.4688	135.79547	0.004796		6		0.028773
				4.5	137.16	122.16707	0.004314		6		0.025886
				3.44	104.8512	106.81374	0.003772		6		0.022633
				3	91.44	99.748993	0.003523		6		0.021136
				2.56	78.0288	92.144173	0.003254		2		0.006508
				1.5	45.72	70.53319	0.002491		2		0.004982
				0.44	13.4112	38.200956	0.001349		2		0.002698
				0	0	0	0		2		0

Perforated Pipe
Capacity
per Bentley Flowmaster
provided by K. Lampkin

Total

0.132542 cfs/ft

slope	pipe dia (in)			full discharge (cfs)
1.00%	60			282
0.50%	60			199
1.00%	36			96
0.50%	36			68

Table 4.1: Perforation Flow Rate Calculations

Figure 4.2: Perforation Pattern

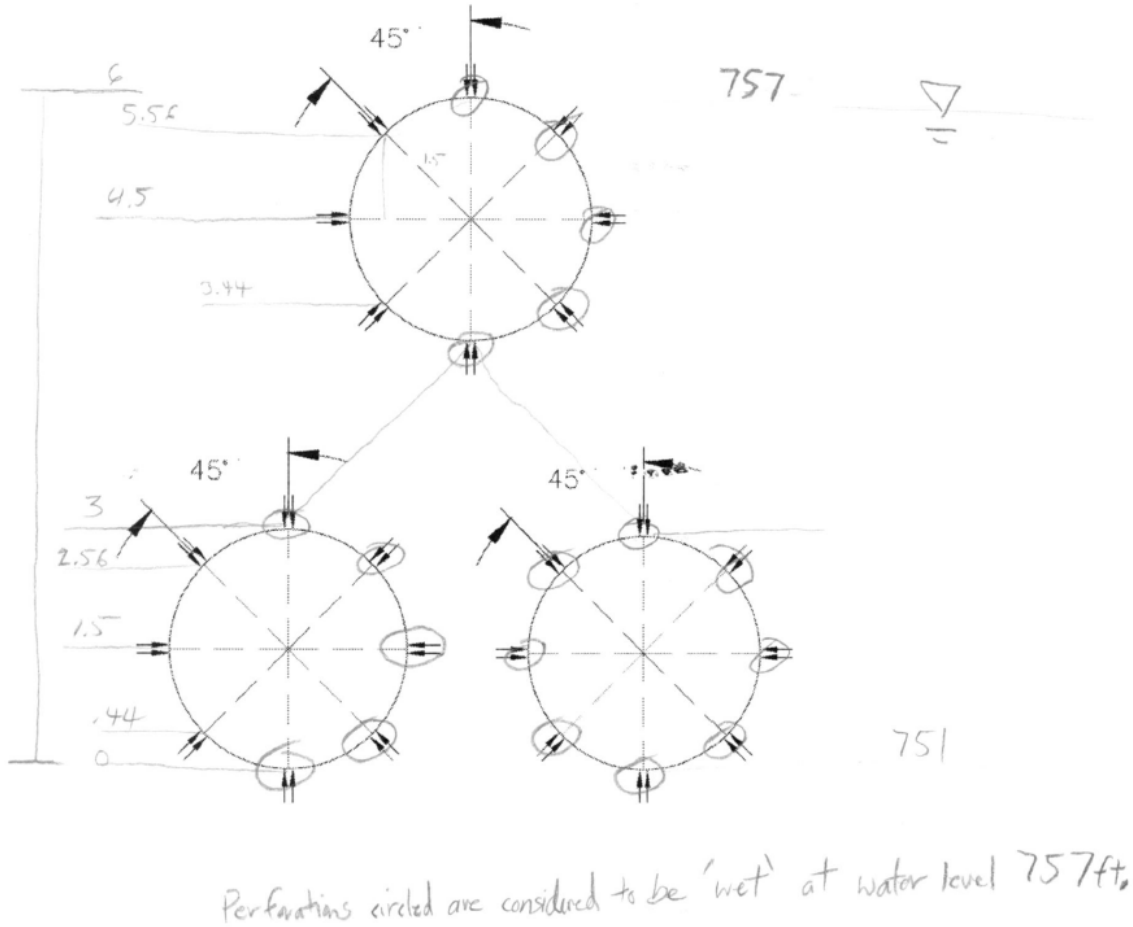
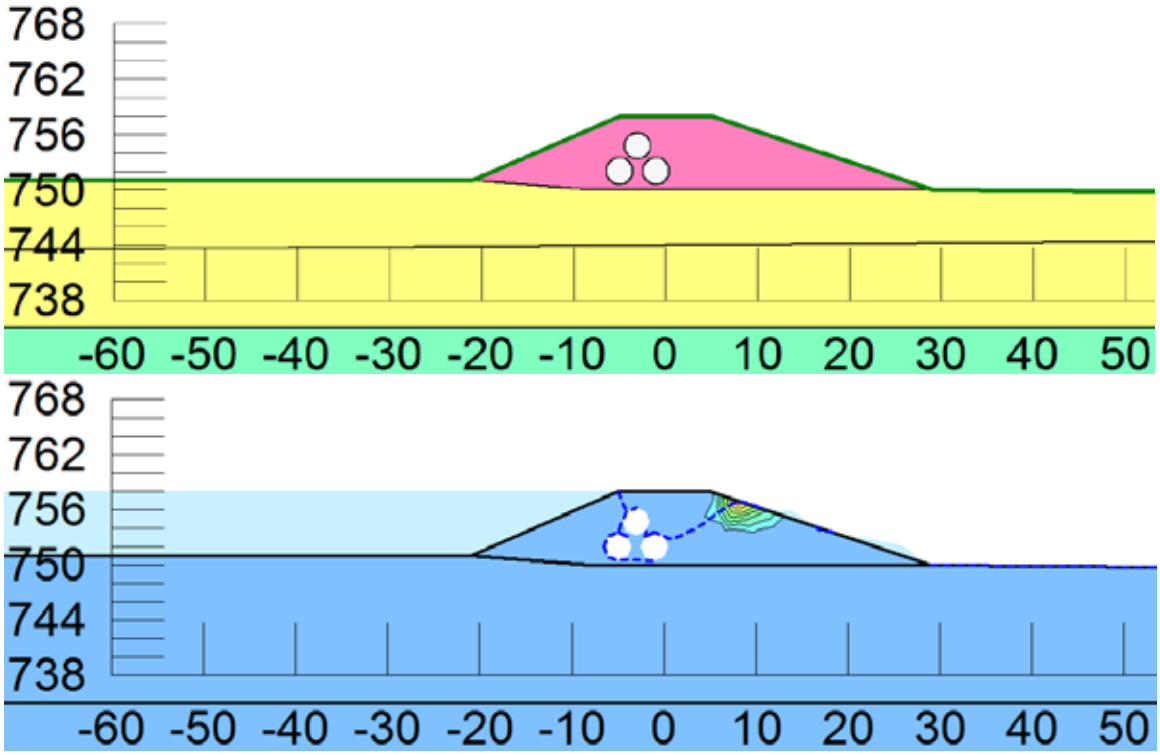


Figure 4.3: Berm Cross Section Seepage Model



4.4.5. Construct a Fence/Earthen Berm Combination, Alternative E, (Eagle Marsh, Basin Divide)

This alternative generally consists of a fence constructed on top of a shortened berm. In theory, only large flood events would overtop the berm, which would then flow through the fence. Erosion protection will need to be in place for this alternative to be effective. Grid type geotextiles, stone protection, or cellular concrete blocks are perceived for use. The erosion protection would be located on the crown, down slope, and a few feet out from the toe, as determined in the design stage.

A borrow site would be needed as the berm would be constructed from borrow material. The width of the berm would likely require the ability to carry a vehicle along its length, in addition to the fence for a significant portion. The berm would generally have 3H:1V side slopes, constructed from compacted clay materials, and would be seeded with grasses. Grade control would be extremely important for this alternative. As the water begins to spill over the berm and through the fence, it is essential that the flow rate be relatively constant over the length of the berm and that flow does not concentrate in any one area. Concentrated flow could lead to a breach of the berm from scour. A concrete sill should be considered along the top of the berm during design.

4.4.6. Construct Bar Screen Barrier at Existing Weir, Alternative F, (Huntington Dam)

This alternative consists of constructing a bar screen barrier along the top of the Huntington Dam located in Huntington, Indiana. A debris boom would also be required.

The bar screen would be connected through a series of concrete piers constructed downstream adjacent to the dam. These piers would likely be founded on bedrock which is exposed in some locations within the channel (Photo 4.2). The foundation type would be a spread foundation bearing on rock with the potential for rock anchors to help resist lateral loads.

The debris boom cable would need to be anchored on either side of the channel. A concrete dead weight poured on rock is anticipated.

Photo 4.2: Exposed Bedrock at Huntington Dam

4.4.7. Construct Vertical Drop Structures with Telemetered Sluice Gate, Alternative G, (Homestead Road)

The vertical drop structure alternative consists of ten 24 ft diameter circular intake structures tied to box culverts to pass the water through the berm. These structures will be lightly loaded. The anticipated foundation type is a concrete mat foundation. Uplift forces during a submerged condition will need to be considered during design.

The adjacent berm which provides the cutoff and through which the ten box culverts travel will need to be constructed from borrow material. A borrow site will need to be established during the design phase. The berm will likely require erosion protection on the upstream side to protect from wavewash during high water. This berm will be similar in construction to other earthen berms in the previous alternatives.

A sluice gate structure is proposed within the berm section in the Graham-McCulloch Ditch. This sluice gate is anticipated to be founded on a mat or spread footing foundation.

4.4.8. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative H, (Eagle Marsh, Basin Divide)

This alternative provides a permanent cutoff for a major flood event by reconstructing the Graham-McCulloch Ditch left descending berm to engineering standards and a precise elevation. The size of the berm will be dependent on soil properties and seepage/slope stability analyses, but would likely consist of a 10 ft crown width with 3H:1V side slopes. A borrow area will be required for this alternative. The amount of borrow material will depend on the amount of material currently within the existing berm, and also on the percentage of that material which is acceptable for use as fill. As the Graham-McCulloch Ditch was dug onsite and the spoils deposited to create the berm on either side, it is anticipated the berm will mainly consist of the same loam material which is found in the area. However, portions of the berm may be unusable due to organic content or unsatisfactory fill.

Erosion protection on the Graham-McCulloch Ditch side of the berm will likely be required at certain intervals due to high velocity flows within the ditch. The berm should be 'overbuilt' by approximately 6 inches in height to account for post-construction settlement of the berm. More overbuild may be necessary depending on the height and location of the berm and should be analyzed during the design stage.

4.4.9. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Demolish Right Descending Berm, and Construct Multi-Cell Wetland Area, Alternative I, (Eagle Marsh, Basin Divide)

This alternative will reconstruct the left descending berm the same as the previous alternative, but it assumes the use of the right descending berm as additional borrow material and will likely not require a borrow site. The wetland area would be constructed in the place of the right descending berm. Temporary stream crossings across the Graham-McCulloch Ditch will be needed to transport the borrow material.

4.5. FURTHER STUDIES, FIELD WORK, TESTS AND ANALYSES AFTER THIS REPORT

Additional borings will be required during the next phase to better characterize the soil properties in the area of the final alternative. A geotechnical engineer should perform a soil exploration of the area and develop testing to characterize the soils based on the selected alternative. Seepage and slope stability analyses would be required to evaluate all critical cross-sections of a berm. Updated survey data for all critical cross-sections would be required. Bearing strength and settlement analyses would have to be completed for select alternatives. Further investigation will also be required for potential sources of borrow materials to determine their quantity and suitability.

AQUATIC NUISANCE SPECIES CONTROLS REPORT
WABASH-MAUMEE BASIN CONNECTION STUDY
FORT WAYNE, INDIANA

APPENDIX F

SECTION 5
CIVIL ENGINEERING

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APPENDIX F

SECTION 5
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APPENDIX F

SECTION 5
CIVIL ENGINEERING

5.1. REFERENCES

1) U.S. Army Corps of Engineers document Great Lakes and Mississippi River Interbasin Study (GLMRIS), Other Pathways Preliminary Risk Characterization, dated 9 November 2010

2) Digital elevation model (DEM) from the United States Geological Survey (USGS) for Allen County, Indiana

3) Eagle Marsh mapping from the National Resources Conservation Service (NRCS)

4) ER 1110-2-1150 "*Engineering and Design for Civil Works Projects*" U.S. Army Corps of Engineers, dated 31 August 1999

5) EM 1110-2-1913 "*Design and Construction of Levees*" U.S. Army Corps of Engineers, dated 30 April 2000

6) ETL 1110-2-571, *"Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures"* U.S. Army Corps of Engineers, dated 10 April 2009

7) Roadside Design Guide, American Association of State Highway and Transportation Officials (AASHTO), 4th Edition 2011

8) Policy on Geometric Design of Highways and Streets, AASHTO, 5th Edition 2004

5.2. UTILITY AND ROAD RELOCATION

Utility information for water, storm and sanitary sewers were provided by the Allen County GIS Department. Power and telephone utilities were not readily available and were obtained by field reconnaissance performed by various Project Delivery Team members. Google Maps identified road names. Preliminary utility and road relocations are shown on the plan sheets, which are located in Appendix G, Sheets CS101 through CS114.

Utility and road relocations (as per Engineering Federal Acquisition Regulation Supplement (EFARS), Appendix Q, Section 73-000 et. seq.) are applicable to utilities and roads which involve relocation, abandonment, vacation, or an alteration of an existing utility or road. The term relocation also includes the raising, lowering, altering, adjusting, or protecting a facility, as well as changing its location.

Attorney's reports of compensability will be prepared during the design stage to determine who has a compensable interest and is empowered to contract with the United States of America for utility and road relocations.

5.3. RAILROAD

A single-track railway exists on an embankment located on the southern border of Eagle Marsh and runs in a northeasterly direction. Through phone calls and emails, Norfolk Southern Railroad Corporation has confirmed they operate trains on the railroad through the study area. They have provided right-of-way and track mapping dated 30 June 1919 of their facilities. The mapping has been updated to include the I-69 bridge crossing constructed in 1966 and pipe replacements along the rail alignment. It appears the right-of-way through the study area varies from a minimum of 44 feet to 72 feet on each side of the rail centerline depending on the location.

Photo 5.1: (Left) Single-track railway borders Eagle Marsh, which is located on the left. Photo taken looking northeast direction.
Photo 5.2: (Right) The railway embankment is shown on the left and the south abutment of the temporary fence barrier is shown on right. Photo taken looking in a southwest direction.

Eight of the nine alternatives discussed in this report tie into the existing north side of the railroad embankment, which is also where the railroad communication signals are believed to be located. During design, the exact location of the communication signals will need to be verified with railroad officials. It is not anticipated there will be any disruption to rail traffic during construction of any of the alternatives. However, Norfolk

Southern Railroad Corporation will likely require flagmen to be present during construction activities located with their right-of-way.

Construction activities for this project that are located within the Norfolk Southern Railroad Corporation right of way are applicable to EFARS (Engineering Federal Acquisition Regulation Supplement), Appendix Q, Section 73-000 et. seq. and will require a relocations contract with the railroad.

Attorney's reports of compensability will be prepared during the design stage to determine who has a compensable interest and is empowered to contract with the United States of America for railroad relocations.

5.4. STAGING AREAS

Staging areas are necessary to give the contractor sufficient room to temporarily store construction equipment and/or materials used to construct the project. For this report, the staging areas are located adjacent to the proposed work as much as possible. Keeping the staging areas close to the construction area will reduce the length of transport of construction equipment and materials through public and private properties and will likely reduce real estate costs for the project.

The staging areas are located and identified on the plan sheets for each alternative. The site plans are located in Appendix G, Sheets CS101 through CS114.

5.5. EXISTING PIPES LOCATED WITHIN STUDY AREA

During the November 2010 field reconnaissance trip, the design team discovered multiple abandoned culverts in the Eagle Marsh area, which may allow the passage of ANS during a storm event. The culverts shown in the photos below are located in the left descending berm of the Graham-McCulloch Ditch in Eagle Marsh.

Photo 5.3 and 5.4: (Left and Right) Partially buried and abandoned culverts located in Graham-McCulloch Ditch may allow ANS movement.

Based on discussions with the Indiana DNR, previous efforts to cover these culvert openings with rip rap have failed due to high head differentials experienced during floods on the Graham-McCulloch in the spring of 2011. Indiana DNR plans to plug and cap the culverts that allow movement of ANS to the east side of the existing temporary barrier fence.

Depending on the alternative selected for this project, all culverts located in the left descending bank of the Graham-McCulloch Ditch will be removed in their entirety or filled with expansive grout. Further investigation of these existing pipes will be carried out during the design stage.

Photo 5.5: (Left) Existing pipes in the Graham-McCulloch Ditch will need to be evaluated during design stage.

5.6. REAL ESTATE

Right-of-way was determined based on location of the proposed work, staging areas, and future access for operation and maintenance of the project. Most of the proposed work will be located on private property. Areas needed for construction, staging, or access have been identified on the plans and designated with the appropriate estate. All construction and permanent access points originate from City and State owned roads where possible, which will reduce land acquisition costs. For operation and maintenance purposes, a minimum of twenty feet is reserved on each side of the proposed structure and/or alignment. Additional areas are to be provided at the end of alignments for vehicle turn-around. This access corridor must be free of obstructions to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, and monitoring.

In some instances where the road may act as part of the barrier to prevent movement of the ANS, right-of-way may be carried across the road to ensure it is not altered in a way that would enable ANS transfer.

Flowage easements will be required for a majority of the alternatives. Further investigations will be completed during the design stage of the project. Additional information regarding flowage easements is explained in the Real Estate Plan, Appendix E.

Real Estate plans have been included in Appendix G, Sheets RW101 through RW114.

5.7. STRUCTURAL ALTERNATIVES

5.7.1. Construct an I-Wall, Alternative A, (Eagle Marsh, Basin Divide)

Alternative A is proposed to construct about 4,448 linear feet of sheet pile I-wall at the approximate location of the hydraulic basin divide. The top of wall is proposed to be at elevation 762.0 at Engle Road and sloping downward to elevation 760 at a point near the existing barn, and continuing at elevation 760 to its south termination. This elevation is based on hydraulic models of the area to prevent the movement of ANS. Additional hydraulic information is located in Section 2, Hydrology and Hydraulics, of this report. The I-wall height varies from about three to nine feet dependent on the existing ground elevation along the alignment.

The south end of the alignment ties into high ground at the Norfolk Southern Railroad embankment. To minimize the disturbance to the railroad, the I-wall will stop at the toe of the railroad embankment. Indiana revetment riprap will be placed between the end of the I-wall and the railroad embankment to prevent passage of ANS. The I-wall will run northward which will require about 2,000 linear feet of clearing and grubbing through a wooded area of Eagle Marsh. The I-wall alignment will then tie into the Engle Road embankment on the south and north sides of the road.

To avoid a gate or sand bag closure across Engle Road during storm events, a berm will be constructed at elevation 762.0 along the south side of Engle Road connecting the I-wall to high ground at the left bank abutment of the Engle Road bridge over the Graham McCulloch Ditch. Raising the road was considered in lieu of this berm, but due to the impacts on new trail areas and adjacent marsh areas on the north side of Engle Road, constructing this berm would be less intrusive. Raising the road would also have significant costs for maintaining traffic on this high volume road during construction.

Photo 5.6: (Left) Engle Road in the vicinity of the Alternative A I-wall.

Vehicular or pedestrian gates were not provided due to the flashiness of the storms in the study area. In addition, the team concluded gates would only increase the operation and maintenance costs associated with this project which would be counterintuitive based on our objectives as defined in Section 1, General.

During the initial visit to Eagle Marsh in November 2010, design team members met with the Little Rivers Wetlands Project (LRWP) board who operates Eagle Marsh. They were

concerned the existing temporary fence barrier prevents the migration of terrestrial animals such as deer. Therefore, three animal crossing ramps were provided in Eagle Marsh to provide crossing of the I-wall. The animal crossings consist of a 3:1 compacted fill with a geogrid surface on both sides of the I-wall. Reference is made to Miscellaneous Details, Sheet CZ001 in Appendix G.

High-voltage overhead electric transmission lines run through the wooded area across Eagle Marsh. Any relocation of these lines would be cost prohibitive since they likely are part of the Eastern Interconnection power grid. From preliminary site reconnaissance, the low wire elevation appears to be high enough for the I-wall to be constructed. However, this will need to be verified during final design if this alternative is selected. Electric lines are also located on high ground north of Engle Road. These lines will unlikely be affected, but during construction the contractor will need to use caution when working in the area. It appears a utility relocations contract will not be necessary.

The site plan for Alternative A is located on plan sheet CS101 in Appendix G.

5.7.2. Construct a Fence and Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative B, (Eagle Marsh, Basin Divide)

Alternative B is proposed to construct about 1,774 linear feet of permanent chain-link fence and about 2,782 feet of earthen berm. The proposed fence will be located east of the Indiana DNR temporary fence in Eagle Marsh. The top of the fence is proposed to be at elevation 760.0 and is based on hydraulic models of the area to prevent the movement of ANS. Additional hydraulic information is located in Section 2, Hydrology and Hydraulics, of this report. The fence height varies from seven to nine feet dependent on the existing ground elevation along the alignment.

The south end of the alignment ties into high ground at the Norfolk Southern Railroad embankment west of the wooded area to avoid clearing and grubbing activities. To minimize the disturbance to the railroad, the fence will stop at the toe of the railroad embankment. Indiana revetment rip rap will be placed between the end of the fence and the railroad embankment to prevent passage of ANS. The fence alignment runs north where it ties into the left descending (east) bank of the Graham-McCulloch Ditch.

Approximately 2,782 linear feet of the existing left descending bank of the Graham-McCulloch Ditch will be demolished and rebuilt. The reconstructed berm will begin at the fence tie-in location and end at wastewater treatment plant (WWTP) access road. New berm will be constructed along the south side of the WWTP road to Engle Road, and continue along the south side of Engle Road to high ground at the left bank abutment of the Engle Road Bridge over Graham McCulloch Ditch. Additional information on the condition of the existing Graham-McCulloch Ditch berms is located in Section 1, General, and Section 4, Geotechnical.

The top of crown of the new earthen berm will be at elevation 760 at its tie in to the fence, and tapering up to elevation 762 at the WWTP road, and contining at elevation 762 to its termination. The berms will have 3:1 side slopes. The design team recommends a minimum ten-foot wide crown be constructed on the berm for LRWP maintenance vehicles. This detail can be discussed further and decided upon during the design stage of the project. However, for cost estimating purposes, the crown width will be ten feet. A shorter alignment of the new berm that would follow the left bank of Graham-McCulloch Ditch in lieu of the longer route following the roadways was considered; the longer route was selected as it would allow the roadway to the WWTP to be adjusted without modification to the existing bridge there, and should have less impact to tow path trail improvements in the area.

High-voltage overhead electric transmission lines cross the Graham-McCulloch Ditch north of the fence tie-in location in Eagle Marsh. Any relocation of these lines would be cost prohibitive since they likely are part of the Eastern Interconnection power grid. From preliminary site reconnaissance, the low wire elevation appears to be high enough for the reconstruction of the Graham-McCulloch Ditch. However, this will need to be verified during final design if this alternative is selected.

Photo 5.7: (left) Photo taken from Towpath Trail bridge looking downstream at Graham-McCulloch Ditch. The wastewater treatment plant is on right.
Photo 5.8: (right) Towpath Trail (before 2011 improvement) looking northeast. The wastewater treatment plant is on the right.

The wastewater treatment plant, which is located on the right descending bank of the Graham-McCulloch Ditch, will not be affected by this alternative. The Graham-McCulloch Ditch berm ties into the wastewater treatment access road. Between Engle road and the Tow Path Trail, the access road is a low volume, two-lane gravel road. In 2011, this road was asphalted from a point near the bridge crossing the Graham-McCulloch Ditch and continuing further to the southwest as part of a larger Fort Wayne Parks Towpath Trail improvement project, for the purposes of recreational bicycling and hiking access. It is anticipated that the wastewater treatment plant access portion of this road will be briefly closed during the demolition and reconstruction of the berm adjacent

to and crossing this road. Due to recent construction in the vicinity of Engle Road for the Towpath Trail and trailhead parking area, if this alternative is selected for further design, additional surveying will be required to determine the final termination point of the berm in the vicinity of Engle Road. A road relocation contract will likely be required for modifications to the wastewater treatment access road. In addition, approximately 95 linear feet of Eagle Marsh access road, which is a one-lane gravel road, will also need to be relocated as part of this alternative.

The site plan for Alternative B is located on plan sheet CS102 in Appendix G.

5.7.3. Construct an Earthen Berm and Pump Station, Alternative C, (Homestead Road)

Alternative C is proposed to construct an earthen berm which prevents the Graham-McCulloch from freely flowing downstream. The earthen berm would divert flow to a pump station which would act as a filter to reduce the likelihood of ANS movement further downstream. The earthen berm and pump station would be located west of Homestead Road near the Norfolk Southern Railroad Corporation at-grade intersection. Additional pump station information is located in Sections 7 and 8, Electrical and Mechanical Engineering, of this report.

The purpose of the pump station is to handle peak flows from the 1% annual chance event on the Graham-McCulloch Ditch. The pump station will be configured utilizing eleven "can sytle" pumps. Eight of the pumps will have an approximate capacity of 130 CFS and the remaining three pumps will be approximately 50 CFS. Each discharge pipe will have a gravity type flap gate to prevent back flow.

Photo 5.9 (left): Homestead Road is located on right. Photo is looking north

About 175 linear feet of earthen berm would be constructed to an elevation of 758.0. The south abutment of the earthen berm would tie into the Norfolk Southern Railroad embankment and the north abutment would tie into Homestead Road.

To prevent water from overtopping Homestead Road, it would need to be raised in place to an approximate elevation of 758.0. Road work will begin north of the bridge which is estimated to be at an approximate elevation of 758.0. Approximately 726 linear feet of Homestead Road is to be altered. Since ponding of water east of Homestead Road may occur during storm events, Indiana revetment rip rap is to be placed on the upstream road embankment to prevent erosion. A road relocation contract will be required.

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The farmer's access on each side of Homestead Road will be maintained. The existing ditch which lies west of Homestead Road (see Photo 5.9) would be diverted downstream of the earthen berm and pump station.

About 1,055 line feet of power and telephone lines and four joint-use utility poles will need to be adjusted on existing alignment. This work will be completed by the owning utility companies. Buried fiber optic cable, located adjacent to the road, will be protected and not be disturbed during construction activities. A utility relocation contract will be required.

The site plan for Alternative C is located on plan sheets CS103 and CS104 in Appendix G.

5.7.4. Construct a Permeable Berm with Telemetered Sluice Gates, Alternative D, (Amber Road)

Alternative D is proposed to construct about 2,113 linear feet of permeable berm that allows water to pass through during high water events but restricts ANS. The berm would be made of open graded rip rap material and would be located east of Amber Road. Gradation of the stone and perforations of the piping would be considered the restrictive sizes that would prevent ANS from passing through the berm. See Section 4, Geotechnical Engineering, of this report for further description of the berm composition. The south abutment of the permeable berm would tie into the Norfolk Southern Railroad embankment, cross the Graham-McCulloch Ditch and tie into high ground. The alignment of the berm is approximately parallel with Amber Road.

On the Graham-McCulloch Ditch, a telemetered sluice gate with automated closure mechanisms will be constructed. During storm events when ANS transfer is imminent, the sluice gates would close blocking normal drainage of the Graham-McCulloch Ditch. Three gaging stations are proposed; one on Junk Ditch (Engle Road) and two on Graham-McCulloch Ditch (Eagle Marsh and Ellison Road). Additional hydraulic information about telemetered sluice gates is located in Section 2, Hydrology and Hydraulics, of this report.

Photo 5.10: (left) Alternative at Amber Road, looking north.

Flow that normally passes through the Graham-McCulloch Ditch would be redirected to pass through the permeable berm. To pass

maximum flow during storm events, islands extending from the berm will be constructed. Ponding of the water may occur upstream of the permeable berm. Additional hydraulic analysis will be required during the design stage to determine the ponding areas and associated flowage easements needed for this alternative.

To reduce the amount of debris that may build-up on the permeable berm, it is proposed a vegetative filter strip be constructed 200-300 feet upstream. The filter strip is proposed to be a 75-foot wide by 1,711 long area of permanent vegetation that will consist of a combination of native, grasses, trees and shrubs.

A twelve-foot gravel access road will be constructed from Amber Road to the project area. Total length of the gravel access road is estimated to be approximately 200 linear feet. Utilities are not located within the project area. A utilities or road relocation contract will not be required for this alternative.

The site plan for Alternative D is located on plan sheets CS105 and CS106 in Appendix G.

5.7.5. Construct a Fence/Earthen Berm Combination, Alternative E, (Eagle Marsh, Basin Divide)

Alternative E is proposed to construct about 4,825 linear feet of permanent chain-link fence and earthen berm combination at the approximate location of the hydraulic basin divide in Eagle Marsh. The top of fence and earthen berm are proposed to be at elevations 762.0 and 753.0 respectively and are based on hydraulic models of the area to prevent the movement of ANS. Additional hydraulic information is located in Section 2, Hydrology and Hydraulics, of this report. The fence height varies from two to nine feet and is dependent on the existing ground elevation along the alignment.

The south end of the alignment ties into high ground at the Norfolk Southern Railroad embankment. To minimize the disturbance to the railroad, the fence will stop at the toe of the railroad embankment. Indiana revetment rip rap will be placed between the end of the fence and the railroad embankment to prevent passage of ANS. The fence will run northward for about 1,200 linear feet until approximate ground elevation 753.0 where the fence/earthen berm combination will begin. The alignment will continue making a slight curve left until it meets the existing Eagle Marsh access road. It is estimated about 2.1 acres of clearing and grubbing along 2,280 linear feet of fence alignment will be required for this alternative.

The existing Eagle Marsh gravel access road will be raised in place about one foot and will serve as an earthen berm for high frequency flooding. An equipment gate will be constructed where the fence crosses the access road. The fence will continue north and be located approximately 250 feet west of the access road.

To avoid a gate or sand bag closure across Engle Road during storm events, a berm will be constructed along the south side of Engle Road to elevation 762 to connect this fence to high ground at the left bank abutment of the Engle Road bridge over the Graham-McCulloch Ditch. This would avoid significant maintenance of traffic costs associated with raising Egngle Road, a high-volume road, which was considered in lieu of this berm.

During the initial visit to Eagle Marsh in November 2010, design team members met with the Little Rivers Wetlands Project (LRWP) board that operates Eagle Marsh. They were concerned the existing temporary fence barrier prevents the migration of terrestrial animals such as deer. Therefore, pedestrian and equipment gates will be provided along the fence alignment in Eagle Marsh. Reference is made to Fence Details, Sheet CZ002 in Appendix G.

High-voltage overhead electric transmission lines run through the wooded area across Eagle Marsh. Any relocation of these lines would be cost prohibitive since they likely are part of the Eastern Interconnection power grid. From preliminary site reconnaissance, the low wire elevation appears to be high enough for the I-wall to be constructed. However, this will need to be verified during final design if this alternative is selected. Electric lines are also located on high ground north of Engle Road. These lines will unlikely be affected but the contractor will need to use caution when working in the area. It appears a utility relocations contract will not be necessary.

The site plan for Alternative E is located on plan sheet CS107 in Appendix G.

5.7.6. Construct Bar Screen Barrier at Existing Weir, Alternative F, (Huntington Dam)

Alternative F is proposed to construct a bar screen across the Huntington Dam on the Little River in Huntington, Indiana. The bar screen structure would be constructed downstream of the existing weir to prevent movement of ANS past the barrier. The bar screen would be slanted downstream to prevent any ANS to jump over the bar screen. The angle of the bar screen would allow any floating debris that may pass the floating debris boom to float upward during high flows and be pushed over the bar screen. The work will include construction of about 327 linear feet of gravel access road off East State Street and about 320 linear feet of gravel access road off W. Riverside Drive.

High-voltage overhead electric transmission lines are located on the right descending bank of the Little River. Any relocation of these lines would be cost prohibitive. From preliminary site reconnaissance, the low wire elevation appears to be high enough for the bar screen barrier construction. However, equipment needed for debris removal may have clearance issues at this location and will need to be verified during final design.

The site plan for Alternative F is located on plan sheet CS108 in Appendix G.

5.7.7. Construct Vertical Drop Structures with Telemetered Sluice Gate, Alternative G, (Homestead Road)

Alternative G is proposed to construct a total of ten 24 foot diameter weir inlets upstream of Homestead Road, which will not be effected by this alternative. In conjunction with the vertical drop structures, about 750 linear feet of permeable berm will be constructed.

Vertical drop structures would act similar to control structures used in lakes, ponds, or detention basins. Low flows would pass through a sluice gate structure in the main channel of the Graham-McCulloch Ditch. The gate would be controlled by gages closing when flows increased and threatened to create a hydraulic connection between basins. After the sluice gate closed, the water surface elevation immediately upstream of the barrier would increase and overtop the drop structures. Each drop structure would pass flows through the berm to a flat-bottom ditch adjacent to Homestead Road by a concrete box culvert. The flat-bottom ditch empties into the Graham-McCulloch Ditch.

An access road from Homestead Road will be necessary for permanent access to the project. Overhead utility lines are located on the downstream side of Homestead Road and will not be affected. It is anticipated that a relocations contract with the Norfolk Southern Railroad Corporation would be necessary to tie into the railroad embankment.

The site plan for Alternative F is located on plan sheets CS109 and CS110 in Appendix G

5.7.8. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative H, (Eagle Marsh, Basin Divide)

Alternative H is proposed to reconstruct about 8,700 linear feet of earthen berm. The left descending berm of the Graham-McCulloch Ditch would be demolished from the south end of the alignment where it ties into high ground at the Norfolk Southern Railroad to the north end at the wastewater treatment access road. The reconstructed berm will generally be constructed in the same location as the existing berm.

The top of crown of the new earthen berm will range from 761.0 at the wastewater treatment access road to 759.0 at the Norfolk Southern Railroad. Due to recent construction in the vicinity of Engle Road for the Towpath Trail and trailhead parking area, if this alternative is selected for further design, additional surveying will be required to determine the final termination point of the berm in the vicinity of Engle Road. The side slopes of the berm will be 3H:1V. The design team recommends a minimum ten-foot wide crown be constructed on the berm for LRWP maintenance vehicles. The berm detail will be discussed further and decided upon during the design stage of the project. However, for cost estimating purposes, the crown width will be ten feet.

The wastewater treatment plant, which is located on the right descending bank of the Graham-McCulloch Ditch, will not be affected by this alternative.

Photo 5.11: (left) Location where Graham-McCulloch Ditch and the railroad meet in Eagle Marsh.

The reconstruction of the left descending berm at the wastewater treatment plant access road, which is a low volume, two-lane gravel road, will likely require a road relocation contract. It is anticipated that this access road will be briefly closed during the demolition and reconstruction of the berm adjacent to the road.

High-voltage overhead electric transmission lines cross the Graham-McCulloch Ditch at the 90 degree bend of the ditch in Eagle Marsh. Any relocation of these lines would be cost prohibitive since they likely are part of the Eastern Interconnection power grid. From preliminary site reconnaissance, the low wire elevation appears to be high enough for the reconstruction of the Graham-McCulloch Ditch. However, this will need to be verified during final design if this alternative is selected. Utility relocations are not expected.

A relocations contract with the Norfolk Southern Railroad Corporation would be necessary to tie into the railroad embankment.

The site plan for Alternative H is located on plan sheets CS111 and CS112 in Appendix G.

5.7.9. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Demolish Right Descending Berm, and Construct Multi-Cell Wetland Area, Alternative I, (Eagle Marsh, Basin Divide)

Alternative I is proposed to reconstruct about 8,700 linear feet of earthen berm. The left descending berm of the Graham-McCulloch Ditch and most of the right descending berm would be demolished from the south end of the alignment where it ties into high ground at the Norfolk Southern Railroad to the north end at the wastewater treatment access road. The left descending berm would be reconstructed and would be in about the same location as the existing berm.

The top of crown of the new earthen berm will range from 761.0 at the wastewater treatment access road to 759.0 at the Norfolk Southern Railroad. Due to recent construction in the vicinity of Engle Road for the Towpath Trail and trailhead parking area, if this alternative is selected for further design, additional surveying will be required to determine the final termination point of the berm in the vicinity of Engle Road.

The side slopes will be 3H:1V. The design team recommends a minimum ten-foot wide crown be constructed on the berm for LRWP maintenance vehicles. The berm detail will be discussed further and decided upon during the design stage of the project; however, for cost estimating purposes, the crown width will be ten feet.

The wastewater treatment plant currently has a berm system around the plant to protect it from flooding. In addition, it appears that a portion of the right descending bank of the Graham-McCulloch Ditch has been reconstructed as part of their berm system. Based on survey data, the average height of the berm system around the plant is at elevation 762.0. Reference is made to Photo 5.13, which shows the right descending bank adjacent to the plant. The bank/ berm appear to be well maintained and securely gated. Therefore, it is assumed the right descending bank adjacent to the plant will remain in place. Further investigation will be required during the design stage if this alternative is selected for construction. The construction of this alternative will not affect the wastewater treatment plant.

The reconstruction of the left descending berm at the wastewater treatment access road, which is a low volume, two-lane gravel road, will likely require a road relocation contract. It is anticipated that the wastewater treatment access road will be briefly closed during the demolition and reconstruction of the berm adjacent to the road.

High-voltage overhead electric transmission lines cross the Graham-McCulloch Ditch at the 90 degree bend of the ditch in Eagle Marsh. Any relocation of these lines would be cost prohibitive since they likely are part of the Eastern Interconnection power grid. From preliminary site reconnaissance, the low wire elevation appears to be high enough for the reconstruction of the Graham-McCulloch Ditch. However, this will need to be verified during final design if this alternative is selected. Utility relocations are not expected.

Photo 5.12: (left) An earthen berm surrounds the wastewater treatment plant to protect it from flooding.
Photo 5.13: (right) The wastewater treatment plant utilizes a portion of the right descending bank of the Graham-McCulloch Ditch as part of their berm system to protect the plant from flooding.

A relocations contract with the Norfolk Southern Railroad Corporation would be necessary to tie into the railroad embankment.

The site plan for Alternative I is located on plan sheets CS113 and CS114 in Appendix G.

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APPENDIX F

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6.1. REFERENCES

1) ACI 318-08, "*Building Code Requirements for Structural Concrete and Commentary"* American Concrete Institute

2) ACI 350-06, "*Environmental Engineering for Concrete Structures"* American Concrete Institute

3) ASCE 7-05, "*Minimum Design Loads for Buildings and Other Structures"* American Society of Civil Engineers

4) EM 1100-2-2100, "*Stability Analysis of Concrete Structure*" U.S. Army Corps of Engineers, dated 01 December 2005

5) EM 1100-2-6053, "*Engineering and Design - Earthquake Design and Evaluation of Concrete Hydraulic Structures*" U.S. Army Corps of Engineers, dated May 2007

6) ER 1110-2-1806, "*Earthquake Design and Evaluation for Civil Works Projects*" U.S. Army Corps of Engineers, dated 31 July 1995

7) REMR-EM-6, "*Mechanical Properties and Corrosion Behavior of Stainless Steels for Locks, Dams, and Hydroelectric Plant Application*" published by Dr. Ashok Kumar, US Army Construction Engineering Research Laboratories (1988)

8) REMR-EM-11, "*Coatings for Use on Wet or Damp Steel Surfaces"*, published by Alfred D. Beitelman, US Army Construction Engineering Research Laboratories (1997)

9) UFC 3-301-01, "*Unified Facilities Criteria – Structural Engineering"* US Army Corps of Engineers/Naval Facilities Engineering Command/Air Force Civil Engineer Support Agency.

6.2. STRUCTURAL ALTERNATIVES

6.2.1 Construct an Earthen Berm and Pump Station, Alternative C, (Homestead Road)

Alternative C involves the construction of a pump station at Homestead Road near the Graham-McCulloch Ditch and Norfolk Southern Railroad Corporation. The alternative includes options for two configurations of pump stations. Either pump station should consist of reinforced, cast-in-place concrete, which includes the pump bay, walls and building floor slab, and pipe inlets/outlets. Foundations should be founded to the frost penetration depth and that depth used in the stability analyses. Deep foundations may be required based on the existing soil conditions. The superstructure building should be constructed of reinforced concrete masonry unit (CMU) block or concrete with a roof support system of precast concrete deck planks. Architectural features will include the roof system and water proofing. Either pump plant configuration includes a structural steel trash rack, assumed to be fabricated from steel bars a minimum of 3-inches deep, spaced no further than 2-inches center-to-center, and a coating system that is capable of being submerged for extended periods of time (comply to REMR-EM-6 or REMR-EM-11 for stainless steel selection or coatings). Conceptual sketches are included shown on Alternative C Site Plan CS103 in Appendix G.

6.2.1.1. Design Criteria

Screening level designs for the pump plant configurations have been completed. The functional layouts were developed by the project mechanical engineer. Computations of the structures' stability were utilized to develop wall and slab thicknesses. Estimates of the concrete and other material quantities have been completed. During design, the pertinent criteria of all applicable publications need to be met.

6.2.1.2. Stability and Strength Requirements

The criteria used to analyze the pump plant stability are based on EM1110-2-2100, *Stability Analysis of Concrete Structures* and EM1110-2-3104, *Structural and Architectural Design of Pumping Stations*. The proposed pump plants were designed per the design flood case, which by definition, is an unusual load condition and the soil information was considered to be "ordinary". The required Factors of Safety for Sliding and Flotation are outlined in Tables 6.1 and 6.2. These tables are excerpted from Chapter 3 of EM 1100-2-2100. The load cases to be analyzed are outlined in detail in Table 6.3.

TABLE 6.1
REQUIRED FACTORS OF SAFETY FOR SLIDING - CRITICAL STRUCTURES

Load Condition Categories Site Information Category	Usual	Unusual	Extreme
Well Defined	1.7	1.3	1.1
Ordinary	2.0	1.5	1.1
For preliminary seismic analysis without detailed site-specific ground motion	-	1.7	1.3
Limited	-	-	-

TABLE 6.2
REQUIRED FACTORS OF SAFETY FOR FLOTATION – ALL STRUCTURES

Load Condition Categories Site Information Category	Usual	Unusual	Extreme
All Categories	1.3	1.2	1.1

Appendix B ("Loading Conditions and Loading-Condition Classification") from EM 1110-2-2100 includes the following description of the load cases to be analyzed for pump plant structures.

(a) Loading Condition 4-4a – Construction Condition.
- Pumping station complete with and without backfill in place.
- No water loads.

(b) Loading Condition 4-4b - Normal Operating Condition.
- Plant operating to discharge routine local floods over a range of exterior flood levels with a maximum 2-year return period.

(c) Loading Condition 4-4e - Maximum Design Flood.
- Maximum water level outside protection line.
- Minimum pumping level inside.

(d) Loading Condition 4-4f - Maximum Pump Thrust.
- Maximum operating floods both inside and outside protection line.
- Maximum pump thrust.

(e) Loading Condition 4-4g - Maintenance Conditions.
- Maximum design water level inside.
- One, more, or all intake bays unwatered.

(f) Loading Condition 4-4j - Pumping Plant Inundated.
- Maximum flood levels inside and outside protection line.
- Pumping plant inoperative.
- Foundation drains inoperative.

• Protection line intact.

(g) Loading Condition 4-4k - Coincident Pool + OBE.
• Coincident pool
• OBE in most critical direction.

(h) Loading Condition 4-4l- Coincident Pool + MDE.
• Coincident pool
• MDE in most critical direction.

TABLE 6.3
PUMPING PLANT LOADING -CONDITION CLASSIFICATION
STRUCTURE TYPE: PUMPING PLANTS, EM 1110-2-3104

Load Case	Loading Description	Classification
4-4a	Construction Condition	UN
4-4b	Normal Operating Condition	U
4-4e	Maximum Design Flood (MDF)	U/UN/E
4-4f	Maximum Pump Thrust	U/UN/E
4-4g	Maintenance Condition	UN
4-4j	Pumping Plant Inundated	E
4-4k	Coincident Pool + Operating Basis Earthquake (OBE)	UN
4-4l	Coincident Pool + Maximum Design Earthquake (MDE)	E

It is noted that the stability requirements based on EM 1110-2-3104 are more stringent than those in the newer EM 1110-2-2100; however the Transmittal letter accompanying EM 1110-2-2100 states the newer document was developed to "provide adequate safety factors for all types of structures and loading conditions, while reducing excess conservatism for infrequent loadings of short duration. This will result in project cost savings when compared to some structures designed using previous criteria. Stability criteria in other manuals are being revised to be consistent with this manual. In the interim, where there are conflicting stability criteria, the provisions of this manual shall govern."

The proposed optional layouts have been designed to a screening level without a sheet pile cutoff or toe drains. Global stability is achieved by increasing the structural mass to resist external loads. A high water table was assumed to the ground surface on the protected or resisting side of the plant, even though it was also assumed that the pump bay was only filled to the minimum pump elevation. Thus the analyses are conservative.

6.2.1.3. Seismic Stability and Frost Penetration

A seismic analysis should be performed for the proposed pump stations. Seismic forces should be developed using pseudo statically-derived accelerations. The resulting seismic forces will then be compared to the flood-induced water and/or soil forces applied to the pump plant structures. As seismic loads are not imposed simultaneously with the flood loads, a determination should be made as to whether or not the seismic loads control the stability or structural analysis of the pump plant. Although the seismic load condition is not expected to be a controlling case, it should still be checked.

When designing the foundation of the pump stations, resistance to frost upheaval should be considered. The foundation should be founded to a depth of 49 inches below grade to account for frost penetration, per UFC 3-301-01. Frost depth was estimated by the nearest location listed in the UFC, Grissom Air Reserve Base (ARB). Given that Huntington is more north of the ARB, frost penetration could be slightly higher, but the variation inherent due to this assumption is negligible for cost estimating purposes. Detailed investigation will need to be performed in order to obtain a more accurate value during design.

6.2.2. Construct Bar Screen Barrier at Existing Weir, Alternative F, (Huntington Dam)

The Huntington Dam is a six foot high concrete dam structure on the Little River in Huntington, Indiana. The dam is approximately 20 miles west of Eagle Marsh, and it is presently unknown as to who owns or has authority over the structure. The current condition of the structure has not been verified, but it should be noted that water is undercutting the dam at about mid-channel (see Photo 6.1). Ideally, the construction/design of the physical barrier should only minimally impact the existing structure, if at all. Any construction that modifies the existing dam would hold the customer liable in a failure event.

Photo 6.1: Huntington Dam during Summer Flow

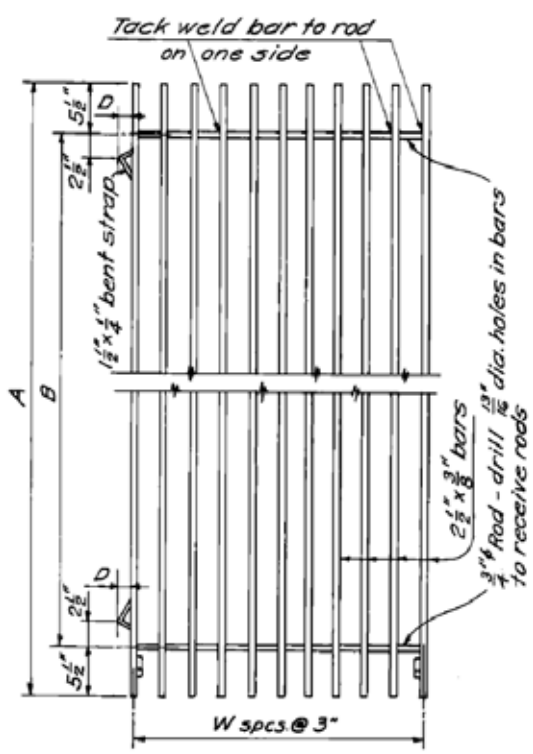
Photo 6.2: Overhead View of Huntington Dam

6.2.2.1. Description of Alternative

The concept behind Alternative F is to create a physical barrier adjacent to the existing dam to prevent the invasive species from swimming upstream during normal flow conditions as well as up to that of the 1% annual chance flood. Top of dam elevations have been surveyed at a rough average of 720.65 (NAVD88), and the 1% annual chance event elevation with risk and uncertainty is calculated to approximately 727. Estimating from a surveyed bank point upstream of the structure, it is assumed that the river bottom elevation downstream is 710. As opposed to placing the physical barrier in the vertical position, it is desired to slope the barrier up to the required height to aid in maintenance of the barrier. The barrier itself should be similar in fashion to the trash rack of a pump station inlet channel, steel bars spaced a desired length in the longitudinal direction with a transverse bar every two to three feet. The "barrier rack" will then be supported by either a frame or concrete pier spaced as necessary to allow the barrier rack to clear span between supports. For more details on the barrier and supports, see corresponding Sections 6.2.2.2 and 6.2.2.3, respectively.

6.2.2.2. Barrier Configuration

The physical barrier is intended to perform in a manner similar to that of a trash rack in a pump station inlet channel. Given that fact, it would be beneficial to mimic the configuration of a typical trash rack. See Figure 6.1 for a typical trash rack configuration out of a Local Flood Protection Project's "As-Built" drawings.



During design, a desired spacing of the longitudinal bars should be selected. The customer should decide on the spacing to ensure a balance between the species size (and possibly maturity) which are required to be blocked and the extent and degree of stream borne trash that could inhibit flow requiring frequent rack maintenance cleaning. In addition to those considerations, a few environmental factors should also be taken into account prior to selecting the spacing.

The barrier rack should be capable of withstanding an impact force from a large diameter log. Judging from photos taken on a site visit in March of 2010, it appears that trees of diameters in magnitudes of one to two feet regularly pass over the structure, see Photo 6.3. The spacing of the bars needs to adequately resist such an impact force.

Figure 6.1: Typical Trash Rack Configuration

Another design factor that could affect the spacing of the bars are concerns with ice accumulation. According Figure 10-2 of ASCE 7-08, Huntington has a one inch 50-year mean recurrence interval uniform ice thickness due to freezing rain. Chapter 10 further explains that this value should be applied radially to any member unprotected from the elements. A one inch thick coating of ice would reduce the effective spacing on the barrier rack by two inches during periods of freezing temperatures. To avoid any

Photo 6.3: Typical Large Logs that Impact Dam

disturbances to the hydraulics of the stream, the minimum spacing of the bars should be 2 ½ inches, larger if possible. If a smaller spacing is required to block certain aquatic nuisance species, a heating element would need to be implemented to ensure substantial amounts of ice does not build up on the barrier rack.

Given that the structure is constructed over an active river and the barrier is to be designed to provide protection during the 1% annual chance flood event, careful considerations need to be taken to extend the life of the structure due to exposure to moisture and submerged conditions. Selection of material/coating of the barrier rack should be based on either REMR-EM-6 or REMR-EM-11 from the Construction Engineering Research Laboratories within the Army Corps of Engineers. It is recommended that galvanized steel be avoided in this application. Galvanization, although primarily intended for members in high moisture conditions, does not necessarily perform well in submerged cases. Stainless steel or a waterproof coating should be applied per the referenced REMRs.

6.2.2.3. Pier Supports

The support for the physical barrier should be concrete piers, but a steel frame could also be used. Concrete would be more beneficial since it will require less maintenance in this hydraulic condition, but a steel frame could possibly be cheaper to construct depending on the design. For cost estimating purposes, a concrete pier system will be assumed.

The number of concrete piers will be based on the maximum allowable clear span designed for the barrier rack. Clear spans of existing trash racks at Local Flood Protection Project (LFPP) pump stations are typically 15-25 feet apart; piers should be similarly spaced. The length of the physical barrier was estimated by measuring the extents of the 1% annual chance event elevations (see Figure 7.5-1), which equates to approximately 225 feet. This would require 9-15 concrete piers depending on the spacing selected. Piers should be placed as close to the Huntington Dam as possible without impacting the structure. Piers should be founded on a spread footing bearing on rock of a designed thickness and width.

Figure 6.2: Limits of 1% Annual Chance Event, (Indiana DNR, 2004)

A design case that should be considered when designing the foundations of the concrete piers is a low flow winter condition. The water levels could get low enough on the downstream side to expose the river bed during the winter months. In this event, frost upheaval could pose an issue to the foundations of the pier structures. The force of frost upheaval should be considered during the foundation design.

Dimensions of each pier support will be determined by the slope of the barrier desired. In Table 6.4, the variations of length based on height and slope of the piers and barrier rack are listed. The minimum height that the top of protection needs to be designed to is the 1% annual chance event elevation including additional height for risk and uncertainty. The height of the piers is calculated from that value, which is 727, then subtracting the estimated height of the river bottom, 710. Therefore, the top of protection required is 17 feet, which is approximately 6.5 feet higher than the top of dam. The barrier rack would be the same height as the Huntington Dam at the most upstream end (720.65), and then slope up to the required top of protection at the downstream end. The 27 feet tall option is included in the table in case the top of protection needs to be extended to account for the aquatic nuisance species' ability to jump above water. The Environmental Protection Agency (EPA) reports that Silver Carp, a species of Asian carp, can jump up to 10 feet into the air. It may not be feasible to design the barrier dam to that height, but the dimensions are included in case that is a desired option.

TABLE 6.4
LENGTHS OF PIERS AND BARRIER RACK

	Length of Concrete Pier		Length of Barrier Rack	
	100 Year Elevation	100 Year Including Jumping Ability	100 Year Elevation	100 Year Including Jumping Ability
	Top of Protection: 17 feet	Top of Protection: 27 feet	Top of Protection: 17 feet	Top of Protection: 27 feet
1 on 12	76.20	196.20	76.46	196.88
2 on 12	38.10	98.10	38.63	99.45
3 on 12	25.40	65.40	26.18	67.41
4 on 12	19.05	49.05	20.08	51.70
5 on 12	15.24	39.24	16.51	42.51
6 on 12	12.70	32.70	14.20	36.56
7 on 12	10.89	28.03	12.60	32.45
8 on 12	9.53	24.53	11.45	29.48
9 on 12	8.47	21.80	10.58	27.25

A low sloped barrier may perform better in attempting to contain the aquatic nuisance species. The species may not easily see the edge of the structure, and therefore may not try to jump it. Although, the smaller the slope, the more maintenance would be required. Shallow slopes will more than likely accumulate large amounts of debris, and would have to be cleared on a regular basis. During design, the necessity of an anchorage or clamping system of the barrier rack to the concrete piers should also be investigated. Reference is made to Alternative F Site Plan CS108 in Appendix G.

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7.1. REFERENCES

1) EM 1110-2-3102 "*General Principle of Pumping Station Design and Layout*" U.S. Army Corps of Engineers, dated 28 February 1995

2) EM 1110-2-3105, "Mechanical and Electrical Design of Pumping Stations" U.S. Army Corps of Engineers, dated 30 November 1999

7.2. STRUCTURAL ALTERNATIVES

7.2.1. Construct an Earthen Berm and Pump Station, Alternative C, (Homestead Road)

A conceptual one-line power distribution diagram was developed for the proposed pump station for Alternative C as described in Appendix F Section 1.5.3. One line diagram utilized a system voltage of 4160 volts. A lighting transformer integral to the switch gear was shown at 240 volts. Design included new medium voltage switchgear with motor starters with reduced voltage soft start capability, and a lighting panel board for general building loads. A budgetary cost estimate was requested from an application engineer at the electrical manufacturer Eaton. Initial estimates were roughly $530,000 for all power distribution equipment. Due to the size of the pump and the simplicity of the necessary control equipment, (all pumps will be manually activated and shut off) a conservative estimate for the control system is $5,000.

The required station power was calculated to be roughly 4 megavolt-ampere (MVA). This number is extremely high and a cost for utility procurement was not determined due to the infeasibility of the required power amount. Power one line diagram was designed to 4160 volts.

7.2.2. Construct a Permeable Berm with Telemetered Sluice Gates, Alternative D, (Amber Road)

A conceptual plan was developed for the permeable berm with telemetry-activated sluice gates. This plan includes actuated gates, which are controlled from three telemetry systems at different locations in close proximity to the site. Two of the telemetry systems shall be located at other locations. The final shall be local to the site.

7.2.3. Construct Vertical Drop Structures with Telemetered Sluice Gate, Alternative G, (Homestead Road)

A conceptual plan was developed for the vertical drop structures with a telemetry-activated sluice gate. This plan includes an actuated gate, which is controlled from three telemetry systems at different locations in close proximity to the site. Two of the telemetry systems shall be located at other locations. The final shall be local to the site.

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SECTION 8
MECHANICAL ENGINEERING

8.1. REFERENCES

1) EM 1110-2-3102 "*General Principle of Pumping Station Design and Layout*" U.S. Army Corps of Engineers, dated 28 February 1995

2) EM 1110-2-3105, "Mechanical and Electrical Design of Pumping Stations" U.S. Army Corps of Engineers, dated 30 November 1999

8.2. STRUCTURAL ALTERNATIVES

8.2.1. Construct an Earthen Berm and Pump Station, Alternative C, (Homestead Road)

Two different pump station configurations have been preliminarily investigated. The pump station is to be located at the corner of Graham-McCulloch Ditch and Homestead Road in Fort Wayne, Indiana. The "prevent" option utilizes grinder pumps and the other option utilizes submersible "can style" pumps. The station will have a minimum pumping capacity of 50 CFS and a maximum pumping capacity 1200 CFS as determined by the Hydrology and Hydraulics Section.

The first alternative is a grinder pump station configuration. Investigation into grinder pumps was requested due to their ability to grind small foreign objects that may enter the pump station. This also reduces the risk of movement of aquatic nuisance species. Due to a grinder pump having inherently smaller pumping capacities, this configuration would require in excess of 75 grinder pumps depending on the pump manufacturer and exact impeller selection. Additionally, this configuration would require a massive and complex pump station structure to house the pumps and an extensive operation and maintenance schedule. Based on this, no further investigation was conducted into a grinder pump configuration.

The second alternative is a "can style" submersible pump configuration. A "can style" pump was selected versus a typical vertical column pump because the pumps can be removed from pump station floor thus reducing confined space entry. The downfall to a submersible pump or vertical column pump configuration is that there is no guarantee of preventing movement of aquatic nuisance species. Since the pump intake and impellers are larger there is an increased

risk that some aquatic nuisance species may pass through the pump. The pump station features are depicted below. These features are rough and for cost estimating purposes only. If the pump station option is selected then a detailed design will be implemented.

(1) Size and Number of Pumps: This pump station configuration utilizes eleven "can style" pumps for the primary flow and one submersible pump for dewater the sump if maintenance is required. Eight of the primary pumps will have an approximate capacity of 130 CFS while the remaining three pumps will be approximately 50 CFS for typical daily inflow. Each "can style" pump will have a steel pump tube to house the pump and a formed suction intake (FSI). The dewater pump will only be installed by a rail system when dewatering is necessary. This reduces the chance of the pump becoming silted in when it is not being operated.

(2) Pump Discharge Pipes: Each 130 CFS pump will utilize a 48-inch discharge pipe and each 50 CFS pump will utilize a 30-inch discharge pipe. The discharge pipes will run from the sump well through the earthen berm and then terminate back into Graham-McCulloch Ditch. Each discharge pipe will utilize gravity type flap gates to prevent backflow into the pump sump. Another option would be having the discharge pipes terminate at a discharge well that would then direct all the water back into McCulloch Ditch by a large gravity pipe. Each discharge pipe will have a gravity type flap gate in the discharge well. No matter which option is selected each discharge pipe will have a gate valve as a secondary means of closure. Additionally, each discharge pipe may require an air vent depending on whether high points exist.

(3) Sluice Gate/Maintenance Bulkhead: A sluice gate or maintenance bulkhead structure will be located at the inlet of the pump station as a means to stop inflow for maintenance and repairs.

(4) Miscellaneous Features: A manually operated trash rack will be provided and designed to meet the requirements of EM 1110-2-3102. Ladders will be provided to access sumps for maintenance.

(5) Please see Structural Section for pump station structure.

(6) Final Design and pump selection will be based on cost and maintenance of the new equipment. The design will meet all of the requirements of the Corps of Engineers Engineering Manuals (EM) and Industry Standards.

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SECTION 9
OPERATION AND MAINTENANCE

9.1. OPERATION AND MAINTENANCE SCHEDULE

For the purpose of this study, preliminary operation and maintenance (O&M) considerations were developed for each alternative. This section provides a list of anticipated cost items for future operations, maintenance, replacement, and repairs to be incurred over a 50-year period of analysis for each of the nine structural alternatives. The mean annual O&M cost estimate was generated for each alternative, based on the 50 year period of operation.

9.2. STRUCTURAL ALTERNATIVES

9.2.1. Construct an I-Wall, Alternative A, (Eagle Marsh, Basin Divide)

- Repair/replace joint material of I-wall monoliths – every 15 years
- Annual inspection

The estimated annual O&M cost for Alternative A is $11,000.

9.2.2. Construct a Fence and Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative B, (Eagle Marsh, Basin Divide)

- Inspect fence after flooding event for possible damage and debris
- Remove debris from secondary debris fence – after each high water event
- Mowing – twice annually
- Replace metal fence material, every 10-20 years
- Replace fence posts, every 20-30 years
- Annual inspection

The estimated annual O&M cost for Alternative B is $18,000.

9.2.3. Construct an Earthen Berm and Pump Station, Alternative C, (Homestead Road)

- Mowing – twice annually
- Large electric utility bill - monthly
- Control system maintenance-as needed
- Crane load testing and maintenance-yearly
- Recondition pump motor– variable, assumed 1 motor every year starting in 5 years for the 50 cfs pumps, 1 motor every year starting in 20 years for the 130 cfs pumps
- Recondition pump components- variable
- Weekly inspection/maintenance of low-flow condition pumps
- Megger testing- annually
- Clean trash racks – monthly and/or after major storm events
- Pump preventive maintenance and lubrication – yearly
- Annual inspection

The estimated annual O&M cost for Alternative C is $600,000.

9.2.4. Construct a Permeable Berm with Telemetered Sluice Gates, Alternative D, (Amber Road)

- Repair erosion/scour areas following high water event
- Inspect berm after high water event to check for possible sediment and debris build up
- Inspect silt fence after every high water event
- Clean sediment from piping – every 10 years
- Debris removal from vegetative filer – annually
- Excavate sediment accumulation of berm – every ten years
- Electrical and communication utility charges for the telemetered sluice gate(s)
- Maintenance of telemetry components
- Annual inspection

The estimated annual O&M cost for Alternative D is $22,000.

9.2.5. Construct a Fence/Earthen Berm Combination, Alternative E, (Eagle Marsh, Basin Divide)

- Debris removal from fence after high water event
- Inspect fence and berm after high water event for possible damage
- Replace metal fence material, every 10-20 years
- Replace fence posts, every 20-30 years
- Annual Inspection

- Mowing – twice annually

The estimated annual O&M cost for Alternative E is $44,000.

9.2.6. Construct Bar Screen Barrier at Existing Weir, Alternative F, (Huntington Dam)

- Debris removal and disposal from debris boom – twice monthly from January – June, monthly from July – December.
- Damaged bar screens from debris will need to be removed and repaired/replaced as needed.
- Debris removal from bar screens – seasonally
- Annual inspection

The estimated annual O&M cost for Alternative F is $96,000.

9.2.7. Construct Vertical Drop Structures with Telemetered Sluice Gates, Alternative G, (Homestead Road)

- Clean debris from trash fence atop the intake structures after each high water event
- Clean debris from sluice gates - seasonally
- Electrical and communication utility charges for the telemetered sluice gate(s)
- Maintenance of telemetry components
- Annual inspection

The estimated annual O&M cost for Alternative G is $26,000.

9.2.8. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Alternative H, (Eagle Marsh, Basin Divide)

- Mowing – twice annually
- Annual inspection

The estimated annual O&M cost for Alternative H is $14,000.

9.2.9. Reconstruct Left Descending Graham-McCulloch Ditch Berm, Demolish Right Descending Berm, and Construct Multi-Cell Wetland Area, Alternative I, (Eagle Marsh, Basin Divide)

- Mowing – twice annually
- Annual inspection

The estimated annual O&M cost for Alternative I is $17,000.

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SECTION 10
COST ESTIMATE

10.1. REFERENCES

1.) ER 1110-2-1302 *"Engineering and Design- Civil Works Cost Engineering"* U.S. Army Corps of Engineers, dated 15 September 2008

2.) *"Agency Technical Review Guidance for Cost Engineering Products"* U.S. Army Corps of Engineers Directory of Expertise for Civil Works Cost Engineering, dated May 2011

10.2. BASIS OF ESTIMATE

The alternatives estimate is based on the design indicated in the report dated February 2012 and depicted on the site plans in Appendix G. This document is considered to be at screening level and given the parameters this estimate shall be considered a Class 4.

WBS: The estimate is organized per the Civil Works Work Breakdown Structure (WBS) by feature.

Acquisition Strategy: Per discussion with the PDT this project is projected to be awarded by "Full and Open Competitive Bidding" process.

Contractor Hierarchy: The estimator assumes different contractor hierarchies due to the range in structural alternatives. With alternatives that include earthen berms as the major work feature, then the Prime contractor is assumed to self-perform the earthwork and subcontract items like fencing and seeding. On alternatives where a concrete structure is the major feature of work, it was assumed that the Prime contractor would perform concrete work and subcontract most other activities.

Construction Methods: The estimator's approach for the mass excavation work items included dozers, hydraulic excavators, and off-road articulating trucks due to the digging depths required and relatively small foot prints of the berms. With the berms only having a 10' crown width and a required six foot deep inspection trench, it was assumed that an excavator and dozer combination was best suited for this task. The work would

commence with an excavator demolishing any existing berm and loading off-road trucks that would dump the material in stockpiles in the work limits. The inspection trench would then be performed using again an excavator dumping the material along side the sloped backed trench. Since this area is a marsh, dewatering will likely be required when digging just a few feet under the existing grade. A dozer will then back fill the trench with compaction from a riding sheepsfoot type roller compactor. The berm will then be constructed by either on-site fill from demolition or off-site fill. On-site fill operations will include an excavator loading the off-road trucks at various stock fill locations. A dozer will then shape the berm placement from the dumped fill. The shaped fill will then be compacted by the means of a riding sheepsfoot type compactor.

Other work items were assumed by using common construction practices. Specifically, the sheet pile in Alternative "A" would be performed by a crane handled hammer and the concrete component would be placed by the means of pumping. The fence in Alternative "B" would be performed first by trenching the footprint, then installing the fence by traditional methods, then backfilling the trench with sand, and setting precast concrete barriers against posts. A subcontractor quote was obtained for this item. Excavation methods described above would be utilized in the pump station Alternative "C". The construction would be performed like any other vertical structure. Alternative "D" would utilize a loader and excavator to embank the aggregate around the perforated pipes that make up the permeable dam. Alternative "E" would be approached by both excavation and fencing methods previously mentioned. Alternative "F" involves constructing concrete piers and bar screens directly adjacent to the downstream side of an existing low-height dam. The estimator assumed a two phase cofferdam consisting of sheet pile panels to create a dry working area. The concrete piers would then be cast-in-place with ready mix being unloaded into a placing bucket maneuvered by a crane to the piers. Alternative "G-I" were approached by excavation methods described above.

10.3. PRICING

Quotes were received for significant or specialized materials and noted throughout the baseline estimate. Aggregate pricing used throughout all alternatives was obtained from Hanson Aggregate (Mr. Rick Hullinger (260) 438-2403). Concrete pricing was obtained from Erie Haven based on the assumption of a 4000 psi mix throughout several alternatives (Mr. Rick Vorndran (260) 760-1269). Sheet pile pricing was obtained from L.B. Foster (Mr. Rich Fifield (800) 824-6166) for the I-wall in Alternative "A". A quote for material and installation was received from R&C Fence (Mr. Don Roop Jr. (260) 478-7667) for fencing found in Alternatives B and E. Quotes were also received for the pumping station pumps and electrical switchgear through the help of the respective engineers.

Crew and production rates used in the alternatives estimate were from the cost book or derived by the estimator. Production rates different from the cost book for mass excavation were derived by the estimator using the Caterpillar Handbook, 39th Edition.

Cost sources: 2010 Cost Book - English. Updated material costs per quotes received and/or production rates as appropriate per estimator's judgment.

Wage Rates: As indicated by the Davis-Bacon Act, Allen County, Indiana decision number IN00006 02/17/2012.

Equipment: The 2009 Equipment Ownership and Operating Expense database Region 2. Updated fuel costs to reflect current market conditions.

Material: The 2010 Cost Book – English (Effective Pricing Date Jan 2010). Updated material costs per quotes received for the major and various items as noted in the estimate costs items.

All costs identified Feature 01 - Lands and Damages are total costs to owner, provided by Corps of Engineers, Louisville District, Real Estate Division. Costs include a 25% contingency. No contractor assigned.

Project Planning, Engineering, and Design (PED) are assessed at 12% of estimated construction cost consisting of Feature 02, Feature 04, Feature 11, and Feature 13. Basis comes from recent Olmsted out-year contracts effort and Paducah Feasibility Report.

Construction Management: 7.5% was used for Construction Division oversight during construction and is based on the recent projects.

10.4. MARKUPS

Price Level Adjustment: For the cost items based on the 2010 Cost Book database, an "inflation" adjustment of 6.3% was applied based on Engineering News Record (ENR) values (Oct11/Jan 10). This markup was not applied to cost items that were supported by current vendor pricing. An escalation rate of 12% was also applied to the MCACES estimate to capture escalation from the estimate pricing level of FY 2012 Q1 to the midpoint of construction of FY 2016 Q2. The four year average of the ENR Building Cost Index is nearly 3% whereas Civil Works Construction Cost Index System (CWCCIS) was running over 4% per year.

Contingencies: The contingencies were developed based on other historical project contingencies. This includes the 19.7% recently experienced with the Olmsted PACR and 19% for the Feasibility Report for the Paducah, KY Flood Protection Rehabilitation Project (FY10). This report is still a precursor to the Feasibility and should be expected to have higher risks. Therefore, 25% was assessed to Alternatives A, B, E, H, and I with the remaining alternatives having 30%. The exception being that Alternative C includes building a pumping station on the Graham-McCulloch ditch. Due to significant power requirements, rough layout, and lacking reconnaissance it was assessed at a 50% contingency. The "*Agency Technical Review Guidance for Cost Engineering Products*"

Directory of Expertise for Civil Works Cost Engineering, dated May 2011 was referenced for the level of contingencies required at this effort.

10.5. SCHEDULE

The estimator's projected project schedule is as follows:
Start of PED: Oct 2013;
Midpoint of PED: Jun 2014;
RTA: Feb 2015;
Start of Construction: Apr 2015;
Midpoint of Construction: Jan 2016;
Completion of Construction: Oct 2016

10.6. ALTERNATIVES ESTIMATE

The alternatives estimate summarized at the account level is provided on the following pages:

U.S. ARMY CORPS OF ENGINEERS

Louisville District

Alternatives Estimate
Aquatic Nuisance Species Controls Report
Wasbash-Maumee Basin Connection
Fort Wayne, Indiana
February-12

Alternative	WBS Account	Description	Cost	Escalation	Contingecy %	Contingency Amount	Totals
A		Construct Concrete I-Wall w/ Sheet Pile					
	1	Real Estate	$119,000	$12,495	25%	Included	$131,495
	11	Levees & Floodwalls	$8,313,839	$997,661	25%	$2,327,875	$11,639,375
	30	Planning, Engineering, and Design	$997,661	$74,825	25%	$268,121	$1,340,607
	31	Construction Management	$623,538	$74,825	25%	$174,591	$872,953
						Alternative A- Estimated Total Cost	**$14,000,000**

Alternative	WBS Account	Description	Cost	Escalation	Contingecy %	Contingency Amount	Totals
B		Construct a Fence and Reconstruct the Left Descending Graham-McCulloch Ditch Berm					
	1	Real Estate	$189,000	$19,845	25%	Included	$208,845
	11	Levees & Floodwalls	$1,745,360	$209,443	25%	$488,701	$2,443,504
	30	Planning, Engineering, and Design	$209,443	$15,708	25%	$56,288	$281,439
	31	Construction Management	$130,902	$15,708	25%	$36,653	$183,263
						Alternative B- Estimated Total Cost	**$3,200,000**

Alternative	WBS Account	Description	Cost	Escalation	Contingecy %	Contingency Amount	Totals
C		Construct an Earthen berm and Pump Station					
	1	Real Estate	$34,000	$3,570	25%	Included	$37,570
	13	Pumping Plant	$12,469,143	$1,496,297	50%	$6,982,720	$20,948,160
	30	Planning, Engineering, and Design	$1,496,297	$112,222	50%	$804,260	$2,412,779
	31	Construction Management	$935,186	$112,222	50%	$523,704	$1,571,112
						Alternative C- Estimated Total Cost	**$25,000,000**

Alternative	WBS Account	Description	Cost	Escalation	Contingecy %	Contingency Amount	Totals
D		Construct a Permeable Berm with Telemetered Sluice Gates					
	1	Real Estate	$157,000	$16,485	25%	Included	$173,485
	4	Dams	$4,349,972	$521,997	30%	$1,461,591	$6,333,559
	30	Planning, Engineering, and Design	$521,997	$39,150	30%	$168,344	$729,490
	31	Construction Management	$326,248	$39,150	30%	$109,619	$475,017
						Alternative D- Estimated Total Cost	**$7,800,000**

Alternative	WBS Account	Description	Cost	Escalation	Contingecy %	Contingency Amount	Totals
E		Construct Fence/Earthen Berm Combination					
	1	Real Estate	$202,000	$21,210	25%	Included	$223,210
	11	Levees & Floodwall	$2,370,849	$284,502	25%	$663,838	$3,319,189
	30	Planning, Engineering, and Design	$284,502	$21,338	25%	$76,460	$382,299
	31	Construction Management	$177,814	$21,338	25%	$49,788	$248,939
						Alternative E- Estimated Total Cost	**$4,200,000**

Alternative	WBS Account	Description	Cost	Escalation	Contingecy %	Contingency Amount	Totals
F		Construct Bar Screen Barrier at Existing Weir					
	1	Real Estate	$85,000	$8,925	25%	Included	$93,925
	6	Fish and Wildlife Facilities	$1,447,586	$173,710	30%	$486,389	$2,107,685
	30	Planning, Engineering, and Design	$173,710	$13,028	30%	$56,022	$242,760
	31	Construction Management	$108,569	$13,028	30%	$36,479	$158,076
				Alternative F- Estimated Total Cost			**$2,700,000**

Alternative	WBS Account	Description	Cost	Escalation	Contingecy %	Contingency Amount	Totals
G		Construct Vertical Drop Structures with Telemetered Sluice Gate					
	1	Real Estate	$25,000	$2,625	25%	Included	$27,625
	4	Dams	$2,726,711	$327,205	30%	$916,175	$3,970,091
	30	Planning, Engineering, and Design	$327,205	$24,540	30%	$105,524	$457,269
	31	Construction Management	$204,503	$24,540	30%	$68,713	$297,757
				Alternative G- Estimated Total Cost			**$4,800,000**

Alternative	WBS Account	Description	Cost	Escalation	Contingecy %	Contingency Amount	Totals
H		Reconstruct Left Decending Graham-McCulloch Ditch Berm					
	1	Real Estate	$230,000	$24,150	25%	Included	$254,150
	11	Levees & Floodwalls	$3,234,560	$388,147	25%	$905,677	$4,528,384
	30	Planning, Engineering, and Design	$388,147	$29,111	25%	$104,315	$521,573
	31	Construction Management	$242,592	$29,111	25%	$67,926	$339,629
				Alternative H- Estimated Total Cost			**$5,700,000**

Alternative	WBS Account	Description	Cost	Escalation	Contingecy %	Contingency Amount	Total Alternative Estimate
I		Reconstruct Left Decending Graham-McCulloch Ditch Berm, Demolish Right Descending Berm, and Construct Multi-Cell Wetland Area					
	1	Real Estate	$310,000	$32,550	25%	Included	$342,550
	11	Levees & Floodwalls	$4,084,199	$490,104	25%	$1,143,576	$5,717,879
	30	Planning, Engineering, and Design	$490,104	$36,758	25%	$131,715	$658,577
	31	Construction Management	$306,315	$36,758	25%	$85,768	$428,841
				Alterantive I- Estimated Total Cost			**$7,200,000**

Backup File: X:\ED-M-C\Civil\FY12\114597 - Ft. Wayne Interbasin Study - Asian Carp\FINAL REVISED ATR DOCS - FEB 2012\Estimate

Prepared By:_____ Checked By:_____ Approved By:_____

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