Hancock County Flood Risk Reduction Program

Final Report: Data Review, Gap Analysis, USACE Plan and Alternatives Review, and Program Recommendation

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Sign-off Sheet

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

Hancock County and the City of Findlay, Ohio areas experience frequent and significant overbank flooding from the Blanchard River and its major tributaries, Eagle Creek and Lye Creek. The U.S. Army Corps of Engineers, Buffalo District (USACE) proposed that a 9.2-mile flood diversion channel be constructed to the south and west of the City to alleviate flooding in downtown. The diversion channel was proposed to convey flood flows from Eagle Creek up to the 4% annual chance exceedance (25-year) event, approximately 3,000 cubic feet per second (cfs), and discharge them back into the Blanchard River downstream of Township Road 130. The USACE project advanced through the planning stages resulting in a Draft Detailed Project Report / Environmental Impact Statement (April 2015) and an unpublished Draft "Final EIS" (March 2016). The most recent cost estimate for the project as proposed by the USACE was approximately $81 million for the 25-year conveyance option and had a draft benefit to cost ratio (BCR) of just less than 1.0, based upon the National Economic Development (NED) model.

In 2016, the project changed from one led by the USACE and more rigidly guided by Federal rules, regulations, and policies to a locally-led, community driven project led by the Hancock County Commissioners and City of Findlay, in cooperation with the Maumee Watershed Conservancy District (MWCD). Stantec Consulting Services Inc. (Stantec) was asked to complete a Gap Analysis (Phase I) as an initial review and assessment of the prior efforts completed by the USACE, with the intent of continuing forward with design and permitting of the Western Diversion of Eagle Creek project. The Gap Analysis yielded four (4) key gaps (listed below) that shifted Stantec's work from advancing the Western Diversion of Eagle Creek to a more comprehensive risk based review and alternatives analysis.

- The project had a poorly defined objective. A more specific and measurable project goal is needed to shape the future phases of the project to determine if the USACE Plan is the correct choice for the local community.

- The latest draft BCR calculated by the USACE based upon the NED model was less than 1.0, the lowest allowable threshold for warranting federal funding and implementation of the proposed improvements by MWCD.

- A risk based evaluation of the performance of the proposed USACE diversion channel project had not been completed. As stated in the USACE Feasibility Study, "There would be a minimal performance of Alternative 13 (Western Diversion of Eagle Creek) when storm events are primarily over either the Blanchard River or Lye Creek watersheds upstream of Findlay, with minimal storm events over the Eagle Creek watershed."

- There are conflicting results within the USACE hydraulic model and reported water surface elevation (WSE) reductions from the USACE Plan. The August 2015 update from the USACE showed an estimated 4.5 feet reduction in the WSE during the 1% annual chance exceedance (ACE) (100-year) flood event at Main Street, while other sources estimated only a 2-foot reduction.

Stantec developed a plan to address or collect information believed to be missing in the material provided by the USACE before proceeding with refinement of the proposed project. The Phase II scope of work included a Work Plan to fill the gaps identified during Phase I, a risk based evaluation of the USACE Plan (Alternative 13 ~ Western Diversion of Eagle Creek), and an evaluation of the Plan's effectiveness (Proof of Concept). Phase II was completed in two (2) distinct parts; Part A included additional data collection and analysis and Part B included the review and refinement of the initial concept and the study of potential project modifications.

The primary outcome from Part A was the development of conclusions and accumulation of data to resolve the four (4) key gaps.

- First, the MWCD, Hancock County, and the City of Findlay provided a clear and measurable program goal of working to achieve a WSE reduction within the Blanchard River and its tributaries during the 1% ACE (100-year) event that will allow Main Street and other critical intersections in and around the City of Findlay to remain open for the passage of emergency response vehicles.

- Second, identification of opportunities for benefits, including those at the local and regional level, that are not currently included within the USACE analysis and should push the BCR well above 1.0.

- Third, the Stantec team highlighted the risks associated with the USACE Plan by comparing contributions to flooding in Findlay due to runoff from different portions of the Blanchard River watershed during different storm events. To further support this effort, analysis of regional precipitation data to discern more likely spatial and temporal patterns over the watershed will be incorporated into the design processes going forward.

- Finally, analysis confirmed the gap identified during the Hydrology and Hydraulics review showing a reduced benefit in flood reduction with the USACE Plan. The proposed diversion project would reduce the WSE by less than 2.0 feet in downtown Findlay, and not the 4.5 feet that was previously reported.

During Part B - Proof of Concept, Stantec reviewed the USACE Plan to determine if it would work, studied how effective it would be at reducing flooding, and analyzed ways to refine the proposed design concept to make it more effective. Several important issues were discovered during the review of the USACE Plan.

- The Western Diversion of Eagle Creek project only controls about 15% of the overall watershed contributing to the flooding in Findlay.

- The August 2007 storm was a distinct event that occurred over about 27-hours. Based on radar data, the center of the storm was approximately over the Eagle Creek and Lye Creek subwatersheds, which are in the middle of the overall Upper Blanchard River watershed. The storm produced a total of approximately 12 inches of rainfall at its center, while the outer bands over the distant portions of the watershed resulted in about 4-5 inches of precipitation. The USACE assumed uniform rainfall over the entire watershed during hypothetical storm events, which based on the August 2007 observations is a conservative assumption.

- Hydrologic modeling of similar rainfall events indicates a hydrologic response in the City of Findlay driven largely by travel time. Runoff from Eagle Creek, Lye Creek and the areas hydrologically close to downtown Findlay results in a shorter duration, more intense initial flood wave or hydrograph peak. The upstream areas of the Upper Blanchard River watershed have a larger portion of the contributing area, but the travel time to Findlay is greater and more attenuation of the flood wave occurs along the way. Flooding from this portion of the watershed results in a longer duration, less intense peak with a larger overall volume. The effect produces an aggregate flood hydrograph in Findlay that has two distinct peaks lagged by 12-hours or more and total duration of runoff significantly longer than the storm event.

    - The USACE Diversion Project would have reduced the first flood peak in 2007, but flooding in Findlay would have still been significant due to the volume and timing of runoff from the portions of the watershed outside of the Eagle Creek subwatershed.

- The Diversion project was only designed to divert the 4% ACE (25-year) flood event flows. Flows above the 25-year flood would continue downstream in Eagle Creek and through Findlay. The Diversion project will require refinements to meet the community’s goal.

- The USACE estimated the cost of the Diversion project to be more than $81 million. Increasing the capacity of the diversion channel to handle the 1% ACE (100-year) event would push the costs above $106 million.

Stantec’s work on Part B included review of project adjustments to the USACE diversion channel plan, as well as additional alternative solutions that could potentially modify, supplement, or even replace the diversion channel.

Stantec first analyzed ways to refine the USACE Plan. Stantec studied the diversion channel sizing, profile, and alignment and multiple inlet locations. Stantec also reviewed the concept of extending the diversion channel to the east to collect flow from Lye Creek and the Blanchard River. The diversion extension was not deemed cost effective as it would likely cost an additional $88 million over the $106 million for the Eagle Creek portion (when sized for the 1% ACE event), pushing the total cost to $194 million (including a 30% contingency).

Stantec also reviewed the hydraulic efficiency of the Blanchard River through and downstream of Findlay. Recommended channel improvements include the removal or four in-line riffles or low head dams, floodplain bench widening between the Norfolk Southern Railroad and Broad Avenue, and improvements to the Norfolk Southern Railroad Bridge. These improvements are expected to cost approximately $20 million (including a 30% contingency) and result in a 100-year event stage reduction at Main Street of approximately 0.9 feet, and even more during lower flows. The hydraulic improvements along the Blanchard River are expected to provide benefit for a range of flows within the river.

Stantec reviewed the potential for dry storage basins throughout the watershed. These conceptual project adjustments were reviewed for technical and environmental feasibility, community impacts and benefits, and preliminary opinions of probable costs. Two (2) areas were identified as having technical merit in reducing peak flows in Findlay. The first is a dry storage basin on Eagle Creek between US 68, County Road 45, and Township Road 49, and the second is a pair of basins south of Mt. Blanchard on the Blanchard River and Potato Run. Conceptual drawings of these sites are provided in the Appendices.

Finally, Stantec re-evaluated the Blanchard to Lye cutoff levee in conjunction with the potential storage alternatives that were identified and evaluated. Stantec determined that a smaller cutoff levee is still necessary to prevent flood waters from crossing over to Lye Creek. However, storage options upstream of Mt. Blanchard may reduce the peak flow on the Blanchard River such that the crossover flows and depths would be minimal even without the construction of a cutoff levee. Stantec is not recommending the Blanchard to Lye cutoff levee at this time.

Stantec recommends that MWCD advance with a flood risk reduction program comprised of the following projects.

- Channel improvements to the Blanchard River within the City of Findlay. The removal of four (4) low head dams or riffle structures, the widening of the floodplain bench between the railroad and Broad Avenue, and modifying the railroad bridge. These improvements can be made independently of the diversion or storage alternatives.

- Dry storage basin on Eagle Creek adjacent to US 68 in lieu of the diversion channel. This project has similar benefit as the diversion at a reduced cost.

- Dry storage basins on the Blanchard River and Potato Run, upstream of Mt. Blanchard. Providing storage at these locations reduces the secondary peak of the flood wave that occurs in Findlay due to singular storms and also helps in controlling out-of-bank flooding along the reach of the Blanchard River between Mt. Blanchard and Findlay. Controlling flooding along that reach has the ancillary benefits of reducing flood frequency to agricultural areas and reducing flood potential along Lye Creek due to potential overflow between the Blanchard River and Lye Creek during large flood events.

The preliminary opinion of probable costs developed for dry storage basins on Eagle Creek, the Blanchard River, and Potato Run is approximately $140 million. Including the Blanchard River modifications in Findlay, along with the dry storage basins results in a preliminary opinion of probable cost of approximately $160 million. These preliminary opinions of probable cost include a 30% contingency. The contingency covers potential administrative and legal fees and obstacles that may arise during the detailed design and construction phases, such as minor utility relocations, site drainage, etc.

Tables E1 through E3 below present the benefits and impacts of the alternatives considered and relative planning level opinions of probable cost for each portion of the program.

Jack Faucett Associates (JFA), a sub-consultant to Stantec, has completed a review and analysis of the anticipated benefit categories utilized within the original USACE Plan (Western Diversion, 25-Year Capacity). Several additional regional and local benefits that could not be factored by the USACE have been identified for inclusion within the evaluation. Based upon the planning level opinion of probable cost for the recommended Full Program (Alternative 4) and the estimated benefits derived from implementation of the program, it is anticipated that the BCR for the Full Program will be at least 1.5. The anticipated BCR for the implementation of the Blanchard River Hydraulic Improvements component (Alternative 2) as an initial phase of work will be at least 4.0.

Stantec will continue to coordinate with the Maumee Watershed Conservancy District, Hancock County and City of Findlay to develop an implementation schedule and work plan for the proposed program following client review and comment on the Proof of Concept.

Table E1 – Benefit / Impact Summary HEC-RAS Results (SCS Type II – NOAA Atlas 14 100-Year, 24-Hour event (5.26 inches) equally distributed across watershed)

Alternative	Modeled Scenario	Blanchard River Maximum Flow at Main Street (cfs)	Blanchard River WSE at Main Street (Feet)	Reduction in WSE at Main Street (Feet)	Max Water Depth on Main Street (Feet) [5.]	Duration Water is 6 Inches Above Main Street (Hours) [6.]	Preliminary Opinion of Probable Cost (Base Cost)	Preliminary Opinion of Probable (With Contingency Included)
0	**Existing Conditions**	16,288	777.6	N/A	4.6	50	N/A	N/A
1	**USACE Plan** [1.]	13,295	776.7	0.9	3.6	45	$63.8 M	$80.9 M
1a	**USACE Plan Increased for the 1% ACE (100-year) Event Capacity**	Hydraulic analysis not simulated due to expected cost					$81.3 M	$105.7 M
1b	**USACE Plan Increased for the 1% ACE (100-year) Event Capacity – With Extension to Lye Creek and the Blanchard River**	Hydraulic analysis not simulated due to expected cost					$149.1 M	$193.8 M
2	**Blanchard River Modifications** [2.]	16,190	776.7	0.9	3.7	40	$15.3 M	$19.9 M
3	**Blanchard River Modifications + Eagle Creek Storage** [3.]	12,455	774.8	2.8	1.8	35	$68.8 M	$89.4 M
4	**Blanchard River Modifications + Eagle Creek Storage + Mt. Blanchard Storage** [4.]	11,078	774.0	3.6	1.0	15	$122.9 M	$159.7 M
5	**Blanchard River Modifications + Eagle Creek Storage + Mt. Blanchard Storage + Blanchard to Lye Cutoff Levee**	11,156	774.1	3.5	1.1	15	$129.3 M	$167.7 M

1. 9.2-mile diversion channel designed for the 4% ACE (25-year) event
2. Removal of four inline dam/riffle structures, floodplain bench widening between Broad Avenue and the Norfolk Southern bridge, and widening of the Norfolk Southern Railroad bridge
3. Dry storage basin on Eagle Creek between US 68, County Road 45 and Township Road 49 sized for the 1% ACE event
4. Dry storage basins on the Blanchard River and Potato Run south of State Route 103 and State Route 37 sized for the 1% ACE event
5. The low elevation at Main Street is approximately 773.0’
6. WSE 6 inches above low elevation at Main Street is approximately 773.5’

Table E2 – Benefit / Impact Summary HEC-RAS Results (SCS Type II – NOAA Atlas 14 100-Year, 24-Hour event (5.26 inches) equally distributed across watershed)

Alternative	Modeled Scenario	Total Acres Directly Impacted by Project Construction	Home Buyouts	New Bridges or Cul-De-Sacs	Area Impacted Outside of Existing Regulatory Floodplain	Acres Removed from Floodplain [7]	Agricultural Acres Directly Impacted by Project Construction [8]	Agricultural Acres Removed from Floodplain	Parcels Directly Impacted by Project Construction [9]	Parcels Removed from Floodplain
0	**Existing Conditions**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	**USACE Plan [1]**	960 [5]	1	13	960	1,690	780	1,140	75	1,670
1a	**USACE Plan Increased for the 1% ACE (100-year) Event Capacity**	~1,000	1	13	~1,000	Hydraulic analysis not simulated due to expected cost				
1b	**USACE Plan Increased for the 1% ACE (100-year) Event Capacity – With Extension to Lye Creek and the Blanchard River**	~1,500	5	19	~1,500	Hydraulic analysis not simulated due to expected cost				
2	**Blanchard River Modifications [2]**	2	0	0	2	280	0	40	5	760
3	**Blanchard River Modifications + Eagle Creek Storage [3]**	1,140 [6]	14	1	860	2,780	880	1,180	55	2,460
4	**Blanchard River Modifications + Eagle Creek Storage + Mt. Blanchard Storage [4]**	2,430 [6]	19	2	1,515	5,060	1,900	2,850	135	2,850
5	**Blanchard River Modifications + Eagle Creek Storage + Mt. Blanchard Storage + Blanchard to Lye Cutoff Levee**	2,460	19	3	1,545	5,280	1,910	3,040	145	2,840

1. 9.2-mile diversion channel designed for the 4% ACE (25-year) event
2. Removal of four inline dam/riffle structures, floodplain bench widening between Broad Avenue and the Norfolk Southern bridge, and widening of the Norfolk Southern Railroad bridge
3. Dry storage basin on Eagle Creek between US 68, County Road 45 and Township Road 49 sized for the 1% ACE event
4. Dry storage basins on the Blanchard River and Potato Run south of State Route 103 and State Route 37 sized for the 1% ACE event
5. Acreage from USACE Draft Final EIS report (Section 8.1)
6. Acreage under berm and expected 1% ACE (100-year) floodplain extents assumed to be acquired through fee-simple purchase
7. Does not include floodplain area within acreage impacted by project construction
8. Agricultural acres include cultivated crop and hay/pasture categories within the National Land Cover Dataset
9. Number of parcels not owned by the City of Findlay or Hancock County

Table E3 shows a summary of the preliminary opinions of probable costs expected for each combination of projects analyzed.

Table E3 – Preliminary Opinion of Probable Cost Summary Table for Each Alternative Option (With Contingency Included)

Alternative Option	Base Cost	Cost with Contingency
USACE Plan (25-Year Diversion of Eagle Creek)	**$63,804,000**	**$80,902,000**
Refined Diversion (100-Year Diversion of Eagle Creek)	$81,300,000	$105,690,000
Diversion Channel Extension (Eagle Creek to Blanchard River)	$67,800,000	$88,140,000
Total 100-Year Diversion Channel with Extension	**$149,100,000**	**$193,830,000**
Riffle/Inline Structures Removal	$780,000	$1,014,000
Floodplain Bench Widening and Railroad Bridge Modifications	$14,500,000	$18,850,000
Total Hydraulic Improvements	**$15,280,000**	**$19,864,000**
Eagle Creek Dry Storage Basin	$53,500,000	$69,550,000
Blanchard River Dry Storage Basin	$34,400,000	$44,720,000
Potato Run Dry Storage Basin	$19,700,000	$25,610,000
Total Storage	**$107,600,000**	**$139,880,000**
Blanchard to Lye Cutoff Levee (from USACE Draft EIS – Appendix B)	**$6,411,000**	**$7,965,000**

Abbreviations

ACE	Annual Chance Exceedance
AWA	Applied Weather Associates
BCA	Benefit Cost Analysis
BCR	Benefit-to-Cost Ratio
BFE	Base Flood Elevation
CFS	Cubic Feet per Second
CSRA	Cost and Schedule Risk Analysis
CY	Cubic Yards
DBH	Diameter at Breast Height
DDF	Depth-Duration-Frequency
EA	Environmental Assessment
GPS	Global Positioning System
HEC-FDA	Hydrologic Engineering Center's Flood Damage Assessment
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HHEI	Headwater Habitat Evaluation Index
HTRW	Hazardous, Toxic and Radioactive Waste
IDF	Intensity-Duration-Frequency
JFA	Jack Faucett Associates
LERRD	Lands, Easements, Rights-of-Way, Relocations, and Disposal/Borrow Areas

LiDAR	Light Detection and Ranging
MSG	Mannik and Smith Group
MWCD	Maumee Watershed Conservancy District
NED	National Economic Development
NEPA	National Environmental Policy Act
NRCS	Natural Resources Conservation Service
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
ODOW ONHD	Ohio Division of Wildlife Ohio Natural Heritage Database
OEPA	Ohio Environmental Protection Agency
OGRIP	Ohio Geographically Referenced Information Program
OHPO	Ohio Historic Preservation Office
OHW	Ordinary High Water
ORAM	Ohio Rapid Assessment Method
PEM	Palustrine Emergent
PMF	Probable Maximum Flood
QHEI	Qualitative Habitat Evaluation Index
RED	Regional Economic Development
ROD	Record of Decision
SOW	Scope of Work
TPC	Total Project Cost
TPCS	Total Project Cost Summary
USACE	United States Army Corps of Engineers

USFWS	US Fish and Wildlife Service
WOUS	Waters of the United States
WRDA 99	Water Resources Development Act of 1999
WQC	Water Quality Certification
WSE	Water Surface Elevation

1.0 INTRODUCTION

Hancock County and the City of Findlay, Ohio areas experience frequent and significant overbank flooding from the Blanchard River and its major tributaries, Eagle Creek and Lye Creek. The U.S. Army Corps of Engineers, Buffalo District (USACE, the Corps) proposed a 9.2-mile flood diversion channel outside Findlay to the south and west of the City. The diversion channel was proposed to convey flow from Eagle Creek and discharge into the Blanchard River approximately 1,500 feet west of Township Road 130. The project advanced through the planning stages resulting in a Draft Detailed Project Report / Environmental Impact Statement (Reference 1 - USACE Draft EIS – April 2015) and an unpublished Draft "Final EIS" (Reference 2 - March 2016) for the proposed project.

Stantec Consulting Services Inc. (Stantec) was contracted by the Hancock County Commissioners (Hancock County) in July 2016 to complete design and permitting for the Western Diversion of Eagle Creek project (USACE Plan); the project recommended by the USACE. Stantec is providing professional services related to the continuation of this flood risk reduction project in phases.

The first phase included Stantec's review of existing data associated with the analysis completed by the USACE in search of potential data and analysis gaps. A plan was developed to address or collect information believed to be missing from the material provided by the USACE from its analysis before proceeding with the refinement of the proposed project.

At the beginning of the second phase Hancock County ceded control of the project to the Maumee Watershed Conservancy District (MWCD). This phase included a Work Plan containing methods and schedules to fill in the gaps identified during Phase I, evaluation of the USACE Plan (Alternative 13) presented in the Draft Feasibility Study / Environmental Impact Statement (EIS), and confirmation of the USACE Plan's effectiveness (Proof of Concept). The purpose of the Phase II work was the progression of the technical efforts required to advance the proposed flood risk reduction project towards development of 30% design plans. Phase II was completed in distinct parts. Part A included additional data collection and analysis and Part B included review and refinement of the initial proposed design concept and study of potential project modifications. Parts A and B have been completed and are documented within this report.

This report summarizes the project background and the tasks performed by the Stantec team during Phase I and Phase II - Parts A and B and includes a recommendation for a flood risk reduction program. Stantec will coordinate with Hancock County, the City of Findlay, and MWCD to develop a separate work plan for the next Phase, 30% (or Stage 1) design plans following agency review of this report.

2.0 BACKGROUND

The study area is the Blanchard River Watershed, a sub-basin of the Western Lake Erie Basin in northwestern Ohio. The Blanchard River Watershed boundary is within Allen, Hancock, Hardin, Putnam, Seneca, and Wyandot Counties. The Blanchard River Watershed drains directly to the Auglaize River, which then flows into the Maumee River before entering Lake Erie. The Blanchard River Watershed consists of alluvial flatlands prone to flooding, resulting in repeated flood damages, including the population centers of Findlay and Ottawa.

This report focuses on the Upper Blanchard River watershed near the City of Findlay and the surrounding areas within Hancock County. Figure 1 shows an overview of the Upper Blanchard River watershed. The Findlay area experiences damages from overbank flooding because the Blanchard River and its major tributaries, Eagle and Lye Creeks, do not have sufficient capacity to convey the flow during significant storm events. The Blanchard River and its tributaries can convey small, frequent storms. However, during large rainfall events, flow exceeds channel capacity and overbank flooding occurs through the City and in nearby agricultural areas. Historical evidence shows substantial damage during large events, such as the 4% annual chance exceedance (ACE) (25-year) or greater floods, and during more frequent storms with higher intensities.

Per the National Weather Service's Advanced Hydrologic Prediction Service, "major flood stage" on the Blanchard River near Findlay occurs when United States Geological Survey (USGS) gage 04189000 at CR 140 is at 13.5 feet or greater. Figure 2 shows the historic flood crests at USGS gage 04189000 downstream of Findlay. The gage data at this site indicates the Blanchard River has reached or exceeded major flood stage sixteen times since 1913. Of these events, six have occurred since 2007. Five events between 2007 and 2016 are among the top ten stages on record; three events peaked at more than 3 feet over major flood stage; the August 2007 event reached a peak stage near the maximum recorded peak of 18.5 feet in 1913.

Flooding has caused extensive damage to downtown businesses and nearby residential areas. Water levels can remain above flood stage for several days, often inundating bridges and approach roads requiring closure. Rescue operations are often required during the floods, and significant cleanup and restoration expenses are incurred by the local, state, and federal government.

The repetitive flooding prompted the Western Lake Erie Study authorization under the Water Resources Development Act of 1999 (WRDA 99). Hancock County requested assistance from the USACE to study and recommend ways to reduce significant flood damages adjacent to the Blanchard River and its tributaries. The USACE Buffalo District began reviewing flooding problems on the Blanchard River in 2007. Meetings with the USACE project sponsor have taken place in person and via conference call on a regular basis since the major flooding event in the Blanchard Watershed in August 2007. Participants at these meetings have included USACE staff and personnel from Hancock County and the City of Findlay. The USACE Buffalo District initiated a General Investigation Feasibility Study in 2011 and prepared the Interim Feasibility Report for the Blanchard River Watershed to satisfy the WRDA 99 requirements and address the growing public concern about flooding.

Figure 1 – Upper Blanchard River Watershed Overview Map

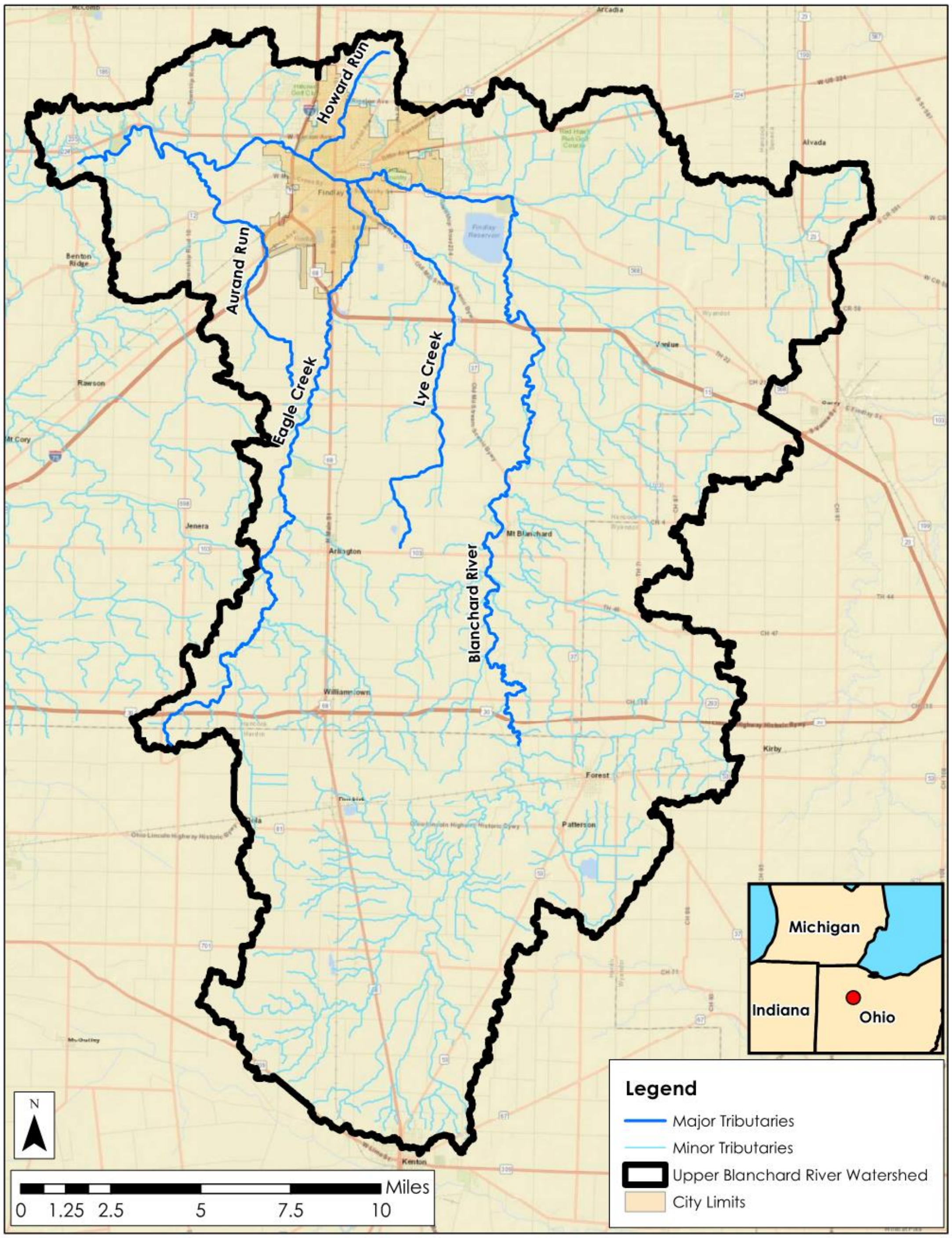
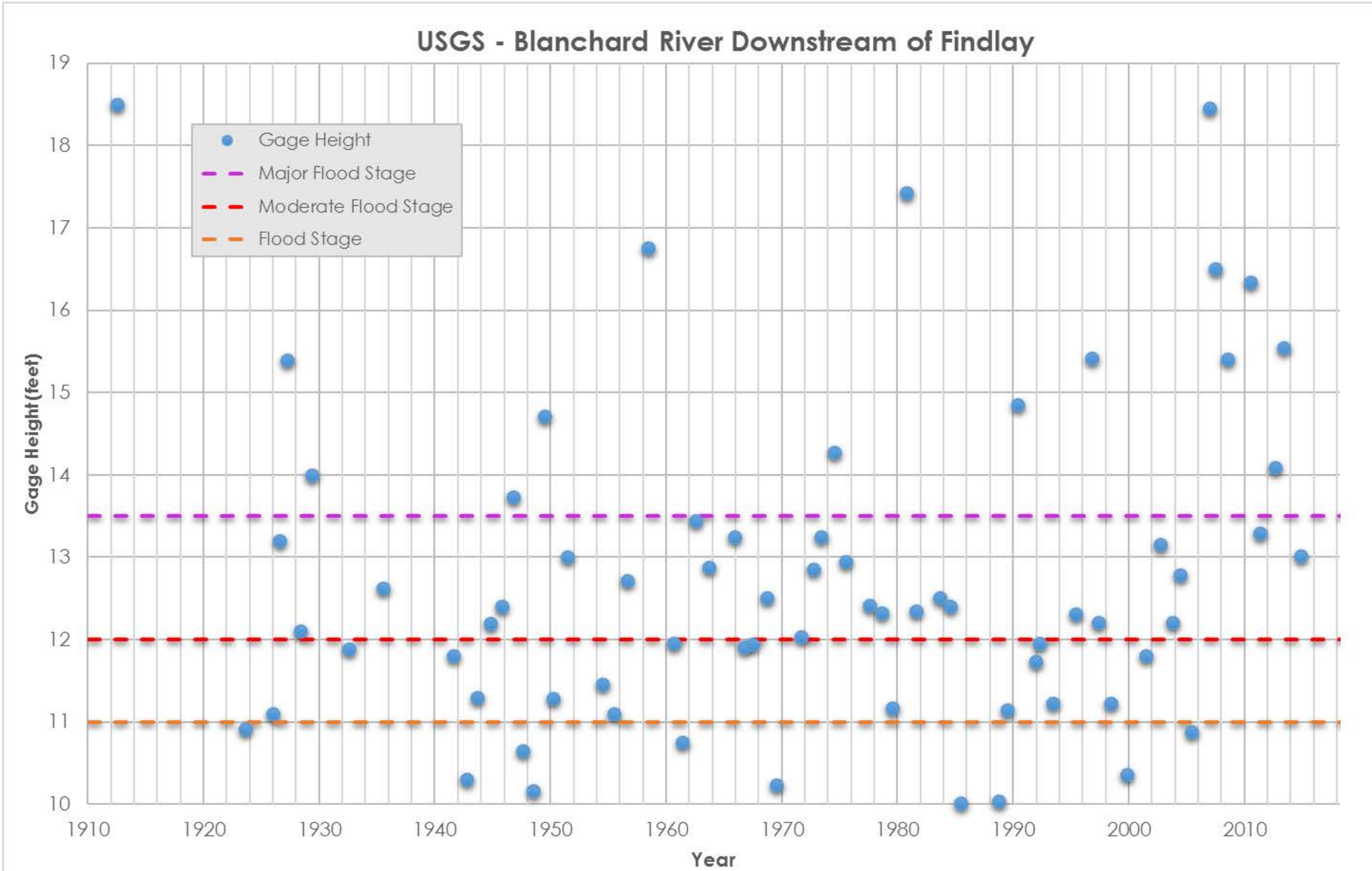


Figure 2 – Historic Flood Crests at USGS Gage 4189000 at County Road 140



2.1 USACE STUDY

The purpose of the USACE study was to evaluate measures for flood risk management in the Blanchard River Watershed, focusing on areas within the City of Findlay. The findings presented within the USACE Feasibility Report were used to determine if there existed a federal interest in providing flood risk management improvements in the Blanchard River Watershed near Findlay. The overall objective of the study was to reduce flood risk and improve the overall quality of life for the residents of the Findlay area. The USACE developed plans to address these objectives including a “No Action” plan and various combinations of structural and nonstructural measures. The USACE evaluated the economic and environmental impacts of each and then reported a recommended plan. The Feasibility Report and Draft EIS presented the results and the public, agency, and peer review comments.

2.1.1 Feasibility Study

The Feasibility Study included coordination with various interested parties and agencies. The Buffalo District USACE participated in regular project meetings since the 2007 flood of the Blanchard River Watershed. Meetings with the resource agencies, including four state agencies, the U.S. Fish and Wildlife Service, and the Federal Emergency Management Agency, have occurred annually, for the most part, since 2009. Meetings with the public began with public scoping meetings in November 2011. Subsequent public meetings included landowner meetings in May 2012, the presentation of the final array of project alternatives in December 2012, several press events during Spring–Autumn 2014, and several public information/ stakeholder meetings in April 2015. The Corps identified eight Indian Nations with ancestral homelands within the Blanchard River Watershed. Of these Nations, the Wyandotte Nation was asked to consult on this study.

The project’s planning objectives are based on the needs and opportunities as well as existing physical and environmental conditions in the study area. In general, the overarching federal objective is to show federal interest in the project through the USACE National Economic Development (NED) analysis consistent with protecting the environment pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements.

The Feasibility Study initially followed the six-step planning process defined in the Principles and Guidelines adopted by the U.S. Water Resources Council and the Planning Guidance Notebook (ER 1105-2-100). In July 2012, the USACE study transitioned to the specific, measurable, attainable, risk informed, and timely (SMART) planning process. Through the SMART planning process, the USACE limits the amount of technical data it must initially collect and relies more thoroughly on its professional engineering judgment, analysis, and economics as it conducts feasibility studies.

As part of the National Environmental Policy Act (NEPA) process, the USACE reviewed 22 public interest categories concerning the Blanchard River Watershed to outline baseline conditions for the project area. The categories included those having environmental, cultural, and social interest. Table 1 lists the 22 public interest categories studied for baseline conditions.

Table 1 – Public Interest Categories

Public Interest Category	
Land Use	Noise
Geology & Soils	Cultural Resources
Groundwater	Utilities & Infrastructure
Streams	Transportation
Floodplains	Aesthetics & Visual Resources
Wetlands	Recreation
Vegetation	Hazardous Substances/Petroleum Products
Wildlife & Aquatic Resources	Socioeconomics
Threatened & Endangered Species	Environmental Justice
Air Quality	Human Health & Safety
Water Quality	Sustainability, Greening & Climate Change

The USACE initially evaluated measures for the Blanchard River Watershed based on the potential of each to reduce flood risk, relative development cost, environmental impacts, and acceptability to the sponsor. The measures included clearing and snagging in the channels, detention basins, channel improvements, high velocity channels, diversions and channel relocations, levees and floodwalls, non-structural measures, bridge removal/replacement/modification, evacuation of the floodplain, and flood warning and emergency measures. The USACE screened these measures using formulation criteria established in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (December 2014) (Reference 3). The criteria included completeness, effectiveness, efficiency, and acceptability.

2.1.2 Alternative Plans

Several of the measures were screened out for various reasons (ultimately because the plans did not fall within the USACE guidelines for either completeness, effectiveness, efficiency, or acceptability). Measures that were carried forward included: Diversion/channel relocation (Western Diversion Alignment 2), Blanchard River to Lye Creek cutoff levee, non-structural measures, and evacuation of the floodplain (part of the No Action plan). The USACE developed an array of nine alternatives that addressed flood risk reduction after qualitative and quantitative screening occurred. The nine plans were created by taking combinations of the screened measures to address the identified problems and meet the screening criteria.

Comparative preliminary cost estimates of the nine viable alternatives used in formulating the National Economic Development (NED) model were prepared. The cost estimate for each alternative was based on historical bid cost data, experience, and/or unit prices adjusted to expected project conditions. The plan that had the highest net benefits was carried forward for further evaluation and refinement. Table 2 shows the list of nine alternatives and the calculated Benefit-to-Cost-Ratio (BCR) for each plan. Alternative 3 was the plan with the highest BCR (1.15) and highest maximum annual benefits.

Table 2 – USACE Economic Evaluation of Identified Alternatives

Alternative	Estimated Annual Net Benefits	Preliminary Benefit-to-Cost Ratio (BCR)
Alternative 1 – No Action Plan	-	-
Alternative 2 – 2% ACE (50-year) event diversion channel with Blanchard–Lye cutoff levee	$343,540	1.12
Alternative 3 – 1% ACE (100-year) event diversion channel with Blanchard–Lye cutoff levee	$435,000	1.15
Alternative 4 – 0.4 % ACE (250-year) event diversion channel with Blanchard–Lye cutoff levee	$319,740	1.10
Alternative 5 – 1% ACE (100-year) event diversion channel without Blanchard–Lye cutoff	$389,500	1.15
Alternative 6 – 1% ACE (100-year) event diversion channel with Blanchard–Lye cutoff levee with 5-year nonstructural component	$241,200	1.08
Alternative 7 – 1% ACE (100-year) event diversion channel with Blanchard–Lye cutoff levee with 10-year nonstructural component	$222,300	1.07
Alternative 8 – 1% ACE (100-year) event diversion channel with Blanchard–Lye cutoff levee with 25-year nonstructural component	($206,600)	0.95
Alternative 9 – Blanchard to Lye cutoff levee only	$702,770	1.03

2.1.3 Final Array

Alternative 3 (1% diversion channel and Blanchard–Lye cutoff levee) was the only plan to advance to the next stage of formulation for optimization. The USACE refined the Alternative 3 plan by scaling the diversion channel to accommodate several different storm frequencies and changing the timing of flows through the diversion structure. The refinement of Alternative 3 led to six additional plans (Alternatives 10 through 15) considered as the Final Array.

The Hydrologic Engineering Center's Flood Damage Assessment (HEC-FDA) model and a cost estimate were created to compare the Final Array (Alternatives 10 through 15). These six alternatives studied three different sizes of the Eagle Creek Diversion Channel – one scenario for each size with and without a cutoff levee from the Blanchard River to Lye Creek. Table 3 provides a summary of Alternatives 10 through 15 and calculated BCRs for each scenario. Alternative 13 was the plan that had the highest BCR (1.30) and maximized annual net benefits. From this screening, the USACE recommended Alternative 13 as the plan that best met the National Economic Development (NED) objectives because it provided the highest net benefits.

Table 3 – USACE Economic Evaluation of Optimized Plan Alternatives

Alternative	Estimated Annual Net Benefits	Preliminary Benefit-to-Cost Ratio (BCR)
Alternative 10 – 1% ACE (100-year) event diversion channel (100 cfs) with Blanchard–Lye cutoff levee	$677,450	1.21
Alternative 11- 1% ACE (100-year) event diversion channel (100 cfs)	$710,290	1.24
Alternative 12 - 4% ACE (25-year) event diversion channel (100 cfs) with Blanchard–Lye cutoff levee	$712,990	1.24
Alternative 13 - 4 ACE (25-year) event diversion channel (100 cfs)	$780,750	1.30
Alternative 14 – 2% ACE (50-year) event diversion channel (100 cfs) with Blanchard–Lye cutoff levee	$702,770	1.22
Alternative 15 – 2% ACE (50-year) event diversion channel (100 cfs)	$763,190	1.27

2.1.4 USACE Plan

Alternative 13 (Figure 3) includes the Western Diversion of Eagle Creek, which diverts flood flows in Eagle Creek to the Blanchard River at a location approximately five miles downstream of the City of Findlay. The diversion channel alignment extends from Eagle Creek upstream of State Route 15 to the Blanchard River downstream of Aurand Run. The diversion channel was designed to extend approximately 9.2 miles and consists of a trapezoidal channel with a bottom width of 25 to 52 feet and a depth of approximately 11 to 12 feet with 4H:1V side slopes.

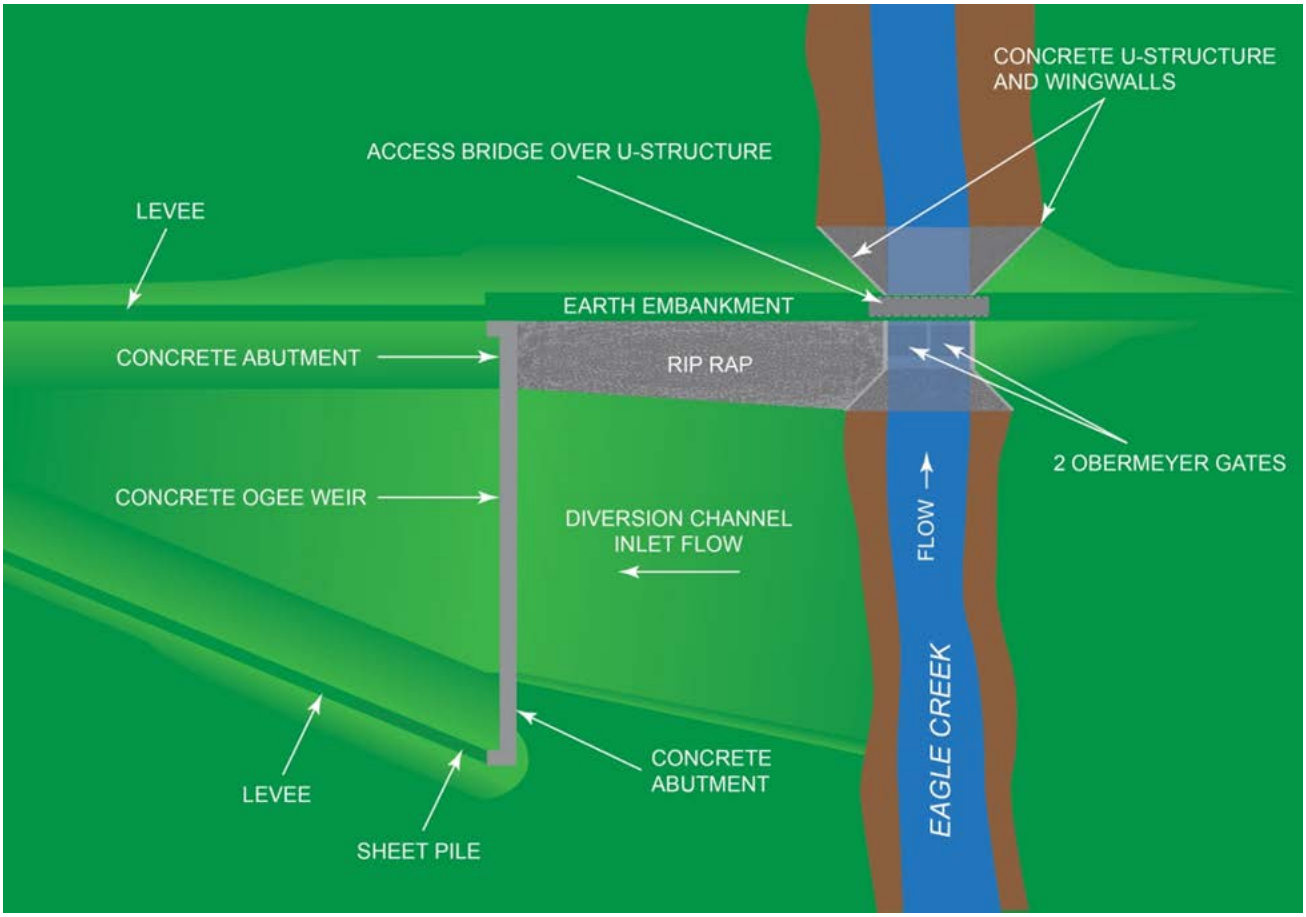
The plan includes the construction of an in-line diversion structure in Eagle Creek. An earthen embankment with a top elevation of 808.6 feet (NAVD88) and approximately 925 feet long would be constructed in line with a control structure to allow water to pool. The proposed diversion control structure on Eagle Creek was planned to be located approximately 1,375 feet downstream of County Road 45 to control the amount of flow diverted to the diversion channel from Eagle Creek.

A gated flow control structure (Obermeyer gates or similar) on Eagle Creek would restrict flow in Eagle Creek to a maximum of 100 cfs when the Blanchard River is forecasted to be above the 20% Annual Chance Exceedance (ACE) flow. Eagle Creek was assumed to always convey at least 100 cfs past the diversion structure during storm events. As flood water levels rise, gates in the control structure on Eagle Creek would be closed as necessary to pool water and divert it into the Western Diversion Channel. The control structure would consist of two 26-foot wide by 16-foot high Obermeyer gates. Flows more than the 100 cfs would be directed into the diversion channel. The diversion channel was designed for the 4% ACE (25-year) event. That is, the diversion channel was designed to handle the 4% ACE (25-year) flow for Eagle Creek upstream of the diversion point, minus the 100 cfs that can continue in Eagle Creek, downstream of the diversion point (about 3,000 cfs). Figure 3 provides an overview of the USACE Plan. Figure 4 shows a conceptual plan view of the USACE Plan's diversion structure on Eagle Creek.

Figure 3 – USACE Plan (Alternative 13)

*Source: USACE Buffalo District Website: http://www.lrb.usace.army.mil/Portals/45/docs/Blanchard/August2015/August-2015-Recommended-Plan.pdf

Figure 4 – USACE Conceptual Plan View of Eagle Creek Diversion Structure



*Source: Figure 7.3c - DRAFT - U.S. Army Corps of Engineers, Buffalo District. (March 2016). “Interim Report in Response to the Wester Lake Erie Basin (WLEB) Blanchard River Watershed Study, Section 441 of the Water Resource Development Act of 1999, General Investigations, Feasibility Study/Final Environmental Impact Statement”; (DRAFT - USACE Feasibility Report/Final EIS).

The USACE prepared a total project cost (TPC) estimate for the final plan using more detailed cost estimating tools. The TPC was computed by estimating the equipment, labor, material, and production rates suitable for the project. This estimate, with a specific price level date, was then escalated for inflation through project completion. Therefore, the cost estimates for the USACE Plan differed between the values used for plan comparison. The preliminary estimate for initial project costs with contingency applied was $80,902,000. Table 4 shows the different items that comprise the initial costs. After applying interest during construction, the project was estimated to cost $86,574,000. The final BCR fell to 0.93 after the Corps prepared the TPC. The USACE Plan was in jeopardy of not being eligible for federal funding since the project’s BCR was less than one.

Table 4 – USACE Plan Initial Costs

Description	Amount	Contingency %	Contingency $	Total
01 – Lands and Damages	$5,511,000	19.4%	$1,068,000	$6,579,000
02 – Relocations	$11,443,000	27.5%	$3,147,000	$14,589,000
06 – Fish and Wildlife	$1,379,000	27.5%	$379,000	$1,758,000
08 – Road, Railroads & Bridges	$2,084,000	27.5%	$573,000	$2,657,000
09 – Channels and Canals	$27,127,000	27.5%	$7,460,000	$34,587,000
15 – Floodway Control & Diversion	$6,830,000	27.5%	$1,878,000	$8,709,000
18 – Cultural Resources	$543,000	27.5%	$149,000	$692,000
30 – Engineering & Design	$6,417,000	27.5%	$1,765,000	$8,182,000
31 – Construction Management	$2,470,000	27.5%	$679,000	$3,149,000
TOTAL	**$63,804,000**		**$17,099,000**	**$80,902,000**

2.2 PROJECT DESIGN TRANSITION

On June 6, 2016, the Hancock County Board of Commissioners submitted a letter to USACE indicating the desire to terminate the study partnership with USACE. The Commissioners indicated it was going to examine the feasibility of implementing the project without USACE assistance and requested that any background study information be provided to the engineering consultant hired for the implementation of the project.

The project changed from one led by the USACE and more rigidly guided by Federal rules, regulations, and policies to a locally-led, community driven project led by the Hancock County Commissioners and City of Findlay, in cooperation with the MWCD. Stantec was contracted by Hancock County to complete the design and environmental permitting for the recommended project. The project advanced, despite having a preliminary BCR less than 1.0, because the team, including The County, City, MWCD, and Stantec, believed that with greater flexibility in project options that more benefits would be realized, resulting in a more favorable BCR. Studying the benefits of flood mitigation through a regional perspective allows the impacts experienced by the community due to repeated flooding to be placed into a greater context.

Since July, 2016 Stantec has been working on the continuation of this flood risk reduction project in phases. The first phase of work included review of existing data associated with the analysis completed by the USACE in search of potential data gaps.

2.3 PHASE I - DATA REVIEW AND GAP ANALYSIS

Stantec collected and reviewed available data relevant to the USACE proposed project. Most of the data reviewed was provided by the USACE on July 14, 2016 via external hard drive. Table

5 shows the categories of information related to the USACE Feasibility Study analysis that were included on the hard drive.

Table 5 – Information Provided by USACE

• Base Map Data	• Real Estate
• Hydrology and Hydraulics (H&H)	• Cost Analysis
• Design and Engineering	• Economics
• Geotechnical	• Cost and Schedule Risk Analysis
• Environmental	• Other reports compiled for the project
• Mitigation Plan	

Additional information was acquired from Hancock County, the Ohio Department of Natural Resources (ODNR) Ohio Division of Wildlife Ohio Natural Heritage Database (ODOW ONHD), USGS, Ohio Geographically Referenced Information Program (OGRIP), and the Ohio Department of Transportation (ODOT) Transportation Information Management System (TIMS).

Stantec also performed a field reconnaissance from public right-of-way near the proposed diversion inlet and outlet and at several locations along the preliminary alignment. No topographic, utility or property boundary surveying or geotechnical borings were performed as part of Phase I.

The purpose of Stantec's data review and data gap analysis was to develop a plan to address or collect information necessary to complete Phase II.

2.3.1 Data Review – Facts and Observations

The sub-sections below are grouped by analysis topic and summarize the observations made by Stantec while reviewing the reports and available data.

2.3.1.1 Field Reconnaissance

Stantec performed a preliminary field reconnaissance at points along the proposed diversion channel alignment where accessible from public roads. Stantec personnel observed site features such as local topography, land uses, and visible infrastructure. Stantec also observed points close to the proposed diversion inlet and outlet. Figure 5 below shows a view of Eagle Creek near the proposed diversion inlet. The purpose of the site reconnaissance was primarily to gain context of project scale.

Figure 5 – View of Eagle Creek Near the Proposed Diversion Inlet

2.3.1.2 Base Map Data

A folder titled "GIS" was located on the USACE hard drive that included project related data such as shapefiles, raster images, and Microsoft Excel documents grouped into the following categories:

- Alternatives
- Aquatic Resource Delineation
- Bedrock
- DEM (Digital Elevation Model)
- Demographics
- Floodplains
- HTRW
- Impacts
- Inundation
- Land Use and Land Cover
- Parks and Recreational Areas
- SHPO (State Historic Preservation Office)
- Soils
- Transportation
- Utilities
- Wetlands

The data extents vary spatially between regional, local, and project specific coverage. For instance, sub-basins were provided for the entire Blanchard River watershed, but some utility shapefiles only appear along the USACE recommended project's alignment. Data to support other alternatives considered by the Corps were not provided.

2.3.1.3 Hydrology and Hydraulics

Stantec reviewed available hydrology and hydraulic data for the Western Diversion of Eagle Creek project. The evaluated data sources include:

- *"Blanchard River Watershed Study Final Feasibility Report, Appendix A: Hydrology and Hydraulics"; U.S. Army Corps of Engineers, Buffalo District; October 2015 (USACE H&H Report)*

- *"Interim Report in Response to the Western Lake Erie Basin (WLEB) Blanchard River Watershed Study, Section 441 of the Water Resource Development Act of 1999, General Investigations, Feasibility Study/Final Environmental Impact Statement"; U.S. Army Corps of Engineers, Buffalo District; March 2016 (USACE Feasibility Report)*

- *"Western Lake Erie Basin (WLEB) Blanchard River Watershed Study, Section 441 of the Water Resource Development Act of 1999, General Investigations, Draft Detailed Project Report / Environmental Impact Statement"; U.S. Army Corps of Engineers, Buffalo District; April 2015 (USACE Draft EIS)*

The USACE Feasibility Study and Final EIS indicate Alternative 13 was the preferred option. Alternative 13 is described in Section 6.3 of the Feasibility Study as follows:

> ***"Alternative 13. 4% ACE (25-year) event diversion channel with Eagle Creek at 100 cfs***
> This alternative calls for building a diversion channel to divert high flows from Eagle Creek to the Blanchard River, downstream of Findlay. The diversion channel alignment extends

> from Eagle Creek upstream of Route 15 to the Blanchard River downstream of Aurand Run. A gated flow control structure on Eagle Creek restricts flow in Eagle Creek to a maximum of the 100 cfs when the Blanchard River is forecasted to be above the 20% ACE flow. Flows in excess of the 100 cfs are directed into the diversion channel. The diversion channel is designed for the 4% ACE (25-year) event. That is, the diversion channel is designed to handle the 4% ACE (25-year) flow for Eagle Creek upstream of the diversion point, minus the 100 cfs that is allowed to continue in Eagle Creek, downstream of the diversion point."

The USACE modeled the watershed's hydrologic response using a Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) model (Reference 4). Peak discharges from the hydrographs produced from HMS model were used as inputs to a steady-state Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic model (Reference 5) of the reaches involved. Both models were calibrated to historic events using NEXRAD precipitation data and gage readings for discharges and water surface elevations.

The models also included simulations for the hypothetical 50%-, 20%-, 10%-, 4%-, 2%-, 1%-, 0.4%-, and 0.2%-ACE (2-, 5-, 10-, 25-, 50-, 100-, 250-, and 500-year) storms. Storm durations of 24-hours were used, while consideration of other durations was not presented. Point precipitation depths from NOAA Atlas 14 Precipitation Frequency Atlas of the United States were selected and applied uniformly across the watershed. The HEC-HMS Frequency Storm approach was used to create hypothetical rainfall hyetographs, which are characterized by intense alternating block storm patterns. The result was temporal patterns more similar to an SCS Type II storm than a Bulletin 71 Huff Quartile or NOAA Atlas 14 Distribution that would typically be used in this region. Spatial variability or orientation of the storm, similar to the procedures described in NOAA Atlas 2 or HMR 52, was not fully accounted for as would ordinarily be considered for a watershed this large. However, a small areal reduction factor was assumed as a part of the HEC-HMS meteorological file by assuming the storm had a total area of 100 square miles over each sub-basin. Point based rainfall depths from NOAA Atlas 14 were used. This approach resulted in an average rainfall application of approximately 90-95% of the NOAA Atlas 14 published point rainfall depth for a 24-hour duration storm applied uniformly over the entire watershed, according to HEC-HMS documentation.

2.3.1.4 Design and Engineering

Stantec reviewed available design data for the Western Diversion of Eagle Creek project. The evaluated data sources include:

- *"Blanchard River Watershed Study Draft Interim Feasibility Study, Appendix E: Engineering and Design"; U.S. Army Corps of Engineers, Buffalo District; January 2016.*
- Phone conversation with Hancock County Project Manager, Mr. Steve Wilson, PE, PS, which took place on July 28, 2016 at 4:00 pm with the design team.

Preliminary design details on the Eagle Creek inline diversion structure and diversion channel are provided in Section 9 of the USACE's Feasibility Study Engineering and Design Appendix. Appendix E, Engineering & Design, includes plan and profile drawings of the proposed alignment. Anticipated roadway and stream crossings, as well as the interpolated top of bedrock line are included on the profile sheets.

The currently proposed 9.2-mile diversion channel alignment would cross the Norfolk Southern Railroad, Interstate 75, State Route 12, and ten county/township roads. The Feasibility Report made recommendations for each of these crossings and presents five categories: Dry Crossings; Local Road Bridges; State Road Bridge; Interstate Highway Bridge; and Railroad Bridge. The report indicated that bridge type studies had been completed for County and Township Road bridges.

2.3.1.5 Geotechnical

Stantec reviewed available geotechnical data for the Western Diversion of Eagle Creek project. The evaluated data sources include:

- *ODOT Transportation Information Management System (TIMS)*
- *USACE (2015) "Draft Geotechnical Engineering Appendix" August 31.*
- *USACE (2016) "Draft Interim Feasibility Study, Appendix E, Engineering & Design." January.*
- *URS/Baird (2013). "Blanchard River Watershed Study – Hancock and Putman Counties, Ohio. Supporting Documentation for the Report Synopsis – Final Array of Plans. Geotechnical Report." March.*

The data presented in URS/Baird (2013) includes several potential alignments of the diversion channel. A summary of historical borings was included, with data sourced from USACE, ODOT, ODNR, the Natural Resources Conservation Service (NRCS), and various private and local projects. A total of 48 preliminary project-specific borings were advanced in 2012 as part of the URS/Baird (2013) study.

Review of the USACE (2015) and USACE (2016) reports indicated that the selected alignment had been modified slightly after 2013. One boring from the 2013 study (F-39-2012) was within 200 feet of the proposed alignment.

Review of ODOT TIMS information resulted in locating two additional borings within 200 feet of the currently proposed alignment. These borings were located on Interstate 75 (Boring 663+00) and CR-9 (Boring 109+00).

The terrain is flat in the surrounding area of the proposed diversion channel. Approximately two-thirds of the watershed basin has a slope of one percent or less. Glacial till is the predominant overburden along the proposed diversion channel, and consists of non-sorted materials ranging from clays and silts to boulders. Historic boring logs indicate groundwater depth varies between approximately 2 and 18 feet deep. Groundwater within the overburden is generally encountered in zones of coarse-grained glacial till, fill, or alluvial deposits. Bedrock elevation near the proposed diversion ranges between approximately 735 and 815 feet. An estimated bedrock surface was created from existing boring data by USACE (2015). Rock excavation is expected to vary in difficulty (hard ripping to blasting) along the proposed channel excavation.

2.3.1.6 Environmental

The discharge of fill material into Waters of the United States (WOUS), use of equipment in the Blanchard River and other aquatic resources, removal of trees and brush in upland areas, ground disturbance activities, and farmland conversion to other land uses would be subject to the jurisdiction of several regulatory authorities. Work authorization under the Clean Water Act, Fish and Wildlife Coordination Act, Endangered Species Act, National Historic Preservation Act, National Environmental Policy Act, and Farmland Protection Policy Act must be in place for work to proceed.

Review of the Draft EIS, Feasibility Study, and other available documentation and correspondence provided by the USACE indicates that future tasks may be categorized per the following laws:

- Sections 404 and 401 of the Clean Water Act,
- Section 7 of the Endangered Species Act,
- Fish and Wildlife Coordination Act,
- Section 106 of the National Historic Preservation Act,
- Farmland Conversion Coordination, and/or
- National Environmental Policy Act.

A Draft EIS was written by the USACE in April of 2015 for the Blanchard River Watershed Study to determine if there was federal interest (i.e. funding) in providing flood risk management improvements. The Draft EIS discussed the flooding problems in Findlay, developed project plans and alternatives, analyzed the economic and environmental impacts of each project alternative, and ultimately recommended a plan. After a recommended plan was developed, an open peer review and comment period took place, which was followed by making the necessary updates and recommendations to the plan. A feasibility study for project implementation was then performed to identify the preferred alternative.

Our understanding is that the USACE does not intend to produce a Final EIS that would lead to a Record of Decision (ROD) since the project is no longer a USACE project. The absence of federal funding will likely change the purpose and need of the project and the Draft EIS, or at least portions of it, may no longer be applicable. Therefore, the federal nexus for this project will be the issuance of a federal permit (i.e., Section 404). Stantec anticipates that the USACE Regulatory Branch will perform its own internal NEPA compliance and that no effort will be necessary on Hancock County’s behalf. There is some possibility that further work on NEPA documentation may eventually be necessary, but currently Stantec does not anticipate additional effort for NEPA compliance to be performed by the County or MWCD.

2.3.1.7 Real Estate

The Real Estate Plan (REP) in the USACE study identified the required Lands, Easements, Rights-of-Way, Relocations, and Disposal/Borrow Areas (LERRD) needed to support the construction, operation, and maintenance of the USACE Plan. Permanent easements (channel improvement and flood protection levee easements) total 234 acres. This area is comprised in part by 25-feet easements on each side of the channel and a 50-feet easement on both sides of the control structure. Nine acres to be acquired in fee for the diversion control structure are also required.

Temporary easements totaling 39 acres will be needed for construction of the proposed channel and control structure. The REP states that approximately 2.1 million cubic yards of excavated material will be disposed of on approximately 200 acres divided between the reaches and designated as temporary disposal areas.

Several utility poles and underground utilities (fiber optic, copper cable, and oil/gas pipelines) could be impacted by the diversion structure and may require relocation.

Induced flooding impacts upstream of the diversion structure will affect approximately 54 acres. The draft preliminary takings analysis, found in the REP, finds the potential for impacts on one property rises to the level of a flowage easement and two require acquisition in fee. There is a residence on one of the fee parcels that will require relocation.

Forty-six acres of stream and 19 acres of wetlands are identified as needing mitigation. Therefore, the total affected LERRD real estate area is approximately 607 acres.

2.3.1.8 Cost and Economics

Stantec reviewed available cost and economic data for the Western Diversion of Eagle Creek project. The evaluated data sources include:

- *"Blanchard River Flood Risk Management Feasibility Study, Appendix B – Economics (Draft)"; USACE, Buffalo District; November 2015 (USACE Draft Economics Report)*
- *"Blanchard River Watershed Study Draft Interim Feasibility Study, Appendix F: Cost Engineering Appendix"; USACE, Buffalo District; January 2016 (USACE Cost Report)*
- *"+Findlay Economic Analysis (Optimization)v5.xlsx"; (USACE Economic Documentation)*
- *"National Economic Development Procedures Manual Overview – IWR Report 09-R-2", U.S. Army Corps of Engineers Institute for Water Resources; June 2009 (USACE NED Overview) (Reference 6)*
- *"Regional Economic Development (RED) Procedures Handbook – 2011-RPT01", U.S. Army Corps of Engineers Institute for Water Resources; March 2011 (USACE RED Handbook)*

The USACE provided a detailed cost estimate for the USACE Plan (25-year Western Diversion of Eagle Creek). This estimate, with a specific price level date, was then escalated for inflation through project completion. Project quantities were developed using Microstation INROADS, Microsoft Excel calculations, and manual calculations, where applicable. The cost estimate was compiled using the Micro-Computer Aided Cost Estimating System, Second Generation (MCACES 2nd Generation or MII).

Quantities for the design were developed by USACE and included: excavation volumes, access roads, clearing and grubbing, toe/field drains, stream crossings, rerouting a tributary before crossing, drainage outlets, utilities, diversion channel outlet protection, cul-de-sacs, dry crossings, bridges, and the Eagle Creek diversion dam. Annual operation and maintenance costs were estimated for the diversion channel (sluice gates and Tide Flex backflow replacement costs and $3/ft. of mowing) and the Obermeyer Gate.

First costs were developed based on project quantities, historical bid cost data, experience, and/or unit prices adjusted to expected project conditions. A cost and schedule risk analysis (CSRA) followed the development of the first costs. Using a Monte Carlo-based risk analysis, a contingency of 27.5% was used for all costs except Lands and Damages based on an 80% confidence interval.

A Total Project Cost Summary (TPCS) was provided including CWCCIS Escalation. The USACE Cost Report shows the final first costs as $80,902,000. Using escalation, the Cost Report lists the final Total Project Cost as $88,146,000 using 21 months of design and 46 months of construction (67 total months).

The USACE used the NED methodology to determine the BCR for each alternative. The costs and benefits were based on November 2015 prices and a project life of 50 years. This 50-year project useful life is used for the purposes of economic analyses and does not mean a project will need to be replaced every 50 years. Costs were annualized to an average annual cost using the FY16 Federal Discount Rate of 3.125% (EGM 16-01). This analysis incorporated risk and uncertainty. The NED benefits considered for this analysis included the reduction in damages to structures, contents, and automobiles. The Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software and generic depth-damage functions were used to estimate damages for without-project and with-project alternatives. Ancillary benefits included avoided emergency response costs and National Flood Insurance Program administrative costs. The Final EIS reports the BCR for Alternative 13 as 1.03. However, the BCR for the USACE Plan became 0.93 after consideration of the updated risk and escalation costs.

2.3.2 Data Gaps

Stantec identified gaps in the data provided during its review. Additional data was needed for Stantec to proceed with the Phase II Proof of Concept. A major gap of the study was an unclear objective/or goal of the project. The USACE Feasibility Report stated that, "The overall objective of the study is to reduce flood risk and improve the overall quality of life for the residents of the

Findlay, Ohio, area." A more specific and measurable project goal is necessary to help shape the Proof of Concept work plan and future phases of the project to determine if the referenced project is the correct choice for the community. It would also help to inform additional benefit/cost work and bring the project BCR back above 1.0.

It is understood that whatever solution is implemented, the City of Findlay will still be at some level of flood risk, albeit reduced. However, the aggregate residual flood risk was not quantified during the USACE study efforts. Residual risk aside, the key gap that must be resolved to keep the project moving is demonstrating an acceptable BCR (greater than 1.0) for the USACE Plan (Alternative 13 – Western Diversion of Eagle Creek).

Another key gap identified was conflicting benefits and results within the USACE hydraulic model and reported water surface elevation (WSE) reductions from the USACE Plan. The August 2015 update from the USACE showed approximately a 4.5 feet reduction in the WSE during the 1% ACE (100-year) flood event at Main Street, while other sources showed only a 2.0 feet reduction. Further analysis would be required by Stantec to close the gap.

2.3.2.1 Base Map Data

Most of the data were self-identified by the folder and filename, however, metadata, which is a written description about digital data, was not provided; there are unknowns as to the source and accuracy of some of the data sets and to which alternatives some of the data are related.

Some of the information associated with utility data was provided spatially at locations within a certain buffer distance of the proposed diversion channel alignment. Additional utility information in the Findlay area will be required to move forward with this design.

The Digital Elevation Model (DEM) provided by USACE (blan_dem) appears to have a 10-feet pixel resolution and is from an unknown source. If needed, project based Light Detection and Ranging (LiDAR) data can be obtained from OGRIP offering 2.5-feet pixels (Reference 7). 2016 aerial photography can be obtained from the Hancock County website (Reference 8).

2.3.2.2 Hydrology and Hydraulics

The USACE hydrologic modeling approach generally seemed valid, and calibration seemed reasonable at the locations presented. The USACE hydraulic modeling approach also generally seemed valid. However, an unsteady hydraulic model, which is a model that accounts for varying flows rather than a single peak flow, would better account for storage in the channels and more accurately depict flood peak attenuation. Unsteady modeling was recommended for future analysis. Additional documentation on calibration and parameter sensitivity/accuracy was recommended to clarify the USACE Hydrology and Hydraulics (H&H) Report.

The Blanchard River watershed just downstream of Findlay has a drainage area of approximately 350 square miles comprised of the sub-watersheds of the Blanchard River, Lye Creek, and Eagle Creek. Eagle Creek near the proposed diversion channel inlet has a drainage area of approximately 50 square miles. The proposed diversion channel relies solely on this portion of Eagle Creek's watershed receiving rainfall to prevent flooding in Findlay. As stated in Section 6.5 of the USACE Feasibility Study, **"There would be a minimal performance of Alternative 13 when storm events are primarily over either the Blanchard River or Lye Creek watersheds upstream of Findlay, with minimal storm events over the Eagle Creek watershed."** For this reason, a risk based evaluation of the performance of a potential diversion channel on Eagle Creek was identified as a data gap.

The rainfall approach used during planning did not account for spatial variability, or varied durations and intensities of storm events. Similar to observations during the August 2007 storm event, a watershed as large as this one would likely experience rainfall patterns with spatial variability and varying temporal patterns. A varied rainfall approach and definitive conclusions regarding impacts from climate change were identified as data gaps.

The HEC-HMS discharges at the downstream outlet of sub-watersheds were not applied to the HEC-RAS cross sections within that catchment in the USACE HEC-RAS model. As an example, the most downstream portions of the Eagle Creek and Lye Creek basins are applied directly to the Blanchard River discharges in the HEC-RAS model. The consequence of this method is that approximately 20-square-miles of affected watershed was not correctly accounted for in the hydraulic modeling.

Inconsistencies were found in the Alternative 13 results between the provided HEC-FDA models and the reported values in "*Final w/ Project*" simulations in HEC-RAS and its associated documentation in the USACE Feasibility Study and H&H Appendix. The HEC-FDA model used a water surface elevation (WSE) profile that has a reduction from existing conditions in downtown Findlay of approximately 2.0 feet, while the HEC-RAS models and floodplain figures appear to show a reduction of approximately 4.5 feet. This is a gap in the USACE provided information that required additional analysis and review within the Phase II efforts.

It was unclear if current channel and bridge surveys were incorporated into the HEC-RAS model. This was later resolved by Stantec by collating available bridge plans and performing additional topographic survey to verify and supplement the channel and structure data.

An additional gap identified was the verification and documentation of the final calibration and results using USGS gage data and frequency analyses.

2.3.2.3 Design and Engineering

Stantec recognized the USACE project design was considered preliminary and that concept refinement was needed. Considering improvements to the USACE Plan (Alternative 13) would likely increase the BCR. Gaps appeared to include refinement of diversion alignment and channel sizing among others.

Preliminary transportation engineering gaps identified included horizontal and vertical alignments and typical sections and cross-sections of roads. Stantec planned to collect existing traffic volume information from the County and request certified traffic volumes for affected ODOT crossings. These volumes were to be used to verify the design criteria listed in the Feasibility Report. A preliminary layout and sizing for potential culverts and drainage ditches was also identified as a future need. Stantec planned to evaluate and lay out Maintenance of Traffic concepts for each crossing.

Bridge type studies, completed by USACE, were assumed to have been reviewed by the County after a discussion with the project team. The assumption was that the County was in general agreement with the Feasibility Report findings as identified in Section 9.3 of Appendix E of the USACE report. It was assumed that bridge type studies are only needed for the proposed crossings on Interstate 75 and State Route 12 and at the Norfolk Southern railroad crossing.

2.3.2.4 Geotechnical

Few historical borings were located within 200 feet of the proposed diversion channel alignment. Further exploration was recommended along the proposed alignment to evaluate existing conditions. Stantec recommended and executed 11 additional borings as part of the Phase II efforts.

Neither of the existing ODOT TIMS borings near the proposed alignment included rock coring. Rock coring will be required if the borings are to be used for bridge design in future phases.

2.3.2.5 Environmental

Significant tasks associated with receiving necessary waterway permits for the diversion channel option include the completion of the USACE ENG FORM 4345 application, and potentially the completion of the OEPA application for a Section 401 Water Quality Certification (WQC). In addition, to gain project authorization through Section 404, the permittee must consult with US Fish and Wildlife Service (USFWS) and ODNR on potential impacts to federal and state listed species (under the Endangered Species Act, Fish and Wildlife Coordination Act), as well as coordinate with the Ohio Historic Preservation Office on potential impacts to historically or culturally significant resources.

After Stantec's preliminary review of the USACE study, the permit scenarios for the project were unknown, and this was identified as a gap. Stantec would need to prepare the permit documents necessary for MWCD to receive work authorization under Section 404 of the Clean Water Act.

Stantec participated in a pre-application meeting on October 6, 2016 to discuss the permit scenarios and construction sequencing as a first step. The pre-application meeting included the USACE (Regulatory) and the 401 coordinator for the NW District Office of the OEPA. Stantec will continue coordination with the USACE (Regulatory) to discuss the overall project construction and conceptual design and the waterway permit scenario that would best be suitable to accomplish the goals of the flood risk reduction project.

2.3.2.6 Real Estate

The USACE Real Estate Plan states "In order to complete the preliminary takings analysis, the attorney has requested to have an agronomist provide additional data regarding the impact of any additional flooding on the soils of agricultural lands. This data has not yet been provided and no cost or contingency is included in the real estate plan."

Additionally, "The inundation of approximately 170 acres along an unnamed ditch that will be crossed by the diversion structure is also possible. A lack of owner provided Right of Entries for survey has hindered H&H's ability to accomplish sufficient modeling to determine the frequency, depth, and duration of any possible inundation. Because of this, a Takings Analysis will be completed in the Planning, Engineering and Design phase (PED) for this specific area" While this is a recognized gap, additional real estate scope is not recommended to be performed until completion of the conceptual design refinement phase.

2.3.2.7 Cost and Economics

Stantec understands the latest cost estimate for the project included risk based components that resulted in a revised project cost of approximately $86 million after applying interest during construction. The BCR for the USACE Plan is 0.93 using the USACE provided benefits. It is understood a BCR greater than 1.0 is necessary for the project to proceed.

The NED benefits associated with transportation and agricultural damages were planned for the project, but not included in the USACE analysis. Other benefits not included in the analysis were loss of life, restored land value, and avoided income losses, among others. These benefits and Regional Economic Development (RED) methodology would likely contribute positively to the BCR with impacts from transportation, business, education, and healthcare facilities. Additionally, operations and maintenance costs appear to be incomplete based on the USACE provided Excel sheet.

Stantec identified Jack Faucett Associates (JFA) as a sub-consultant to review in further detail the economic data provided by the USACE. Specifically, JFA studied the USACE draft Economics Appendix to identify potential additional NED benefits that may be derived and other benefits by utilizing the RED model, versus the NED model utilized by the USACE.

Some of the additional benefit opportunities identified by JFA during the Phase I USACE data review included income losses, transportation damages, agricultural damages, cleanup costs, and location, intensification, and employments benefits. Initial analysis by JFA indicated "The USACE estimated the benefits and costs from a National Economic Development (NED) perspective and not from a regional (county-level) Regional Economic Development (RED) perspective. USACE originally estimated that the BCR would be 1.30 for the preferred alternative, but subsequent refinement of cost estimates has resulted in the BCR dipping just below 1.00. The study team has discovered a number of additional potential categories of benefits. The addition of these benefits will likely raise the NED BCR well above 1.00 and the RED BCR even higher."

More information regarding the economic gap analysis performed by JFA is provided in Appendix A of this report (Phase 1 Memorandum: Review and Assessment of the "Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (Draft)").

The project advanced forward, despite having a BCR less than 1.0, because the team believed that with greater flexibility in project options through a regional context that more benefits would be realized - including those mentioned above.

2.3.3 Questions for Clarification

Stantec developed questions about the previous study during the data review and gap analysis phase that could best be answered through coordination with the USACE. Some of these questions were first brought up during a conference call with the USACE, Stantec, and the Hancock County Engineer's Office on August 9, 2016. A list of questions needing clarification is presented in Appendix B of this report. These questions were forwarded on to the USACE on August 16, 2016 for review. The USACE provided a written response to the list of questions dated September 14, 2016. The USACE response is included in Appendix C of this report.

3.0 PHASE II – PART A – DATA GAP COMPLETION

Four key gaps were identified during Phase I:

1. The project had an unclear objective.

2. The latest BCR calculated was less than one.

3. The project lacked a risk based evaluation of the performance of the proposed diversion channel. As stated in the USACE Feasibility Study, "There would be a minimal performance of Alternative 13 when storm events are primarily over either the Blanchard River or Lye Creek watersheds upstream of Findlay, with minimal storm events over the Eagle Creek watershed."

4. There are conflicting benefits and results within the USACE hydraulic model and reported water surface elevation (WSE) reductions from the USACE Plan. The August 2015 update from the USACE showed approximately a 4.5 feet reduction in the WSE during the 1% ACE flood event at Main Street, while other sources showed only a 2.0 feet reduction.

An outcome of Stantec's Phase I data review and gap analysis was a plan to address or collect information believed to be missing from the material provided by the USACE from its analysis to proceed with the refinement of the USACE Plan. The sub-sections below describe the work to fill the identified gaps.

3.1 PROJECT OBJECTIVE

One of the key gaps identified during Stantec's Phase I review was that the project had a poorly defined objective. The objective of the USACE study was to reduce flood risk and improve the quality of life for the residents of the Findlay area. The USACE project's planning objectives were based on needs and opportunities plus existing physical and environmental conditions in the study area. In general, the prime federal objective is to contribute to the National Economic Development (NED) model consistent with protecting the environment pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. From this screening, the USACE recommended Alternative 13 as the plan that best met the NED objectives because it provided the highest net benefits.

A more specific and measurable project goal is needed to shape the Proof of Concept work plan and future phases of the project to determine if the USACE Plan is the correct choice for the local community. For the Proof of Concept Phase, the client provided a clear and measurable project goal of achieving a 4.5 feet WSE (Water Surface Elevation) reduction at Main Street in Findlay during the 1% ACE flood event or a storm similar to the 2007 flood of record. Main Street was used as a reference point for planning purposes as this location represents a centralized location to where flooding typically occurs within the community.

Achieving this goal will allow Main Street and other critical intersections in and around the City of Findlay to remain open for the passage of emergency response vehicles during the 1% ACE (100-year) flood event. The proposed objective would also reduce the number of residential properties required to obtain flood insurance, decrease prolonged inundation and increase retention of productive farmlands, decrease flooding at public parks and facilities, and preserve opportunities for job creation and retention in and around the City of Findlay and Hancock County.

The 1% ACE event can relate to many different hydrographs and flow rates. As a result, the WSEs observed through Findlay will vary depending on the intensity, location, and durations of the storm events. As the project advances forward, Stantec will work with the client to continually refine the project objective by setting a specific WSE as a goal and identifying key locations where flood reduction is desired.

When the City and County elected to move away from USACE as the lead agency and begin working through MWCD on a local level, the client confirmed that this is now a community driven project, one that will be designed with the community in mind. As such, the Benefit-Cost Analysis (BCA) will concentrate on data and impacts that are regionally focused as opposed to the NED requirement of the USACE. The regional focus will provide a project that is right for the community, but still must obtain a BCR greater than one.

3.2 GEOTECHNICAL ANALYSIS

Stantec recommended further exploration along the proposed alignment to evaluate existing conditions. The objective of the Phase II drilling plan for the project was to obtain preliminary geotechnical information regarding soil and rock type, erodibility, depth to bedrock, rock ripability, and properties needed for preliminary design of channel crossing structures.

The work was conducted within the right-of-way at existing roadway intersections along the proposed alignment. Private site access was not requested as part of Phase II. Access to stream crossings on private property, railroad crossing, and the upstream areas of the diversion channel (near the proposed diversion channel dam, weir, and inlet structure) was not available. Borings for such structures were not included in the Phase II work plan.

Detailed information regarding the geotechnical analysis is located in Appendix D of this report – Report of Geotechnical Exploration.

3.3 LAND AND AERIAL SURVEY

Stantec subcontracted with Bockrath & Associates Engineering and Surveying, LLC (Bockrath) to perform field survey on the geotechnical boring locations mentioned in Section 3.2 and cross sections within the Blanchard River in the area of downtown Findlay. Additionally, Bockrath identified Kucera International Inc. as a sub-consultant to conduct an aerial survey over the surrounding project area.

3.3.1 Geotechnical Boring Location Survey

Bockrath provided spatial location data for each boring location as documented in Appendix D - Report of Geotechnical Exploration.

3.3.2 Blanchard River Survey

Stantec recommended a survey within the Blanchard River near downtown Findlay to confirm/refine the hydraulic model. The Bockrath survey included approximately 55 cross sections along the Blanchard River through Findlay from top of bank to top of bank, plus an additional 10 feet on either side of the bank. Bockrath collected information at each bridge structure including top of deck, rails, lower cord, abutment location, and pier information. Site photographs and sketches accompanied the bridge survey.

3.3.3 Aerial Survey

Kucera flew an aerial survey in late November and early December 2016 during leaf-off and crop-harvested conditions. The survey covered approximately 280 square miles around Findlay and the nearby vicinity within the Blanchard River watershed. The survey included digital aerial photography and aerial LiDAR surveying supporting 1-inch = 20-feet scale, 0.5-foot contour aerial mapping within the area with delivery of area-wide color digital ortho-imagery and georeferenced raw LiDAR point cloud data. The processed data will support future design needs regarding topographic survey.

3.4 HYDROLOGY AND HYDRAULICS

3.4.1 Hydrology Calibration Review

The USACE Hydrologic and Hydraulic Model Report did not present a detailed description of the calibration results for the HEC-HMS model. An event that occurred in October 2011 was used as the primary calibration data set for the HEC-HMS model, while events in September 2011, February 2008, and August 2007 were used for verification purposes. During the Phase 1 Data Review and Gap Analysis, the approach and parameters generally seemed valid. Upon further review of the model, the October 2011 calibration event resulted in a reasonable match between model results and observed runoff at five USGS stream gage locations.

Minor changes to the model geometry were made to adjust the Eagle Creek subwatershed boundaries. The watershed boundary provided by USACE somewhat resembled that of the USGS 12-digit Hydrologic Unit Code (HUC-12) watershed, but did not match the latest USGS National Hydrologic Dataset (NHD) stream delineation. Approximately 7 square miles of drainage area, about two percent of the total watershed area above Findlay, had been omitted as a result. Stantec subsequently added that area to the upper reaches of the Eagle Creek watershed.

Stantec also added junctions to allow for adequately characterizing other potential flood mitigation options being considered and linkage of the HEC-HMS and the unsteady state HEC-RAS models. A HEC-HMS model utilizes topography, land use, and rainfall estimates to predict flow hydrographs for various rainfall events. The HEC-RAS model utilizes channel cross sections, hydraulic structure geometry, and roughness coefficients to predict flood levels along a stream channel.

Results were compared to the original USACE HEC-HMS model to identify potential inconsistencies and re-calibration was not deemed necessary. Results herein are based on Stantec's preliminary H&H analyses, which include appropriate conservative assumptions for planning purposes.

3.4.2 Hydraulic Model Conversion

Stantec recommended converting the existing steady-state HEC-RAS model into an unsteady model to better account for storage in the channels and flood peak attenuation. An unsteady-state model was created using the existing project steady-state model as a starting point.

3.4.2.1 Geometry File Updates

The HEC-RAS existing conditions geometry file was reviewed for accuracy during the model conversion process. The channel geometry was compared to the surveyed cross sections obtained by Bockrath and updated when necessary. Hydraulic structures within the HEC-RAS model such as bridges and culverts were also reviewed and compared to available construction drawings and survey data. The input data for the structures were generally valid. Changes were made to the model when there were clear discrepancies between the modeled structure and the available record drawings. Changes included updating the modeled width of the State Route 15 bridge over the Blanchard River from 40 feet to 80 feet, and updating the dimensions of a culvert at the upstream end of Howard Run (HAN 095-5.35). Ineffective flow areas were examined at each cross section and updated as needed to represent existing conditions. Ineffective flow stations were set to "permanent" in some instances to achieve model stability.

3.4.2.1.1 Interpolated Sections

The existing conditions hydraulic model contained interpolated cross-sections. These cross sections were often calculated between dissimilar shaped cross section geometries. Interpolated cross sections were removed from the model during the model conversion process. This change was primarily made because the interpolated sections did not accurately represent channel geometry and were not necessary for model stability.

3.4.2.1.2 2-D Flow Area

An area south of the Findlay Water Reservoir located between the Blanchard River and Lye Creek is very flat and provides an overland connection between the two streams during flooding events (this is the area targeted by USACE for the cut off levee). The land is predominantly comprised of agricultural fields with a few structures. During flood events with elevated WSEs in the Blanchard River, flow overtops the left overbank and proceeds overland to the west toward Lye Creek. This section of land bounded by State Route 37, State Route 15, the Findlay Reservoir, and the Blanchard River was modeled as a two-dimensional (2-D) mesh to accurately simulate the overland flow because most of the area does not contain a defined channel.

3.4.2.1.3 Blanchard River and Potato Run Model Extension

The upstream-most cross section on the Blanchard River was approximately 3,500 feet upstream of State Route 15 within the existing conditions model provided by the USACE. The model geometry was extended to the south in order to simulate proposed projects in the vicinity of the Village of Mt. Blanchard. The Blanchard River was extended to the south to about 2.5 miles north of State Route 30 (along the river centerline). Potato Run was added into the model geometry as well extending from the confluence with the Blanchard River to approximately 2,000 feet east of the Hancock/Wyandot County line. Approximately 160 cross sections were generated along the Blanchard River and Potato Run using Light Detection and Ranging (LiDAR) data obtained from OGRIP. Manning's roughness values were estimated using 2016 aerial photography downloaded from the Hancock County website. Several bridge structures were added along the Blanchard River and Potato Run based on data provided by the USACE.

3.4.2.2 Unsteady Flow Files

Flow change locations were created within the hydraulic model based on the HEC-HMS basin delineations. The inflow points were generally assigned to cross-sections at the downstream end of each correlating sub-basin to match the routing of the hydrologic models. Unsteady flow files were created based on the simulations for the hypothetical 50%-, 20%-, 10%-, 4%-, 2%-, 1%-, 0.5%-, and 0.2%-ACE (2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year) storms. These flow files within HEC-RAS reference the final existing conditions HEC-HMS ".dss" file containing the simulated runoff hydrographs. Minimum flows were assigned at each boundary condition location for model stability.

3.4.3 Hydraulic Calibration Review

High water marks were recorded by the USGS for the 2007 flood of record (Reference 9). These data points were used for validation of the hydraulic model. A gage analysis was performed using the USGS gage downstream of Findlay (USGS 04189000 – Blanchard River near Findlay OH) to verify the flows observed in the HEC-RAS model.

3.4.4 Discussion on Hydrology Risk Analysis

Eagle Creek, near the proposed diversion channel inlet location, has a watershed area of approximately 15% of the overall drainage area of the Blanchard River in Findlay. The proposed diversion channel relies on this portion of the watershed receiving enough rainfall and contributing enough of the flooding in Findlay that a diversion of the flows would prevent the flood from otherwise occurring. As stated in the USACE Feasibility Study, "There would be a minimal performance of Alternative 13 when storm events are primarily over either the Blanchard River or Lye Creek watersheds upstream of Findlay, with minimal storm events over the Eagle Creek watershed."

The effectiveness of the Eagle Creek Diversion Channel depends on the spatial extent, variability, and timing of the storm. Stantec reviewed the hydrologic modeling and retained Applied Weather Associates (AWA) to review historic storm events in the region, including the August 2007 event. The conclusion was the USACE analyses were conservative in terms of spatial and temporal patterns applied to the storm events and did not adequately predict the potential performance of the proposed diversion channel. Hypothetical storms considered were more intense and produced more rainfall runoff than would most likely occur.

The USACE hydrologic model (with the minor updates described above) with an SCS Type II storm with a 24-hour duration applied uniformly over the entire watershed was used for planning purposes to continue the Proof of Concept work. This approach was used for each of the alternatives considered. While this is a conservative assumption, it is appropriate for the planning stages of the project. Stantec recommends a design storm with the following characteristics be used as the recommended project moves from planning to design and construction:

- Storm Spatial Distribution – AWA has derived an idealized spatial pattern for this region based on a series of 25-30 actual historic large storm events within the region. The spatial pattern is similar to that of NOAA Atlas 2 or HMR-52 and is comprised of a set of ellipsoids with lengths of the major and minor axes related by a fixed ratio and a pre-determined orientation based on the storm observations. The storm includes areal reduction factors that allow point precipitation to be accurately reduced as the area impacted moves from a centroid point outward beyond 10-, 20-, 50-, 100-, 1,000-square miles etc.

- Temporal Pattern – AWA also derived an idealized rainfall hyetograph for the area using the historic storm data. The hyetograph closely resembles a Huff or NOAA Atlas 14, 3rd Quartile Storm event and is less severe than an SCS Type II or Alternating Block storm event.

- Duration – Stantec's hydrologic modeling indicates storms of durations less than 24-hours are less likely to result in flooding in Findlay. Since the watershed upstream of Findlay is so large, the Blanchard River initially floods more due to the volume of runoff than the short-term peak flow rates. Conversely, storms having durations greater than about 36-hours increase flood volumes and floodplain extents, but do not substantially increase peak water surface elevations because the flood inundation is in the flatter overbank portion of the floodplain. For the purposes of considering flood mitigation, Stantec recommends a 24-hour duration storm be considered. This is also supported by a large number of the AWA historic storms, and the August 2007 flood of record, having a response on the watershed similar to a 24-30 hour event.

- Rainfall Depth – NOAA Atlas 14 is generally accepted as a reliable source of rainfall depths for a given return period and duration. Those values are recommended as point rainfall depths for the design storm; however, the spatial storm pattern and areal reduction factors noted above should be applied.

- Rainfall Centroid – The last variable Stantec considered in the hydrologic analysis was the location of the most intense portion of the storm event. Statistically, a given storm could be centered anywhere within the watershed with an equal chance of occurrence. Stantec found the peak discharge rates had relatively small variations if the center occurred over the Eagle Creek or Lye Creek sub-watersheds, but as the storm center was placed farther north or south in the watershed the discharge in Findlay varied more significantly. Application of the storm to several locations is recommended to determine that which produces the most critical results in terms of both volume and peak runoff rate.

3.5 ENVIRONMENTAL PERMITTING

Stantec identified unresolved permitting issues during Phase I and provided a road map forward to receive work authorization under Section 404/401 of the Clean Water Act. The pending issues identified during the gap analysis process included NEPA processing by the USACE planning branch, ESA compliance, the 404/401 permitting scenario (Nationwide or Individual), and Section 106 compliance.

3.5.1 Planned Regulatory Meetings

Stantec attended a 404/401 pre-application meeting with USACE-Buffalo District and OEPA to discuss the regulatory path forward. Additionally, Stantec collaborated with Mannik and Smith Group (MSG) and requested a meeting with the Ohio Historical Preservation Office (OHPO) to discuss Section 106 compliance.

3.5.1.1 404/401 Pre-Application

Stantec met with the USACE and OEPA on October 6, 2016 to discuss the permit scenarios and construction sequencing that would meet the goals of the project. The meeting participants discussed the overall project construction and conceptual design and the waterway permit scenario that would best be suitable to accomplish the goals of the project. The 404/401 pre-application meeting attendees included staff from Stantec, MWCD, the USACE-Buffalo District (both planning and regulatory) and OEPA. Stantec provided a brief overview of the project with a formal presentation to the other attendees. The overview consisted of the project's purpose and need, the project's "nature of activities" and the project's potential impacts to the WOUS. Stantec solicited feedback on potential permit strategies, necessary field surveys, and potential mitigation obligations. The meeting attendees were then briefed on field safety, followed by a site visit to key locations in the potential project area.

During the pre-application meeting three major items were discussed:

- USACE determined that given the size and public involvement of the proposed project, that an Individual Permit (IP) was appropriate.

- An update on the current NEPA status was provided by the USACE Planning Branch representative, Mike Pniewski. The Planning Branch does not intend to publish a final EIS for the Western Diversion. The regulatory branch will take over the NEPA process. It is anticipated that an Environmental Assessment (EA) will suffice based on the level of expected impacts.

- A brief update was provided by Mike Pniewski regarding Section 106- cultural and historical resource consultation. Moving forward, the Programmatic Agreement (PA) for Section 106 is no longer necessary. Stantec stated that they had been working with MSG to set up a meeting with OHPO. The next steps forward are a Phase 1 Archeological and Architectural Survey within the proposed western corridor.

3.5.1.2 Section 106

On October 24, 2016, a meeting was held with representatives from OHPO to discuss the Western Diversion of Eagle Creek Project and the approach to Section 106 compliance. The major item discussed in the meeting was that OHPO would like to see a study plan that outlines the consultation process. The developed plan would be sent to OHPO for study plan approval.

A predictive model and work plan was compiled by MSG in November of 2016. The purpose of these documents will be to provide a starting point for consultation with OHPO with regards to the project's potential impacts to archaeological resources. The study plan explains the predictive model and proposed survey methods for the Phase 1 archaeological survey.

3.5.2 Field Surveys

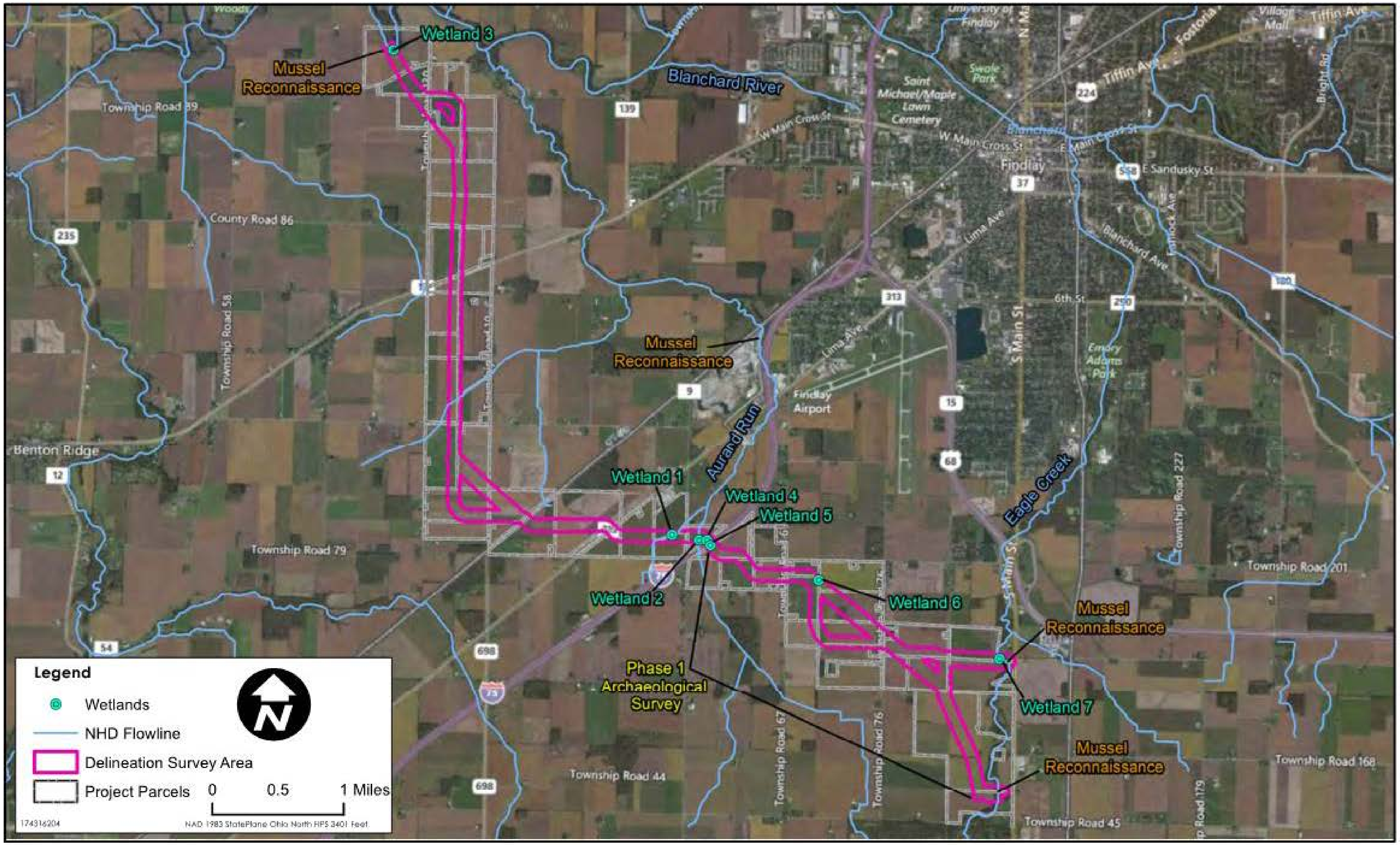
The following initial field surveys were scheduled and conducted within the Western Diversion corridor to provide support for the Section 404/401 permitting process based on previous correspondence with the regulatory agencies:

- Wetland delineation survey;
- Habitat Assessment for Threatened, Endangered, and Sensitive (TES) bat species;
- Reconnaissance level mussel survey;
- Phase 1 Archaeological Survey.

3.5.2.1 Wetland Delineation Survey

An onsite wetland survey was conducted to delineate the extent of potential jurisdictional WOUS to be determined by the USACE-Buffalo District. Project footprint areas to survey for potential WOUS included right-of-way (ROW) corridor for the construction of the Western Diversion channel with alternate alignments. The diversion channel would extend approximately 9.2 miles from the inlet at Eagle Creek to the outlet at the Blanchard River. The wetland delineation survey area covered a 300-foot corridor surrounding the proposed channel with alternate alignments, totaling approximately 710 acres (Figure 6).

Figure 6 – Permitting Surveys and Reconnaissance Map



Sources: National Hydrography Dataset- USGS
Service Layer Credits: Bing Aerial Imagery, 2014

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Wetlands were delineated using the protocols developed in the USACE manual for the Midwest Regional Supplement. Streams were assessed using the Headwater Habitat Evaluation Index (HHEI) and streams with more than 1 square mile of drainage area were assessed using the Qualitative Habitat Evaluation Index (QHEI). Wetlands were assessed for quality and function using the Ohio Rapid Assessment Method (ORAM). Other stream dimensions such as Ordinary High Water (OHW) width and depth were surveyed for permitting purposes.

On October 24-27, 2016, wetland scientists from Stantec, performed the wetland delineation survey. Most of the survey area was upland agriculture land with adjacent woodlots. The streams observed crossing the corridor were a mix of low gradient ditches that had ephemeral, intermittent and perennial flow regimes. These features were channelized, straight line, agricultural conveyances that were part of the drainage tile pattern or the result of a road embankment. The Aurand Run tributary within the survey area had a wetland feature directly abutting the stream feature. One of the drainage ditches did not have stream characteristics, (bed or bank, or OHW) rather was a Category 1 wetland, dominated by reed canarygrass (*Phalaris arundinacea*). Blanchard River and Eagle Creek both had shaded riparian forest habitat while the other streams and wetlands were open, sunlit, agricultural ditches. Approximately seven wetlands (less than 2 acres total) and six streams were delineated and assessed for quality and function. No Category III wetlands were observed and only a few were Category I wetlands due to the dominant presence of invasive species. The remaining wetlands within the survey corridor were Category II Palustrine Emergent (PEM), cowardin class. Stantec is developing separate report summarizing the wetland and stream delineation work at the time of this report issuance.

3.5.2.2 Habitat Assessment – Threatened and Endangered Bat Species

On October 24-27, 2016, the habitat within the study area (same as the wetland delineation survey area, Figure 6) was evaluated for its potential to be suitable habitat for the Indiana bat (*Myotis sodalis*) and northern long-eared bat (*Myotis septentrionalis*). A reconnaissance level ecological survey was conducted identifying the existing habitats within the study area, which included documenting the vegetative plant communities, land cover/land use, and potential roosting tree habitat.

Correspondence on December 15, 2016 with the USFWS reiterated recommendations regarding compliance measures with Indiana Bat and northern long-eared bat. The service recommended seasonal tree clearing, between October 1 and March 31, when Indiana bats and northern long-eared bats would not be present. The service also recommended further coordination if tree clearing acreage is to exceed 15 acres.

3.5.2.3 Mussel Reconnaissance Survey

Reconnaissance surveys are used to determine whether formal surveys for mussels in unlisted or Group 1 streams are needed per Ohio Mussel Survey Protocols. Federally listed species are not expected in unlisted or Group 1 streams. Surveys were conducted on Eagle Creek, Aurand Run and the Blanchard River (Figure 6) on November 2-3, 2016.

Aurand Run is an unlisted stream in Hancock County, Ohio with a drainage area of approximately 5 square miles at the location of the proposed diversion channel alignment. Stantec field staff surveyed several hundred feet of Aurand Run upstream, downstream and at the intersection of the proposed diversion channel to determine if flow pattern changes might affect any mussels. No mussels were observed within Aurand Run during the survey.

Eagle Creek is a Group 1 stream with a drainage area of approximately 50 square miles. Surveyors searched approximately 690 feet downstream and 300 feet upstream of the project area and proposed diversion inlet in Eagle Creek for a total of 232 minutes. During these surveys, fifteen living individuals were observed, comprised of three different species. Fresh, dead, and weathered specimens were observed for an additional three species. Living species found included *P. grandis*, *L. siloquoidea* and *L. complanata*. Shells were found for *A. ferussacianus*, *F. flava* and *A. plicata*.

The Blanchard River is a Group 1 stream downstream of State Route 568 with a drainage area of approximately 376 square miles where it connects to the project footprint at the diversion channel outlet. Three surveys were conducted on the Blanchard River on November 3, 2016 covering approximately 1,800 feet for 270 minutes. Substrate at this location appeared suitable for mussel habitat as it had high percentages of sand, gravel, and cobble. Evidence of fourteen species was observed during these surveys. A total of nine living individuals was observed comprised of five species. Living species include *P. alatus*, *L. complanata*, *T. donaciformis*, *A. marginata* and *L. siloquoidea*.

3.5.2.4 Phase 1 Archeological Survey

In November and December 2016, MSG performed a Phase 1 Archeological survey within the proposed channel alignment, east of Interstate 75 to Eagle Creek (Figure 6), where ground disturbance is currently proposed. The survey involved looking for and collecting artifacts that can provide information about the history of the Findlay area. In areas identified as “high probability” and with vegetation cover, holes were hand excavated (50 centimeters by 50 centimeters by up to 50 centimeters deep) with shovels. Field work was suspended due to inclement weather and may resume in the area west of Interstate 75 at a later date. A separate report summarizing the Archeological work is under development at the time of this report issuance.

3.5.3 Continued Regulatory Authority, Agency, and Public Coordination

3.5.3.1 Cultural/Historical Resource Public Meeting (East of Interstate 75)

A public outreach meeting took place on November 22, 2016, hosted by Stantec and MSG. The purpose of this meeting was to provide public outreach for the cultural and historical resources within the project corridor east of Interstate 75. This meeting provided the public an opportunity to learn the cultural and historical resource study approach and share cultural and historical resource information. Two landowners brought artifacts from their properties.

3.6 COST & ECONOMICS

JFA developed regional economic models and performed benefit-cost analyses based upon the conceptual plan recommended by Stantec (described in Section 5.0 of this report). This benefit-cost analysis included updating the existing benefits, evaluating National Economic Development (NED) benefits not previously included, and looking at potential Regional Economic Development (RED) benefits. The following is a listing of the key benefits identified in the development of the updated BCR by JFA:

- Structural Damages
- Vehicular Damages
- Transportation Cost Impacts
- Emergency Response Cost Impacts
- National Flood Insurance Program (NFIP) Premiums and Administrative Costs
- Business Losses (Gross and Net Sales)
- Agricultural Losses
- Environmental Losses

Each of the above categories are fully defined within the JFA BCR analysis report. The revised plan recommended by Stantec and the additional regional benefits result in a program-wide BCR greater than 1.0. A complete copy of the BCR analysis and report completed by JFA is attached as Appendix E of this report and titled, "*Hancock County Flood Risk Reduction Program: Benefit Cost Analysis*".

3.7 TRANSPORTATION

Stantec reviewed available transportation information for crossings along the proposed diversion corridor including available traffic data and roadway classifications to establish design standards for alignments, profiles, and typical sections. These standards were summarized in tabular format and compared to the standards used in the previous study with the differences highlighted. Value engineering suggestions were provided for those crossings which did not seem to warrant grade separation from the channel based on very low traffic volumes. Stantec collected initial information for typical sections and developed conceptual maintenance of traffic schemes to facilitate development of project scheduling. Figure 7 below shows the data collected for each crossing of the proposed diversion channel and Figure 8 details the conceptual maintenance of traffic schemes. Figure 8 also shows a preliminary sequence of construction assuming a four-season construction duration along with suggested detour routes for each roadway. An effort was made to place traffic volumes on detour routes that are on the same order of magnitude as the road being detoured. Multiple roadways may be closed at the same time, with the restriction that a roadway may not be closed if it is being used as part of a detour for another closed roadway (e.g. TR 130 may not be closed while either TR 89 or CR 86 are closed).

Figure 7 – Transportation Design Data Collected at each Crossing

ROADWAY	TREATMENT	TRAFFIC COUNT (ADT)			FUNCTIONAL CLASSIFICATION	TERRAIN	DESIGN SPEED (MPH)	LANE WIDTH (FT)	SHOULDER WIDTH (FT)	GUARDRAIL OFFSET (FT)	GRADED WIDTH (FT)	NOTES
		WEST/NORTH	EAST/SOUTH	YEAR								
TR 89	Cul-de-Sac	86 E of TR 58	201 W of CR139	2016	Rural Local	Level	55	Per County Standards		n/a	n/a	
TR 130	Bridge	71 S of CR 84		2015	Rural Local	Level	55	11	1	4 (Road)/1 (Bridge)	7	Bridge shoulder width based on AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (p. 21).
CR 86	Bridge	1022 W of CR 128	647	2015	Rural Minor Collector	Level	55	11	4	4	7	
SR 12	Bridge	2560 E of SR 235	7073 E of TR 139	2016	Rural Major Collector	Level	55	12	4	8	11	USACE report lists **10'** shoulders.
CR 84	Bridge	437		2016	Rural Local	Level	55	11	4	4	7	
TR 10	Low Road Crossing	208		2015	Rural Local	Level	55	11	0	n/a	7	Roadway shoulder width based on AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (p. 21).
Railroad	Bridge	n/a		n/a	n/a		n/a					
CR 313	Bridge	3163		2016	Rural Major Collector	Level	55	12	4	8	11	USACE report lists **11'** lanes.
CR 9	Bridge	2521 N of CR 84	803 S of CR 37	2016	Rural Minor Collector	Level	55	12	4	8	11	803 ADT yields **11'** lanes (this matches USACE report).
I-75	Bridges	47305		2015	Rural Interstate	Level	70	12	12 RT/4 MED	14 RT/6 MED	17 RT/9 MED	USACE report lists **12'** shoulders.
TR 67	Bridge	207		2016	Rural Local	Level	55	11	1	4 (Road)/1 (Bridge)	7	Bridge shoulder width based on AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (p. 21).
CR 76	Cul-de-Sac	76		2015	Rural Local	Level	55	Per County Standards		n/a	n/a	County Road per Classification PDF and County map.
TR 49	Cul-de-Sac	333		2015	Rural Local	Level	55	Per County Standards		n/a	n/a	

Figure 8 – Conceptual Maintenance of Traffic and Construction Schedule

CONSTRUCTION SEASON				TREATMENT	DETOUR ROUTE
2018	2019	2020	2021		
		TR 89		Cul-de-Sac	Eastbound TR 89 traffic south on CR 128 to east on CR 86 to north on TR 130; Westbound TR 89 traffic south on TR 130 to west on CR 86 to north on CR 128 (these detours will be permanent).
TR 130				Bridge	Eastbound TR 89 traffic south on CR 128 to east on CR 86; Westbound TR 89 traffic south on CR 139 to southwest on SR 12; Northbound TR 130 traffic either (1) Northeast on SR 12 to north on CR 139; or (2) West on CR 86 to north on CR 128.
	CR 86			Bridge	Eastbound CR 86 traffic south on SR 235 to northeast on SR 12; Westbound CR 86 traffic southwest on SR 12 to north on SR 235.
		SR 12		Bridge	Northeast bound SR 12 traffic north on SR 235 to east on CR 86; Southwest bound SR 12 west on CR 86 to south on SR 235.
			CR 84	Bridge	Eastbound CR 84 traffic north on TR 130 to northeast on SR 12 to south on CR 9; Westbound CR 84 traffic north on CR 9 to southwest on SR 12 to south on TR 130.
			TR 10	Low Road	Northbound TR 10 traffic northeast on CR 313 to north on CR 9 to west on CR 84; Southbound TR 10 east on CR 84 to south on CR 9 to southwest on CR 313.
Railroad				Bridge	Shoefly construction will likely cross CR 84, TR 10, and TR 79; CR 313 must remain open during shoefly construction, as CR 84 and TR 10 are part of the detour for CR 313; CR 84 and TR 10 shoefly construction must not be done concurrently, as CR 84 is part of the detour for TR 10.
CR 313				Bridge	Northeast bound CR 313 traffic south on SR 235 to north on I-75 to east on SR 15 to Lima Avenue; Southwest bound CR 313 (Lima Avenue) west on SR 15 to south on I-75 to north on SR 235.
		CR 9		Bridge	Northbound CR 9 traffic west on SR 103 to north on SR 698 to northeast on CR 313; Southbound CR 9 southwest on CR 313 to south on SR 698 to east on SR 103.
I-75 is independent of all other construction.				Bridges	Construct crossovers between the SR 698 overpass and the CR 9 overpass and between Aurand Run and the CR 313 overpass. Build one bridge at a time.
	TR 67			Bridge	Northbound TR 67 traffic west on TR 50 to north on CR 9 to east on TR 80; Southbound TR 67 traffic west on TR 80 to south on CR 9 to east on TR 50.
	CR 76			Cul-de-Sac	Northbound CR 76 traffic east on TR 49 to north on TR 77 to west on TR 80; Southbound CR 76 traffic east on TR 80 to south on TR 77 to west on TR 49 (these detours will be permanent).
			TR 49	Cul-de-Sac	Eastbound TR 49 traffic south on CR 76 to east on CR 45 to north on US 68 (this detour will be permanent); Westbound TR 49 traffic south on US 68 to west on CR 45 to north on CR 76.

3.8 DATA GAP COMPLETION SUMMARY

The primary outcomes from the Phase II, Part A data collection and analysis were answers to the four key gaps identified during the Phase I review.

1. Hancock County, the City of Findlay, and MWCD provided a clear and measurable project goal of achieving roughly a 4.5 feet WSE reduction at Main Street during the 1% ACE (100-year) or equivalent flood event. Achieving this goal will allow critical intersections in and around the City of Findlay to remain open for the passage of emergency response vehicles and provide several other measurable benefits for the region.

2. Additional opportunities for NED and RED benefits were found and analyzed that brought the BCR above 1.0.

3. The Stantec team highlighted the risks associated with the USACE Plan by comparing contributions to flooding in Findlay due to runoff from different portions of the Blanchard River watershed during different storm events. To further support this effort, analysis of regional precipitation data to discern more likely spatial and temporal patterns over the watershed will be incorporated into the design processes going forward.

4. Analysis confirmed the gap identified during the Hydrology and Hydraulics review showing a reduced benefit in flood reduction with the USACE Plan. Preliminary analysis shows the proposed USACE diversion project would reduce the WSE by less than 2.0 feet in downtown Findlay, and not the 4.5 feet that was previously reported. Stantec is developing project refinements and modifications during Part B of the Proof of Concept in order to meet the project goal.

4.0 PHASE II – PART B – PROOF OF CONCEPT

The initial goals of Phase II, Part B - Proof of Concept were to evaluate the USACE Plan's effectiveness, recommend changes or improvements to the plan, and finalize a conceptual plan for proceeding on to the next design phase. Alternative analysis was added as a work item following completion of Part A and review of key gap No. 4.

4.1 USACE PLAN – DOES IT WORK?

Several data gaps and questions were identified during the Phase I Data Review and Gap Analysis related specifically to the hydraulic and hydrologic analyses performed by the USACE. Generally, these questions related to the modeling approach and the residual risk of flooding in the City of Findlay associated with a diversion channel on Eagle Creek.

4.1.1 Flows and Hydraulic Profiles Discussion

The August 2007 storm was a distinct event that occurred over about 27-hours. Based on radar data, the center of the storm was approximately over the Eagle Creek and Lye Creek subwatersheds, which are in the middle of the overall Blanchard River watershed. The storm produced a total of approximately 12-inches of rainfall at its center, while the outer bands over the distant portions of the watershed resulted in about 4-5 inches of precipitation. USACE had assumed uniform rainfall over the entire watershed during hypothetical storm events, which based on the August 2007 observations is a conservative assumption.

Hydrologic modeling of similar rainfall events indicates a hydrologic response in the City of Findlay driven largely by travel time. Runoff from Eagle Creek, Lye Creek and the areas hydrologically close to downtown results in a shorter duration more intense initial flood wave or hydrograph peak. The upper Blanchard River watershed has a larger portion of the contributing area, but the travel time to Findlay is greater and more attenuation of the flood wave occurs along the way. Flooding from this portion of the watershed results in a longer duration less intense peak with a larger overall volume. The effect produces an aggregate flood hydrograph in Findlay that has two distinct peaks lagged by 12-hours or more and total duration of runoff significantly longer than the storm event.

Figure 9 below shows HEC-HMS modeling output of the Blanchard River hydrograph in downtown Findlay (black line) during a 100-year, 24-hour SCS Type II event (equally distributed over the entire watershed), along with the contributing flows that form this shape (Eagle Creek, Lye Creek, and Upper Blanchard sub watersheds). The dashed red line represents the August 2007 flooding event as simulated through the HMS model.

The first major peak in the existing conditions flow hydrograph is over 15,200 cfs (about a 20.0 feet depth at Main Street, or elevation 777.5 feet). This flow rate is the result of a combination of flow contributions from Eagle Creek, Lye Creek, and the rising limb of the Blanchard River hydrograph. Much of the rising limb comprises of contributions from sub-basins closer to the downtown area and east of the City near the water reservoir. A second distinct peak is formed almost entirely from flow contributions from the upper Blanchard River watershed (about 10,500 cfs).

Figure 9 shows that even with the hypothetical removal of 100% of the flow from both Eagle Creek and Lye Creek, downtown Findlay would still experience flow rates of about 10,500 cfs. Based on a rating curve at Main Street (Figure 10), 10,500 cfs equates to a depth of about 18 feet, or an elevation of 775.5 feet (2.5 feet above the bridge deck at Main Street). According to the HEC-HMS output and based on the hydraulic model's rating curve, completely removing flow from Eagle Creek and Lye Creek would result in a maximum WSE reduction of about 2.0 feet during the 1% ACE (100-year) base flood event.

Figure 9 – HEC-HMS - Existing Conditions Flow Hydrographs – Downtown Findlay

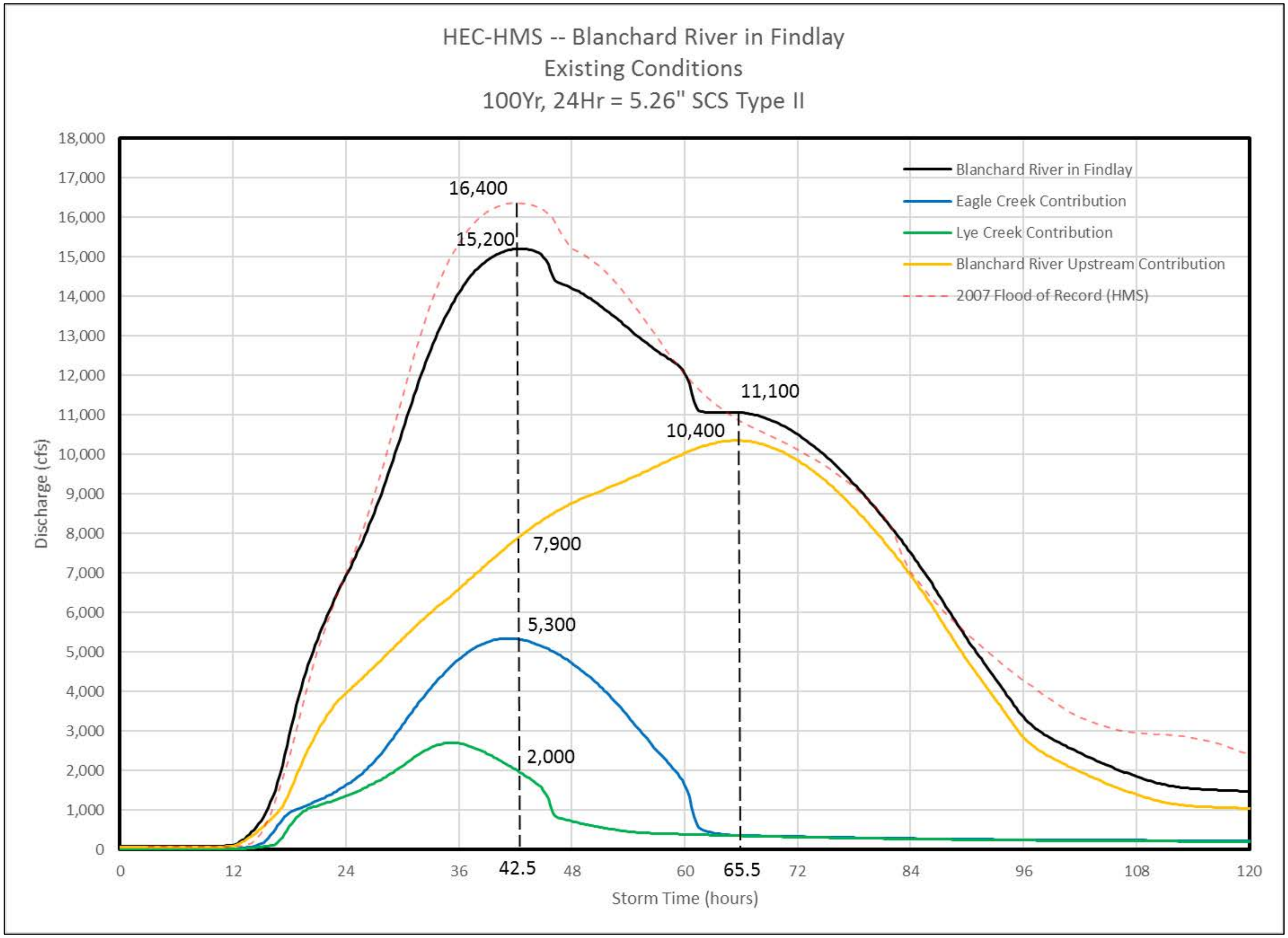
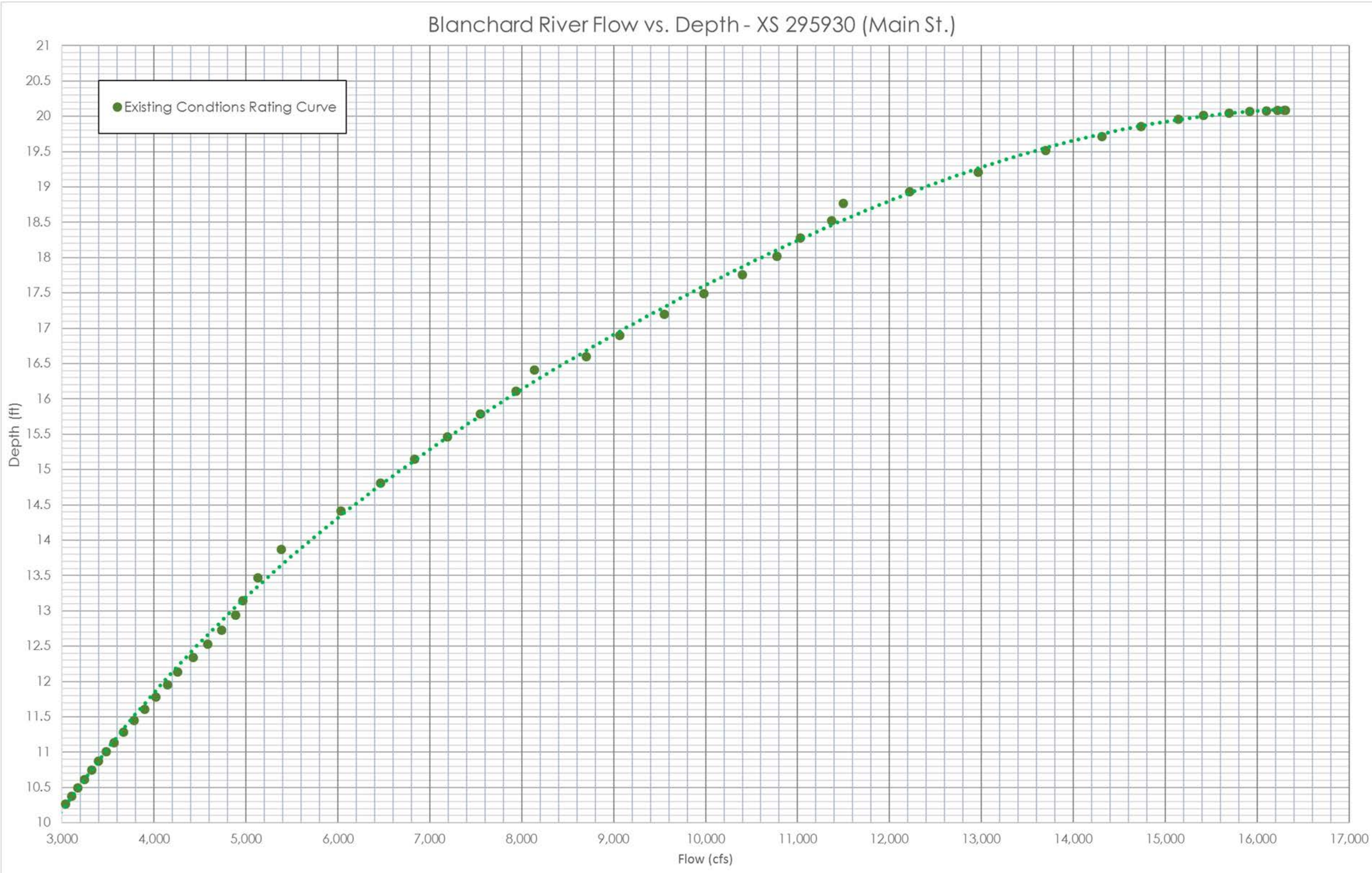


Figure 10 – Flow Profile Rating Curve at Main Street (HEC-RAS Cross Section 295930)



4.2 PROJECT REFINEMENT REVIEW

The Western Diversion of Eagle Creek will reduce flood levels in Findlay and is still a viable alternative. However, the Eagle Creek sub-watershed comprises only 15% of the Blanchard River watershed upstream of Findlay. Focusing flood damage reduction efforts just on Eagle Creek may not result in effective flood level reductions in Findlay and the surrounding area if a rainfall event were to occur outside the Eagle Creek sub watershed (i.e. in the Lye Creek or Blanchard River portions of the watershed). Due to these reasons and the stage reduction benefits of the proposed Eagle Creek Diversion channel being less than previously anticipated, Stantec was asked to review and analyze the USACE feasibility report while also looking for other potential flood risk reduction projects in the Upper Blanchard River watershed. The goal given to Stantec was to seek significant flood level reductions in Findlay assessing not only the plan recommended by the USACE, but to review other locally preferred alternatives that might enhance its effectiveness and provide additional economic benefits. The challenge is finding a combination of alternatives that meets the goal of flood damage reduction and is cost effective while environmentally sound.

4.2.1 Diversion Channel Refinement

Stantec assessed the proposed design of the USACE Plan to see if an alternate size, profile, alignment, inlet configuration, or operational scheme might be more cost effective or provide greater benefit.

4.2.1.1 Sizing

As initially designed by USACE, the Eagle Creek Diversion Channel has a capacity of about 2,950 cfs corresponding to a 4% ACE (25-year) event. For final design purposes, Stantec recommended the channel have capacity for a 1% ACE (100-year) event, which would be about 4,500 cfs. Stantec performed hydraulic calculations to determine the new channel widths required.

4.2.1.2 Profile

The profile of the diversion channel was adjusted such that the intersection with Aurand Run becomes an at-grade crossing. This adjustment would eliminate the need for a control structure and aqueduct at the intersection of the two channels.

Additional geotechnical information, including rock depths, along the proposed channel alignment were used to adjust the channel profile in some sections. The adjustments reduced rock excavation by making the channel have a more consistent grade and making the cross section shallower and wider to accommodate the same design discharges. Figure 11 shows a conceptual layout of a refinement to the diversion channel profile.

4.2.1.3 Alignment

The USACE diversion channel alignment had several sharp, 90-degree bends that were intended to minimize the disturbance of parcels along the alignment. After adjusting the channel widths, a number of these bends could be eliminated and adjustments could be made to the horizontal alignment of the channel that resulted in a shorter length and fewer parcels impacted. Figure 12 shows a conceptual view of possible refinements to the diversion channel alignment.

4.2.1.4 Inlet Relocation

Shifting the proposed diversion inlet downstream on Eagle Creek has the potential to decrease the diversion channel length by approximately 4,000 feet. Locations upstream and downstream of Township Road 49 on Eagle Creek were considered as potential options. Berms would need to be constructed along the banks for over 1-mile on both sides of Eagle Creek to make these inlet relocation options work and maintain flow within the banks of Eagle Creek. The berms would extend from the diversion inlet and tie into higher ground elevations equal to the top of the diversion channel. As an alternative to extending berms up Eagle Creek, a long inlet weir and wider, shallower channel was considered to reduce the water surface elevation at the inlet. Figure 12 shows a conceptual view of the possible relocation of the diversion channel inlet.

Figure 11 – Diversion Channel Profile Refinements

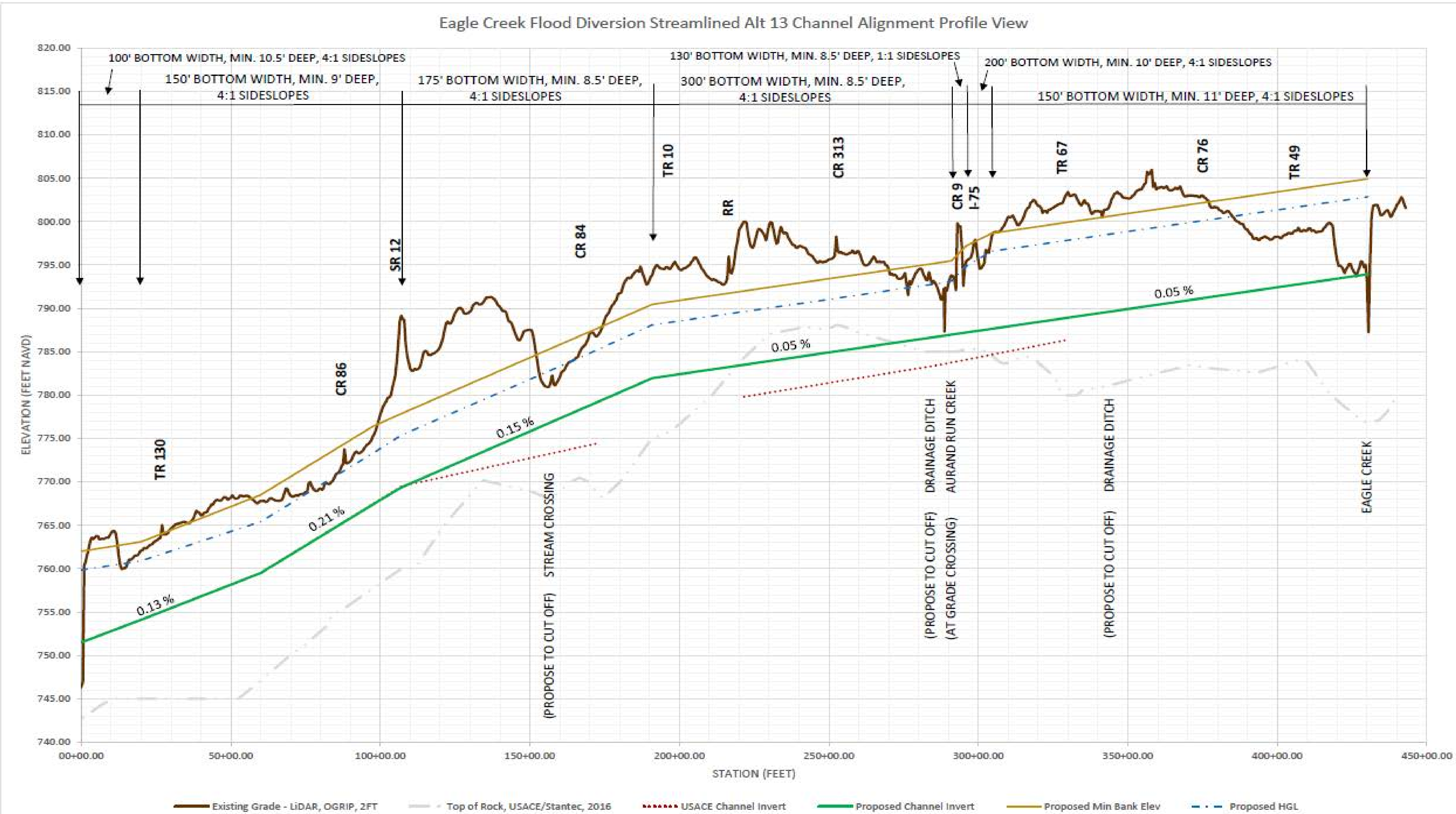
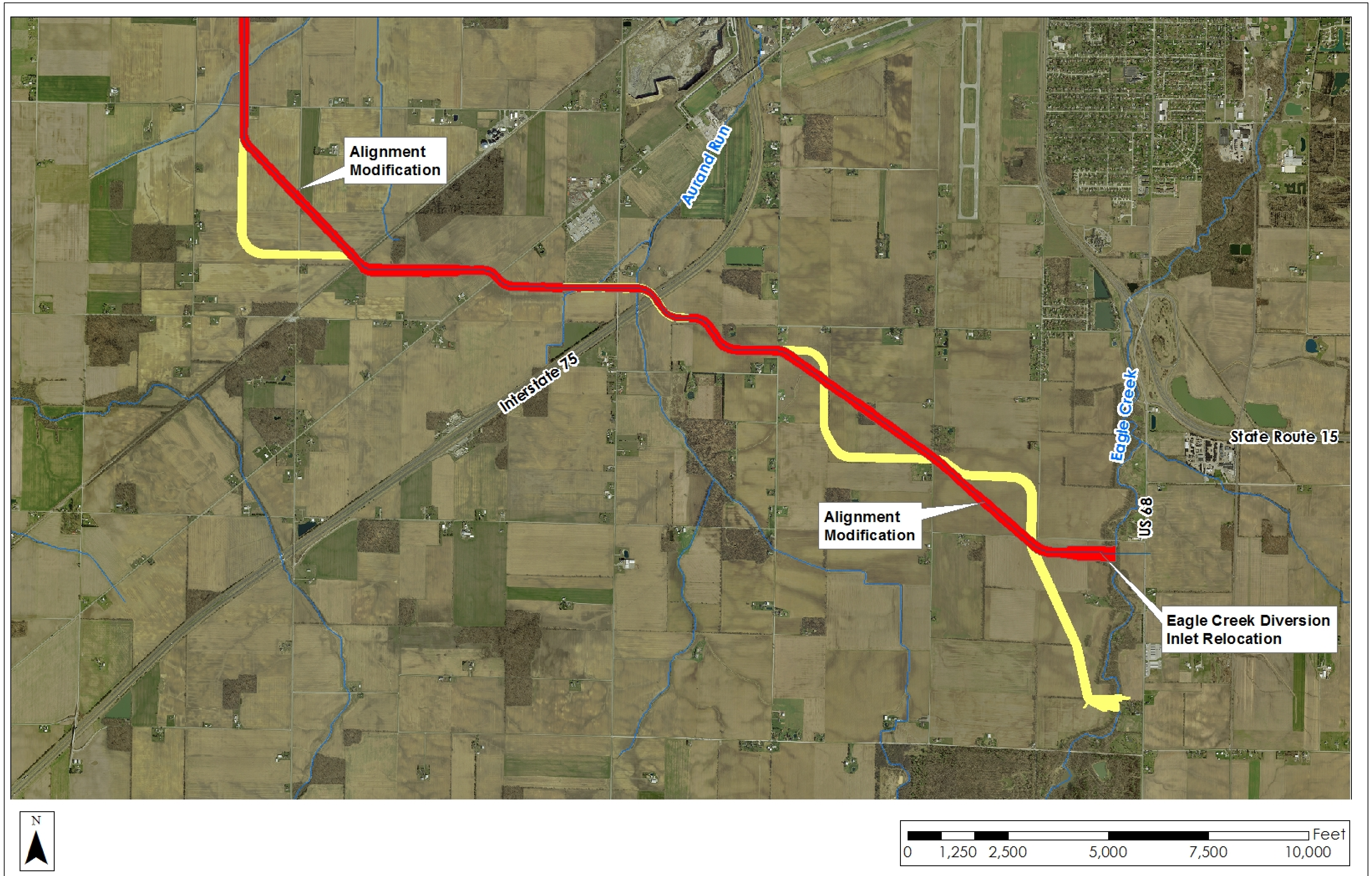


Figure 12 – Diversion Channel Alignment Modifications and Inlet Relocation



4.2.2 Diversion Channel Extension

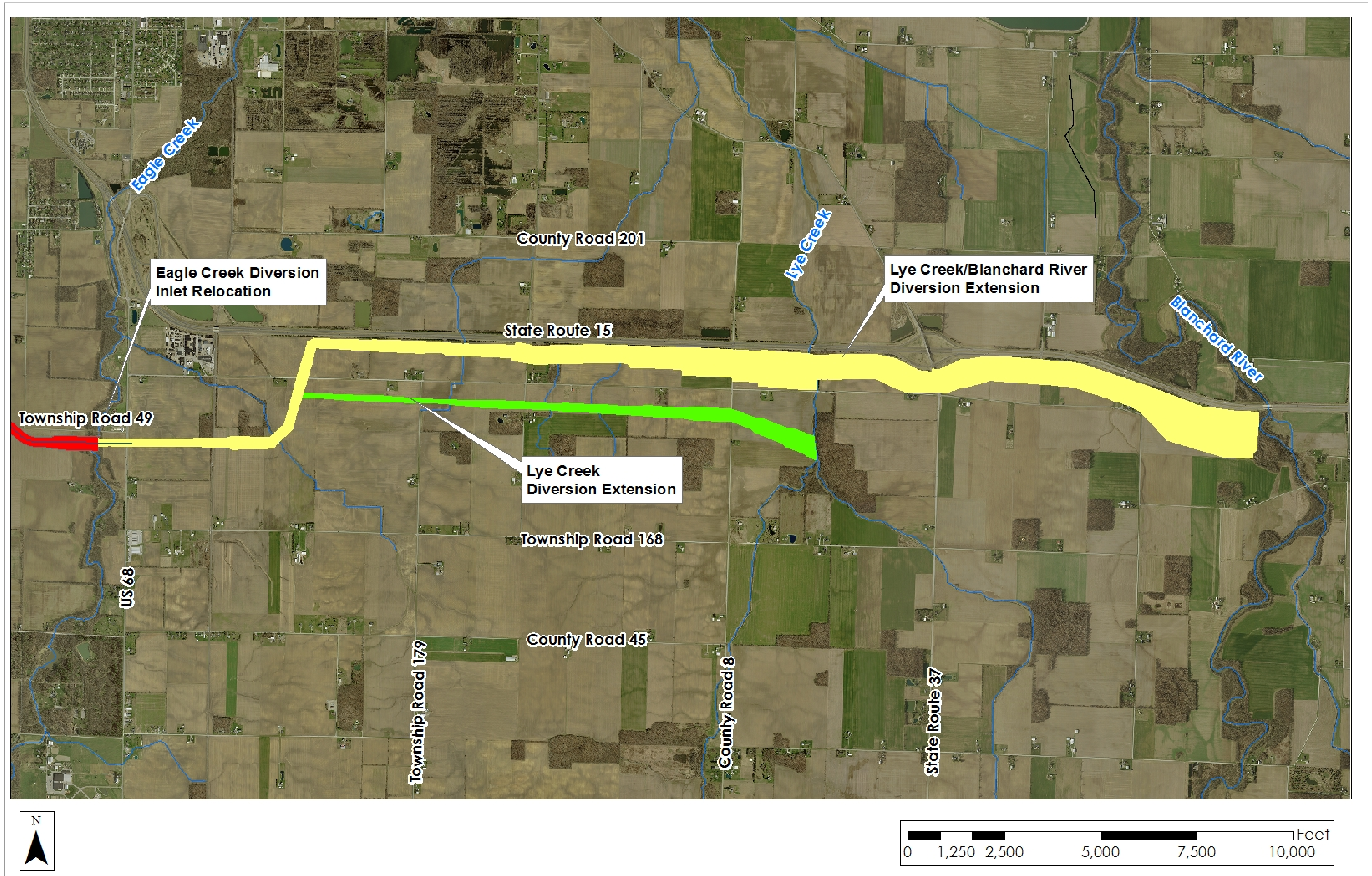
An extension of the proposed diversion channel eastward to Lye Creek and to the Blanchard River was considered and reviewed for technical feasibility and cost effectiveness. Extending the diversion channel to the east would increase the drainage area diverted around Findlay, and ultimately would decrease the risk of flooding. This project was mentioned in the USACE feasibility report, but the report lacked sufficient detail to provide a recommendation.

The capacity of the diversion channel would need to be increased to at least the 1% ACE (100-year) flow level, as described in Section 4.2.1 above, in order for the Western Diversion of Eagle Creek to accommodate additional flow from Lye Creek and the Blanchard River. Water surface elevation limitations along the diversion channel extension require the Western Diversion of Eagle Creek to be configured as “wide and shallow” to keep the water level below US 68. The Western Diversion inlet would also need to be relocated downstream on Eagle Creek to match the diversion extension alignments described in the subsections below.

4.2.2.1 Diversion Channel Extension to Lye Creek

A 3.5-mile extension of the diversion channel to Lye Creek is technically feasible by beginning the channel extension on Eagle Creek near the intersection of Township Road 49 and US 68 and extending eastward parallel to State Route 15. The channel, sized for an additional 2,000 cfs, could be graded at 0.05 percent slope to allow for drainage from Lye Creek to the west. With 4:1 side slopes, the channel extension would need bottom widths ranging between 50 and 500 feet and depths between 3 and 8 feet. The extended diversion channel would intersect an additional four existing roadways (including US 68) and one railroad in route to Lye Creek. Long bridges or culverts would be needed at the railroad and road crossings that could not be eliminated. A second diversion inlet structure with gates similar to that on Eagle Creek would also be needed on Lye Creek. Figure 13 shows the conceptual location for a proposed diversion channel extension to Lye Creek.

Figure 13 – Diversion Channel Extension to Lye Creek and the Blanchard River



4.2.2.2 Diversion Channel Extension to the Blanchard River

A 6-mile extension of the proposed diversion channel would allow flow to be collected from both Lye Creek and the Blanchard River. The extension is technically feasible by beginning the channel extension on Eagle Creek near the intersection of Township Road 49 and US 68 and extending eastward parallel to State Route 15. The channel could be sized to divert an additional 3,000 cfs from Lye Creek and the Blanchard River. However, diversion inlet capacity should be considered relative to maximum flow capacity of each channel segment.

The channel between the Blanchard River and Lye Creek to the west could be graded at a 0.03 percent slope. When sized to carry 3,000 cfs, the channel with 4:1 side slopes would need widths ranging between 600 and 1,200 feet at depths between 2 and 3 feet. No controlled gate structure would be necessary at the Blanchard River. Instead, the river channel under the State Route 15 bridge would be modified to constrict flow so that water is directed into the diversion channel toward Lye Creek. A gate structure would be needed at Lye Creek to direct flow from Lye Creek and the Blanchard River toward the Eagle Creek diversion channel. Between Lye Creek and Eagle Creek, the channel when sized to carry 3,000 cfs would need bottom widths ranging from 200 feet to 900 feet, at depths between 2 feet and 7 feet.

The extended diversion channel would intersect an additional six existing roadways (including US 68) and one railroad in route to the Blanchard River. Bridges or culverts would be needed at the railroad and road crossings that could not be eliminated. A second diversion inlet structure with gates similar to that on Eagle Creek would also be needed on Lye Creek. Figure 13 shows the conceptual location for a proposed diversion channel extension to Lye Creek and the Blanchard River.

4.2.2.3 Diversion Channel Extension Summary

An extension of the diversion channel east to Lye Creek and the Blanchard River appears to be technically feasible, however, there would be several design challenges. The land between Eagle Creek and the Blanchard River is flat with several ridges of bedrock. Therefore, the extension of the diversion channel would likely need to be wide and shallow in order to convey the required flows. The required widths for this channel would create the need for at least four bridges.

There are also unknown challenges related to the timing of inflows from the three separate sub-watersheds and appropriately sizing the subsequent diversion conveyance system. Additionally, flows from the three contributing waterways would likely be conveyed downstream of Findlay faster through the diversion channel and potentially create a higher water surface elevation profile downstream of the City. The impacts of this analysis were not studied, but would be required for future phases of design.

The diversion channel extension is feasible, however shallow rock and low gradient causes significant impact to land, properties, and transportation features as shown in Figure 13. Based on preliminary opinions of probable cost, the diversion channel extension option was not included for further hydrologic or hydraulic analysis.

4.2.3 Blanchard River Modifications

Hydraulic improvements were reviewed within the Blanchard River corridor in the City of Findlay and downstream. These projects included cleaning the river, deepening and widening the channel, creating a “high velocity” concrete channel, removal of inline dam/riffle structures, excavation of floodplain benches to widen the active floodplain, and modifications to local bridges to provide increased conveyance during high flows.

4.2.3.1 Modifying the Blanchard River’s Geometry

Several options were reviewed related to increasing the conveyance capacity of the Blanchard River by removing debris, changing the shape, and reducing the roughness of the channel. These hydraulic improvements included clearing and snagging, deepening and widening, and lining with the river with concrete to create a “high-velocity” channel.

Clearing and snagging involves removal of vegetation along the overbanks. Even though several site visits to the Blanchard River indicated a relatively “clean” channel with limited debris or obstruction, hydraulic models were used to lower the Manning’s roughness coefficients along the overbank to simulate the clearing and snagging process. The results showed minimal improvement during the 1% ACE event.

Bedrock was observed at several locations along the Blanchard River. Deepening of the main channel would require extensive excavation of rock. As discussed below, widening of the Blanchard River was considered at specified locations.

A “high-velocity” channel was simulated in the hydraulic model by changing the channel roughness coefficient for the entire length of the Blanchard River to 0.015, a value typical of concrete. While the modeled results showed a reduction in the water surface profile through Findlay, flooding would be exacerbated downstream. Due to the nature of this solution, the project would not likely be technically, economically, or environmentally feasible.

4.2.3.2 Riffles and Inline Structure Removal

The hydraulic impact of low-head dams and “riffle” structures on the Blanchard River in Findlay was evaluated to determine if removal or modification could reduce local flood levels. Stantec considered the five dam/riffle structures located along the Findlay corridor (Figure 14):

1) Upstream of Broad Avenue and adjacent to Swale Park;
2) Downstream of the Norfolk Southern railroad bridge;
3) Upstream of Cory Street and Downstream of Main Street;

4) Upstream of South Blanchard Street; and
5) Adjacent to Riverside Park.

Figure 14 – Riffles/Inline Structures on Blanchard River through Findlay

The removal of these structures was reviewed and simulated within the hydraulic model to determine the extent of potential flood level reductions. While the low-head dam adjacent to Riverside Park provides a reduction in the WSE upstream of the dam's location, Stantec did not proceed with analysis of this removal because it is upstream of downtown and the major flooding areas and because of the dam's historical significance. Simulations show removing the remaining four structures in the Blanchard River may provide a modest benefit when looking at the cumulative reduction in the WSE in downtown Findlay. Preliminary modeling results show about a 0.3 feet reduction in the 1% ACE (100-year) BFE upstream of the inline structure removals. The effects of these removals are expected to increase when combined with other hydraulic modifications such as the floodplain bench widening.

4.2.3.3 Floodplain Bench Widening

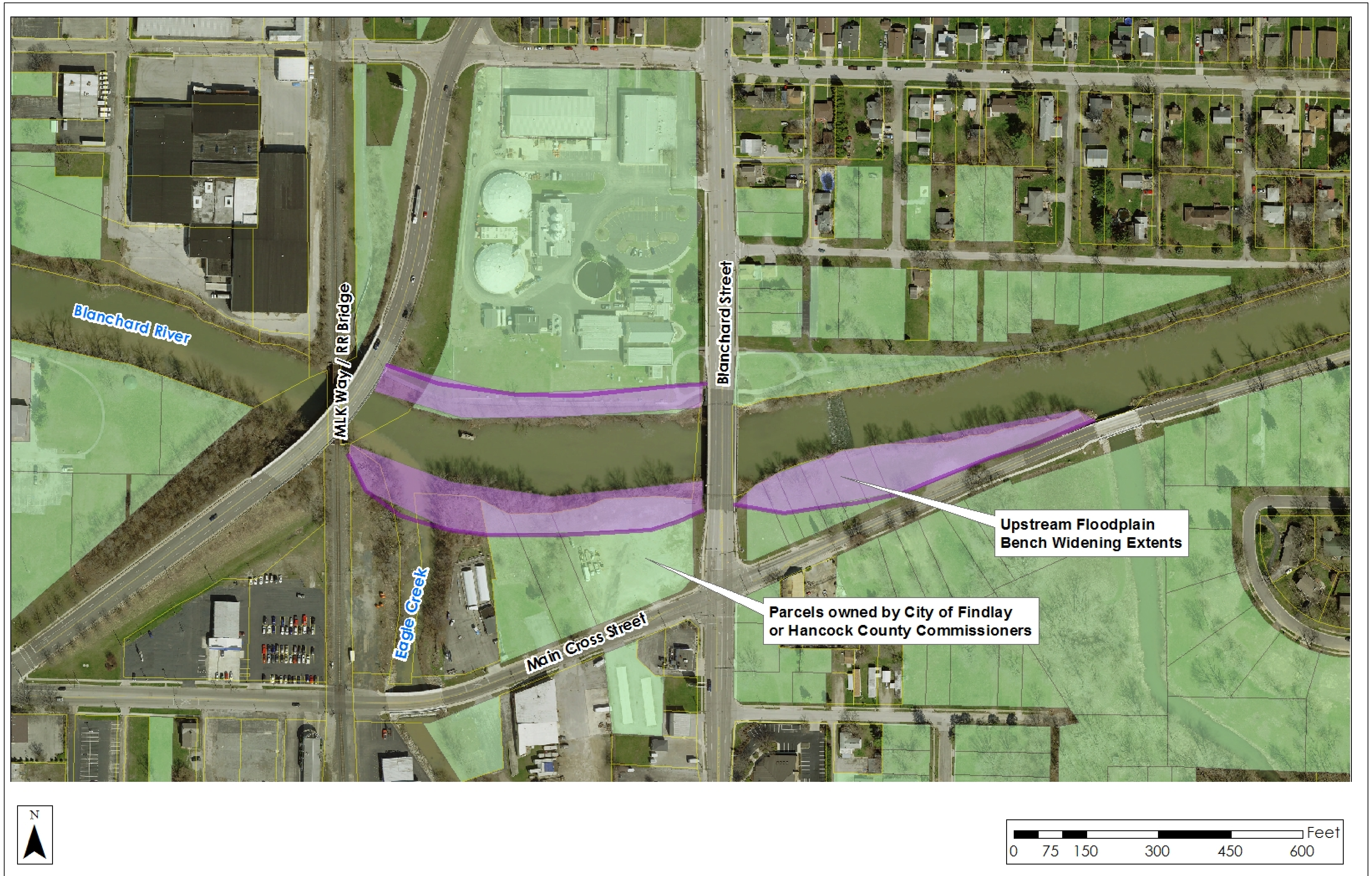
Stantec reviewed channel floodplain bench widening options on the Blanchard River in Findlay at multiple locations; they were simulated within the hydraulic model to determine if flood level reductions were possible and if the flood reductions could be achieved in a cost-effective manner.

One location studied is on the right overbank of the Blanchard River (north side) between Broad Avenue and approximately 50 feet upstream of the Norfolk Southern Railroad Bridge downstream of Cory Street (downstream widening). The widening of the proposed floodplain bench is generally between 250 and 400 feet. Figure 15 shows the location and extents of the proposed downstream option.

Another reviewed location is comprised of a section of the Blanchard River from Martin Luther King Parkway to approximately 750 feet upstream of Blanchard Street (upstream widening). Widening on either side of the channel is generally between 50 and 75 feet. Figure 16 shows the location and extents of the proposed upstream widening. The floodplain widening sites were generally selected based on expected WSE reductions and locations where parcels are owned by the City of Findlay and/or Hancock County.

Figure 15 – Downstream Extents of Floodplain Bench Widening on Blanchard River through Findlay

Figure 16 – Downstream Extents of Floodplain Bench Widening on Blanchard River through Findlay



4.2.3.3.1 Design Criteria

The geomorphic channel forming flow area is commonly referred to as the bankfull area. Stantec assumed no excavation would occur within the bankfull area for conceptual design. The bankfull area was estimated based on Eastern United States regional curve (Reference 10) and site investigations by Stantec in October of 2016. The designed bankfull flow area for the downstream and upstream widening sections was approximately 800 square feet. The bankfull flow elevation was estimated at the downstream end of each widening section. Stantec assumed the simulated 50% ACE (2-year) event water surface slope from the HEC-RAS model would be approximately the same slope observed during bankfull flow. Bankfull elevations at the upstream cross-sections were estimated based on this water surface slope. The bankfull elevation is often considered the OHW for permitting purposes.

The channel's proposed floodplain widening extents were fixed as described above. A bankfull bench was extended to the extents of the widening and then graded to the existing topography at a 3:1 slope.

4.2.3.3.2 Floodplain Widening Excavation

The downstream floodplain expansion work is expected to require approximately 337,000 cubic yards of excavation. Some of the soils within the excavation zones are expected to be contaminated based on documentation provided by the client. The assumed contaminated sites were factored into the preliminary opinions of probable cost as this material would potentially require disposal off-site in a landfill. Additional consideration was given to existing utilities in the proposed limits of excavation. Relocation costs were incorporated into the estimate for sanitary sewer, water monitoring wells and overhead electric lines that were identified on the site.

The upstream widening section would require approximately 22,700 cubic yards of excavation. After reviewing the hydraulic simulation results, Stantec did not proceed with further analysis of the upstream widening option due to the minimal expected benefits in reducing the 1% ACE (100-year) BFE.

4.2.3.4 Bridges

Bridges, especially older ones, can often be the sources of flow constrictions on rivers causing increased upstream flooding. Several bridges through Findlay (Figure 17) and downstream of the City (Figure 18) along the Blanchard River were reviewed to estimate the benefits associated with bridge modifications.

Figure 17 – Bridges on Blanchard River through Findlay

Figure 18 – Bridges on Blanchard River Downstream of Findlay

4.2.3.4.1 RR Bridge Downstream of Cory Street

Preliminary hydraulic modeling results show the railroad bridge downstream of Cory Street to be a constriction that increases the WSE upstream for flood events. Modifications to the existing Norfolk Southern railroad bridge, such as raising the elevation of the low chord and/or adding another span to create a larger opening, were evaluated to determine the extent of the benefit and cost effectiveness. Through conversations with the USACE and the client, Stantec has learned that discussions have taken place with Norfolk Southern in the past regarding potential modifications to this railroad bridge. The bridge appears to be several decades old and there is apparent interest from Norfolk Southern in replacing or modifying the existing bridge structure. Stantec analyzed both raising the deck of the bridge in 1 foot increments up to 3 feet or adding in an additional span approximately 50 feet in length. Preliminary results show increasing the opening of the railroad bridge decreases the WSE upstream of the structure. Figure 19 shows the railroad bridge looking downstream on the Blanchard River from Cory Street.

Figure 19 – Norfolk Southern Bridge Downstream of Cory Street

4.2.3.4.2 RR Bridge Under Dr. Martin Luther King Parkway

The railroad bridge under Martin Luther King Parkway was reviewed for impact to the 1% ACE (100-year) BFE. For simplification, the entire bridge structure and ineffective flow areas were removed from the hydraulic model to determine the maximum benefit associated with modifications to the bridge. Complete removal of this structure showed a benefit of a couple of hundredths of a foot reduction during the 1% ACE (100-year) base flood event. Stantec did not continue to analyze this modification due to the minimal benefits anticipated.

4.2.3.4.3 County Road 139 & County Road 140 Bridges

Both County Road 139 and County Road 140 bridges were identified as potential constrictions and were also reviewed for potential reductions in the 1% ACE (100-year) BFE through modification to the bridges. Again, the entire bridge structures and roadway embankments were completely removed from the hydraulic model for simplification to determine the maximum potential benefit. Although the simulated results showed a decreased WSE immediately upstream of each bridge after removal, the benefit dissipated upstream through downtown Findlay. Stantec did not continue to analyze these modifications due to the minimal benefit observed (about 0.2' feet reduction in the 100-year BFE at Main Street after removing both bridges).

4.2.3.5 Hydraulic Improvements Summary

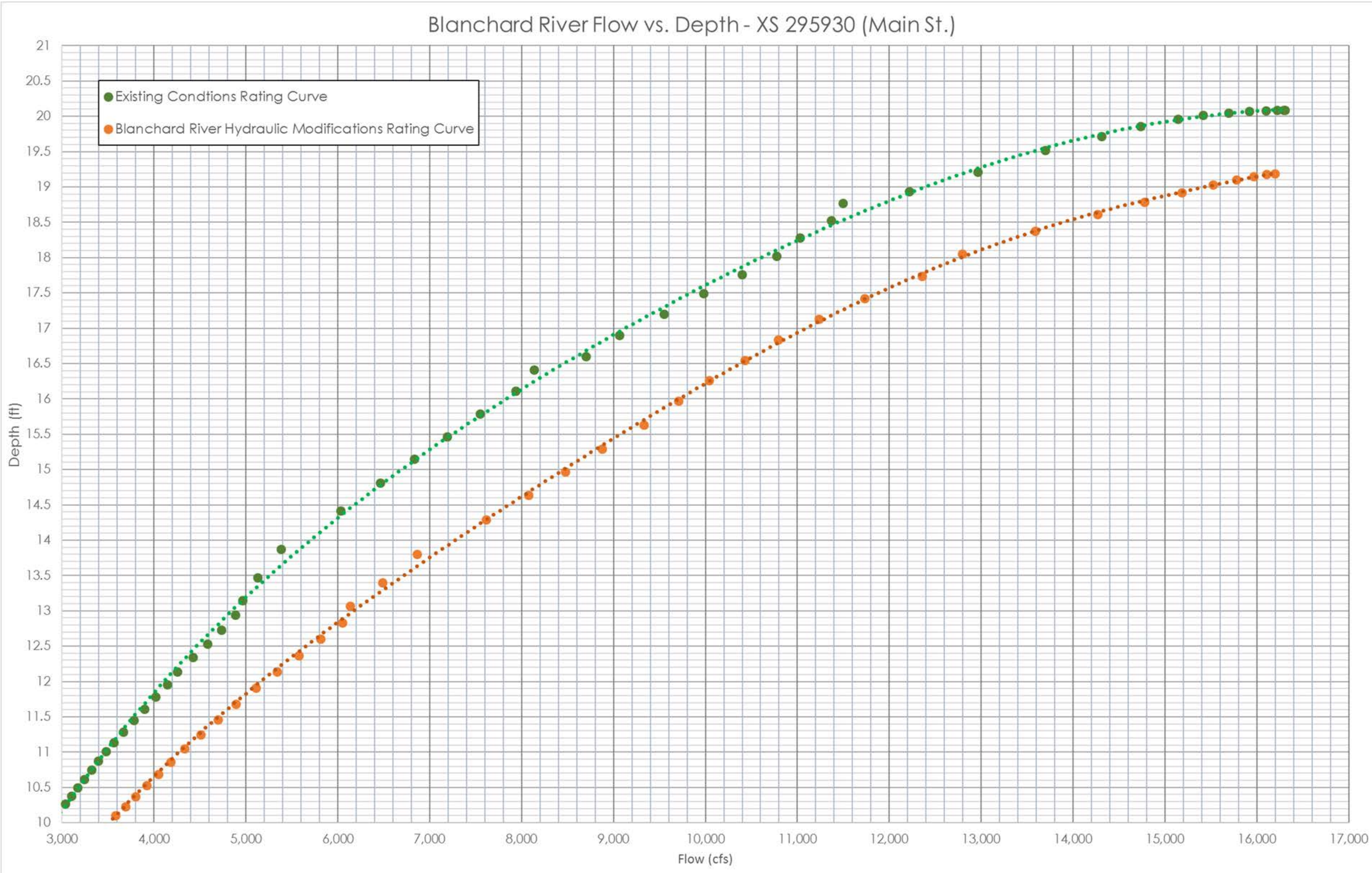
A select combination of the hydraulic improvements mentioned above are estimated to reduce the 1% ACE (100-year) BFE within the Blanchard River in downtown Findlay by about 1 foot. The combination of modifications includes floodplain bench widening between Broad Avenue and the Norfolk Southern Railroad bridge, adding a 50-foot span to the Norfolk Southern Railroad bridge, and the removal of the following dam/riffle structures located along the Findlay corridor:

1) Upstream of Broad Avenue and adjacent to Swale Park;
2) Downstream of the Norfolk Southern railroad bridge;
3) Upstream of Cory Street and Downstream of Main Street; and
4) Upstream of South Blanchard Street.

The combination of projects is expected to provide increased conveyance during increased flows. Figure 20 shows the updated rating curve at Main Street once the modifications along the Blanchard River were included in the project's hydraulic geometry.

The selected hydraulic improvements are expected to increase the flood level reductions by various amounts, depending on the flow rate within the Blanchard River. With the implementation of the listed hydraulic improvements, the stage reduction in the area upstream of the floodplain bench widening is expected to vary between approximately 1 foot to about 1.5 feet based on the discharge in the Blanchard River. There are two ways to look at the rating curves shown in Figure 20; 1) the hydraulic geometry could be made more efficient, allowing the Blanchard River to carry additional flows during storm events, or 2) the amount of water that needs to be diverted or retained to meet the project goal is reduced if these hydraulic improvements are made.

Figure 20 – Flow Profile Rating Curve at Main Street with Blanchard River Modifications



4.2.4 Storage

Regional flood detention areas (dry storage basins) on the Blanchard River, Lye Creek and Eagle Creek were evaluated to determine if suitable locations exist; if the storage areas were effective at reducing flood levels in the Findlay vicinity; and if they could be cost effective. Stage storage curves were developed at seven different locations and were analyzed to determine the storage areas effectiveness in reducing peak flows in and around Findlay. These storage basins were reviewed primarily for economical, technical, and environmental feasibility. Coordination with agencies such as USFWS will be required to discuss potential impacts or improvements to the stream corridors. Each of the dry storage basins were analyzed assuming static primary spillway discharge structures such as simple box culverts.

The storage detention basins are anticipated to remain dry a majority of the time with the exception of providing increased flood protection during certain storm events. These types of facilities have less impacts on habitat, aquatic and terrestrial species, and other environmental concerns compared to a typical retention water reservoir. Another benefit of the dry basins is that agricultural land upstream of the storage berms may remain in use and would not be permanently removed from production. In the case of a storm event with a 1% chance of happening each year, durations of storage would last for a couple of days with depths of water varying based on the distance from the watercourse and the embankment.

4.2.4.1 Blanchard River

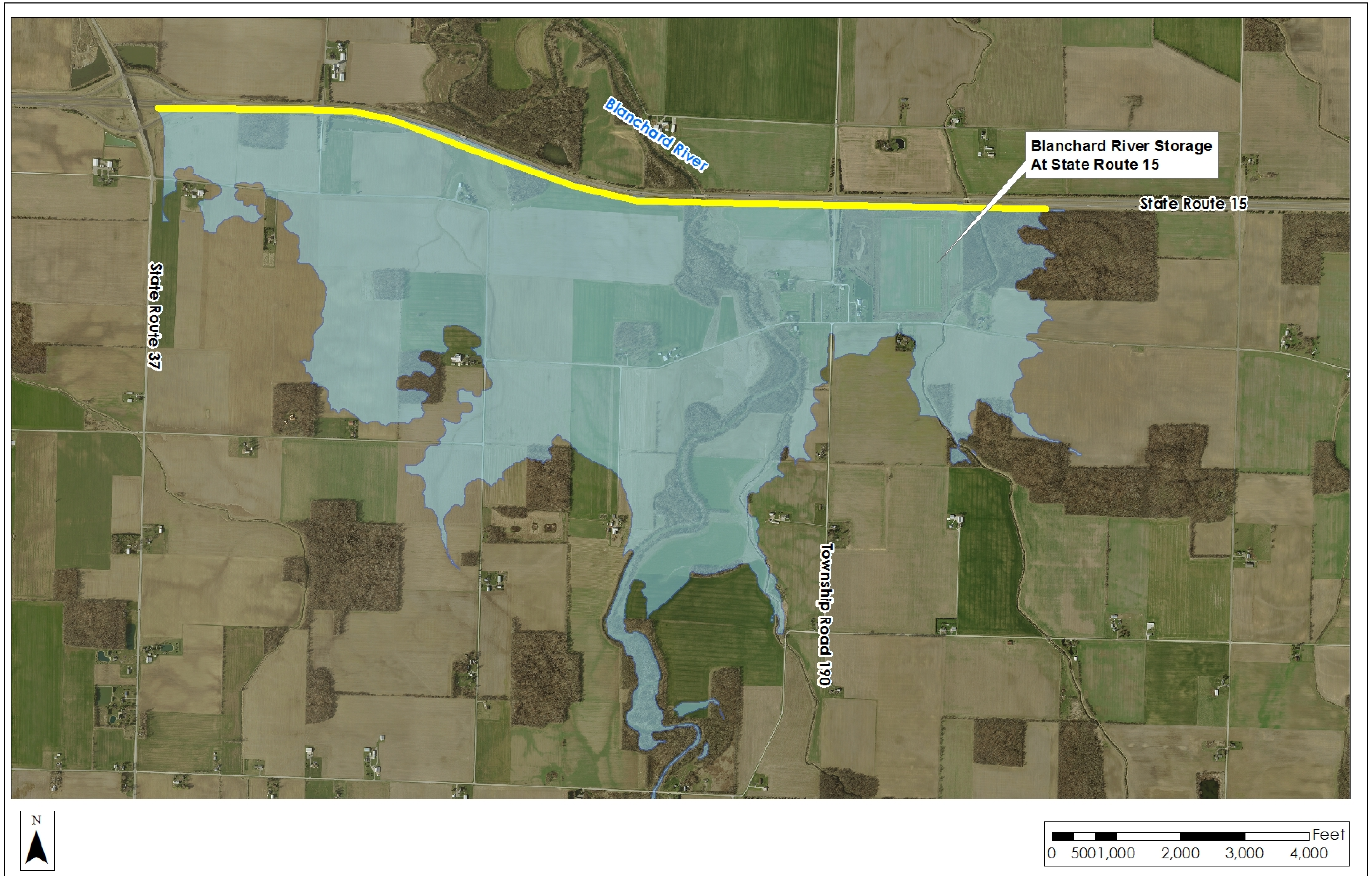
The upper Blanchard River watershed has about 350 square miles of drainage area contributing flow through the City of Findlay. Much of this drainage area is routed directly into the Blanchard River. The Blanchard River is approximately 50 miles in length from the top of the watershed through downtown Findlay. Stantec reviewed this stretch of river to find suitable locations for storage that could potentially be cost effective with minimal impacts to the surrounding area.

4.2.4.1.1 State Route 15

The area upstream of State Route 15 on the Blanchard River (Figure 21) was considered as a potential option for storage due to its proximity to Findlay (capturing a large percentage of drainage area) and the potential to use the existing roadway embankment as a berm. Stage-storage curves were developed both for existing ground and for excavation scenarios. The roadway elevation along State Route 15 near the Blanchard River is approximately 805 feet. Assuming 2 feet of freeboard, the existing ground stage storage curve was analyzed up to 803 feet (about 1,600 acre-feet) to predict potential benefit in reducing the peak flow rates. Due to the substantial volume of water and peak flow values observed on the Blanchard River, 1,600 acre-feet did not provide a substantial benefit in reducing the peak flow rate.

Stantec also reviewed the volume of excavation necessary to provide meaningful storage capacity at this location. Two additional scenarios were reviewed involving excavation down to elevation 802 feet and 800 feet. Although these scenarios would provide about 2,500 acre-feet and 4,000 acre-feet of storage respectively, they would require 2 million and 4.5 million cubic yards (cy) of excavation. With excavation costs ranging between $10/cy and $20/cy, Stantec determined that this location did not provide sufficient benefit in reducing the 100-year BFE for the estimated construction costs that would be required so this site did not move forward as a feasible storage location.

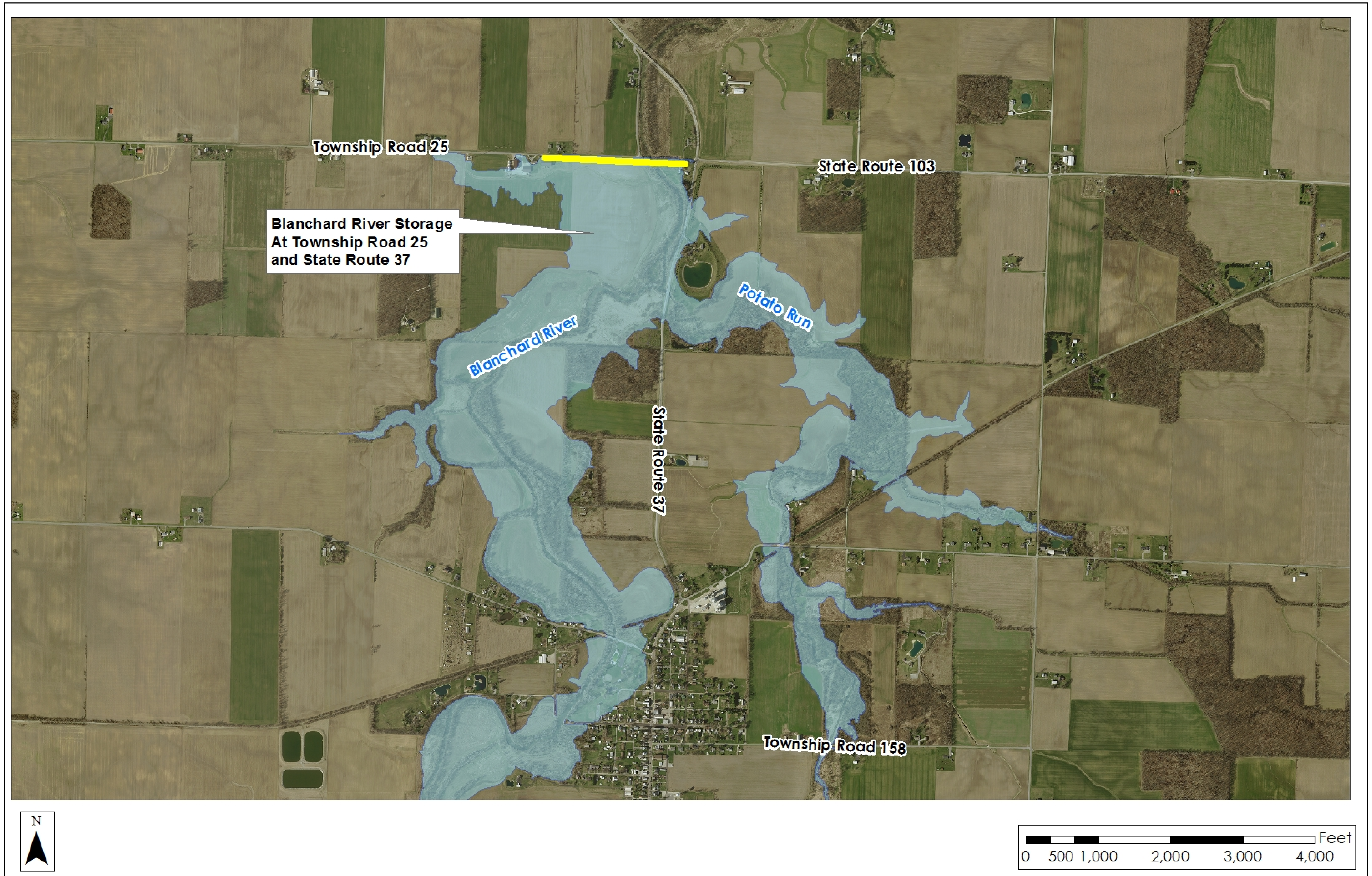
Figure 21 – Storage on the Blanchard River at State Route 15



4.2.4.1.2 Downstream of Mt. Blanchard at Township Road 25 and State Route 37

Stantec reviewed the storage capacity at a location adjacent to Township Road 25 and State Route 37, about one mile downstream of the Village of Mt. Blanchard (Figure 22). Approximately 2,500 acre-feet of storage would be available at elevation 828 feet using the existing ground topography and assuming 2 feet of freeboard to elevation 830 feet. Inundation impacts were observed at the north end of Mt. Blanchard and along State Route 37. Peak flow values modeled on the Blanchard River were not significantly improved by the 2,500 acre-feet of storage at this location. Stantec did not proceed with further analysis of this storage location.

Figure 22 – Storage on the Blanchard River at Township Road 25 and State Route 37



4.2.4.1.3 Upstream of Mt. Blanchard at State Route 37 and State Route 103

Stantec analyzed the storage capacity at two locations upstream of Mt. Blanchard on the south side of State Route 103 and State Route 37 (Figure 23). The Blanchard River in this area flows parallel to, and is west of, County Road 17. Potato Run, a tributary to the Blanchard River about 4,000 feet to the east, flows on the east side of County Road 17. Storage options were considered at both locations due to the undulating terrain near the river corridor.

Up to 12,000 acre-feet of storage could be available on the Blanchard River to reduce the peak flow rates downstream. Additionally, Potato Run could provide up to 4,300 acre-feet of storage at an elevation of 856 feet.

A few potential impacts to structures and roadways were identified when the storage basins were modeled on the Blanchard River and Potato Run. However, the benefits associated with the storage at these two locations to reduce peak flows in Findlay warranted further investigation.

The second peak in the Blanchard River flow hydrograph in Findlay, discussed in Section 4.1, is the result of flow contributions from the Upper Blanchard sub-watershed. A reduction in peak flow rate from the Upper Blanchard watershed should contribute to the reduction in flooding not only in Findlay, but also in Mt. Blanchard and along a long stretch of the Blanchard River corridor where flow routinely leaves the banks during larger storm events (including the Blanchard to Lye crossover). The peak flow rate through Mt. Blanchard could be reduced by as much as 4,000 cfs, depending on the combination of different sized embankments on the Blanchard River and Potato Run.

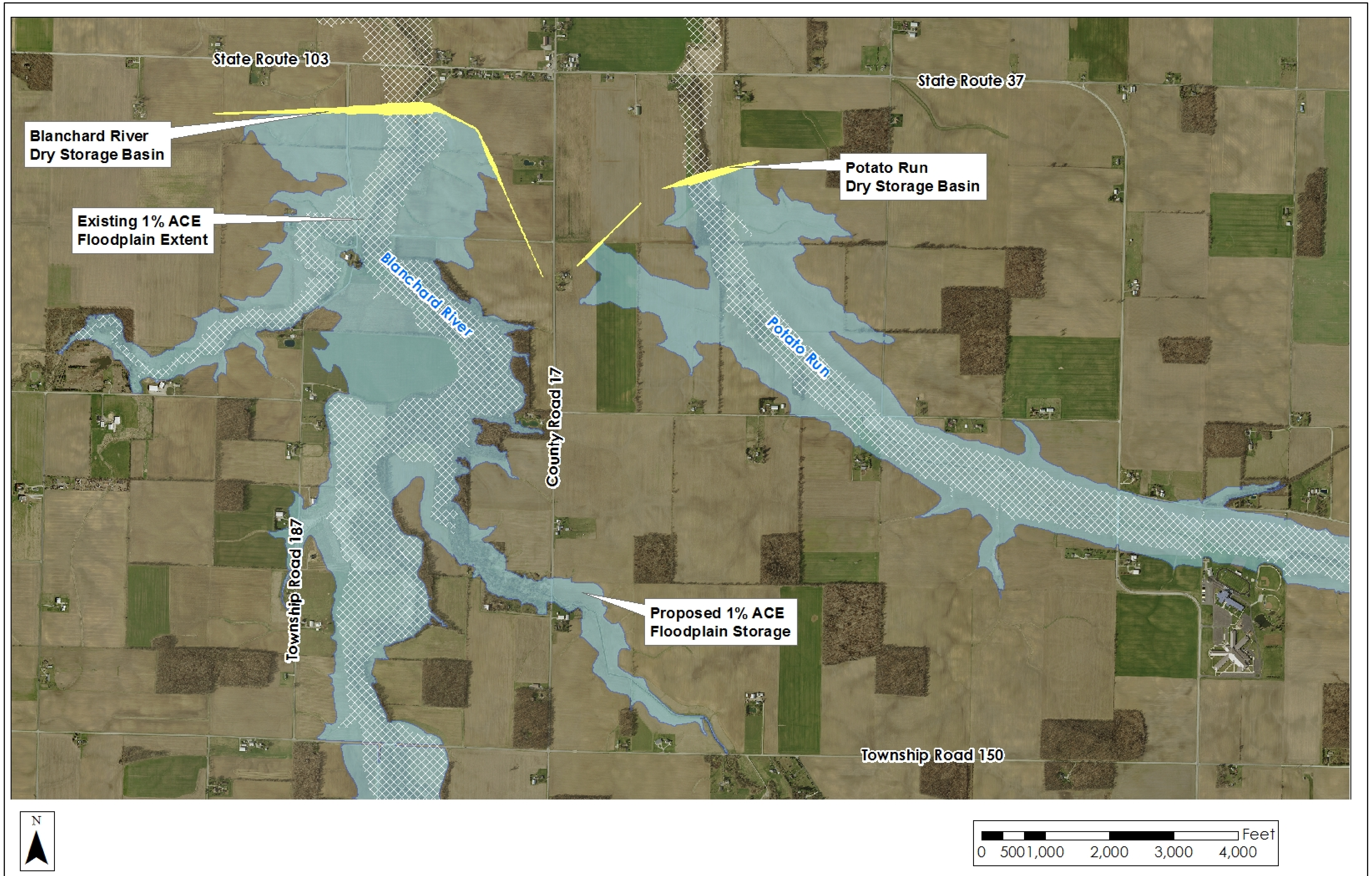
Several storage layouts and dam heights were reviewed to find options that would reduce the peak flow rate down the Blanchard River, while minimizing the social and environmental impacts. The top of embankment elevation for the location on the Blanchard River was assumed to be 858 feet, while the maximum water surface elevation for the 1% ACE (100-year) event was assumed to be 851 feet. This freeboard allowed for construction of an auxiliary spillway to pass the Probable Maximum Flood (PMF) event and to allow for wave run-up and other factors. The embankment height would be approximately 30 feet tall over the channel. A few potential impacts to structures and roadways were identified when the storage basin was modeled on the Blanchard River, however, the expected benefits associated with reducing the peak flow at this location warranted further investigation.

The top of embankment elevation for the location on Potato Run was assumed to be 858 feet, while the maximum water surface elevation for the 1% ACE (100-year) event was assumed to be 854 feet. This freeboard allowed for construction of an auxiliary spillway to pass the PMF event and to allow for wave run-up and other factors. The embankment height would be approximately 25 feet tall over the channel. A few potential impacts to roadways were identified when the storage basin was modeled on Potato Run, but no impacts to structures were identified. The proposed storage areas would intercept about 109 square miles of the

Blanchard River's headwaters and approximately 21 square miles of the headwaters of Potato Run.

The principal spillway on the Blanchard River was sized as a single structure that would result in the maximum amount of flow reduction without exceeding a maximum WSE of approximately 851 feet during the 1% ACE event. A standard box culvert structure 25-feet by 8-feet with a 0.5 percent slope was used for this conceptual analysis resulting in a reduction in peak discharge on the Blanchard River from about 7,900 cfs to 4,700 cfs. A 5-feet by 3.5-feet box culvert with a 0.5 percent slope on Potato Run resulted in a reduction in peak discharges from about 2,100 cfs to about 400 cfs during the 1% ACE event. A reduction in peak flow on the Blanchard River would decrease the flooding along the Blanchard and reduce the peak of the flow hydrograph on the Blanchard River in downtown Findlay. Additionally, the receding limb of the flow hydrograph through Findlay would be modestly reduced, decreasing the duration of flooding by up to 24 hours during the 1% ACE event.

Figure 23 – Storage on the Blanchard River and Potato Run at State Route 103 and State Route 37



4.2.4.1.3.1 Conceptual Embankment Cross Sections

Stantec designed conceptual cross-sections of the embankment(s) that could satisfy current dam design criteria per the conditions known about the site. This sub-section summarizes the assumptions used, and discusses seepage and slope stability results associated with a conceptual cross-section based on USACE and ODNR requirements for slope stability.

Assumptions were made to detain the flood water on the Blanchard River at an elevation of 855 feet at the proposed dam location upstream of Mt. Blanchard for the conceptual embankment cross sections. Freeboard requirements depend on multiple factors, including wave run-up, wind effects, and others that are beyond the scope of a conceptual design. To simplify, a freeboard requirement of 3 feet was assumed. Geotechnical explorations specific to this project option have not been conducted. Historic boring logs from a 1954 project for the State Route 103 bridge over the Blanchard indicate soil overburden between 0 and 18 feet, but typically less than 8 feet. The bedrock elevation is between approximately elevation 821 and 824. The following conceptual design calculations assume that overburden soils will be removed to the top of bedrock, and dam construction will begin at that level.

USACE design criteria for slope stability of dams includes the following criteria shown in Table 6 – USACE Design Criteria for Slope Stability(EM 1110-2-1902):

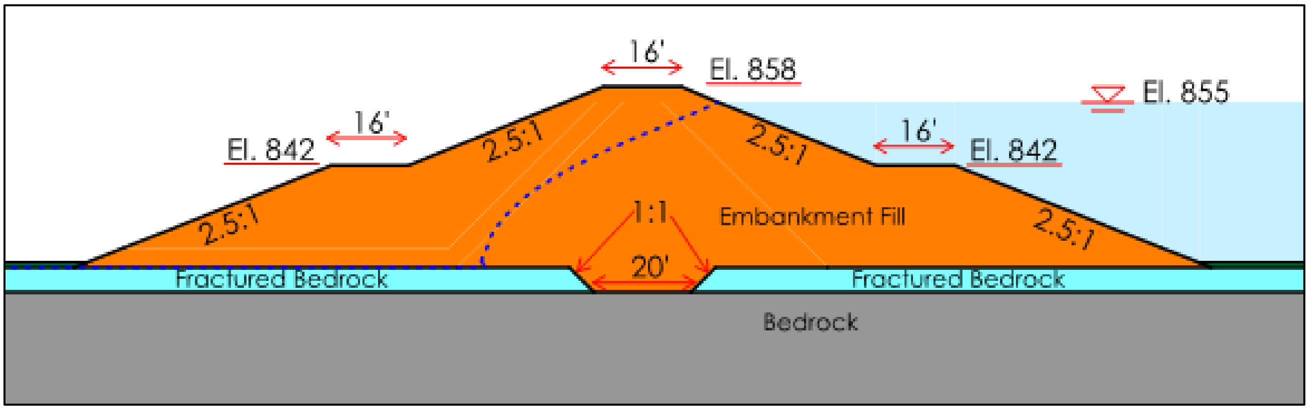
Table 6 – USACE Design Criteria for Slope Stability

Analysis Condition	Required Minimum Factor of Safety	Slope
End of Construction	1.3	Upstream and Downstream
Long-term (Steady seepage, maximum storage pool, spillway crest or top of gates)	1.5	Downstream
Maximum Surcharge Pool	1.4	Downstream
Rapid Drawdown	1.1 - 1.3	Upstream

The proposed dam is considered a detention-style dam meaning that it only impounds water during flood conditions for short durations. It was assumed that a steady-state seepage condition would not develop at the maximum flood elevation of 855 (see Figure 24). Preliminary calculations considered the “end of construction,” “long-term,” and “maximum surcharge pool” conditions. The seepage model used for the evaluated scenarios assumed that headwater (upstream) was approximately 2 feet above the top of rock, and tailwater (downstream) was at the top of rock. The lowest top of rock elevation, from the historic State Route 103 geotechnical exploration, was used to provide a maximum cross section with the crest of the dam.

The preliminary flood hydrograph (analyzed separately from this calculation) indicated that the flood waters would be in place for a short duration of approximately three days. It was assumed, therefore, that steady state seepage conditions would not develop through the dam cross section, and that the maximum surcharge pool could be modeled with normal flow pore water pressures, and a surcharge load applied to the upstream side of the dam. Rapid drawdown concerns were not addressed during the conceptual dam analyses. Bedrock and fractured bedrock were assumed to be impenetrable for slope stability calculations. Figure 24 shows the conceptual design of the proposed cross section and other assumptions are listed below.

Figure 24 – Conceptual Cross Section No. 1



- Homogeneous, impervious clay embankment
- Core material properties assigned based on Stantec experience with similar structures - SC or CL classification, also NAVFAC Table 1 for SC/CL
- Flood elevation of 855 feet
- Crest elevation of 858 feet (for freeboard)
- Cutoff trench: 5 feet deep x 20 feet bottom width (USBR *Design of Small Dams* suggestion)
- Embankment horizontal permeability = 1 x 10^{-8} ft./s = 3 x 10^{-7} cm/s
- Embankment anisotropy ratio = 5 (USBR, typical value for embankment core material)
- Embankment Effective Stress Shear Strength Parameters: c' = 0 psf, φ' = 28˚
- Embankment Total Stress Shear Strength Parameters: c = 500 psf, φ = 15˚

Table 7 – Slope Stability Results – Conceptual Cross Section No. 1

Analysis Condition	Required Minimum Factor of Safety	Calculated Factor of Safety	Analyzed Pool Condition and Shear Strength Parameters
End of Construction	1.3	2.4	Normal headwater, total stress shear strengths
Long-term (Steady seepage, maximum storage pool, spillway crest or top of gates)	1.5	1.4[1]	Normal headwater, effective stress shear strengths
Maximum Surcharge Pool	1.4	2.4	Normal headwater pore pressures, flood surcharge to El. 855, total stress shear strengths
		1.4	Normal headwater pore pressures, flood surcharge to El. 855, effective stress shear strengths
		1.4	Flood headwater pore pressures (El. 855), effective stress shear strengths

[1] Preliminary result is less than the required minimum factor of safety. Further discussion is provided below.

The evaluated cross section generally meets USACE slope stability criteria based on the conceptual level assumptions on material strength and permeability properties. The crest and benches provide 16-feet widths to allow for vehicle access for maintenance and monitoring.

Analyses resulted in a long-term, normal flow condition factor of safety that nearly meets acceptance criteria ($FS = 1.4$, $FS_{required} = 1.5$). If a homogeneous clay embankment is the desired cross section, the side slopes could be flattened from 2.5:1 to 3:1, increasing the factor of safety against the relatively shallow sloughing failure surface between the crest and the downstream bench of the dam. Additionally, further study of the borrow soil may indicate greater long-term, effective stress shear strength of the material than what has been assumed. Further evaluation of the site and testing of borrow material will be required prior to moving from conceptual to preliminary design.

4.2.4.2 Eagle Creek

Figure 9 (Existing Conditions Flow Hydrographs – Downtown Findlay) shows the flow contribution from Eagle Creek is nearly directly aligned with the first and highest peak flow in the Blanchard River hydrograph at Main Street. Reductions in flow on Eagle Creek should directly correlate to reduced flooding along Eagle Creek and along the Blanchard river through Findlay. Stantec reviewed storage options on Eagle Creek as part of the inlet relocation review. The terrain around Eagle Creek near County Road 45 and US 68 is such that a rapid decline in elevation is observed from south to north, going from approximately 815 feet to 800 feet. Using the high ground to the south, a three-sided perimeter embankment can be formed to create a dry storage area. Up to 10,000 acre-feet of storage could be available at an elevation of 810 feet.

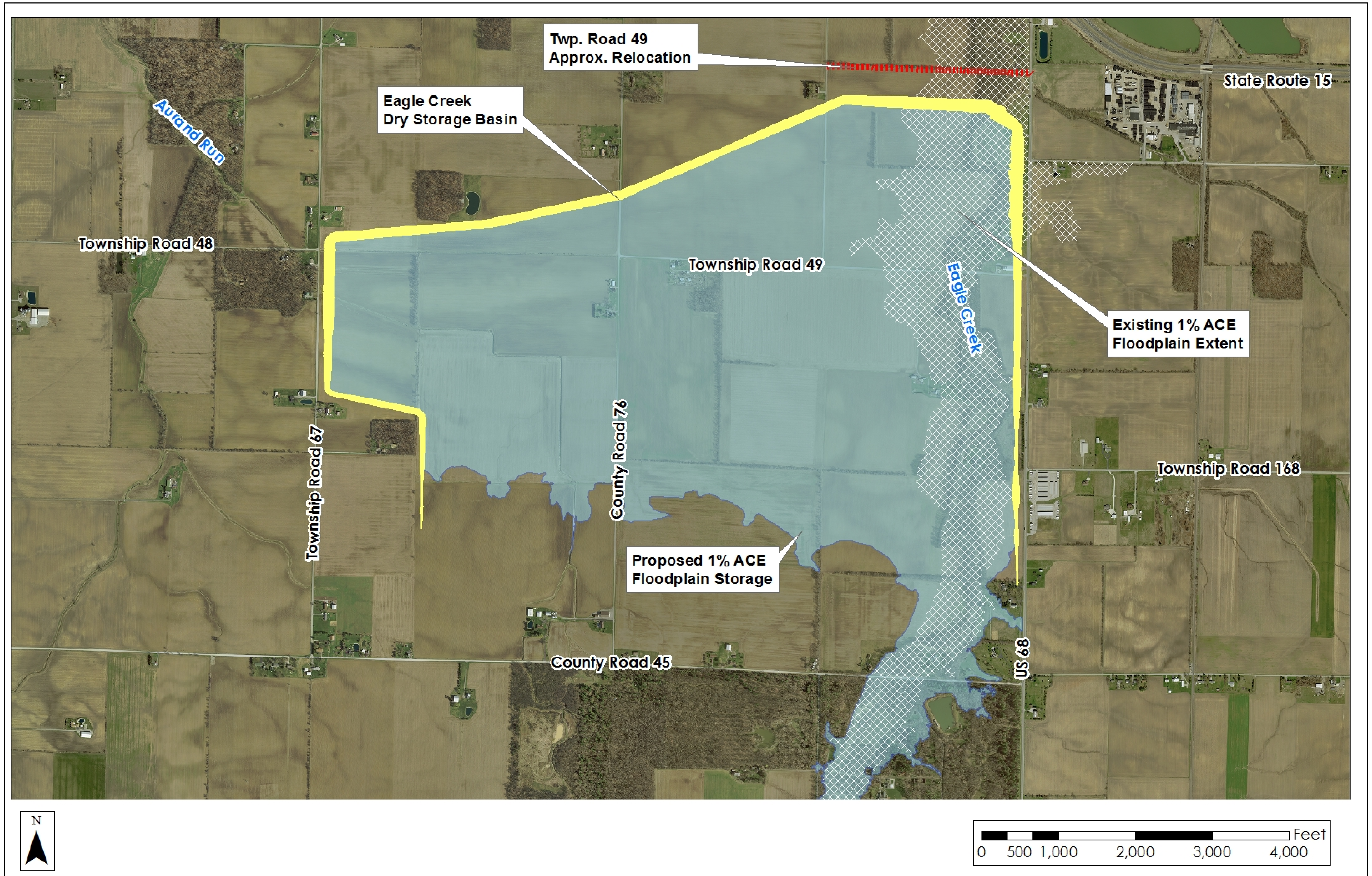
Several storage layouts were reviewed to find options that would reduce the peak flow rate down Eagle Creek in a comparable manner to the Western Diversion of Eagle Creek project. The size of the storage footprint relates to how much excavation is needed to obtain a large enough storage capacity. The conceptual footprint analyzed strikes an approximate balance in earthwork for this option. The east side of the perimeter embankment in the final configuration runs parallel to US 68 beginning near the intersection with County Road 45. The northern side of the embankment is aligned generally to the north of Township Road 49 and the western limits are at Township Road 67 (Figure 25).

Existing contours were used to create a base stage-storage curve on Eagle Creek. The volume of excavation required to achieve a cut/fill balance in earthwork to build a dam or embankment was assumed to originate from the interior of the embankment. This proposed excavation volume was added to the stage-storage curve at Eagle Creek. The top of embankment elevation was assumed to be 812 feet, while the maximum water surface elevation for the 100-year event was assumed to be 807.5 feet. This 4.5-feet of freeboard allowed for construction of an auxiliary spillway to pass the Probable Maximum Flood (PMF) event and to allow for wave run-up and other factors. The assumed configuration of the embankment was 4:1 side slopes with a 20-feet wide top. The berm height would generally be 8 to14 feet tall, and about 30 feet tall over Eagle Creek. A few potential impacts to structures and roadways were identified when the storage basin was modeled on Eagle Creek. Despite these impacts, the expected benefits associated with reducing the peak flow at this location warranted further investigation. Figure 25 shows a conceptual layout of storage on Eagle Creek.

The proposed Eagle Creek storage area would intercept about 51 square miles of Eagle Creek's headwaters and approximately 1 square mile of the headwaters of Aurand Run. The existing conditions hydrology model indicates an existing peak discharge of approximately 140 cfs for this sub-watershed of Aurand Run during the 1% ACE (100-year) event. The storage basin is assumed to have a discharge structure on Aurand Run that will allow no more than 500 cfs into Aurand Run, while the remainder of flow into the storage area would discharge into Eagle Creek. Channel modifications downstream along Aurand Run would potentially be needed for this configuration.

Using the HEC-HMS model for preliminary analysis, the primary spillway on Eagle Creek was sized as a single structure that would result in the maximum amount of flow reduction without exceeding a maximum WSE of approximately 807.5 feet during the 1% ACE event. Standard culvert structures available in HEC-HMS were used for this conceptual analysis. A 4.5-feet by 4.5-feet box culvert resulted in a reduction in peak discharges on Eagle Creek from about 4,900 cfs to about 450 cfs during the 1% ACE event. Storage on Eagle Creek is expected to produce similar results in flood level reduction as the Western Diversion of Eagle Creek when the diversion channel is sized for the 1% ACE (100-year) flood event. A reduction in peak flow on Eagle Creek would decrease the flooding along Eagle Creek and reduce the peak of the flow hydrograph on the Blanchard River in downtown Findlay.

Figure 25 – Conceptual Storage Area on Eagle Creek



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4.2.4.3 Lye Creek

Figure 9 (Existing Conditions Flow Hydrographs – Downtown Findlay) shows the flow contribution from Lye Creek is also aligned mostly with the first and highest peak flow in the Blanchard River hydrograph at Main Street. Although the terrain near Lye Creek was generally flatter than other areas, the corridor was reviewed for suitable locations for storage areas that could be effective at reducing flood levels in downtown Findlay. Stage storage curves were analyzed to determine the capacity to reduce peak flows in and around Findlay.

4.2.4.3.1 Upstream of State Route 15

The area upstream of State Route 15 on Lye Creek was considered as a potential option for storage due to its proximity to Findlay (capturing a large percentage of Lye Creek's drainage area) and the potential to use the existing roadway embankment as a berm. After reviewing the local topography, the lowest elevation on the State Route 15 roadway embankment is about 800 feet. The ground elevations upstream of the embankment are generally between 796 feet and 800 feet. Storage capacity would be minimal with allowance for freeboard. Stage-storage curves were not developed at this location because extensive amounts of excavation would be required for this option to be technically feasible. Figure 26 shows the potential storage area upstream of State Route 15.

4.2.4.3.2 Downstream of State Route 15 at State Route 37

A location north of State Route 15 provided more opportunity for storage due to the more dissected terrain. Stantec identified a location for an embankment upstream of where Lye Creek flows under State Route 37. An 8 to 10 feet tall berm would provide approximately 800 acre-feet of storage at elevation 798. The maximum WSE was limited to below 800 feet to avoid overtopping State Route 15. The berm would typically be less than 2 feet tall for most its alignment near State Route 37 and County Road 8. A primary spillway modeled as a culvert with a rise of 8 feet and a span of 32 feet at 0.5 percent slope should reduce the peak discharge on Lye Creek from about 2,000 cfs to 1,600 cfs with a peak elevation of 797.5 feet during the 1% ACE (100-year) event. Figure 27 shows the area downstream of State Route 15 on Lye Creek where capacity was analyzed.

4.2.4.3.3 Downstream of State Route 15 at State Route 37 and Township Road 205

A third location on Lye Creek between State Route 37 and Township Road 205 was reviewed for potential storage capacity. This was an option with the potential for dual benefits due to the position on Lye Creek and its location downstream of the Blanchard to Lye crossover. Existing contours were used to develop a stage-storage curve for this option. At an elevation of 790 feet, approximately 800 acre-feet would be available for storage. The storage basin was assumed to have a single outlet structure sized for maximum peak discharge reduction without exceeding this elevation. Using a 6 feet by 24 feet culvert configuration results in a reduction in peak discharge from about 2,000 cfs to 1,475 cfs during the 1% ACE event. Figure 28 shows the area between State Route 37 and Township Road 205 on Lye Creek where storage capacity was reviewed.

Figure 26 – Storage Area Upstream of State Route 15 on Lye Creek

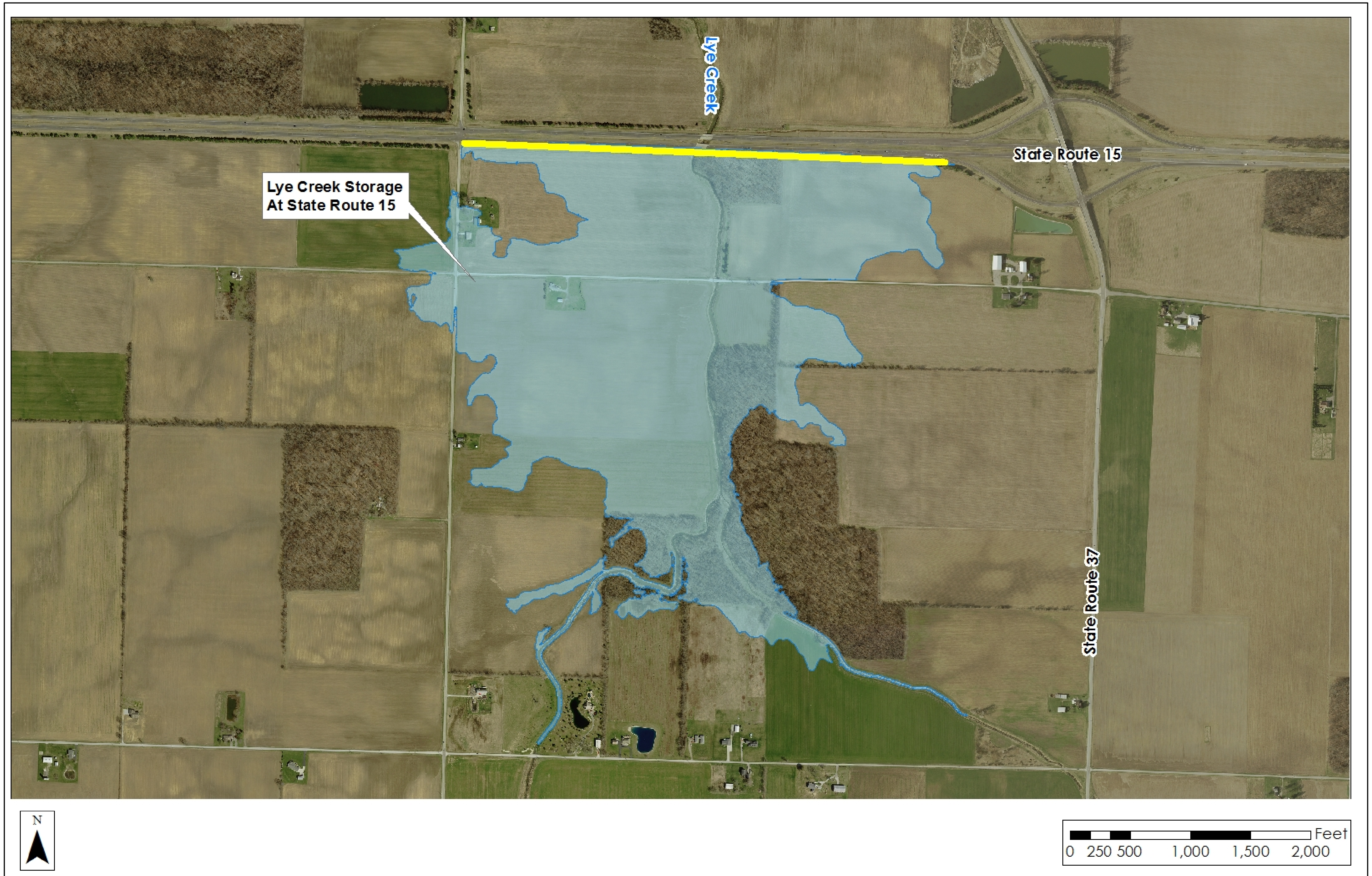


Figure 27 – Storage Area Downstream of State Route 15 at State Route 37 on Lye Creek

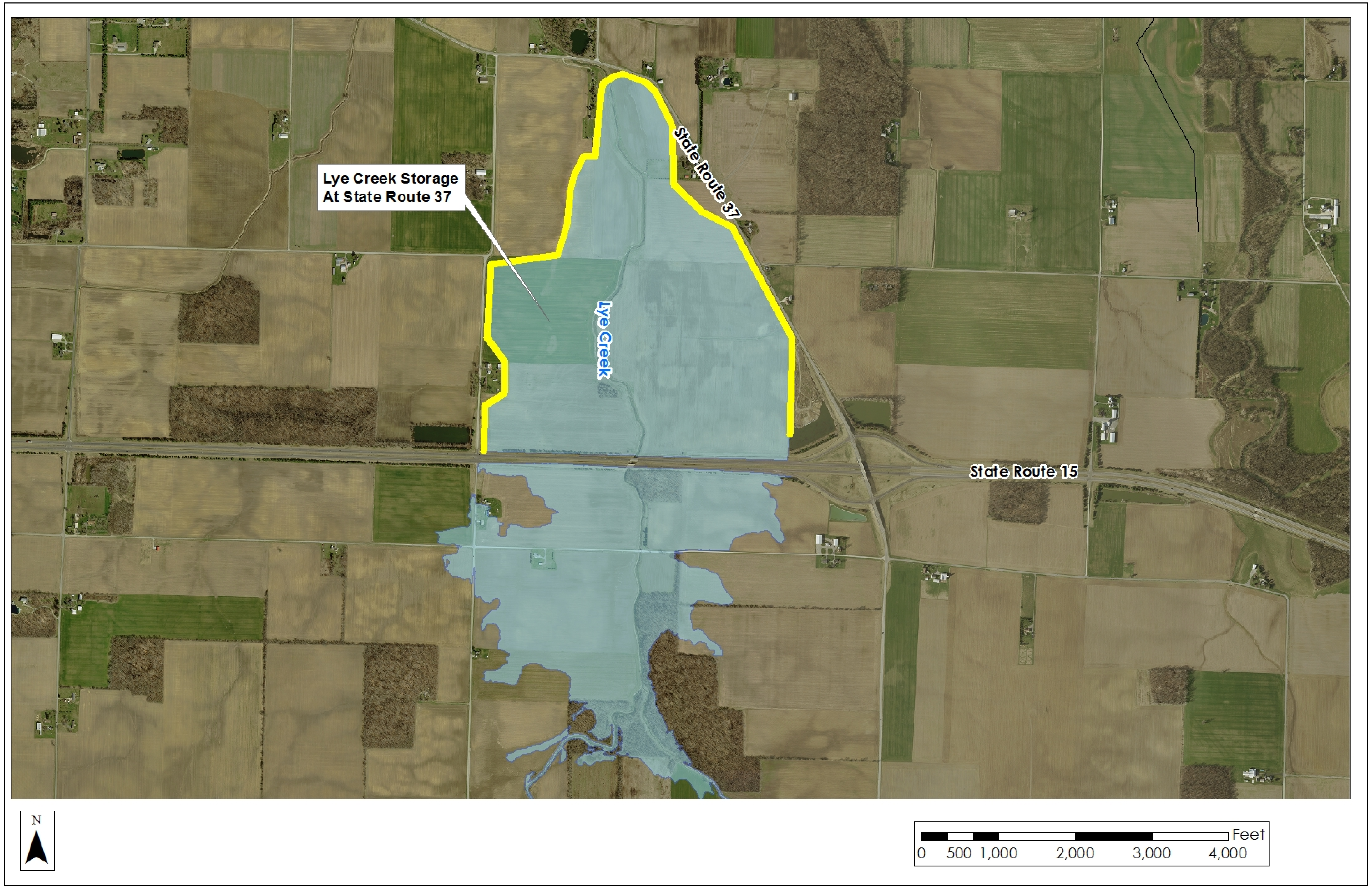
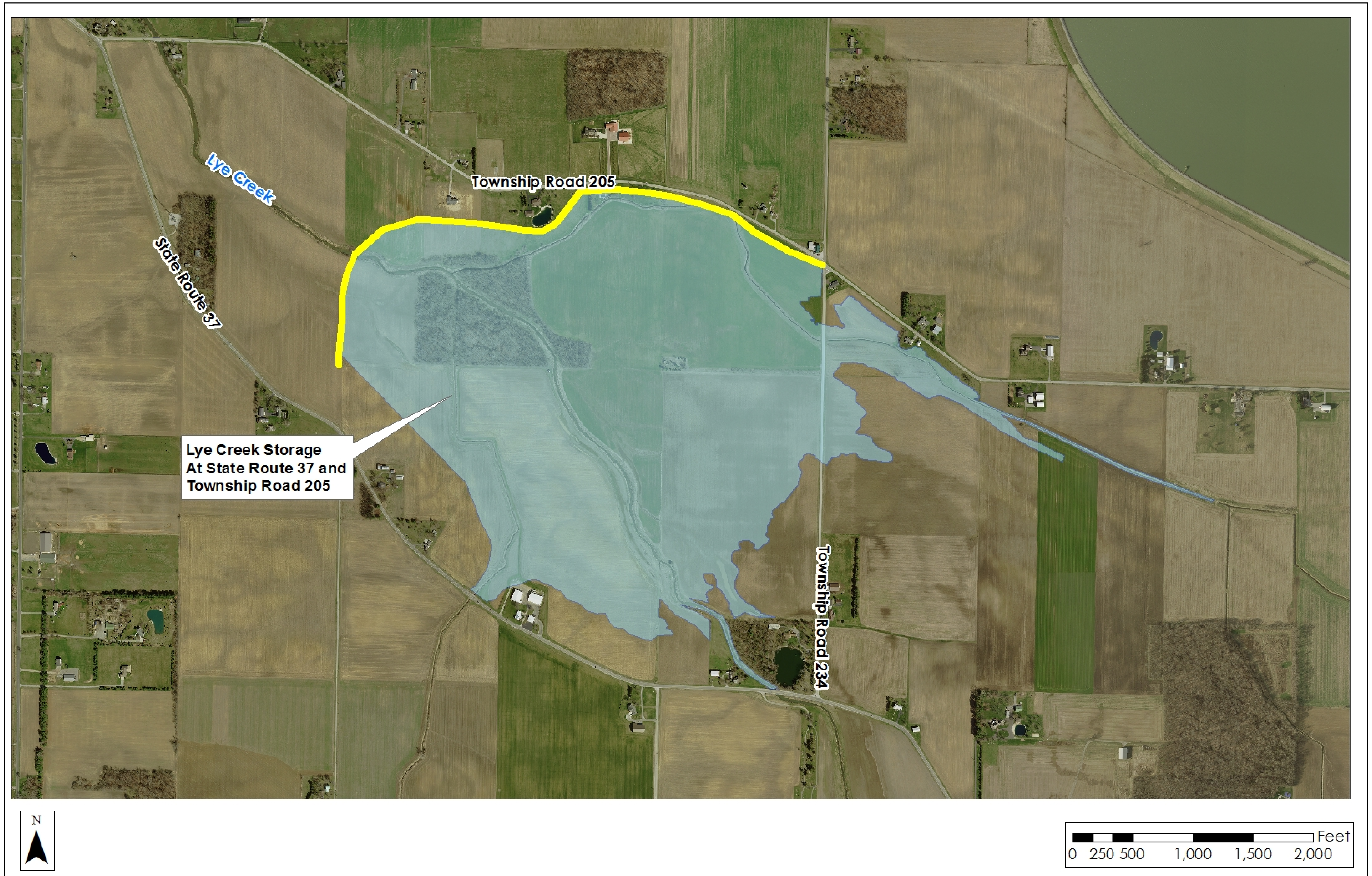


Figure 28 – Storage Area Between State Route 37 and Township Road 205 on Lye Creek



4.2.4.4 Storage Location Combinations

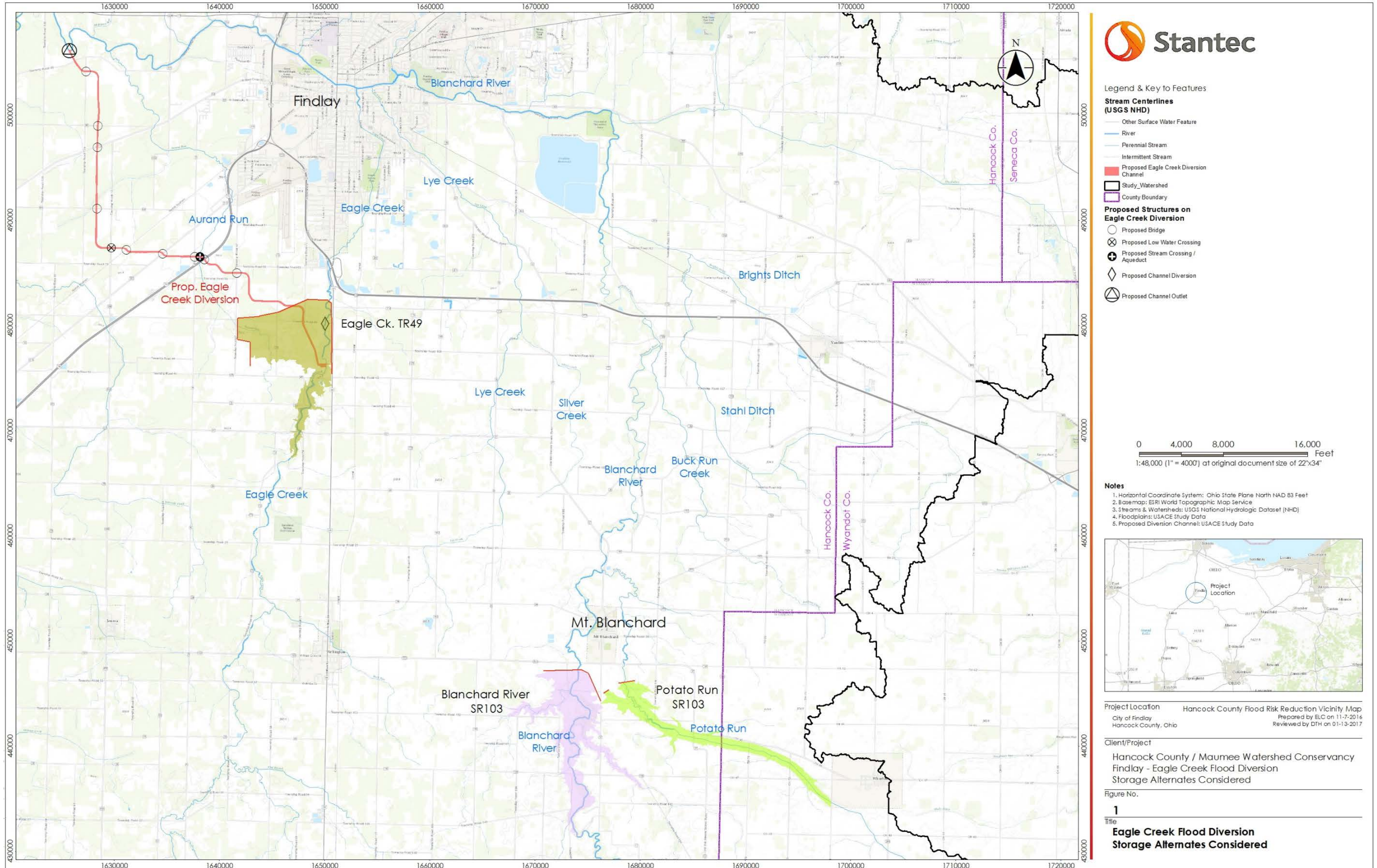
Although each storage area reduced peak flow rates on a localized scale, preliminary HEC-HMS simulations show that combining certain basins together actually increases the peak flows on the Blanchard River in Findlay due to the timing of the hydrographs. For example, the storage areas on Lye Creek were not large enough to delay the discharge out of the basins significantly. As a result, the discharge out of the Lye Creek storage options when combined with the rising limb from the lower Blanchard River sub-basins increases the peak discharge in Findlay compared to the option with no storage on Lye Creek.

Stantec recommends a flood risk reduction program for the community that involves a combination of storage alternatives. This combination would include storing as much flow on Eagle Creek and Potato Run as possible and sizing an embankment on the Blanchard River upstream of Mt. Blanchard to balance the need to decrease peak flows while limiting impacts to structures and the environment. Figure 29 shows an overview of where the recommended storage options are located.

HANCOCK COUNTY FLOOD RISK REDUCTION PROGRAM

Phase II – Part B – Proof of Concept
April 3, 2017

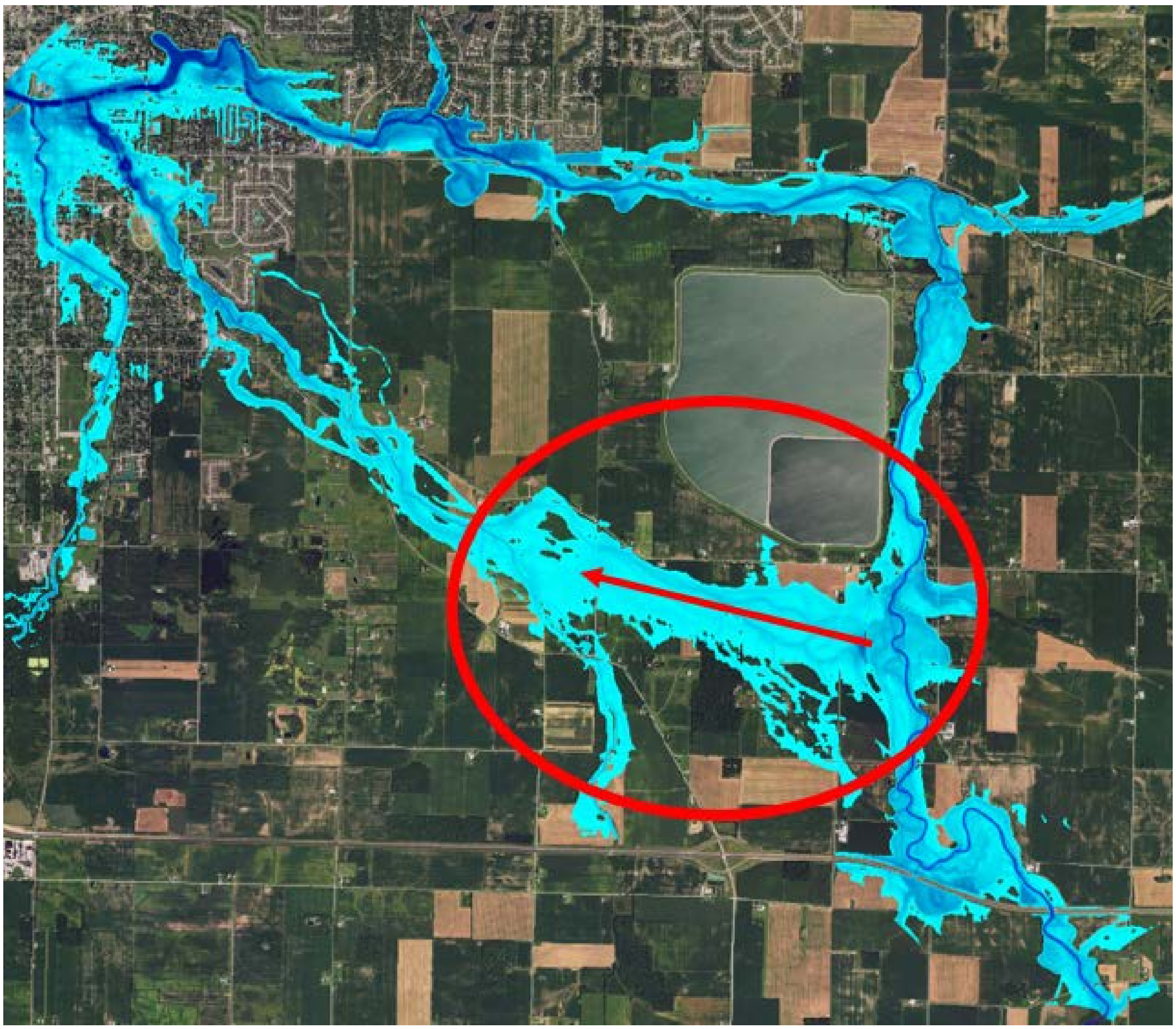
Figure 29 - Potential Storage Locations



4.2.5 Blanchard-Lye Cutoff Levee

The existing conditions hydraulic model shows that flood flows overtop the Blanchard River overbanks in the area just south of the Findlay Water Reservoir and flow over land to the west and enter Lye Creek. This condition matches observations during extreme flooding events (Figure 30). The USACE initially investigated a cutoff levee to prevent this condition. However, in the USACE feasibility study it is stated, "while the Blanchard to Lye cutoff levee was economically justified, the plan induced flooding to almost 1,600 acres of agricultural lands. This wasn't acceptable to the local community." The USACE initial cost of the cutoff levee was approximately $8 million.

Figure 30 – Example of Flow Crossover Area Between the Blanchard River and Lye Creek



This Blanchard to Lye cutoff levee was re-evaluated by Stantec in conjunction with the potential storage alternatives that were identified and evaluated. Stantec determined that a smaller cutoff levee is still necessary to prevent flood waters from crossing over to Lye Creek. Storage alternatives will reduce the peak flow in the Blanchard River, the net result from combining the storage and the cutoff levee option is a reduction in the area of induced flooding upstream and downstream of the cutoff levee, and a flooded area less than the extent of the existing 1% ACE floodplain.

Storage options upstream of Mt. Blanchard are able to reduce the peak flow on the Blanchard River such that the crossover flows and depths would be minimal even without the construction of a cutoff levee. As a result of implementing storage on the Blanchard River and Potato Run, the peak flow on Lye Creek and the resulting 1% ACE floodplain are due to the runoff from the Lye Creek sub-watershed, and not the crossover flow from the Blanchard River. Therefore, the benefit of the cutoff levee would be isolated to the agricultural land between the Blanchard River and Lye Creek; therefore, Stantec did not perform additional analysis and is not recommending the Blanchard to Lye cutoff levee at this time.

4.3 PROJECT REFINEMENT MODEL RESULTS

The project refinement results in the following Sections are considered preliminary and may change as the hydrologic and hydraulic models are further refined. The results for the conceptual alternative analyses were generated using the flow hydrograph inputs from the revised USACE hydrologic model with an SCS Type II storm with a NOAA Atlas 14 100-year, 24-hour event duration (5.26 inches) applied uniformly over the entire watershed. The inflows from the hydrologic HEC-HMS model were applied to the hydraulic HEC-RAS model in order to simulate the hypothetical event. The results in the following Sections are conservative for analyzing the conceptual, planning level alternatives based on Stantec's hydrologic risk analyses.

4.3.1 HEC-RAS Model Results at Main Street in Findlay

Table 8 provides a summary of benefits achieved at Main Street for each alternative modeled based on the WSE results during the 1% ACE (100-year, 24-hour) flood event using an SCS Type II temporal pattern.

Table 8 – Benefit Summary HEC-RAS Results (SCS Type II – NOAA Atlas 14 100-Year, 24-Hour event (5.26 inches) equally distributed across watershed)

Alternative	Modeled Scenario	Blanchard River Maximum Flow at Main Street (cfs)	Blanchard River WSE at Main Street (Feet)	Reduction in WSE at Main Street (Feet)	Max Water Depth on Main Street (Feet) [5.]	Duration Water is 6 Inches Above Main Street (Hours) [6.]
0	**Existing Conditions**	16,288	777.6	N/A	4.6	50
1	**USACE Plan** [1.]	13,295	776.7	0.9	3.6	45
1a	**USACE Plan Increased for the 1% ACE (100-year) Event Capacity**	Hydraulic analysis not simulated due to expected cost				
1b	**USACE Plan Increased for the 1% ACE (100-year) Event Capacity – With Extension to Lye Creek and the Blanchard River**	Hydraulic analysis not simulated due to expected cost				
2	**Blanchard River Modifications** [2.]	16,190	776.7	0.9	3.7	40
3	**Blanchard River Modifications + Eagle Creek Storage** [3.]	12,455	774.8	2.8	1.8	35
4	**Blanchard River Modifications + Eagle Creek Storage + Mt. Blanchard Storage** [4.]	11,078	774.0	3.6	1.0	15
5	**Blanchard River Modifications + Eagle Creek Storage + Mt. Blanchard Storage + Blanchard to Lye Cutoff Levee**	11,156	774.1	3.5	1.1	15

1. 9.2-mile diversion channel designed for the 4% ACE (25-year) event
2. Removal of four inline dam/riffle structures, floodplain bench widening between Broad Avenue and the Norfolk Southern bridge, and widening of the Norfolk Southern Railroad bridge
3. Dry storage basin on Eagle Creek between US 68, County Road 45 and Township Road 49 sized for the 1% ACE event
4. Dry storage basins on the Blanchard River and Potato Run south of State Route 103 and State Route 37 sized for the 1% ACE event
5. The low elevation at Main Street is approximately 773.0’
6. WSE 6 inches above low elevation at Main Street is approximately 773.5’

4.3.2 HEC-RAS Flow Hydrographs

Figure 31 through Figure 35 show the flow hydrographs in downtown Findlay for Alternatives 0, 1, 3, 4, and 5. Hydrographs for Alternative 2 are not shown as the hydraulic improvements do not affect the inflow hydrographs. Results were produced using the preliminary HEC-RAS unsteady state hydraulic model.

Figure 31 - Alternative 0 - Existing Conditions Flow Hydrographs

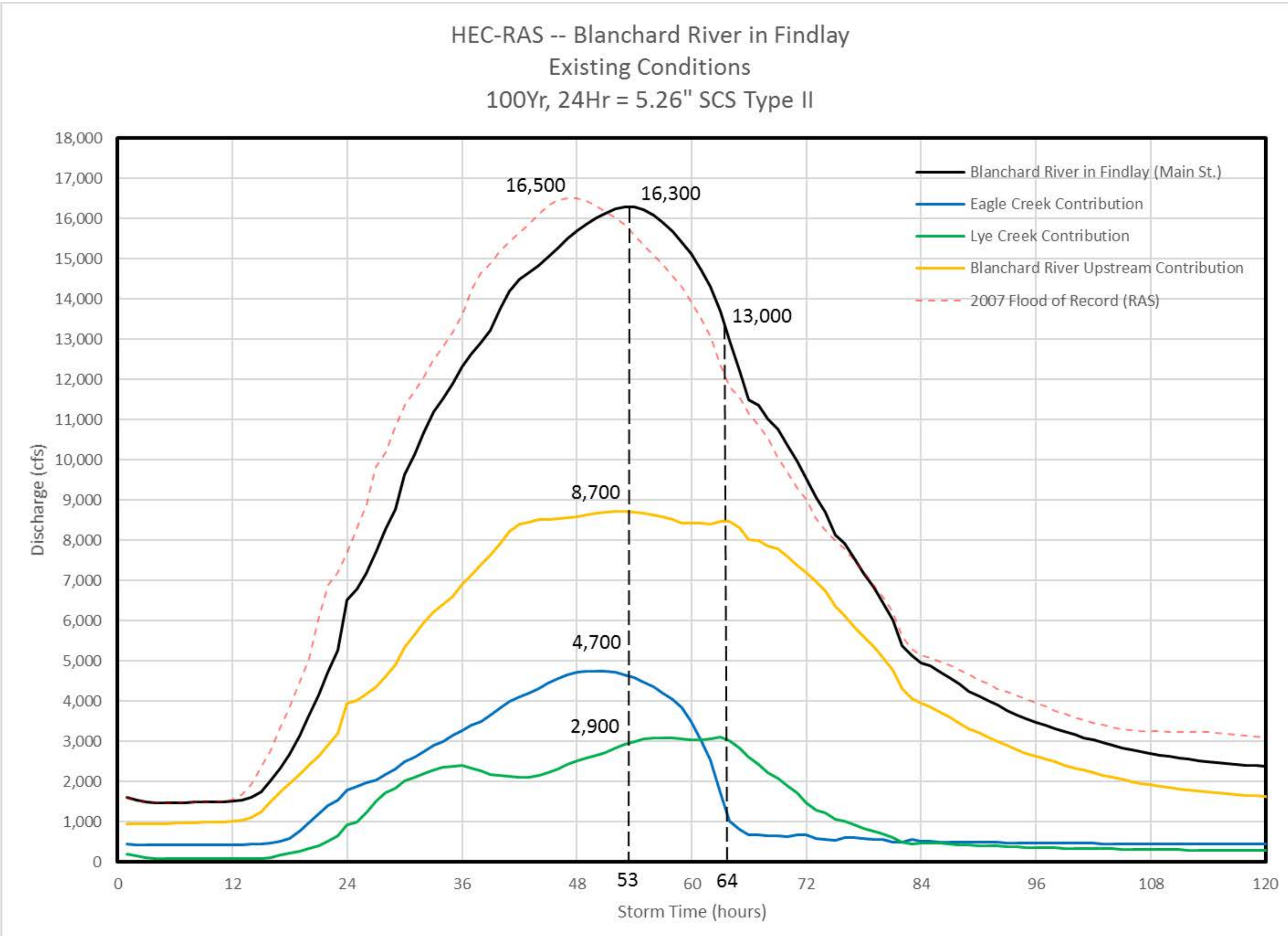


Figure 32 – Alternative 1 - USACE Plan (Alternative 13 – 25-Year Eagle Creek Diversion Channel)

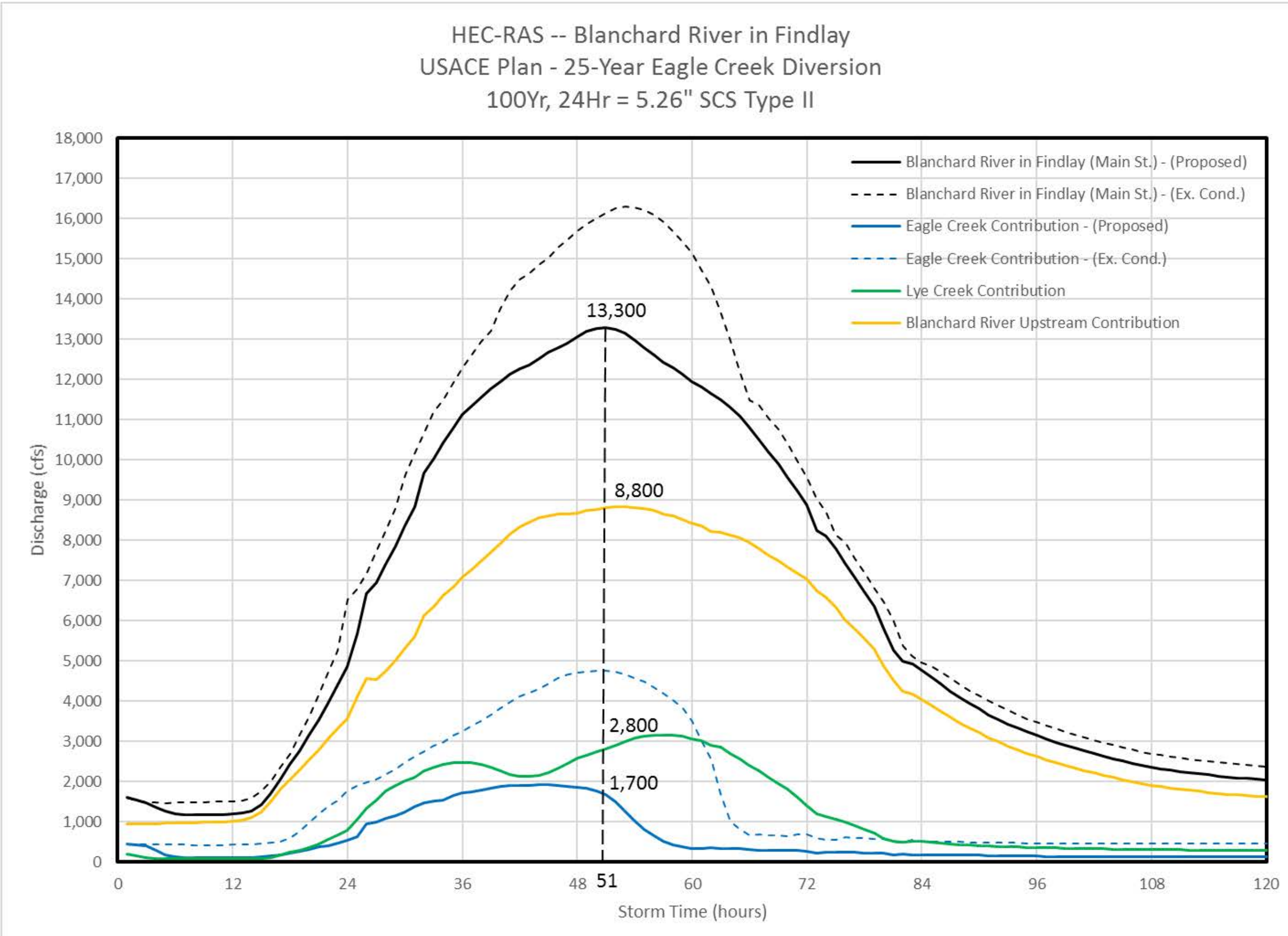


Figure 33 - Alternative 3 – Hydraulic Improvements, Eagle Creek Storage Flow Hydrographs

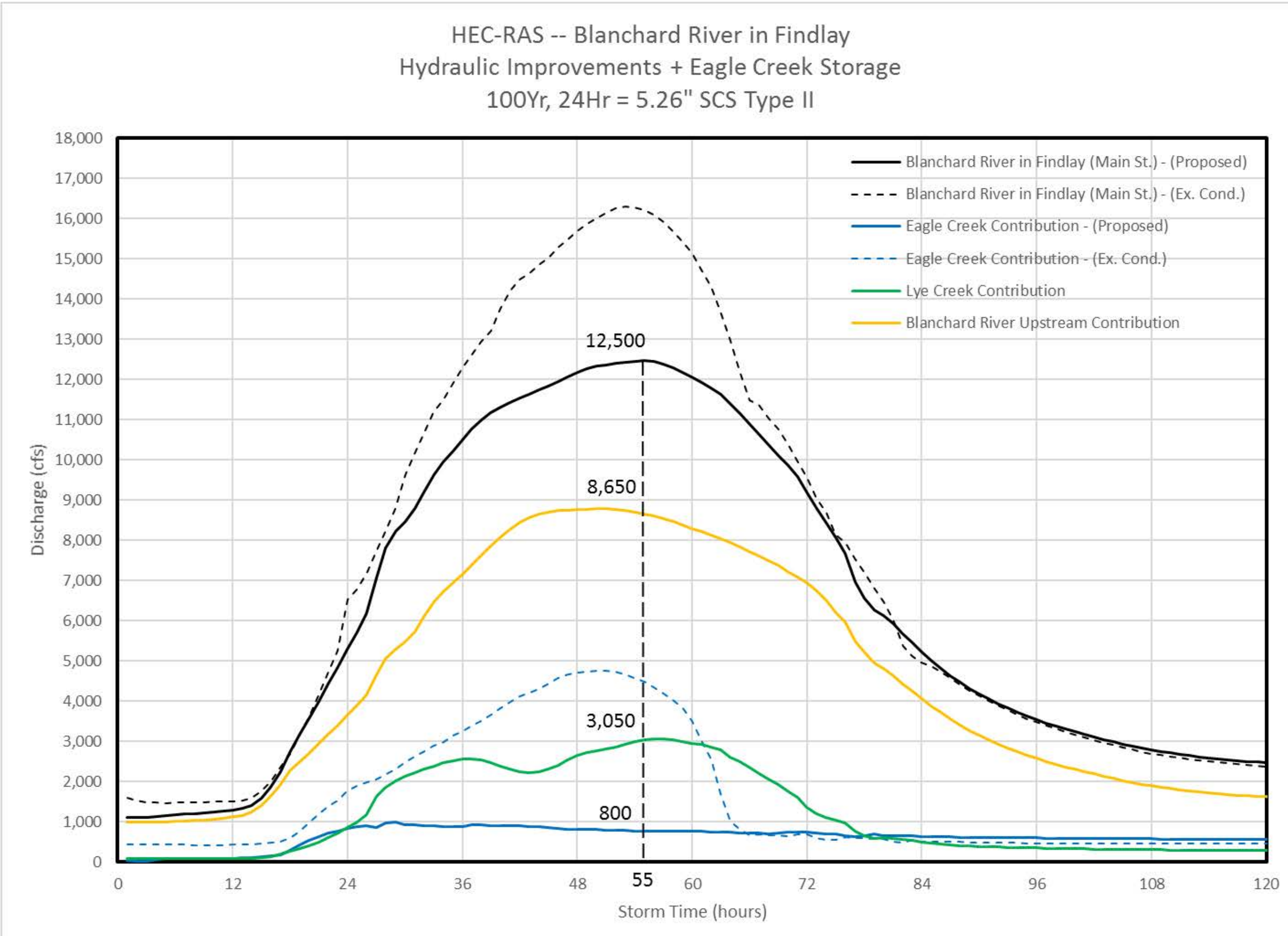


Figure 34 - Alternative 4 – Hydraulic Improvements, Eagle Creek Storage, Mt. Blanchard Storage Flow Hydrographs

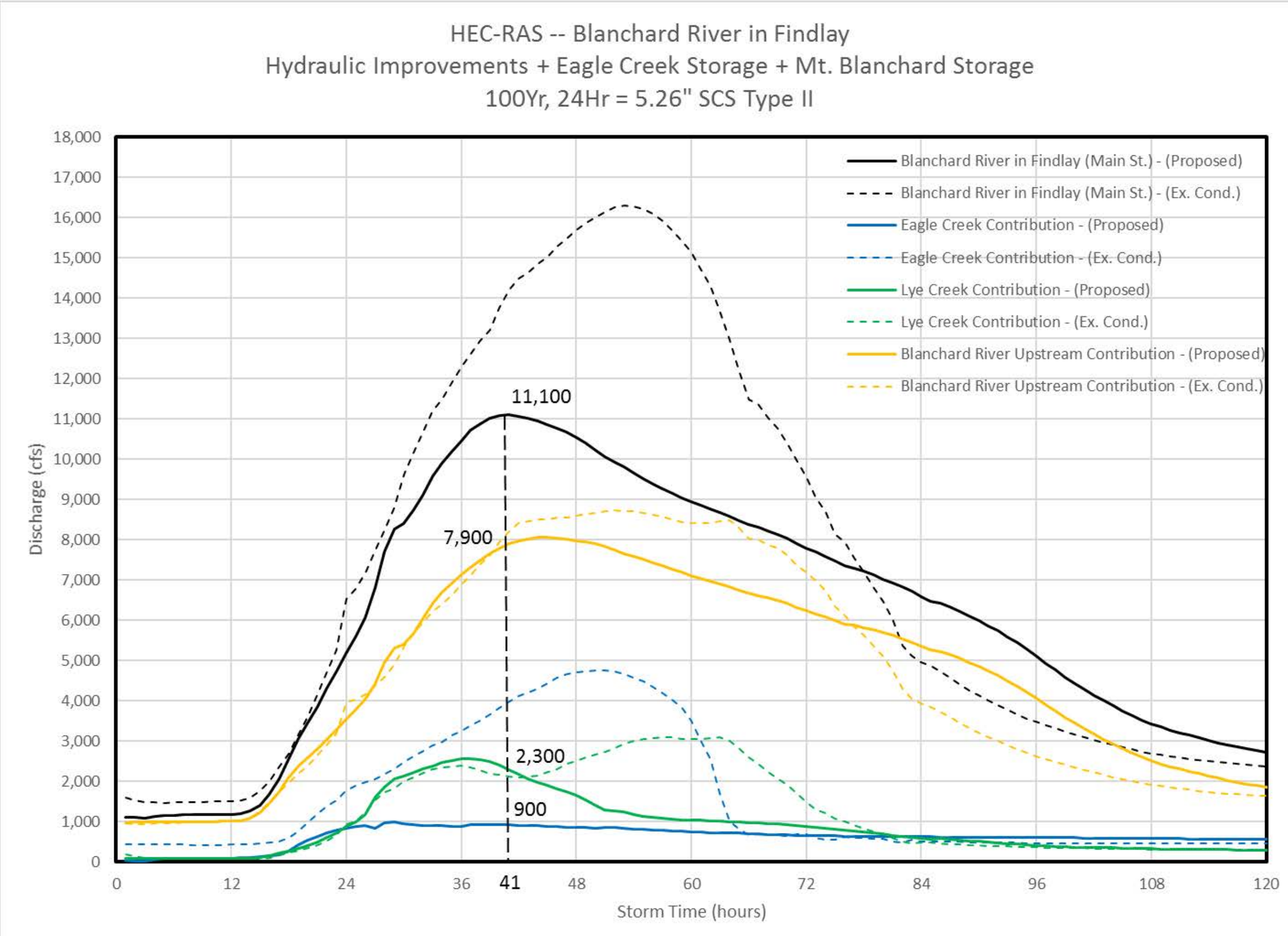
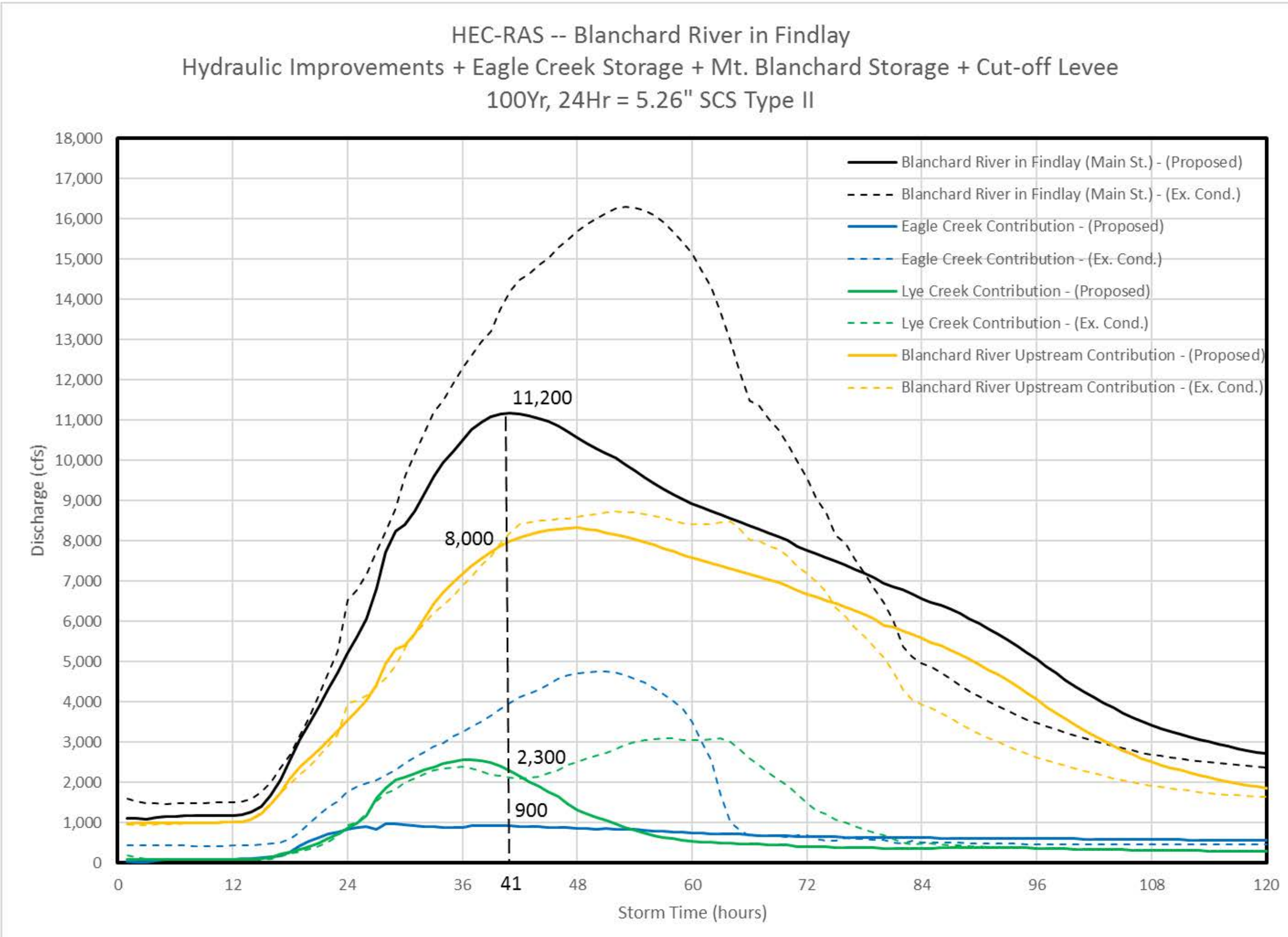


Figure 35 - Alternative 5 – Hydraulic Improvements, Eagle Creek Storage, Mt. Blanchard Storage, Cutoff Levee Flow Hydrographs



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4.4 PROJECT REFINEMENT IMPACTS AND BENEFITS RESULTS

Stantec understands there is a balance that must be achieved between benefit to the local community and the potential for adverse impacts associated with the cost and construction of improvements. Stantec reviewed several project combinations seeking an environmentally friendly, cost-effective solution to this complex problem.

4.4.1 Environmental Impacts and Benefits

As of the date of this report there has been no substantive consultation with resource agencies regarding potential impacts and/or benefits of the Project Refinement options. Nor have any field investigations been conducted. However, pending these efforts, it is possible to broadly characterize some of the readily apparent environmental impacts and benefits of each option.

4.4.1.1 Riffles and Inline Structure Removal

Removal of the inline structures may have temporary isolated impacts to jurisdictional WOUS as a result of construction access, placement of temporary fills, etc. Overall the project is expected to be beneficial for aquatic ecosystems as lentic habitats are converted to lotic ecosystems and as fish passage at low flow is improved. This will favor aquatic species adapted for life in flowing water and should result in net improvement to the Designated Beneficial Uses of the Blanchard River.

4.4.1.2 Floodplain Bench Widening

It is anticipated that environmental impacts associated with this option, if any, will be of limited magnitude and temporary duration. The proposed construction is expected to occur above the OHW mark so impacts to jurisdictional WOUS will largely be avoided. Impacts to special status species are not expected because of the urban setting and disturbed nature of the site. It is anticipated that the project can proceed on a schedule that will accommodate seasonally sensitive periods for listed species (i.e., tree clearing windows), however improbable their presence at the site. Impacts to historical and archaeological resources have been evaluated for isolated portions of the project area but are unknown for most of the site.

The project, by expanding the floodplain, is expected to provide a small benefit to aquatic ecosystems by reducing the magnitude of physical forces working on the river bed. Additional opportunities for wetland and stream mitigation are available at this site.

4.4.1.3 Storage Options

In this section Stantec considers the two storage options jointly because the analysis of the impacts and benefits, as described above, has not progressed to the point to discuss specific impacts.

Some impacts from construction are anticipated and may include:

- Placement of permanent fill into Eagle Creek and the Blanchard River;
- Placement of fill in wetlands; and
- Temporary impacts to water quality during construction.

The dry storage basin options will alter the shape of the flow hydrograph during elevated flows. Peak flow rates will be reduced and flows on the receding limb of the hydrograph are likely to be higher for longer durations. However, the shifting of the magnitude and duration of these flows is expected to fall within the natural range of variation for most aquatic and floodplain species. Impacts, if any, should be minimal. Areas immediately upstream of the dam will be inundated for longer periods than under natural conditions during large storm events, but this affect will dissipate with distance from the dam.

The Blanchard River in the vicinity of the proposed storage location is known to harbor the federally endangered mussel rayed bean (*Villosa fabalis*). It is uncertain how the proposed project will affect this species but it is anticipated that this will be analyzed in more detail through formal consultation with the USFWS under Section 7 of the Endangered Species Act.

4.4.2 Impacts and Benefits Summary Table

Stantec reviewed cumulative benefits and impacts for each alternative; Table 9 below highlights the benefits and impacts associated with various combinations of projects related to the number of acres benefited/impacted, the number of agricultural acres benefited/impacted, and the number of parcels benefited/impacted. Again, for planning purposes, the results in this table were generated using the flow hydrograph inputs from the revised USACE hydrologic model with an SCS Type II storm with a NOAA Atlas 14 100-year, 24-hour event duration (5.26 inches) applied uniformly over the entire watershed. The inflows from the hydrologic model were applied to the hydraulic model in order to simulate the hypothetical event. Based on Stantec's hydrologic risk analyses, this has been determined to be a conservative assumption for analyzing the conceptual alternatives.

Table 10 provides the benefit of Stantec's Final Array of recommended alternatives using historic radar rainfall to generate the 2007 flood of record compared to existing conditions.

Table 9 – Benefit / Impact Summary HEC-RAS Results (SCS Type II – NOAA Atlas 14 100-Year, 24-Hour event (5.26 inches) equally distributed across watershed)

Alternative	Modeled Scenario	Blanchard River Maximum Flow at Main Street (cfs)	Blanchard River WSE at Main Street (Feet)	Reduction in WSE at Main Street (Feet)	Max Water Depth on Main Street (Feet) [5]	Duration Water is 6 Inches Above Main Street (Hours) [6]	Total Acres Directly Impacted by Project Construction	Home Buyouts	New Bridges or Cul-De-Sacs	Acres Impacted Outside of Existing Regulatory Floodplain	Acres Removed from Floodplain [9]	Agricultural Acres Directly Impacted by Project Construction [10]	Agricultural Acres Removed from Floodplain	Parcels Directly Impacted by Project Construction [11]	Parcels Removed from Floodplain
0	**Existing Conditions**	16,288	777.6	N/A	4.6	50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	**USACE Plan** [1]	13,295	776.7	0.9	3.6	45	960 [7]	1	13	960	1,690	780	1,140	75	1,670
1a	**USACE Plan Increased for the 1% ACE (100-year) Event Capacity**	Hydraulic analysis not simulated due to expected cost					~1,000	1	13	~1,000	Hydraulic analysis not simulated due to expected cost				
1b	**USACE Plan Increased for the 1% ACE (100-year) Event Capacity – With Extension to Lye Creek and the Blanchard River**	Hydraulic analysis not simulated due to expected cost					~1,500	5	19	~1,500	Hydraulic analysis not simulated due to expected cost				
2	**Blanchard River Modifications** [2]	16,190	776.7	0.9	3.7	40	2	0	0	2	280	0	40	5	760
3	**Blanchard River Modifications + Eagle Creek Storage** [3]	12,455	774.8	2.8	1.8	35	1,140 [8]	14	1	860	2,780	880	1,180	55	2,460
4	**Blanchard River Modifications + Eagle Creek Storage + Mt. Blanchard Storage** [4]	11,078	774.0	3.6	1.0	15	2,430 [8]	19	2	1,515	5,060	1,900	2,850	135	2,850
5	**Blanchard River Modifications + Eagle Creek Storage + Mt. Blanchard Storage + Blanchard to Lye Cutoff Levee**	11,156	774.1	3.5	1.1	15	2,460	19	3	1,545	5,280	1,910	3,040	145	2,840

1. 9.2-mile diversion channel designed for the 4% ACE (25-year) event
2. Removal of four inline dam/riffle structures, floodplain bench widening between Broad Avenue and the Norfolk Southern bridge, and widening of the Norfolk Southern Railroad bridge
3. Dry storage basin on Eagle Creek between US 68, County Road 45 and Township Road 49 sized for the 1% ACE event
4. Dry storage basins on the Blanchard River and Potato Run south of State Route 103 and State Route 37 sized for the 1% ACE event
5. The low elevation at Main Street is approximately 773.0'
6. WSE 6 inches above low elevation at Main Street is approximately 773.5'
7. Acreage from USACE Draft Final EIS report (Section 8.1)
8. Acreage under berm and expected 1% ACE (100-year) floodplain extents assumed to be acquired through fee-simple purchase
9. Does not include floodplain area within acreage impacted by project construction
10. Agricultural acres include cultivated crop and hay/pasture categories within the National Land Cover Dataset
11. Number of parcels not owned by the City of Findlay or Hancock County

Table 10 – Benefit / Impact Summary HEC-RAS Results (2007 Flood of Record) [1.]

Alternative	Modeled Scenario	Blanchard River Maximum Flow at Main Street (cfs)	Blanchard River WSE at Main Street (Feet)	Reduction in WSE at Main Street (Feet)	Max Water Depth on Main Street (Feet)	Duration Water is 6 Inches Above Main Street (Hours)	Total Acres Directly Impacted by Project Construction	Acres Removed from Floodplain	Agricultural Acres Directly Impacted by Project Construction	Agricultural Acres Removed from Floodplain	Parcels Directly Impacted by Project Construction	Parcels Removed from Floodplain
0_2007	**Existing Conditions**	16,495	777.6	N/A	4.6	50	N/A	N/A	N/A	N/A	N/A	N/A
4_2007	**Stantec Final Array [2.]**	11,056	774.0	3.6	1.0	25	2,430	4,970	1,900	2,930	135	2,550

1. Flow hydrographs produced within HMS model using provided radar rainfall dataset were input into the preliminary HEC-RAS model to generate results
2. Stantec's Final Array is Alternative 4 in Table 9 (Blanchard River Modifications, Eagle Creek dry storage basin, Blanchard River dry storage basin and Potato Run dry storage basin)

4.5 PROJECT REFINEMENT PRELIMINARY OPINIONS OF PROBABLE COST

Preliminary, planning level opinions of probable project costs were developed for selected conceptual alternative projects. These estimates were created based on expected quantities measured from the conceptual designs. The detail in opinions of probable cost are intended to be on a similar scale to the USACE Plan's estimate for comparison purposes. Unit costs similar to those utilized by the USACE were applied to the alternatives reviewed by Stantec, when appropriate.

4.5.1 Property Acquisition

While details of property acquisition would occur later in any future design process, Stantec used a conservative flat rate for cost per acre for purposes of the preliminary opinions of probable cost. Stantec assumed fee-simple purchase of the permanently impacted lands and area falling within the 1% ACE event floodplain. A second, lesser unit rate was assumed for land where flowage easements were expected between the 1% ACE floodplain and the probable maximum flood extents.

4.5.2 Project Contingencies

The USACE developed a detailed cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for its recommended plan. The USACE performed a Monte Carlo-based risk analysis on project costs for the USACE Plan. The purpose of this risk analysis study was to present the cost and schedule risks considered and determine the project contingencies at a recommended 80% confidence level of successful execution to project completion. Based on the results of the CSRA, the USACE used a contingency value of 27.5% of the base project cost at an 80% confidence level of successful execution for most of its project costs.

Stantec assumed a flat 30% contingency for each line item in the preliminary opinions of probable cost for the alternatives considered. While costs were reviewed for accuracy at the conceptual level, the 30% contingency covers unforeseen administrative and legal fees and obstacles that may arise during the detailed design and construction phase, such as minor utility relocations, site drainage, etc.

4.5.3 Mobilization, Demobilization, and Preparatory Work

Within the USACE Plan's project cost estimate line items, the USACE assumed a mobilization cost of 4% for preparatory work (survey layout, permits, submittals, etc.) on large components of the project such as the diversion channel, utility relocation, and the diversion structure.

Stantec applied a rate of 5% to construction costs to account for potential mobilization and demobilization. Additional costs were included for preparatory work such as survey staking and construction layout.

4.5.4 Engineering & Design and Construction Management

The cost Appendix in the USACE report indicates the USACE calculated pre-construction, engineering, and design (PED), and supervision and administration costs based on the *Non-Cap Example TPCS Sep 2015 Rev 0.* These costs were then further revised based on engineering judgment. The USACE cost component percentages were revised to reflect an overall PED rate of 13% and a supervision and administration rate of 5%.

Stantec applied a rate of 15% for professional services (engineering, design, and permitting) and 5% for project construction and administration for all alternatives considered. An additional 2% rate was applied to the larger scale projects for construction phase services.

4.5.5 Diversion Channel Preliminary Opinions of Probable Cost

Table 11 presents the total costs for the USACE Plan as shown in the USACE Draft Final EIS report for purposes of comparison. Stantec prepared a preliminary opinion of probable cost for the diversion channel when refined to have the capacity to convey the 1% ACE (100-year) event. The quantities measured for the conceptual design of the larger diversion channel produced an increased cost as expected. The revised quantities for the 1% diversion channel reflect a shortened alignment length (8.2 miles versus 9.2 miles). While the proposed alignment is shorter, the revised channel size and profile equates to more soil excavation (3.2 million cy as opposed to 2.1 million cy) but with less volume of rock excavation expected and less soil fill required for berms. Table 12 provides the preliminary opinion of probable cost for the diversion channel refined to convey the 1% ACE flow from Eagle Creek. The increased costs reflect the additional land that would need to be purchased as well as the increased bridge spans that would be required.

Table 11 – USACE Plan (25-Year Diversion of Eagle Creek) Opinion of Probable Cost (from USACE Draft EIS)

Description	Amount	Contingency %	Contingency $	Total
01 – Lands and Damages	$5,511,000	19.4%	$1,068,000	$6,579,000
02 – Relocations	$11,443,000	27.5%	$3,147,000	$14,589,000
06 – Fish and Wildlife	$1,379,000	27.5%	$379,000	$1,758,000
08 – Road, Railroads & Bridges	$2,084,000	27.5%	$573,000	$2,657,000
09 – Channels and Canals	$27,127,000	27.5%	$7,460,000	$34,587,000
15 – Floodway Control & Diversion	$6,830,000	27.5%	$1,878,000	$8,709,000
18 – Cultural Resources	$543,000	27.5%	$149,000	$692,000
30 – Engineering & Design	$6,417,000	27.5%	$1,765,000	$8,182,000
31 – Construction Management	$2,470,000	27.5%	$679,000	$3,149,000
TOTAL	**$63,804,000**		**$17,099,000**	**$80,902,000**

Table 12 – Refined Diversion (100-Year Diversion of Eagle Creek) Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$3,100,000	30.0%	$930,000	$4,030,000
01 – Lands and Damages	$5,000,000	30.0%	$1,500,000	$6,500,000
02 – Relocations	$600,000	30.0%	$180,000	$780,000
06 – Fish and Wildlife	$1,400,000	30.0%	$420,000	$1,820,000
08 – Road, Railroads & Bridges	$17,300,000	30.0%	$5,190,000	$22,490,000
09 – Channels and Canals	$34,100,000	30.0%	$10,230,000	$44,330,000
15 – Floodway Control & Diversion	$6,000,000	30.0%	$1,800,000	$7,800,000
18 – Cultural Resources	$500,000	30.0%	$150,000	$650,000
30 – Engineering & Design	$10,200,000	30.0%	$3,060,000	$13,260,000
31 – Construction Management	$3,100,000	30.0%	$930,000	$4,030,000
TOTAL	**$81,300,000**		**$24,390,000**	**$105,690,000**

4.5.6 Diversion Channel Extension Preliminary Opinions of Probable Cost

Extending the diversion channel to the east from Eagle Creek to Lye Creek and the Blanchard River would require more land acquisition, another diversion structure, and the construction of at least four more bridges at additional cost. Table 13 presents the preliminary opinion of probable cost for the diversion channel extension to the Blanchard River (exclusive of the cost for the 100-Year Western Diversion of Eagle Creek cost). The extension of the diversion channel to Lye Creek and the Blanchard River results in a preliminary opinion of probably cost of about $88 million. The diversion extension cost, in addition to the 100-year diversion of Eagle Creek cost, would result in an estimated total of approximately $194 million.

Table 13 – Diversion Channel Extension (Eagle Creek to Blanchard River) Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$2,300,000	30.0%	$690,000	$2,990,000
01 – Lands and Damages	$9,600,000	30.0%	$2,880,000	$12,480,000
02 – Relocations	$500,000	30.0%	$150,000	$650,000
06 – Fish and Wildlife	$800,000	30.0%	$240,000	$1,040,000
08 – Road, Railroads & Bridges	$10,600,000	30.0%	$3,180,000	$13,780,000
09 – Channels and Canals	$22,200,000	30.0%	$6,660,000	$28,860,000
15 – Floodway Control & Diversion	$8,600,000	30.0%	$2,580,000	$11,180,000
18 – Cultural Resources	$500,000	30.0%	$150,000	$650,000
30 – Engineering & Design	$8,300,000	30.0%	$2,490,000	$10,790,000
31 – Construction Management	$4,400,000	30.0%	$1,320,000	$5,720,000
TOTAL	**$67,800,000**		**$20,340,000**	**$88,140,000**

4.5.7 Hydraulic Improvements Preliminary Opinion of Probable Cost

Table 14 provides the preliminary opinion of probable cost for removing the four specified riffle/inline structures in the Blanchard River. Each structure removal is expected to cost approximately $250,000. Table 15 details the preliminary opinion of probable cost for the work required to widen the floodplain for a portion of the Blanchard River, and modify the railroad bridge downstream of Cory Street. A majority of the widening costs are expected to relate to excavation and the potential need to haul material to an off-site landfill.

Table 14 – Riffle/Inline Structures Removal Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$40,000	30.0%	$12,000	$52,000
01 – Lands and Damages	$10,000	30.0%	$3,000	$13,000
02 – Relocations	$0	30.0%	$0	$0
06 – Fish and Wildlife	$20,000	30.0%	$6,000	$26,000
08 – Road, Railroads & Bridges	$70,000	30.0%	$21,000	$91,000
09 – Channels and Canals	$380,000	30.0%	$114,000	$494,000
15 – Floodway Control & Diversion	$50,000	30.0%	$15,000	$65,000
18 – Cultural Resources	$10,000	30.0%	$3,000	$13,000
30 – Engineering & Design	$110,000	30.0%	$33,000	$143,000
31 – Construction Management	$90,000	30.0%	$27,000	$117,000
TOTAL	**$780,000**		**$234,000**	**$1,014,000**

Table 15 – Floodplain Bench Widening and Railroad Bridge Modifications Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$400,000	30.0%	$120,000	$520,000
01 – Lands and Damages	$100,000	30.0%	$30,000	$130,000
02 – Relocations	$200,000	30.0%	$60,000	$260,000
06 – Fish and Wildlife	$100,000	30.0%	$30,000	$130,000
08 – Road, Railroads & Bridges	$2,500,000	30.0%	$750,000	$3,250,000
09 – Channels and Canals	$8,200,000	30.0%	$2,460,000	$10,660,000
15 – Floodway Control & Diversion	$100,000	30.0%	$30,000	$130,000
18 – Cultural Resources	$100,000	30.0%	$30,000	$130,000
30 – Engineering & Design	$1,800,000	30.0%	$540,000	$2,340,000
31 – Construction Management	$1,000,000	30.0%	$300,000	$1,300,000
TOTAL	**$14,500,000**		**$4,350,000**	**$18,850,000**

4.5.8 Storage Preliminary Opinions of Probable Cost

Table 16, Table 17, and Table 18 provide the preliminary opinions of probable cost for the three dry storage basin options each sized for the 1% ACE event. The total opinion of probable cost for the three storage options would be approximately $140 million. This option, combining the three dry storage basins, is estimated to be about $54 million less expensive than a comparatively sized diversion channel extension project, which includes the Western Diversion sized for the 1% ACE event flows from Eagle Creek ($140 million versus $194 million).

Table 16 – Eagle Creek Dry Storage Basin Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$1,200,000	30.0%	$360,000	$1,560,000
01 – Lands and Damages	$18,900,000	30.0%	$5,670,000	$24,570,000
02 – Relocations	$100,000	30.0%	$30,000	$130,000
06 – Fish and Wildlife	$500,000	30.0%	$150,000	$650,000
08 – Road, Railroads & Bridges	$1,600,000	30.0%	$480,000	$2,080,000
09 – Channels and Canals	$10,300,000	30.0%	$3,090,000	$13,390,000
15 – Floodway Control & Diversion	$10,900,000	30.0%	$3,270,000	$14,170,000
18 – Cultural Resources	$300,000	30.0%	$90,000	$390,000
30 – Engineering & Design	$6,600,000	30.0%	$1,980,000	$8,580,000
31 – Construction Management	$3,100,000	30.0%	$930,000	$4,030,000
TOTAL	**$53,500,000**		**$16,050,000**	**$69,550,000**

Table 17 – Blanchard River Dry Storage Basin Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$600,000	30.0%	$180,000	$780,000
01 – Lands and Damages	$13,600,000	30.0%	$4,080,000	$17,680,000
02 – Relocations	$100,000	30.0%	$30,000	$130,000
06 – Fish and Wildlife	$2,500,000	30.0%	$750,000	$3,250,000
08 – Road, Railroads & Bridges	$800,000	30.0%	$240,000	$1,040,000
09 – Channels and Canals	$2,600,000	30.0%	$780,000	$3,380,000
15 – Floodway Control & Diversion	$7,800,000	30.0%	$2,340,000	$10,140,000
18 – Cultural Resources	$200,000	30.0%	$60,000	$260,000
30 – Engineering & Design	$4,200,000	30.0%	$1,260,000	$5,460,000
31 – Construction Management	$2,000,000	30.0%	$600,000	$2,600,000
TOTAL	**$34,400,000**		**$10,320,000**	**$44,720,000**

Table 18 – Potato Run Dry Storage Basin Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$400,000	30.0%	$120,000	$520,000
01 – Lands and Damages	$8,400,000	30.0%	$2,520,000	$10,920,000
02 – Relocations	$0	30.0%	$0	$0
06 – Fish and Wildlife	$200,000	30.0%	$60,000	$260,000
08 – Road, Railroads & Bridges	$1,400,000	30.0%	$420,000	$1,820,000
09 – Channels and Canals	$1,100,000	30.0%	$330,000	$1,430,000
15 – Floodway Control & Diversion	$4,500,000	30.0%	$1,350,000	$5,850,000
18 – Cultural Resources	$100,000	30.0%	$30,000	$130,000
30 – Engineering & Design	$2,400,000	30.0%	$720,000	$3,120,000
31 – Construction Management	$1,200,000	30.0%	$360,000	$1,560,000
TOTAL	**$19,700,000**		**$5,910,000**	**$25,610,000**

4.5.9 Blanchard to Lye Cutoff Levee Preliminary Opinion of Probable Cost

Table 19 provides the preliminary opinion of probable cost for the Blanchard to Lye Cutoff Levee as provided by the USACE in the *Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT)* (November, 2015). The cost developed by the USACE for the Blanchard to Lye Cutoff Levee was approximately $8 million.

Table 19 – Blanchard to Lye Cutoff Levee Opinion of Probable Cost (from USACE Draft EIS)

Description	Amount	Contingency %	Contingency $	Total
01 – Lands and Damages	$3,760,000	25.0%	$940,000	$4,700,000
06 – Fish and Wildlife	$40,000	22.3%	$9,000	$49,000
08 – Road, Railroads & Bridges	$190,000	25.0%	$48,000	$238,000
09 – Channels and Canals	$1,620,000	23.7%	$385,000	$2,005,000
15 – Floodway Control & Diversion	$330,000	20.0%	$66,000	$396,000
18 – Cultural Resources	$20,000	35.9%	$7,000	$27,000
30 – Engineering & Design	$260,000	29.0%	$75,000	$335,000
31 – Construction Management	$180,000	19.6%	$35,000	$215,000
TOTAL	**$6,400,000**		**$1,565,000**	**$7,965,000**

4.5.10 Preliminary Opinions of Probable Cost Summary

Table 20 provides a summary of each alternative option's preliminary opinion of probable cost. Table 21 lists the opinion of probable cost for each alternative listed in Table 8.

Table 20 – Preliminary Opinion of Probable Cost Summary Table for Each Alternative Option

Alternative Option	Base Cost	Cost with Contingency
USACE Plan (25-Year Diversion of Eagle Creek)	**$63,804,000**	**$80,902,000**
Refined Diversion (100-Year Diversion of Eagle Creek)	$81,300,000	$105,690,000
Diversion Channel Extension (Eagle Creek to Blanchard River)	$67,800,000	$88,140,000
Total 100-Year Diversion Channel with Extension	**$149,100,000**	**$193,830,000**
Riffle/Inline Structures Removal	$780,000	$1,014,000
Floodplain Bench Widening and Railroad Bridge Modifications	$14,500,000	$18,850,000
Total Hydraulic Improvements	**$15,280,000**	**$19,864,000**
Eagle Creek Dry Storage Basin	$53,500,000	$69,550,000
Blanchard River Dry Storage Basin	$34,400,000	$44,720,000
Potato Run Dry Storage Basin	$19,700,000	$25,610,000
Total Storage	**$107,600,000**	**$139,880,000**
Blanchard to Lye Cutoff Levee (from USACE Draft EIS – Appendix B)	**$6,411,000**	**$7,965,000**

Table 21 – Preliminary Opinion of Probable Cost Summary Table for Each Alternative

Alternative	Base Cost	Cost with Contingency
Alternative 0 – Existing Conditions	N/A	N/A
Alternative 1 – USACE Plan (25-Year Diversion of Eagle Creek)	$63,804,000	$80,902,000
Alternative 1a – Refined USACE Plan (100-Year Diversion of Eagle Creek)	$81,300,000	$105,690,000
Alternative 1b – Refined USACE Plan (100-Year Diversion of Eagle Creek + Diversion Extension to Lye Creek and the Blanchard River	$149,100,000	$193,830,000
Alternative 2 – Blanchard River Modifications	$15,280,000	$19,864,000
Alternative 3 – Blanchard River Modifications + Eagle Creek Dry Storage Basin	$68,780,000	$89,414,000
Alternative 4 – Blanchard River Modifications + Eagle Creek Dry Storage Basin + Mt. Blanchard Dry Storage Basins	$122,880,000	$159,744,000
Alternative 5 – Blanchard River Modifications + Eagle Creek Dry Storage Basin + Mt. Blanchard Dry Storage Basins + Blanchard to Lye Cutoff Levee	$129,280,000	$167,709,000

4.5.11 Project Operation, Maintenance, and Repair

Preliminary project operation, maintenance, and repair (OM&R) tasks were not included in the preliminary project refinement opinions of probable cost. These OM&R items will include, but not be limited to: Maintenance Personnel, Equipment, Vehicles, Office/Garage, Replacement Costs, Engineering, Administration, Board of Directors, Appraisers and Conservancy Court, Legal Fees, State Dam Safety Permits, and Liability Insurance Coverage. Manual labor would include mowing, and removing obstructions such as vegetation, trash, debris, or other miscellaneous structures present within the easement area, repairing erosion and repairing or replacing riprap. Additional OM&R would be required for the inline diversion structures and gates critical to the performance of the diversion channel options.

4.6 PROOF OF CONCEPT SUMMARY

Phase II, Part B – Proof of Concept was initially scoped to review and refine the USACE Plan as it was presented in the Feasibility Study, and make refinements to that plan which would improve its effectiveness. During this phase, Stantec reviewed the USACE Plan to determine if it would work, studied how effective it would be at reducing flooding, and analyzed ways to refine the proposed design concept to make it more effective.

Reviewing the hydrology and hydraulics of the existing conditions demonstrated how the flow contributions from Eagle Creek, Lye Creek, and the upstream portion of the Blanchard River combine to create the flooding conditions experienced at Main Street. It is evident that there are two distinctive peaks of concern. The first and largest one is comprised of contributions from Eagle Creek, Lye Creek, and the Blanchard sub-basins closer to the downtown area. The second peak is almost entirely from the upper Blanchard River watershed. Both peaks cause flooding conditions at Main Street.

The USACE Plan only diverts flows from Eagle Creek during flooding conditions. This diversion reduces the first flood peak expected through Findlay, but does not reduce the second peak. Therefore, the USACE Plan is only partially effective since it does not reduce the flooding conditions near Findlay caused by the second peak.

To increase the effectiveness of the USACE Plan, Stantec studied the diversion channel sizing, profile, and alignment; including multiple inlet locations. Stantec also looked at the concept of extending the diversion channel to the east to intercept flood flows from Lye Creek and the Blanchard River. Additional project refinements studied include hydraulic improvements to the Blanchard River within the City of Findlay, a Blanchard-to-Lye cutoff levee, and multiple locations for dry storage basins. These conceptual project refinements were reviewed for technical and environmental feasibility, community impacts and benefits, and preliminary opinions of probable costs. The refinements were also assessed with respect to regulatory requirements and permitting.

Based on Stantec's review of the existing conditions, the USACE Plan, and various project refinements, a combination of Blanchard River modifications (Hydraulic Improvements) within downtown Findlay and upstream dry storage basins on Eagle Creek and the Blanchard River (including Potato Run) produces the most effective results in reducing the flooding in and around the City of Findlay for both peaks. The cut-off levee between the Blanchard River and Lye Creek was also evaluated, but the benefit was found to be minimal since the upstream storage will reduce the peak flows in the cut-off area.

Preliminary opinions of probable costs for the USACE Plan are $80.9 million, but this project only diverts the 4% ACE (25-year) from Eagle Creek, controls about 15% of the watershed, and only reduces the first peak of flooding through Findlay. Refining this project to divert the 1% ACE (100-year) event and extending the diversion to Lye Creek and the Blanchard River to reduce both flood peaks through Findlay increases the expected cost to $194 million.

Preliminary opinions of probable costs were developed for the Blanchard River modifications in Findlay, along with the dry storage basins on Eagle Creek, the Blanchard River, and Potato Run (Full Program). These alternative projects, when combined, reduce both flood peaks through Findlay for a preliminary opinion of probable cost of $160 million.

Stantec recommends that the community move forward with a program comprised of the Blanchard River modifications (Hydraulic Improvements) through the City of Findlay and the dry storage basins on Eagle Creek, Potato Run and the Blanchard River (Alternative 4, Full Program). A detailed BCA was developed by JFA for the recommended Full Program for the purposes of this report, as well as an interim BCA for the Hydraulic Improvements component (Alternative 2).

4.7 PROJECT BENEFIT COST RATIO

JFA has completed a review and analysis of the anticipated benefit categories utilized within the original USACE Plan (Western Diversion of Eagle Creek, 4% ACE (25-Year) Capacity). Several additional regional and local benefits that could not be factored by the USEACE have been identified for inclusion within the evaluation. Based upon the planning level opinion of probable cost estimate for the recommended Full Program (Alternative 4), the preliminary hydraulic modeling WSE reductions, and the estimated benefits derived from implementation of the program, it is anticipated that the BCR for the Full Program will be at least 1.5. The anticipated BCR for the implementation of the Blanchard River Hydraulic Improvements component (Alternative 2) as an initial phase of work will be at least 4.0. The BCR analysis efforts are issued as an addendum to this document as Appendix E, "*Hancock County Flood Risk Reduction Program: Benefit Cost Analysis*".

5.0 DISCUSSION AND RECOMMENDATIONS

The USACE Plan for the 25-year diversion channel will not meet the project goal. Water surface elevations in Findlay would remain well above Main Street due to the flow from Lye Creek and the Blanchard River even if the Western Diversion of Eagle Creek's capacity were to be increased to carry the full 1% ACE (100-year) flows.

Preliminary analysis of project modifications and review of supplemental projects that could be added, show that the WSEs in downtown Findlay at Main Street can be reduced by approximately 3.6 feet during the 1% ACE (SCS Type II event). Alternative 4 is believed to be the most cost effective way to reduce flood levels close to the community's goal while also spreading projects throughout the watershed as a means of better managing flood risk. This alternative includes projects on the Blanchard River through the City (floodplain bench widening, railroad bridge modifications, and riffle/low dam removals), flood storage on the Blanchard River and Potato Run upstream of Mt. Blanchard, and flood storage on Eagle Creek.

Alternative 4 does not result in a net water surface drop of 4.5 feet at Main Street for the SCS Type II storm with a NOAA Atlas 14 100-year, 24-hour event duration (5.26 inches) applied uniformly over the entire watershed. However, it is Stantec's opinion that Alternative 4, when implemented, will likely result in a 100-year water surface elevation below the deck of Main Street Bridge for a general 100-year event which includes areal reduction factors to account for reduced spatial distribution and less intense temporal patterns typical of local storms.

Stantec recommends the Eagle Creek dry storage basin option over the larger Western Diversion of Eagle Creek option because of preliminary opinions of probable cost ($69.4 million for Eagle Creek storage compared to $105.8 million for the 100-year diversion channel), reduction in number of parcels impacted, and a similar estimated water surface elevation. The components of Alternative 4 may be constructed in any order. Stantec recommends beginning with the hydraulic improvements on the Blanchard River, next constructing the Eagle Creek dry basin, and then the Blanchard River and Potato Run dry basins.

The recommended plan will benefit several locations across the community including these specific locations:

- Reduced flooding over Main Street at the Blanchard River between Center Street and Sandusky Street;
- Reduced flooding through large stretches of residential areas along Eagle Creek;
- Reduced flooding of large areas of suburban and agricultural properties between the dry storage basins and the City of Findlay;
- Reduced flooding of agricultural properties downstream of the City of Findlay;
- Reduced overtopping/closure of SR-15 at Eagle Creek and along US-68;
- Reduced closure of US-224 between County Road 140 and Interstate 75;
- Reduced flooding for major intersections and business in downtown Findlay;

- Reduced flooding near the Hunter's Creek Subdivision and County Fairgrounds along Lye Creek;
- Reduced closure of the Martin Luther King Parkway just east of downtown Findlay;
- Reduced time of temporary inundation of agricultural lands near SR-15 along the Blanchard River; and
- Reduced flooding of the public park and local parcels within the Village of Mt. Blanchard.

5.1 CONCEPTUAL DRAWINGS

Conceptual drawings were developed showing the approximate location, plan, and profiles for the proposed Alternative 4 projects. The drawings are provided Appendix F of this report.

5.2 NEXT STEPS

The recommended suite of projects should now be reviewed by the Maumee Watershed Conservancy District and other key stakeholders (The City of Findlay, Hancock County, local residents, businesses, and the agricultural community among others). If approved, the project or combination of projects will be incorporated into the MWCD Official Plan to move forward with planning, design, permitting, and eventually construction.

Stantec understands that the floodplain bench widening is already part of the MWCD official plan. With that in mind, this project could be implemented on a quicker timeline, especially since most of the parcels required for the project are already owned by the City or the County. The community will see immediate benefit in reduced flooding during storm events. The project is expected to be beneficial and cost effective while having limited impacts to the environment.

The planning level costs presented in this report are given for comparative purposes and should not be used for capital planning. Additional work in advancing the recommended alternatives to Stage 1 plans (30% design) should begin. This work will include site survey, geotechnical exploration, and preliminary design and will better refine the planning level costs.

6.0 REFERENCES

1. U.S. Army Corps of Engineers, Buffalo District. (April 2015). "Western Lake Erie Basin (WLEB) Blanchard River Watershed Study, Section 441 of the Water Resource Development Act of 1999, General Investigations, Draft Detailed Project Report / Environmental Impact Statement"; (USACE Draft EIS).

2. ***DRAFT*** - U.S. Army Corps of Engineers, Buffalo District. (March 2016). "Interim Report in Response to the Wester Lake Erie Basin (WLEB) Blanchard River Watershed Study, Section 441 of the Water Resource Development Act of 1999, General Investigations, Feasibility Study/Final Environmental Impact Statement"; (DRAFT - USACE Feasibility Report/Final EIS).

3. Principles and Requirements for Federal Investments in Water Resources (March 2013). https://www.whitehouse.gov/administration/eop/ceq/initiatives/PandG

4. U.S. Army Corps of Engineers. (2013). Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS). Version 4.0. Hydrologic Engineering Center, Davis, California.

5. U.S. Army Corps of Engineers (2016). Hydrologic Engineering Center River Analysis System. Version 5.0.1. Hydrologic Engineering Center, Davis, California.

6. USACE National Economic Development Manuals. http://www.corpsnedmanuals.us/

7. 2.5-Feet Resolution LiDAR DEM - Downloaded from http://ogrip.oit.ohio.gov/ (January, 2016).

8. 2016 6-inch imagery - Downloaded from Hancock County website. http://downloads.ddti.net/HancockOH/. (October, 2016).

9. U.S. Department of the Interior - U.S. Geological Survey. "Floods of August 21-24, 2007, in Northwestern and North-Central Ohio, Straub, Ebner, and Astifan. With the Federal Emergency Management Agency. (Open-File Report 2009-1094). https://pubs.usgs.gov/of/2009/1094/pdf/ofr20091094_entire.pdf

10. Dunne, T., & Leopold, L. B. (1978). Water in environmental planning: New York, W.H. Freeman and Company.

7.0 STANTEC INTERNAL QA/QC PROCESS

Stantec employs a Project Management (PM) Framework containing a list of tasks to be completed in conformance with our ISO9001:2008 registered Quality Management System. Specifically, the PM Framework sets the expectations for the quality assurance processes to be completed for all projects. The intent is that final documents will be affixed with a professional seal and signature of the licensed professional taking responsibility for a final document. The PM Framework requirements for signing final documents are the minimum requirements for work completed within Stantec to provide a level of quality assurance and quality control (QA/QC).

Final documents must also have an independent technical review (ITR) conducted and signed by the independent reviewer prior to issuance. The independent review of the final documents is completed by a qualified professional not directly associated with the development of the documents. For larger or more complex assignments, multiple independent reviews and independent reviewers may be required to meet the intent of this requirement.

For this Proof of Concept Report and supporting appendices, multiple QA/QC and ITR reviews were conducted by various professionals examining the individual technical aspects of the various chapters and report sections, as well as overall report content. QA/QC reviews were completed by the following professionals:

- Scott Peyton, PE – Technical Project Manager
- Adam Hoff, PE – Administrative Project Manager
- Bryon Ringley, PE – Environmental Technical Lead
- Erman Caudill, PE – H&H Technical Lead
- Kyle Blakely, PE – Geotechnical Lead
- Thomas Morman, PE – Transportation Lead
- Cody Fleece – Permitting Lead

ITRs were completed by the following professionals:

- Stan Harris, PE, Stantec Consulting Services Inc.
- James Rozelle, PE, Stormwater Engineering, LLC
- Daniel Hoffman, PE, Stantec Consulting Services Inc.

APPENDICES

Appendix A – PHASE 1 MEMORANDUM: REVIEW AND ASSESSMENT OF THE "BLANCHARD RIVER FLOOD RISK MANAGEMENT FEASIBILITY STUDY APPENDIX B – ECONOMICS (DRAFT)"

Phase 1 Memorandum:

Review and Assessment of the "Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (Draft)"

Prepared For:

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December 7, 2016

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Executive Summary

In Phase 1, the study team reviewed U.S. Army Corps of Engineers (USACE) report, "The Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT)", and associated spreadsheets. The team identified the following issues and reached the following conclusions:

Benefit-Cost Ratio (BCR): The USACE only estimated the benefits and costs from a National Economic Development (NED) perspective and not from a regional (county-level) Regional Economic Development (RED) perspective. USACE originally estimated that the BCR would be 1.30 for the preferred alternative, but subsequent refinement of cost estimates has resulted in the BCR dipping just below 1.00. The study team has discovered a number of additional potential categories of benefits (see below). The addition of these benefits will likely raise the NED BCR well above 1.00 and the RED BCR even higher.

Report Content: The report did not provide cross-alternative summary tables and graphics and detailed estimates of benefits to allow comparison of alternatives and reality checking of results.

Project Spreadsheets: The study team reviewed each of the spreadsheets and found only a few insignificant calculation errors. However, the author of the spreadsheets did not link all of the data items so that full checking back to the original source of all the calculations was not possible.

Structure Values: Rather than using tax assessments, USACE valued structures using square footages from a 10% sample of floodplain structures, square foot building costs from RSMeans, and adjustments for depreciation. The report does not describe the variance between their values and tax assessments, provide average structure values the two methods provided, or compare results with Census data.

Vehicle Damages: USACE assumed floods would damage 30 percent of privately owned vehicles based on data from the Southeast Louisiana Evacuation Behavioral Report following Hurricanes Katrina and Rita. Flooding in Findlay is more likely to be of associated with flash type flooding in comparison to large hurricanes. USACE makes no mention of public and commercial vehicles as well as vehicles at dealerships, auto repair shops, public parking lots, office buildings, etc. The report aggregates results for vehicles with structure and content damages rendering it impossible to judge whether the results are reasonable or comparable to actual damages.

Income losses: The report quotes USACE guidance that flood losses include income losses, which are the loss of wages or net profits to business. However, the report then makes no further mention of income losses. It is also not apparent that USACE estimated lost school days, missed medical appointments, and other social costs.

Transportation Damages: USACE did conduct an analysis of increased vehicle operating costs and travel times due to roadway closures, but never incorporated the results into the report or benefit-cost analysis. The spreadsheet shows zero road closures for I-75in both the base and with project alternatives, despite statements to the contrary in the text of the report. The report also notes that flooding has resulted in the closure of rail crossings, but it is not apparent that USACE estimated delays, rerouting, and other costs resulting from these closures.

Agricultural Damages: USACE did conduct an analysis of agricultural damages due to inundation, but never incorporated the results into the report or benefit-cost analysis. The spreadsheet is also incomplete.

Emergency Response Costs: USACE sourced estimates by structure type to the Hancock County Engineer, but did not document the methodology or describe what was included in the estimate. It is not apparent whether the estimate includes relocation and reoccupation costs.

National Flood Insurance Program (NFIP) Administrative Costs: USACE employed the average NFIP administrative cost per household, but does not provide a citation or describe the estimate. It is not clear if it is the average administrative cost for all households or for those suffering flooding.

Cleanup Costs: It is not apparent that USASCE included costs for damages to utilities, roads, rail lines, and other infrastructure, as well as cleanup of debris and restoration costs.

Discount Rates, Net Present Values, and Interest during Construction: The estimates and methodologies that USACE employed appear unusual and require additional scrutiny.

Location, Intensification, and Employment Benefits: USACE did not estimate RED benefits. Location benefits accrue when a reduction in flood risk allows new activities to locate in the floodplain. Intensification benefits accrue due to increases in income where the economic activity does not change (i.e. higher value crops). Employment benefits (i.e. jobs building levees, etc.) accrue from the construction of a project. Each of these can also be partial NED benefits when using unemployed labor in especially depressed areas.

Chapter 1: Introduction

The City of Findlay, Ohio engaged the services of Stantec to analyze the feasibility of alternative structural and non-structural flood control approaches in their community. The U.S. Army Corps of Engineers (USACE), Buffalo District, previously published a report in November 2015 entitled, "The Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT)." Jack Faucett Associates (JFA) is supporting Stantec by updating that report. In Phase 1 of the support, JFA conducted a review of the USACE report. This paper summarizes that review. In Phase 2 of the support, JFA will conduct an updated benefit-cost analysis (BCA) of the selected flood mitigation project as part of a new Blanchard River flood control study.

1.1 Organization of the Memorandum

This memorandum contains four chapters. Chapter 1, the introductory chapter, describes the project background along with a brief history of the flood area and progress on flood mitigation efforts to date. It also provides an overview of the study effort, report organization and project rationale. Chapter 2, Methodology, enumerates the tasks included in Phase 1 of the project and the literature and spreadsheets reviewed by JFA. It also provides an overview of benefit-cost analysis (BCA) and describes the types of benefits included. Chapter 3 is a critical review of the Blanchard Economics Report and the benefit-cost analysis that the U.S. Army Corps of Engineers (USACE) conducted including methodological, data and calculation issues. Chapter 4 outlines potential additional project benefits not included in the USACE report, and describes methods to calculate those benefits and costs, according to the literature and USACE guidance.

1.2 Background and Flood History

The Blanchard River Watershed, a portion of the Maumee River Watershed, is located within the counties of Putnam, Hancock, Seneca, Allen, Hardin, and Wyandot in northwest Ohio. The Blanchard River has a history of flooding dating back to January 1846, causing significant damages in the City of Findlay and Village of Ottawa. According to the stream gage located at Findlay[1] maintained by the U.S. Geological Survey (USGS), at least once in 15 of the past 20 years the Blanchard River has reached flood stage. Between December 2006 and March 2008, Findlay flooded four times with events considered larger than the 10 percent annual chance flood. Two of the four flooding events were within the top five floods ever recorded in the city.[2]

Three types of flooding occur most often in the Blanchard River Basin – river flooding, flash flooding and urban flooding. Often flooding also takes place in the urban areas of Findlay, particularly in the spring when the snows melt and rainfall increases.[3] In the City of Findlay and the Village of Ottawa, millions of dollars in damage result from flooding in the high-value downtown business district. Both businesses and residences experience substantial damage. Flooding often persists for days during flooding events, resulting in major cleanup and restoration expenses to the local, state and federal government.[4]

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[1] USGS streamgage located in Blanchard River near Findlay, Ohio (04189000)
[2] National Weather Service. http://www.weather.gov/
[3] USACE, Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT), November 2015
[4] Ibid.

In addition to the flood damage to residences and small businesses, flooding damages disrupts the local road system, and area manufacturing businesses and rail systems. During these periods, closures and delays are typical.

The purpose of the Blanchard Economics Report conducted by the USACE was to investigate alternative measures and strategies for providing flood risk management in the Blanchard River Watershed. USACE reviewed the economic, social, and environmental effects of alternative flood mitigation strategies, produced a Feasibility Study Report, and considered the recommendation of a project for authorization by the US Congress. Processes that USACE investigated for flood risk management included upstream impoundments, levees, floodwalls, diversion channels, and channelization as well as non-structural flood proofing actions.[5]

1.3 Recent Developments

The original plan scheduled the selected flood mitigation project to begin around 2022, with completion in approximately five years. However, the USACE reevaluated its range of nine proposed flood-control alternative plans (including the “without project action or no action plan” alternative), finding issues that would have delayed publication of its final “chiefs report” by six months to a year. In addition, USACE increased its projected cost of one of the key mitigation components, the diversion channel, from $60.5 million to $80 million.[6] At the higher cost, the USACE no longer considered the project benefits to justify the project costs. More precisely, the benefit to cost ratio for the project had fallen below 1.0 and was therefore unlikely to receive federal funding.

The benefit cost ratio is determined by dividing the present value of total economic benefits by present value of total economic costs. The benefit-cost ratio indicates which project alternatives produces the most benefits for every dollar of cost. Projects with high benefit-cost ratios produce the most efficiency per dollar invested. Projects proposed by the USACE compete for federal funding. Ordinarily, the ratio of benefits to costs must exceed 1.0 to be eligible for federal funding. Projects with a benefit cost ratio of 3-to-1 are most likely to receive federal funding.

However, the sector of the USACE working on the Blanchard River project was seeking permission to use new computer modeling that considered climate and other changes, and frequency of flooding in order to improve the project’s chances of federal funding. Then, the Hancock County commissioners learned that they still owed money to the USACE for work already completed, plus any additional funds to complete the proposed project. Meanwhile, to reduce flood damages, the city was purchasing additional buildings for demolition in areas that flooded repeatedly.

Therefore, based on the proposed delay, additional costs and other issues, the Findlay community chose to investigate additional flood reduction options and reassess the choices presented by the USACE. The Ottawa Council and the Blanchard River Food Mitigation Coalition requested the Maumee Watershed Conservancy District take over the project. They removed the U.S. Army Corps of Engineers from the project in June 2016. Thus, the USACE is no longer involved in the Findlay flood mitigation project. The Hancock County commissioners no longer expect federal funding, foregoing the expected 65 percent match in federal funds. At present, all control and funding will emanate from the Findlay community,

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[5] Final Independent External Peer Review Report Blanchard River Watershed, Ohio, Feasibility Report and Environmental Impact Statement, Battelle Memorial Institute, June 18, 2015

[6] For a breakdown of the $80 million estimate, see Maumee District takes over flood plans. The Courier, September 9, 2016.

which began taxing itself in 2009 to move towards a solution to their flooding problems.[7] This sales tax of 0.25 percent also pays for building demolition of structures repeatedly damaged by floods.[8]

The application of benefit cost analysis has a long-standing history in the region to augment community information and inform local decision-making. Historically, the Ohio Conservancy Law, passed in 1914, gave the state authority to establish watershed districts to raise funds for improvements through taxes.[9] In the early 20th century, the Miami Conservancy District project brought this approach to fruition with its use of complex simulation and optimization modeling, detailed cost–benefit analysis, and its linking of economics, engineering, science, and law into a far-reaching solution to a complex water resources problem.[10] The Miami Conservancy District is a river management agency operating in Southwest Ohio to control flooding of the Great Miami River and its tributaries.

1.4 Project Description and Rationale

In September 2016, Hancock County Commissioners agreed to hand over the day-to-day duties of managing flood mitigation efforts in Hancock County to the Maumee Watershed Conservancy District. The conservancy district is the second largest in the state, representing 15 counties. The conservancy has the experience assessing these issues and the authority to deal with drainage in the watershed. However, finances for the project are still under county control.

In mid-2016, Hancock County's commissioners engaged Stantec, to provide a second opinion of the plan proposed by the USACE. Stantec discovered errors in the USACE's Hydraulic Model, reducing the flood reduction estimate of the selected project alternative from approximately 4.5 feet to about 2 feet in downtown Findlay at Main Street. Stantec received direction from the client that the goal of the project was to reduce the stage of the 1 percent annual chance event in downtown Findlay by about 4.5 feet. As a result, Stantec reviewed the recommended USACE plan for optimizations and took a step back to see if there were any other opportunities or locations for refinements to the base project.

Stantec hired JFA to conduct Phase 1 and Phase 2 of the project described below, which included evaluating the current benefit-cost analysis report and other tasks. When completed, the revised benefit cost analysis may demonstrate to the Findlay community that the project benefits outweigh the costs and garner additional support for moving forward. However, as some of the flood improvements may involve the use of land currently supporting agriculture, the selected alternative is likely to encounter some community resistance. The county commissioners hope the BCA will demonstrate to the community that despite these concerns, the project is highly beneficial to the City of Findlay and its residents.

Stantec completed the Gap Analysis in August 2016. It determined the additional information needed to determine if the USACE's Eagle Creek diversion channel, the recommended plan, was still the preferred best available option. Stantec recommended additional surveying and to develop an "unsteady-state-model" for the waterway. This type of model considers factors like water retention, storage areas and

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[7] Notice posted in Federal Register, Vol. 81, No. 145, Thursday, July 28, 2016 by Department of Defense.
[8] Of the half-percent sales tax increase beginning in 2009, half is used for flood control and half for county operations. Maumee District takes over flood plans. The Courier, September 9, 2016.
[9] http://www.ohiohistorycentral.org/w/Ohio_Conservancy_Law
[10] Holmes, K. & Wolman, M. Early Development of Systems Analysis in Natural Resources Management from *Man and Nature* to the Miami Conservancy District. Environmental Management (2001) 27: 177

peak flows to determine flooding impact. It also planned taking additional soil borings along the route of the proposed diversion channel. Stantec and a local subcontractor will also determine whether the waterways contain freshwater mussels, an endangered species, and if there are wetlands areas or archeological finds.

The proposed diversion channel cuts along 38 properties west of Findlay. Concerned that the proposed diversion channel may not be sufficient to protect the city, Stantec recommended several modifications that could serve as additional backups, including removing dams on the Blanchard River and cutting retention “benches” into the side of the riverbank as it flows through the city. Dredging and cleaning the river, a proposed remedy that some local members of the agricultural community suggested, was determined to be a non-viable solution, as the river bottom generally flows on bedrock.

The JFA Phase 1 involvement in the project included seven tasks. The following chapter describes each of the Phase 1 tasks and provides an overview of the Phase 1 methodology.

Chapter 2: Phase 1 Methodology

Chapter 2 describes the purpose and tasks involved in Phase 1 of the project. It also lists the studies and spreadsheets the study team reviewed, provides background on benefit-cost analysis and expands on the types of benefits measured in this phase of the project.

2.1 Phase 1 Study Tasks

Seven tasks comprise Phase 1 of the project. This section describes each of the seven tasks.

- **Task 1: Review Existing Benefit-Cost Analysis (BCA) -** The JFA study team reviewed the existing BCA. JFA reviewed both the Blanchard Economics Report and data spreadsheets provided by Stantec. JFA reviewed key assumptions of the BCA including percent of motor vehicles evacuated, discount rates, construction costs, damages avoided, and others.

- **Task 2: Identify Errors, Omissions, and Missed Opportunities -** In this task, JFA identified and described any issues found in the report calculations. Staff identified a series of potential omissions and missed opportunities. It proposed research alternatives and solutions and discussed their impacts on the existing report.

- **Task 3: Update Existing BCA -** In this task, the study team considered potential updates to the existing BCA for the recommended project, Alternative #13. This update was to be limited to correcting any errors or omissions in the original BCA. However, study staff did not find substantial errors or new data from readily available sources that they could use to quickly recalculate or update the BCA.

- **Task 4: Evaluate NED Benefits Not Included in Existing Analysis -** JFA staff researched National Economic Development (NED) benefits that were not included in the previous analysis. These NED benefits include transportation, agriculture, loss-of-life, restored land value, and avoided income losses to business. This evaluation included a review of USACE ERs and The Economic Principles and Guidelines. To complete this task, JFA also reviewed other BCA flood studies of interest to this project with emphasis on procedures applied in these reports.

- **Task 5: Evaluate Potential RED Benefits -** The study team researched, evaluated and enumerated potential Regional Economic Development (RED) benefits that the BCA could include. For each benefit, JFA summarizes calculation methodologies, potential magnitude, and strengths and limitations.

- **Task 6: Plan Phase 2 -** In this task, JFA staff developed a work plan for Phase 2 outlining the tasks and costs to prepare a fully updated BCA. The work plan specifies the exact steps required to complete a full BCA for the proposed project, taking into account any issues identified in the previous tasks.

- **Task 7: Prepare Memorandum/Report -** In Task 7, JFA developed this report. It describes the work undertaken in Phase 1 and the results of the efforts. The report includes the work plan for Phase 2 of the project as noted above in Task 6.

2.2 Literature Reviewed

The JFA study team reviewed a considerable number of reports provided or recommended by Stantec or identified through JFA's research. Stantec provided JFA temporary access to a number of reports located on its FTP directory. These reports included

- Western Lake Erie Basin (WLEB) Blanchard River Watershed Study, Section 441 of the Water Resource Development Act of 1999, General Investigations, DRAFT, Detailed Project Report/Environmental Impact Statement, USACE , Buffalo District, April, 2015

- Blanchard River Watershed Study Final Feasibility Report Appendix A: Hydrology and Hydraulics Hydrology and Hydraulic Engineering, USACE, October 2015

- Economic and Environmental Guidelines for Water and Related Land Resources, Implementation Studies, US Water Resources Council, March 10, 1983

- Janik, J And Kohl, P. Western Lake Erie (Wleb) Real Estate Plan, Blanchard River Watershed Feasibility Study, Findlay, Ohio. USACE Buffalo District, Real Estate Division, January 28, 2016

- Blanchard River Watershed Study Interim Feasibility Report, Appendix E: Environmental Appendix, USACE Buffalo District, November 2015

- Review Plan, Blanchard River Watershed, Ohio Feasibility Report Flood Risk Management And Ecosystem Restoration Blanchard River PMP, Appendix F Review Plan, January 24, 2012

- Risk-Based Analysis For Evaluation Of Hydrology/Hydraulics, Geotechnical Stability, And Economics In Flood Damage Reduction Studies, Er 1105-2-101, USACE, 1 March 1996

- Final Independent External Peer Review Report, Blanchard River Watershed, Ohio, Feasibility Report and Environmental Impact Statement, Battelle Memorial Institute, June 18, 2015

- Water Resources Policies and Authorities, Civil Works Review, USACE, December 15, 2012

- Final Information Quality Bulletin for Peer Review, Office of Management and Budget, December 16, 2004

- Blanchard River Watershed Study, Draft Interim Feasibility Study, Appendix E, Engineering & Design, January 2016

- Interim Report in response to the Western Lake Erie Basin (WLEB) Blanchard River Watershed Study Section 441 of the Water Resource Development Act of 1999 General Investigations Feasibility Study/Final Environmental Impact Statement, USACE, March 2016

- Planning Guidance Notebook, USACE, Er 1105-2-100, 22 April 2000

The review of the aforementioned and related reports allowed JFA to understand the nature and scope of the project. Furthermore, it supplied the political and social history of the project, the work USACE performed, and the status of the undertaking to date.

JFA was unable to locate, or in some cases access, a limited number of the reports recommended by Stantec. These included:

- Geotechnical, Structural and Civil Engineering Report
- Abbreviated Risk Analysis
- Mitigation and Monitoring Plan
- Risk Register
- Decision Log

These reports are not critical for this review; nevertheless, JFA will review them in its literature review as part of Phase 2.

2.3 Spreadsheets Reviewed

Stantec supplied JFA with three project spreadsheets to review. The three spreadsheets, each in Excel format are:

- Spreadsheet #1: Non-Structural Economic Analysis
- Spreadsheet #2: Interest During Construction Estimate
- Spreadsheet #3: Findlay Economic Analysis

The JFA Team describes and reviews these spreadsheets in Chapter 3 of this report.

2.4 Fundamentals of Benefit Cost Analysis

This section provides a brief overview of the essentials of benefit-cost analysis (BCA). Benefit-cost analysis is an economic technique to evaluate what is achieved (benefits) compared to what is invested (costs).[11] BCA analyzes whether the value of benefits exceeds the value of the costs. This allows decision makers to allocate resources in an efficient manner.

BCA can assist decision makers select the best alternative by monetizing both benefits and costs. The first comparison in BCA is to calculate the net benefits by subtracting economic costs from total economic benefits. This allows the analysis to scale a range of alternatives for comparison. The second comparison is to calculate the benefit-cost ratio by dividing the present value of total economic benefits by present value of total economic costs. The ratio allows for ranking or comparing different projects by informing which alternative produces the most benefits for every dollar of cost (total benefits/total costs). A benefit cost ratio of one (1) indicates the total benefits equal the total costs. For each dollar of cost, a dollar of benefit accrues. If the ratio is less than one (1), the total costs exceed the total benefits. This indicates a poor investment of resources.

For projects such as flood risk management, decision makers can compare and prioritize projects from across the nation. Projects with higher benefit cost ratios are preferred and the BCR becomes a factor in which projects are funded, given limited federal resources. In this project, USACE used BCA to compare a range of flood mitigation alternatives. Exhibit 2-1 provides some useful applications of BCA.

[11] USACE & Institute for Water Resources. Economics Primer. IWR Report 09-R-3, June 2009.

Exhibit 2-1: Useful Applications of Benefit Cost Analyses

Comparison of benefits to costs over the life of a project is not a simple issue of adding up the benefits. The value of a dollar changes with time. A dollar an entity spends or earns in the future is usually worth less than it is today. To compare multiyear projects, one must account for the changing value of the dollar. Two factors account for the diminishing value of the dollar with time. These two factors are inflation and the time value of resources. BCA compares projects in real or base year dollars, with the effects of inflation removed. The process measures the time value of resources by the annual percentage factor known as the discount rate. Through discounting, decision makers can objectively compare different investment alternatives based on their respective current values.

The US Army Corps of Engineers developed a series of manuals describing how to evaluate urban benefit water and related resources implementation projects. JFA followed the guidance of these manuals in reviewing the current BCA. As described below, analysts can also use these USACE-derived procedures to estimate National Economic Development (NED) and Regional Economic Development (RED) benefits and costs of water resource projects.[12] [13] Exhibit 2-2 provides the major steps in the BCA process. The objective of the following section is to discuss in greater detail several methodological issues required by USACE procedure. These issues include defining the base case condition, project alternatives, Regional Economic Development (RED) measures, National Economic Development (NED) measures, and analysis methodology.

[12] USACE, Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, 1983

[13] Planning Guidance Notebook" (Engineering Record No. 1105-2-100).

2.5 Base Case Condition ("Without Project Alternative")

An important aspect of benefit-cost analysis and USACE water-resource study guidelines is the selection of a base case (i.e. a "without-project condition") and its comparison with alternative projects. According to the USACE's Planning Guidance Notebook, the without-project condition is defined as, *"… the most likely condition expected to exist in the future in the absence of a proposed water resources project. Proper definition and forecast of the future without-project condition are critical to the success of the planning process. The future without-project condition constitutes the benchmark against which plans are evaluated."*[14]

2.6 Definition of NED and RED Benefits

The USACE defines National Economic Development (NED) benefits as benefits that accrue to the nation as a whole: *"Beneficial effects in the NED account are increases in the economic value of the national output of goods and services from a plan."*[15] The methodology employed by the USACE recognizes NED benefits as only those impacts that would be lost to the nation in the absence of the project. In addition, USACE recognizes improvements in efficiency, such as reductions in the nation's overall flood protection bill as NED benefits.

The USACE defines Regional Economic Development (RED) benefits as benefits that accrue at the regional level. According to the USACE Principles and Guidelines, *"The RED account registers changes in the distribution of regional economic activity that result from each alternative plan."*[16]

Exhibit 2-2: Major Steps in the Benefit Cost Analysis Process

1. Establish objectives
2. Identify constraints and specify assumptions
3. Define the base case and identify alternatives
4. Set the analysis period
5. Define the level of effort for screening alternatives
6. Develop base case damage estimate
7. Estimate benefits and costs relative to base case
8. Evaluate risks
9. Compare net benefits and rank alternatives
10. Make recommendations

2.7 Definition of the RED Area

According to the USACE Principles and Guidelines, *"The regions used for RED analysis are those regions with in which the plan will have particularly significant income and employment effects."*[17] For this study, Hancock County is the core of the RED area.

2.8 Benefit-Cost and Net Present Value Analysis

To determine whether an investment is justifiable, the project sponsor performs a Benefit-Cost Analysis (BCA) that quantifies the benefits and costs. The analysis can analyze benefit and cost quantities in many ways, such as total benefits minus total costs (i.e. net present value analysis) or benefits divided by costs (i.e. benefit-cost ratio). However, in order to be meaningful, a BCA must not only express all benefits and costs in monetary terms, it must also account for the change in the value of the dollar over time.

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[14] USACE. 2000. "Planning Guidance Notebook." (Engineering Record No. 1105-2-100, Section 2-4.b.(1)). http://www.usace.army.mil/publications/eng-regs/er1105-2-100/

[15] USACE. 1983. "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." p.8, Section 1.7.1.(b).

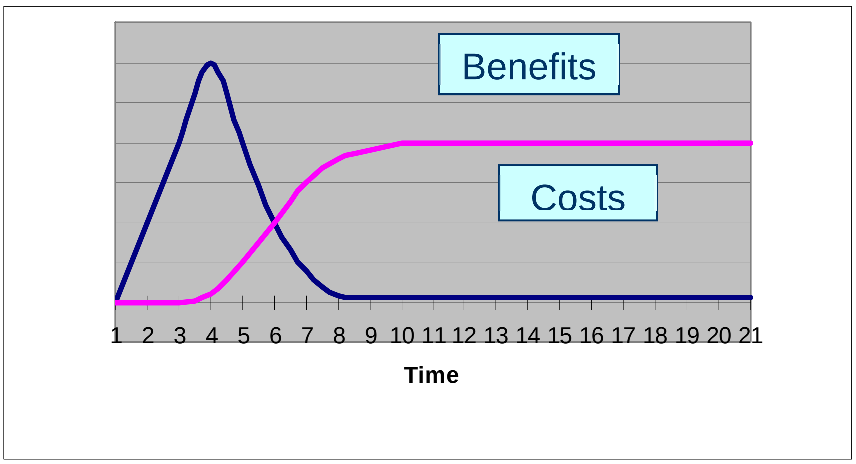
[16] Ibid., p. 11, Section 1.7.4.(a)(1).

[17] USACE. 1983. "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." p. 11, 1.7.4.(a)(2).

The value of a dollar changes not only with inflation, but also because today's dollar is worth more than a dollar available years from now. For example, a single dollar available today would be worth more than one single dollar in five years because it could be invested and earn interest for five years. An economic concept called "net present value," accounts for the impact of time on the value of money and discounts the future value of a dollar. This concept of net present value is important because the timing of costs and benefits of a project are often different.

A frequent observation in public infrastructure projects is that costs accrue both immediately and over time, while benefits accrue over time after the majority of costs accrue. Exhibit 2-3 provides a sample of typical project benefit and cost flows. Costs, as considered by an engineer for example, inflate over time to reflect generally accepted increases in the costs for goods and services. This provides an estimate of the cash that is going to be necessary to complete a project. However, benefits, as considered in economics, discount as they move into the future. Net present value provides the common ground against which the analysis considers costs and benefits.

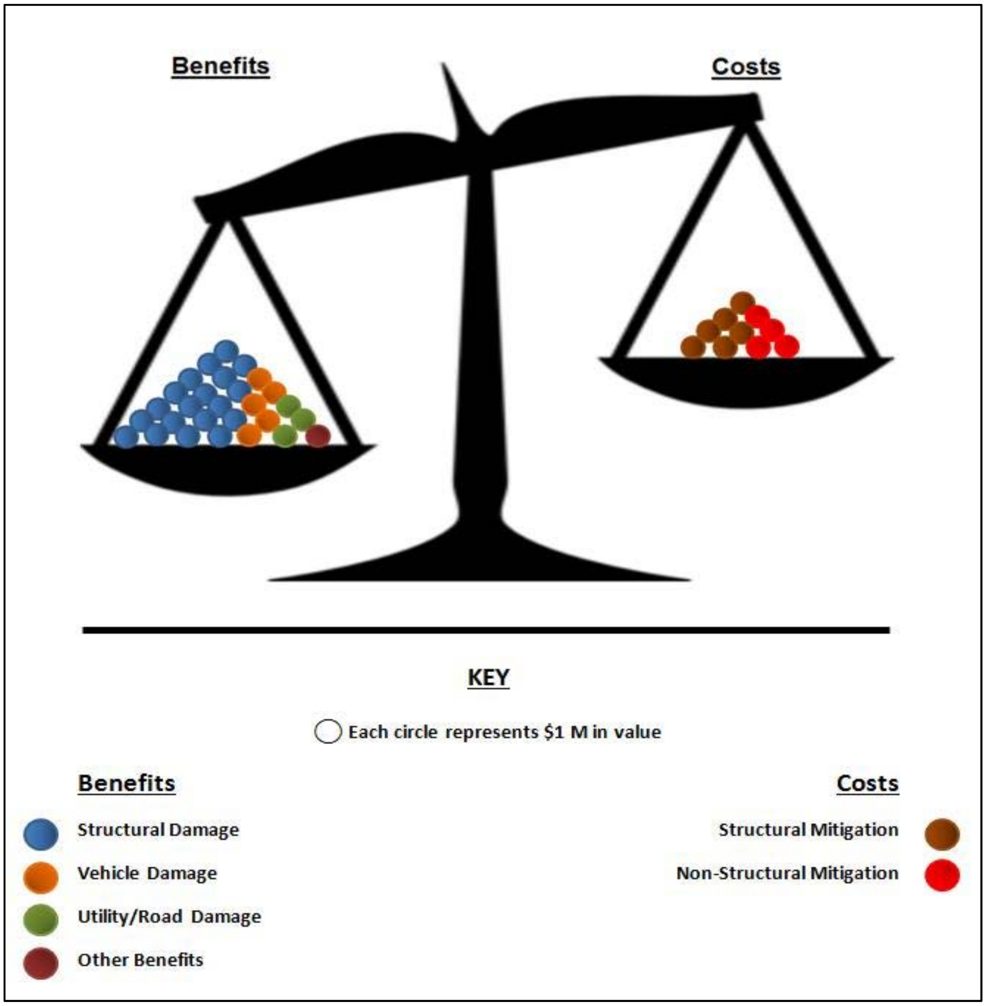
Exhibit 2-3: Sample Project Costs and Benefit Streams



2.9 Economic Analysis Methodology

Estimating the National Economic Developments (NED) benefits is initial step in the economic analysis methodology. NED benefits are changes in value to the national output of goods and services expressed in monetary units. NED contributions are those that accrue in the planning area and the rest of the nation from the selected project. NED benefits typically include flood damage reduction avoided in commercial and residential buildings, vehicles, transportation, utilities, equipment, road, crops and others. Exhibit 2-4 provides an example of how the BCA weighs benefits and costs against each other.

Exhibit 2-4: Example of Benefits Versus Costs in Flood Mitigation BCA



To determine loss estimation, the JFA Team uses Hazus (developed by FEMA) or Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software.[18] These estimated avoided flood losses are the NED benefits for the project case. The models calculate losses using depth-damage curves that associate flooding depth as measured from the first finished floor, to damage expressed as a percent of replacement cost of the building. Other curves relate to contents, building interiors, etc.

The next step is to estimate economic impacts of the projects. The BCA can use IMPLAN (IMpact Analysis for PLANning) modeling system to develop estimates of economic impacts (RED Account Benefits) for activities associated with the various project alternatives. IMPLAN is an input-output model originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the USDI Bureau of Land Management to assist the Forest Service in land and resource management planning. The University of Minnesota began work on IMPLAN databases in 1987. In 1993, the Minnesota IMPLAN Group, Inc. (MIG) privatized the development of the IMPLAN data and software. A major benefit of using IMPLAN is that it contains 509 industries at the county, MSA or state level, so analysts can use the most accurate information for any specific expenditure. Other benefits of using the

[18] These programs are described in Section 5.5.

IMPLAN model are that it develops consistent estimates of economic impacts, jobs, and tax revenues and estimates at the national, state, and county levels.

To calculate and add the total impacts on Hancock County requires an economic model that calculates impacts through multiple tiers of expenditures. Analysts can use IMPLAN for this purpose. IMPLAN is an economic modeling system that uses input-output analysis to analyze effects of an economic stimulus on a specified economic region. Input-output analysis is a method of examining relationships between businesses and between businesses, and consumers in an economy. Two types of input-output studies exist. A primary input-output study uses data collected directly from industries. A secondary input-output study constructs the necessary accounts using data collected from other sources and it uses other primary studies for inter-industry transaction information. IMPLAN is a modeling system that falls under the category of secondary input-output studies.

Economists often refer to the multiple tiers of expenditures calculated by an input-output model as direct, indirect, and induced impacts. Direct impacts are changes in employment, wages and other economic activity related to flood protection construction and operation, and new resident home construction. Indirect impacts are changes in employment, wages, and other economic activity in industries and sectors that provide inputs to those industries. Induced impacts reflect the increased demand for goods and services in any industry and sector resulting from the increased wages and employment in sectors and industries directly and indirectly impacted by activities during and following a change in flood protection. An example of an induced impact is increased demand for retail food in the region.

The IMPLAN model provides data at three basic levels of geographic disaggregation: national, state, and county. The analyst can combine these geographic units can be combined to construct any regional grouping the user desires. For example, in this study, Hancock County is the RED region, and in addition, the model can conduct a statewide or national analysis. The ease with which the user can construct alternative regional aggregations, while preserving critical intra and interregional trade flow information, is a principal advantage of IMPLAN.

Chapter 3: Review of Current Benefit-Cost Analysis (BCA)

As part of the Phase 1 work effort, JFA staff reviewed the existing benefit-cost analysis (BCA). This chapter focuses on the assumptions, methodologies, and calculations that USACE staff employed as described in their economics appendix and implemented in their spreadsheets. The following chapter focuses on the additional potential benefits that could be included in the benefit-cost analysis.

3.1 USACE Economics Report

The benefit-cost analysis for the project is contained in the "Blanchard River Flood Risk Management Feasibility Study, Appendix B – Economics (DRAFT),"[19] hereinafter referred to as the "Blanchard Economics Report." This report is 151 pages including appendices and enclosures. Chapter 2, Economic Framework on pages 19-43 presents the methodology that USACE employed.

The remainder of the report is largely filler. Pages 1-19 contain demographic information on the region that USACE does not appear to use in the calculation of benefits and costs. Pages 45-126 provide five-page analyses of individual alternatives with the same five tables and several paragraphs repeated. USACE did not include tables that summarize findings across alternatives, complicating analysis across these scenarios. This lack of cross-alternative tables makes it difficult to compare the advantages and disadvantages of each alternative, as well as complicating the process of assessing the consistency of estimates between and among alternatives.

The introduction to Chapter 2, Economic Framework states, "*The analyses of without-project and with-project damages include damages or costs incurred from a range of categories. Categories considered in the economic analysis are: damages to structures and contents, damages to automobiles, increased emergency response expenditures, evacuation and subsistence expenditures, reoccupation costs, and costs for commercial cleanup and restoration. These categories are intended to capture a substantial portion of the financial burden incurred by a flood event; however, they are not comprehensive enough to capture every cost or damage that could result from flooding in the area. Transportation and agricultural damages have not been quantified to date, but will be included in the economic analysis prior to release of the Final Detailed Project Report*."

The following subsections address each of the categories that USACE considered in the economic analysis as enumerated in the previous paragraph. These include

- Damages to Structures And Contents
- Damages to Automobiles
- Increased Emergency Response Expenditures, Evacuation and Subsistence Expenditures, Reoccupation Costs, and Costs for Commercial Cleanup and Restoration
- Transportation and Agricultural Damages

Finally, the introduction to Chapter 2, Economic Framework states, "*The FY16 discount rate of 3.125% (EGM 16-01) is utilized for present value calculation. Costs and benefits are expressed in November 2015*

[19] "Blanchard River Flood Risk Management Feasibility Study, Appendix B – Economics (DRAFT)," U.S. Army Corps of Engineers (USACE), Buffalo District, November 2015.

prices and a 50-year planning period is assumed." The final subsection in this analysis addresses discount rates, net present values, and interest during construction.

Damages to Structures and Contents

The USACE methodology for estimating damages to structures and contents follows standard procedures and appears, for the most part, to be free from methodology or calculation issues. USACE used the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software to estimate damages to structures and contents. This model is the standard in the industry.

This procedure begins with a structure inventory, which categorizes structures by type (residential, commercial, public, industrial). The procedure further classifies residential structures by number of stories and presence of a basement. The second step was to gather structure latitudes and longitudes. The third step was to estimate first floor elevations using field observation. The forth step was to calculate the depreciated replacement value for each structure. The fifth step was to gather or estimate depth damage functions (DDFs) for each property by type of property.

For each severity of flooding event, the model knows the probability of that event, the depth of the water at each property, the elevation of each property, the value of the structure and contents, and the percent of damage that a given depth of water will cause at that property (the DDF). The model uses this information to simulate the average annual damage that would occur in a given year.

The only significant issue in these procedures was the establishment of the depreciated replacement value for each structure. The report states, "*Hancock and Putnam County tax assessors provided value data for residential and non-residential structures in the study area. The tax assessor data listed multiple valuation components (e.g., land, improvement) for each parcel that could be used to represent the value of structures in the study area. To ensure compliance with USACE guidance requiring the use of depreciated replacement values for structures, a random sample of the structures were valued using RSMeans, a commercially available valuation method for comparison to the tax assessor valuations. A field inventory of 10% of the structures in the study area was conducted to collect characteristics of the structures, such as size, condition, quality, roofing material, etc. The characteristics are input variables used to estimate the replacement value using RSMeans. The replacement values were adjusted for depreciation using ratios developed by the Institute for Water Resources (IWR). The depreciated replacement values calculated for the sample of inventoried structures were compared to tax assessor values to determine if a relationship between the data sets could be identified. However, there was great variance between the data sets and a relationship could not be identified.*"

USACE used the results they obtained using the random sample of structures valued using RSMeans. While tax assessments are notorious for being inconsistent and inaccurate, the report does not describe the variance between the two sets of values or provide the average value per structure that the two methods provided. The report does provide a map with each structure represented by a dot that varies in size and color depending on the value. However, USACE leaves the reader to speculate what the average value per structure used in the analysis was and how it's value relative to assessed values or the Census values the report provides in the opening chapter on demographics. The study team will conduct more research into this issue in Phase 2.

Damages to Automobiles

The Blanchard Economic Report states, "*According to the Southeast Louisiana Evacuation Behavioral Report (2006) following Hurricanes Katrina and Rita, approximately 70 percent of privately owned vehicles are used for evacuation during storm events. The remaining 30 percent of the vehicles are parked at residences and are subject to flooding. It was assumed that a similar evacuation pattern would be used for Findlay, with 30 percent of the automobiles remaining at the household when evacuating*."

This assumption of 70 percent of vehicles evacuated requires additional research. Flooding in Findlay is more likely to be of associated with flash type flooding in comparison to large Hurricanes such as Katrina and Rita. For example, Economic Guidance Memorandum, 09-04, Generic Depth-Damage Relationships for Vehicles, provides data on vehicle percentage of respondents moving at least one vehicle to higher ground by warning time.[20]

The Blanchard Economic Report also discusses the number of vehicles. It notes, "*The residential structure inventory in each study area was used to determine the location of automobiles. Two sources provided estimates of the number of vehicles per household. The Department of Transportation (2009) estimated an average of 1.9 vehicles per household for the United States; American Factfinder (U.S. Census Bureau, 2014) estimated 1.8 vehicles per household for Hancock County, and 2.1 vehicles per household for Putnam County. Based on the findings, two vehicles per residential household were considered appropriate for use in the study." The study also notes, "The elevation of the automobiles was assumed to be the elevation of the structure's adjacent grade, which was estimated using digital elevation maps and GIS.*"

While none of these assumptions appear unreasonable, automobiles and other motor vehicles are not all personal and are not all parked at residences. There are company automobiles, commercial vehicles, dealerships, auto repair shops, public parking lots, office buildings, etc. Our firm has developed automobile damage estimating procedures for the Hazus model and the data take into account all types of structures, not just residences, and parking patterns by time of day. The study team will conduct more research into these issues in Phase 2.

One unfortunate aspect of the USACE Blanchard Economic Report is that it does not provide any separate estimates of the damages or reduction to damages for motor vehicles. The report provides dozens of tables that include automobile expected annual damages both with and without the project for multiple alternatives. However, the tables aggregate results for automobiles with structure and content damages. It is therefore impossible to judge whether the combined estimates appear reasonable.

Increased Emergency Response Expenditures, Evacuation and Subsistence Expenditures, Reoccupation Costs, and Costs for Commercial Cleanup and Restoration

The Blanchard Economic Report cites Engineer Regulation 1105-2-100 for guidance on what the report terms "Ancillary benefits." The Engineer Regulation 1105-2-100 Planning Guidance Notebook as quoted in the report states, "*Nonphysical flood losses include income losses and emergency costs. Income losses are the loss of wages or net profits to business over and above physical flood damages that usually result*

[20] Economic Guidance Memorandum, 09-04, Generic Depth-Damage Relationships for Vehicles, Department Of The Army, U.S. Army Corps of Engineers, Washington, D.C., 22 June 2009.

from a disruption of normal activities. Estimates of these losses must be derived from specific independent economic data for the interests and properties affected. Prevention of income losses result in a contribution to national economic development only to the extent that the losses cannot be compensated for by postponement of an activity or transfer of the activity to other establishments. Emergency costs include those expenses resulting from a flood that would not otherwise be incurred. For example, the costs of evacuation and reoccupation, flood fighting, and administrative costs of disaster relief; increased costs of normal operations during the flood; and increased costs of police, fire, or military patrol. Emergency costs should be determined by specific survey or research and should not be estimated by applying arbitrary percentages to the physical damage estimates."[21]

The report makes no further mention of income losses. However, Attachment A to the report, Commercial and Industrial Flood Damage Survey, did ask respondents to report the "Number of lost business days" and the "Amount of lost net income ($)" from past flooding events. However, the report does not provide their answers to these questions. The following chapter of this memorandum discusses the estimation of these potential benefits in more detail.

The report divides emergency costs into "Emergency Response Costs Avoided" and "National Flood Insurance Program (NFIP) Administrative Costs Avoided."

The report defines emergency response costs as costs that "*are incurred by Federal, State, and local government agencies to provide emergency services and debris removal during a flood*." The report then notes, "*Emergency response estimates were provided for residential ($1,900) and non-residential ($11,200) structures by Steve Wilson, Hancock County, OH Engineer*." The report does not provide any other documentation of the estimate, the methodology that the engineer employed, or a description of what the engineer included in the estimate. USACE multiplied the estimate by the number of structures inundated in each alternative such that the benefit is proportional to the number of structures each alternative protects from inundation.

Several issues with this procedure require further research. First, as stated above, there is no documentation of the estimate, the methodology employed, or a description of what was included. At minimum, this additional detail would be required. Second, several of the costs Engineer Regulation 1105-2-100 described do not appear to be related to a structure, or even to the number of structures. This further raises questions as to the methodology that USACE employed.

For NFIP costs avoided, the report notes "*Homes and buildings in high-risk flood areas with mortgages from federally regulated or insured lenders are required to have flood insurance. When an insured home is flooded administrative costs are incurred to service claims. A reduction in flooding would reduce or eliminate these claims and associated costs. Reduced administrative costs are a claimable flood risk management benefit per USACE EGM 06-04*."

To estimate these NFIP costs avoided, USACE employed the "*average NFIP administrative cost per household ($192).*" The report does not provide a citation for this dollar amount or discuss how it is calculated or what it includes. It is not clear whether it is an administrative cost for all NFIP households or for those that suffer a flood event. USACE multiplied the estimate by the number of structures

[21] Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, Planning Guidance Notebook, ER 1105-2-100, Department of the Army, U.S. Army Corps of Engineers, Washington, DC, 22 April 2000.

inundated in each alternative such that the benefit is proportional to the number of structures each alternative protects from inundation. The study team will conduct more research into this issue in Phase 2.

Transportation and Agricultural Damages

The Blanchard Economic Report states, "*Transportation and agricultural damages have not been quantified to date, but will be included in the economic analysis prior to release of the Final Detailed Project Report (see sections 2.5.5 and 2.5.6 for details)*." However, sections 2.5.5 and 2.5.6 do not exist in the Blanchard Economic Report. USACE did complete a separate write-up of transportation and agricultural damages avoided along with spreadsheets. However, it does not appear that USACE ever included these materials in any of the formal reports or the benefit-cost analysis.

The Blanchard Economic Report states, "*The Blanchard River Watershed is located in the center of an extensive transportation network of road and rail systems. The level of accessibility afforded by this network has contributed significantly to both local and regional economic growth. Although Hancock County is largely rural, it is also home to many businesses, (including Cooper Tire, Hearthside Foods, Marathon Petroleum, and Whirlpool Corporation) that can quickly and easily export manufactured goods using the area's many convenient State routes and interstates. During flood events, transportation infrastructure in the study area (including, but not limited to, I-75) is significantly impacted. Closure times range from short to relatively long to account for inundation, debris clearance, and safety assessments which vary by storm and transportation route. During major flood events, a majority of the Blanchard River crossings are closed. Major flooding has also resulted in the closure of several Blanchard River rail crossings.*"

The USACE transportation spreadsheet (Blanchard Transportation Model Oct2015 (Findlay Only)) requires additional analysis. For example, the spreadsheet shows zero road closures for I-75 in both the base and with project alternatives, despite the statement to the contrary in the quote above. Also, note that USACE titled the spreadsheet, "Findlay Only," which indicates the analysis is only partial.

The report also notes, "*This region has experienced many flood disasters that resulted in Presidential and Gubernatorial Disaster Declarations. These disasters have caused millions of dollars in damages to homes, businesses, personal property, and agriculture*." In addition, farmers have also been extremely vocal in opposition to the flood control strategies, so understanding how the alternatives affect this interest group will be crucial to designing and selecting a flood control plan.

The USACE agricultural spreadsheet (Blanchard Agriculture Model Oct2015) also requires additional analysis. The version that Stantec provided to JFA, includes the field value "#NAME?" in all of the results cells indicating that the analysis was incomplete.

Given, the importance and size of these damages and the potential magnitude of the benefits it is difficult to understand why USACE would present the results of the BCA without completing and including these items. The following chapter of this memorandum discusses the estimation of these potential benefits in more detail.

Discount Rates, Net Present Values, and Interest during Construction

Benefit-cost analysis uses discount rates to place multiple year dollars on a consistent basis. This is because large portions of costs of a project typically occur before benefits occur, the time pattern of costs and benefits can vary between alternatives, and individual monetary flows may reflect differing assumptions regarding inflation. In addition, BCA must account for the time value of money, the notion that in the absence of inflation, economic actors would rather have a dollar today than one in the future.

To avoid the complications of forecasting inflation, BCA typically utilizes estimates that are all in today's dollars (i.e. current dollars) and utilizes a real discount rate (i.e. an interest rate where inflation has been subtracted out) to remove the time value of money and to place all monetary streams on a consistent basis. In contrast, where monetary flows are in nominal (year of expenditure) dollars (i.e. dollars that include inflation), BCA uses a nominal interest rate (i.e. an interest rate where inflation has not been subtracted out), to remove both the time value of money and inflation, which places all monetary streams on a consistent basis.

For example, the Office of Management and Budget (OMB) at the Federal government publishes both a nominal and real interest rate.[22] Exhibit 3-1 quotes the OMB guidance.

Exhibit 3-1: OMB Discount Rate Guidance

Nominal Discount Rates. A forecast of nominal or market interest rates for calendar year 2016 based on the economic assumptions for the 2017 Budget is presented below. These nominal rates are to be used for discounting nominal flows, which are often encountered in lease-purchase analysis.

Nominal Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
2.0	2.4	2.7	2.9	3.2	3.5

Real Discount Rates. A forecast of real interest rates from which the inflation premium has been removed and based on the economic assumptions from the 2017 Budget is presented below. These real rates are to be used for discounting constant-dollar flows, as is often required in cost-effectiveness analysis.

Real Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
0.3	0.6	0.8	1.0	1.2	1.5

Analyses of programs with terms different from those presented above may use a linear interpolation. For example, a four-year project can be evaluated with a rate equal to the average of the three-year and five-year rates. Programs with durations longer than 30 years may use the 30-year interest rate.

[22] See "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," Circular A-94, Appendix C, Office of Management and Budget, Revised November 2015. Accessed at: https://www.whitehouse.gov/omb/circulars_a094/a94_appx-c

The Blanchard Economic Report employs the discount rate USACE specifies in Guidance Memorandum, 16-01, Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2016.[23] USACE obtains the rate from U.S. Department of the Treasury, which computes it as the average market yields on interest-bearing marketable securities of the United States that have 15 or more years remaining to maturity. The 2016 rate of 3.125 percent is consistent with OMB forecasts but USACE reports it for a different term. Note that this is a nominal interest rate, as Treasury has not removed inflation. Moreover, USACE only publishes one discount rate, leaving the question as to how an analyst would treat future dollars that included or did not include inflation.

The study team posed the questions of why the real discount rate did not have inflation removed and why there was no distinction between real and nominal discount rates to the USACE contact. However, his response did not clarify the issue. He stated, "*My response … assumes that you are working on a Federal Water Resources Project governed by the Principles and Guidelines and other policy and law. If your project is not, then my answer would be different. The appropriate discount rate for economic analyses is the current discount rate, 3.125% for FY 16. This rate is provided by the U.S. Treasury based on outstanding average debt with 15 years or greater to maturity. Typically for non-budgetary decisions, USACE uses the costs and benefits in constant dollars at current price levels and then applies the current discount rate to NPV and average annual*."[24]

While discount rates are a somewhat technical and esoteric issue, higher discount rates almost invariably result in lower benefit-cost ratios. Therefore, the project team will revisit this issue in Phase 2. In addition, USACE applied this nominal discount rate to construction expenditures to increase construction costs to include "Interest during Construction" (IDC). In our experience, this is not standard practice in BCA, and warrants further examination.

3.2 USACE Benefit-Cost Spreadsheets

Stantec supplied JFA with three project workbooks to review. The three workbooks were in Microsoft Excel format. Two of the workbooks are small subordinate workbooks containing relatively few spreadsheets. One workbook calculates interest during construction and one develops cost estimates for non-structural solutions. The third workbook is the main benefit-cost workbook that USACE used to calculate and present BCA results. It contains 34 spreadsheets. The following sections of this report describe the worksheets and the content included in each of the three Excel workbooks.

Workbook #1: Interest During Construction Estimate (Pfisterer)

This workbook has two spreadsheets. The first spreadsheet (FINAL NED Plan Estimate) summarizes construction costs including a revised estimate of interest during construction based on a 67-month construction period for the final NED plan. It also contains an estimate of operations and maintenance costs (O&M) and annual monitoring for the duration of the project. The second spreadsheet calculates interest during construction by month. It has a row for each of the 67 months and 23 columns of data and calculations. Both of the spreadsheets in this workbook are also contained in Workbook #3,

[23] See "Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2016, "Economic Guidance Memorandum 16-01, Department of the Army, U.S. Army Corps of Engineers, Washington, DC, 14 October 2015.
[24] E-mail correspondence from Jeremy M. LaDart, Economist, Office of Water Project Review, Directorate of Civil Works, USACE Headquarters, 202-734-1861, September 29, 2016.

although the first (FINAL NED Plan Estimate) contains some additional calculations; however they appear to be side calculations with no stated purpose.

The study team found no errors in the spreadsheets. However, the author of the two spreadsheets had manually typed in or pasted values in all of the data cells rather than linking it back to the original source of the estimates, with the exception of some account codes. For example, the author typed in the construction cost for “channels and canals.” Therefore, there is no link back to the source data to examine for errors in transcribing the estimate or the calculation of the estimate. This is true for the entire workbook. The second spreadsheet calculates IDC, which as discussed above, the study team will review in Phase 2.

Workbook #2: NS Economic Analysis - Alternative 3 with 5yr 10yr 25yr

The second workbook contains five spreadsheets. The first (Output from SAS) and the last (Struct_Detail_Out) contain what appear to be inputs and outputs from a SAS program. (Struct_Detail_Out) contains 9,582 lines of data for individual structures, while (Output from SAS) contains 5,226 lines of data for individual structures. The SAS output includes information on the floodplain (5 year, 10 year or 25 Year) along with non-structural treatments applied and the cost of that treatment. The rows for each of the 73 structures that the SAS program selected for non-structural treatment are first and highlighted. The author of the spreadsheet had created a table to the right of the data output summarizing the cost. The study team found no errors in the spreadsheets. However, the author of the two spreadsheets had transcribed all of the data rather than linking it back to the original source of the estimates, preventing any backward checking.

The Blanchard Economic Report notes, “*In order to assign and evaluate nonstructural measures, a Statistical Analysis System (SAS) based algorithm was utilized. This algorithm assigns least cost non-structural measures based on various flood depths and adjusts structure attributes given the selected measure. For example, if a three-foot structural raise were assigned it would amend first floor elevation three feet higher than the original value. Revised structure attributes were used to estimate expected annual benefits via HEC-FDA. The nonstructural algorithm was developed by USACE New York District*.” This appears to be consistent with this workbook.

The second spreadsheet (Potential Non-Structural) extracts the individual rows for each of the 73 structures that the SAS program selected for non-structural treatments and the author of the spreadsheet added tables to the right of the data that provides counts of structures by floodplain and non-structural treatment. In total, 23 structures are included in the 5-year analysis, 27 in the 10-year analysis, and all 73 in the 25-year analysis. The study team found no errors in this spreadsheet.

The fourth spreadsheet (HEC-FDA Benefit Reference) contains a cut-and paste table in picture form that reports the average annual damages from the without project case and for the 100-year diversion channel with each level of non-structural projects. The author of the spreadsheet typed the results into tables below the picture. These results were for use in the calculations in the (Results Summary) spreadsheet. The study team found no errors in this spreadsheet.

That spreadsheet (Results Summary), the third in the Workbook, provides a summary of the non-structural annual costs, benefits, net benefits and cost/benefit ratios by floodplain. These include the first costs from the SAS output along with estimates for Temp Relocation, Contingency, Survey/Appraisal, E&D, S&A, and Interest during Construction.

There are two side-by-side tables. The first provides costs based on April 2008 estimates and the second updates the estimates to November 2014 prices. The author updated most of the estimates using EM 1110-2-1304, the Civil Works Construction Cost Index System. The spreadsheet provides the index for April 2000 (738.89), November 2014 (811.01), and the ratio (1.09761). However, the author did not update the estimates for Temp Relocation, Survey/Appraisal, and E&D and manually typed in the estimates for Interest during Construction, which the author did not derive from a formula. The study team found no errors in this spreadsheet.

Workbook #3: Findlay Economic Analysis (Optimization)v5

The third workbook contains 34 spreadsheets. This workbook includes spreadsheets providing data on the benefits, costs, and benefit/cost ratios for each proposed alternative flood mitigation plan individually, along with summary tables highlighting key results of the calculations. The spreadsheet includes economic parameters, a summary of ancillary benefits, non-structural plan components and calculations, and expected annual damage for each of the 15 alternative flood mitigation scenarios.

The first spreadsheet in this workbook (Econ Parameters), calculates various percentages that analysts can apply to dollars or streams of dollars in future years. All of these percentages use the discount rate of 3.125 percent and the number of years into the future. The study team found no errors in this spreadsheet. The economic parameters are:

- Amount of $1 compounded
- Amount of $1 per period
- Sinking Fund
- Present worth of $1 in future
- Present worth of $1 per period
- Partial payment

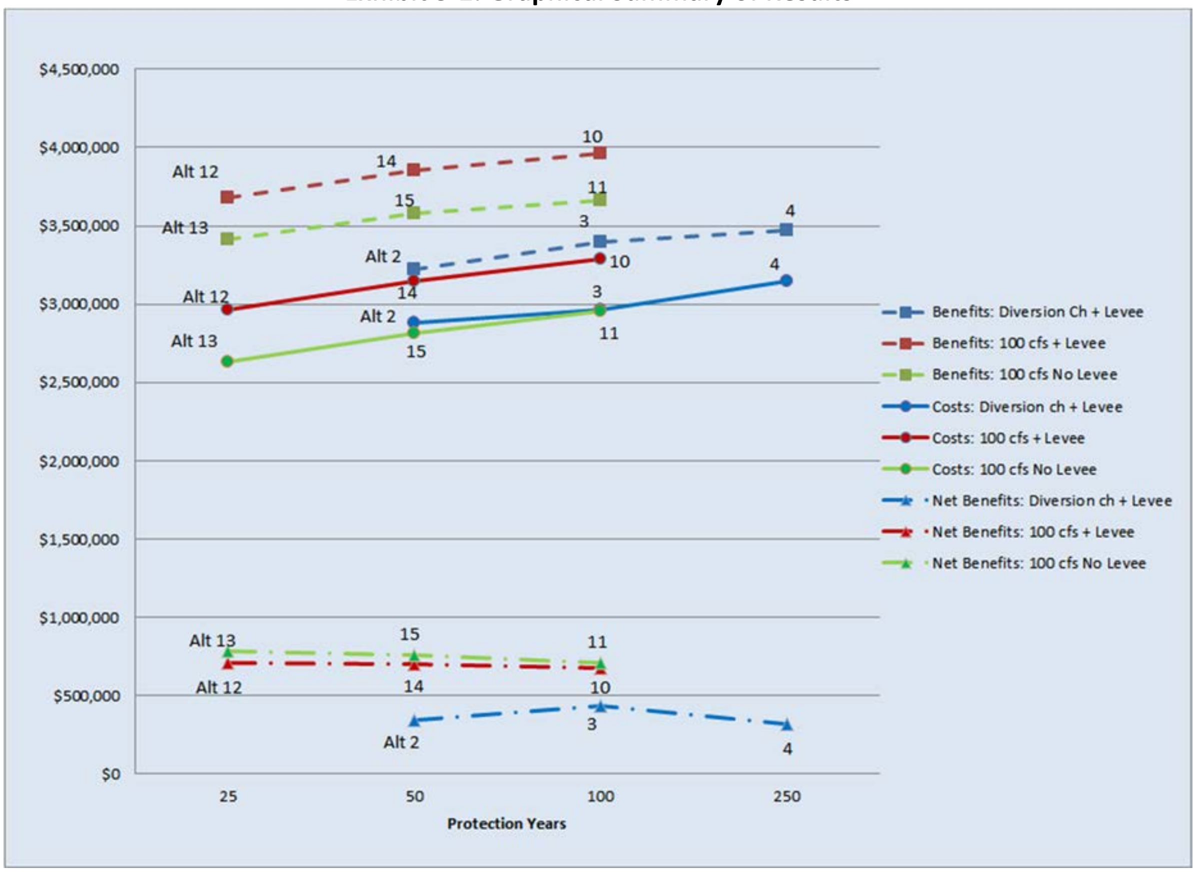
The second spreadsheet in this workbook (Ancillary Benefit Summary), provides emergency response and NFIP administrative costs (damages) for the without project scenario and for each alternative. The spreadsheet also provides net costs (benefits) for each alternative. The author of the spreadsheet manually entered all of the data without links to other spreadsheets and there are no calculations. The study team found no errors in this spreadsheet.

The third and fourth spreadsheets in this workbook (FDA Ref – NS FINAL) and (FDA Ref – May 2015 (ALT)), each contains a cut-and paste table in picture form. In each spreadsheet, the author of the spreadsheet typed the results into tables. In the second of these spreadsheets, the author entered the estimate for expected annual damages without the project as 4974.30 rather than 4917.31. None of the other data is rounded and the study team found no other errors in these spreadsheets.

The fifth spreadsheet in this workbook (Econ Analysis All Plans), contains Average Annual Benefits, Average Annual Cost, Average Annual Net Benefits, and the BC-Ratio. The author created the table using cells linked to other spreadsheets in the workbook and simple calculations. The study team found no errors in this spreadsheet.

This is an excellent summary table of the type lacking in the USACE report. The study team used the data in this table to create a graph of the benefits, costs, and net benefits by alternative. These types of summary graphics are useful in comparing alternatives and in insuring that estimates are logical and error free. Exhibit 3-2 provides this graphical summary of results. The graph indicates a rational pattern among the results, supporting a conclusion that there are not significant errors in the calculations. Alternative 10 provides the most benefits, Alternative 4 is the most expensive and Alternative 13 provides the largest net benefit, although only by a small amount while providing a minimal (25-year) level of protection.

Exhibit 3-2: Graphical Summary of Results



Spreadsheets 6 through 20 provide results for each of 15 alternatives. The first 14 of these spreadsheets are titled with the scenario number and a brief description of the alternative (i.e. Alt2 – Econ – Q=50 Div & BLC). Exhibit 3-2 provides an example of the contents of a results spreadsheet for Alternative 13, which is the preferred alternative. The cells in these spreadsheets either contain links to other spreadsheets in the workbook or contain simple formulas. USACE reprinted each of these spreadsheets in the Blanchard Economic Report, for example, Exhibit 3-3 is Table 6-28 in the report.

Exhibit 3-3: Example of Results Spreadsheet

ECONOMIC PARAMETERS		
FY16 Federal Discount Rate:		3.125%
Partial Payment Factor:		0.039793
Present Worth $1 (50 Years @ 3.125%):	$	25.13

Q = 25-yr Diversion, NO BLCL, 100 cfs Assumption

BENEFITS

AVERAGE ANNUAL BENEFITS		
Residential, Commercial, Auto Damages Avoided:	$	3,283,450
Emergency Response Costs Avoided:	$	121,100
NFIP Administrative Costs Avoided:	$	6,200
Total AA Benefits:	$	3,410,800

COSTS

INVESTMENT COSTS		
Total First Cost:	$	60,340,291
Interest During Construction:	$	2,792,000
Total Investment Costs:	$	63,132,000

AVERAGE ANNUAL COSTS		
Average Annual Investment Cost:	$	2,512,000
Average Annual O&M Cost:	$	95,000
Average Annual Monitoring Cost:	$	23,000
Total AA Costs:	$	2,630,000

ECONOMIC ANALYSIS

FY16 Discount Rate = 3.125%

AVERAGE ANNUAL NET BENEFITS	
$	780,800

BC ANALYSIS	
AA BENEFIT:	$ 3,410,800
AA COST:	$ 2,630,000
BC Ratio:	1.30

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES	
$	1,690,850

Exhibit 3-4 provides a snapshot of the final spreadsheet in this group (Final NED Plan Summary). It also provides updated results for Alternative 13. The benefits have not changed for Alternative 13; however, the costs are higher, resulting in a lower BC Ratio. This table is not in the Blanchard Economic Report.

Exhibit 3-4: Example of Results Workbook

ECONOMIC PARAMETERS		
FY16 Federal Discount Rate:		3.125%
Partial Payment Factor:		0.039793
Present Worth $1 (50 Years @ 3.125%):	$	25.13

Q = 25-yr Diversion, NO BLCL, 100 cfs Assumption

BENEFITS

AVERAGE ANNUAL BENEFITS		
Residential, Commercial, Auto Damages Avoided:	$	3,283,450
Emergency Response Costs Avoided:	$	121,100
NFIP Administrative Costs Avoided:	$	6,200
Total AA Benefits:	$	3,410,750

COSTS

INVESTMENT COSTS		
Total First Cost:	$	80,903,000
Interest During Construction:	$	5,671,000
Total Investment Costs:	$	86,574,000

AVERAGE ANNUAL COSTS		
Average Annual Investment Cost:	$	3,445,000
Diversion Channel & Drainage Structures:	$	188,000
Movable Dam:	$	32,000
Total AA Costs:	$	3,665,000

ECONOMIC ANALYSIS

FY16 Discount Rate = 3.125%

AVERAGE ANNUAL NET BENEFITS	
$	(254,250)

BC ANALYSIS		
AA BENEFIT:	$	3,410,750
AA COST:	$	3,665,000
BC Ratio:		0.93

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES	
$	1,690,850

These spreadsheets aggregate results for each scenario and present them in tables. There are no complex calculations and the study team found no errors in these tables.

The next thirteen spreadsheets, 21 through 33, contain cost estimates. The first of these (Cost Summary (All)), has two tables, the first lists incremental costs by type (First Cost, Interest During Construction, Annual O&M, Annual Monitoring) for four structural and four non-structural measures. The second table provides total costs by type for Alternatives 2 through 10. The first table pulls data from other spreadsheets in the workbook and the second table sums appropriate measures for each alternative. The study team found no errors in this spreadsheet.

Spreadsheet 22, the second of the cost spreadsheets (Cost Summary NS) is the same as the third spreadsheet in the Workbook #2 (Results Summary), with two exceptions. First, Interest during Construction for the price-updated portion of the spreadsheet is higher. This seems reasonable as most of the other costs also increased. Second, benefits have decreased. The updated benefit estimates are from the third spreadsheet in this workbook (FDA Ref - NS FINAL).

The remaining ten cost spreadsheets are similar in content, with the exception of spreadsheet 26. This spreadsheet is also contained in Workbook #1, as the second spreadsheet (Cost Schedule). It calculates interest during construction by month. It has a row for each of the 67 months and 23 columns of data and calculations.

The content of the other nine cost spreadsheets are similar to the first spreadsheet (FINAL NED Plan Estimate) in the first workbook. It summarizes construction cost with rows for account codes and columns for construction subtotal, contingency percentage, contingency, and total. The nine sheets report costs for various measures (i.e. 100-year diversion channel) and vintage. as the rows including a revised estimate of interest during construction based on a 67-month construction period for the final NED plan. Most of the spreadsheets also include estimates of operations and maintenance costs (O&M) and annual monitoring for the duration of the project. These are generally in plain text to the outside of the main tables. The study team found no errors in these spreadsheets.

Spreadsheet 33 (Environ Mitigation Costs (Ruby)) is the last of the cost worksheets. It provides a breakdown of environmental mitigation costs and key assumptions used in the calculations, for Alternatives 2 through 10. The study team found no errors in this spreadsheet.

Spreadsheet 34, the last in this workbook (Paul C Cost Assumptions) provides information on how to develop costs for the optimization alternatives (i.e. the 100 cfs alternatives). The spreadsheet contains only text and therefore no calculation errors. The spreadsheet notes, "*Using the previous costs, while not exact, should get us accurate enough numbers that we can compare all three channel capacities and be able to select a plan, and move forward with optimization. Exact cost numbers could be developed later if need be.*"

Chapter 4: Additional Potential Benefits

The JFA study team identified a number of additional potential benefits in their review of the Blanchard Economic Report. Additional potential benefits are benefits that JFA believes should have been included in the report, but were not. The inclusion of these factors would improve the accuracy and usability of the findings.

Additional potential benefits identified by JFA include accounting for road closures, business loses, lost income/wages, temporary relocation/reoccupation costs, agricultural loses, among other factors. USACE typically divides these additional benefits into National Economic Developments (NED) Benefits or Regional Economic Development (RED) benefits.[25] As noted in the USACE's NED manual, *"National Economic Development benefits are defined … as increases in the economic value of the goods and services that result directly from a project. NED benefits are increases in National wealth, irrespective of where in the United States they may occur. NED costs are the opportunity costs of diverting resources from another source to implement the project and the uncompensated economic loss from detrimental project effects. A project is considered economically feasible if the NED benefits are higher than the NED costs. The benefit-cost ratio would then be greater than one."*

The manual defines RED benefits as follows, "*Regional Economic Development (RED) Benefits refer to economic gains from a project in a specific geographic area. These gains are measured by the net increases of income and employment. RED benefits include transfers or redistribution of wealth from other regions of the country as well as increases in National wealth incident to that specific region. While RED benefits cannot be used in determining the costs and benefits of the NED plan, they can be extremely helpful to the local sponsor in assessing the value and financial feasibility of the project*." An example of a RED benefit is spending by construction workers that will increase the economic activity of the community, which in turn increases sales taxes collected in the area. Another example is that businesses may relocate to a community after the flood mitigation practices go into effect and because of the greater flood protection. These actions increase economic activity in a region, while having no effect from a national perspective.

The following section describes and details the additional benefits identified. The following sections also review measurement issues.

4.1 Road Closures

Roadway damage as an outcome of flooding events results in road closures, traffic rerouting, increased operating costs and traffic delay.[26] In the Blanchard Economics Report, the USACE authors[27] promised the quantification of transportation damages in the Final Detailed Project Report. However, as far as the JFA Team can ascertain, they are not included in current report and USACE never produced the pledged final report. The USACE acknowledges the consequence of road flooding costs, as noted:

[25] USACE. National Economic Development Procedures Manual – Urban Flood Damage. IWR Report 88-R-2, March 1988. Pp. I-3 – I-5.

[26] Ibid

[27] Blanchard River Flood Risk Management Feasibility Study Appendix B- Economics (DRAFT), USACE, November 2015, p. 20.

> *"The Blanchard River Watershed is located in the center of an extensive transportation network of road and rail systems. The level of accessibility afforded by this network has contributed significantly to both local and regional economic growth. Although Hancock County is largely rural, it is also home to many businesses, (including Cooper Tire, Hearthside Foods, Marathon Petroleum, and Whirlpool Corporation) that are able to quickly and easily export manufactured goods using the area's many convenient State routes and interstates.*
>
> *During flood events, transportation infrastructure in the study area (including, but not limited to, I-75) is significantly impacted. Closure times range from short to relatively long to account for inundation, debris clearance, and safety assessments which vary by storm and particular transportation route. During major flood events, a majority of the Blanchard River crossings are closed. Major flooding has also resulted in the closure of several Blanchard River rail crossings*."[28]

Estimation Methodology

The USACE in its National Economic Development Procedures Manual for Urban Flood Damage describes the recommended method for estimating the costs of rerouting traffic.[29] Rerouting may last for several months while transportation departments repair the roadways. The costs of traffic disruption include, additional operating costs per vehicle including depreciation, maintenance and fuel per mile of detour and, the traffic delay costs per passenger and commercial vehicles.

Step one for determining traffic operating cost is to map the inundation in terms of frequency, depth and duration of flooding along major stretches of road that are subject to flooding. The manual describes eights steps to determine the operating costs of the traffic rerouting with focus on how long the roadway is impassible, truck and automobile traffic counts on the affected bridges and thoroughfares, miles of the original and diversion routes, average operating costs for vehicles, etc.[30]

The second step in the calculation is to determine traffic delay costs from the rerouting. Again, it describes eight steps for this calculation for trucks and autos based on additional time for taking the alternative route, traffic counts and speeds, average passengers per vehicle, local wage rates, etc.[31]

USACE has developed the majority of the methodology and data for Findlay in their unpublished estimates of transportation damages avoided. The study team will update their methodology and estimates. JFA has experience measuring road closure delays. For example, JFA conducted a similar assessment for a benefit cost analysis conducted for Ohio's Muskingum Watershed Conservancy District. For this client, JFA estimated the benefits of improved access to roadways in a floodplain both in and around reservoirs as well as where floodwaters may be stored during periods of heavy rain. JFA calculated lost wages of stranded residents and increased travel costs and lost time for travelers forced to use these detours. [32]

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[28] Ibid, Section 1.3, p. 2.
[29] U.S. Army Corps of Engineers, National Economic Development Procedures Manual - Urban Flood Damage, IWR Report 88-R-2, Chapter VII, March 1988.
[30] Ibid, pp. VII-7-8.
[31] Ibid, pp. VII 9-10.
[32] Jack Faucett Associates. Benefit Analysis of the MWCD Official Plan (including all Amendments) final Report. July 27, 2007.

4.2 Business Loses

The USACE report included flood damage to structures and contents in the discussion of benefits avoided from flood mitigation alternatives. To assess business damage, the USACE authors surveyed business owners affected by the flood. The project's Survey of Commercial and Industrial Flood Damage, which business owners completed, included three categories of contents: equipment, furniture, and inventory/products.[33] Survey items did not include queries about loss of sales, staffing levels, hours of operation, wages, and related variables.

Estimation Methodology

The reduction of business losses, or benefits, because of the flood mitigation efforts should have been included in the study. JFA plans to investigate this factor in its BCA by interviewing or surveying business owners in the Findlay downtown and surrounding area.

4.3 Lost Income/Wages

The Blanchard Economics Report mentioned loss of income/wages in the section on Ancillary Benefit Categories.[34] The report cites the exact reference for the guidance methodology required for this estimate.[35] However, the report goes no further in estimating this factor.

Estimation Methodology

The USACE report quotes its own guidance informing how lost wages should be included over and above physical flood damages. The guidance goes on to explain the method to derive those estimates. However, lost income or lost wages do not appear to be included in the Blanchard Economic Report results. The NED Manual classifies income loss under non-physical damage.[36] The manual defines it as "*the loss of wages or net profits to businesses over and above physical flood damages. It results from a disruption of normal activities that cannot be recouped from other businesses or from the same business at another time. Prevention of income loss can be counted as a national benefit only to the extent that such loss cannot be offset by postponement of an activity or transfer of the activity to other establishments*."[37]

Under some conditions, income loss is an NED benefit. The NED Manual state, "*Income losses are reductions in the national income when flooding or the threat of flooding halts production or delivery of goods and services. National losses occur 1) when the production or delivery of these goods and services are not recuperated by postponing the activity or transferring it to another location, or, 2) when there are additional costs caused by delay or transfer of the activity. Income losses are incurred by businesses and labor as a result of flood induced shut-down in the production and delivery of goods and services. These losses can occur at any time during three periods: 1) flood warning, when business operations shut down and effort concentrates on damage prevention and evacuation; 2) flood inundation, when flood fighting and evacuation continues; and, 3) cleanup and restoration, when there may be a phasing in of normal activity. Even the threat of flooding can cause shut down of business operations for extended*

[33] U.S. Army Corps of Engineers. Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT). November 2015. P. 130.

[34] Ibid, Section 2.5

[35] ER 1105-2-100 – Section 3-3 Flood Damage Reduction – Types of Flood Damage.

[36] USACE. National Economic Development Procedures Manual – Urban Flood Damage. 1988 Section VII-2.

[37] Ibid.

periods along large river basins. Inundation can vary from several hours to over a week, depending on the sources of flooding. Income losses may occur directly to the business or institution being flooded. Losses may occur indirectly when roads are closed and public utilities are cut off. Business losses can also occur from the spoilage of perishable commodities and when their processing or distribution are interrupted by flooding. Income losses also include any additional transportation or production costs that occur from transferring production from one area to another."[38]

USACE methodology measures the amount of income loss, as an NED consideration, as the value added from the activity at the particular business.[39] The procedure for computing income-loss for any given business is given by the following equation:

$$L= N*V*(D/H)$$

Where:
L = the income loss for an individual business
N = the number of employees
V = the annual value-added by the business per employee
D = the duration in operating hours that a business is closed, and
H = the number of hours the business operates in one calendar year.

One method to calculate the value-added for the business is by multiplying the number of employees in the business by the average value added per worker for that industry.

Lack of income and sales loses due to flooding that causes an establishment to close, is a potential additional benefit. These estimates should have been included in this BCA as costs avoided or benefits of the flood mitigation alternatives.

A similar cost for school-aged children is the loss of school hours because of flooding which damages school buildings or makes attendance impossible due to closed roads. It too is not included in the report and could have been quantified and added as damages avoided.

4.4 Temporary Relocation/Reoccupation Costs

When a flood damages or destroys residential structures, residents must relocate until repairs or replacement habitats become available. As stated in the NED Manual, "*Temporary relocation includes the additional living expenses incurred by floodplain residents who are forced to find temporary housing during and after a flood*."[40] As noted, structures may become uninhabitable for a number of reasons: 1) extended periods of inundation, 2) severe structural damage, 3) extensive debris or silt deposits, and 4) cut-off of transportation routes or utilities.

The NED Manual elaborates the various costs incurred. It notes that costs fluctuate based on the level of inundation and length of displacement. They include, 1) costs of motels or apartment rentals, 2) food costs in excess of ordinary food costs, 3) additional commuting costs to work or school, 4) opportunity costs of time spent in making households repairs, contracting for repairs, and the purchase of new

[38] Ibid.
[39] "Value-added" refers to the increase in value to a final product or service solely from input by the facility in question. The analysis should consider Only factors that provide real increases in the value of output.
[40] NED Manual, p. VII-13

furniture and personal effects. The analysis should take into account the net difference in utility expenses.[41]

Estimation Methodology

The recommended method for collecting the cost information, according the NED Manual, is to interview a sample of flood victims who have experienced various levels of flooding. These costs do not appear in the Blanchard Economics Report. The analysis should consider these avoided costs in the BCA.

4.5 Agricultural Loses

Flooding damages most crops grown in North America.[42] According to the Blanchard Economics Report, less than 2 percent of the employed population of Hancock County works in agriculture, forestry, fishing, hunting, and mining.[43] In Findlay itself, the proportion is less than one percent.[44] However, much of the watershed outside of the communities of Findlay and Ottawa is high quality productive farmland. Any flood mitigation or ecosystem plan that takes these lands out of crop production is quite likely to meet resistance from local farm bureaus and farmers.[45]

With regard to flooding, the USACE notes, "*These disasters have caused millions of dollars in damages to homes, businesses, personal property, and agriculture*."[46] Thus, the USACE acknowledges agricultural damages in the Economic Framework section of the study.[47] Agricultural losses in terms of losses avoided would be benefits of the flood mitigation projects.

Estimation Methodology

The U.S. Army Corps of Engineers developed a manual of how to assess agricultural flood damage.[48] The manual details how to measure crop flood damage, damage to farm buildings, stored crops, farm machinery, livestock, etc. USACE has developed the majority of the methodology in their unpublished estimates of agricultural damages avoided. The study team will update their methodology and estimates.

JFA has previous experience with agricultural damage estimates. For example, in two distinct projects for the same client, the JFA Team determined the economic benefits of reduced flooding of agricultural lands of the Margaret Creek Sub-district for the Hocking Conservancy District of Ohio. JFA updated annual agricultural benefits in five categories, such as "reduction in floodwater and sediment damage to crops and pastures," and "reduction in indirect damages such as the inability to market milk, livestock, and crops," prorated the earlier findings to current dollar values using an appropriate discount rate, and annualized the benefits over a 70-year life of the project.

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[41] P. VII-13-14.

[42] Butzen, S. Flooding Impact of Crops. https://www.pioneer.com/home/site/us/agronomy/crop-management/adverse-weather-disease/flood-impact/

[43] [43] U.S. Army Corps of Engineers. Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT). November 2015 p. 16.

[44] Ibid.

[45] Blanchard River Watershed, Ohio. Feasibility Report. Appendix F Review Plan, January 24, 2012 p.8.

[46] Ibid, Section 1.2, p. 2.

[47] Ibid p. 20.

[48] U.S. Army Corps of Engineers. National Economic Development Procedures Manual – Agricultural Flood Damage. IWR Report 87-R-10. October 1987.

4.6 Additional Potential Benefits

The JFA study team suggests there may be several additional potential benefits that USACE did not considered in the Draft Economics report. USACE may have noted these benefits in the report, but not included them in the analyses. In some cases, USACE promised to include them in an upcoming final report that USACE never authored. In a few other cases, the economics literature recognizes categories of benefits that USACE did not mention them in the current report.

Utility Damages (Electricity and Water Treatment)

Another cost for individuals or for the affected region as a whole, is the loss of utility services following a flooding incident. The *National Economic Development Procedures Manual – Urban Flood Damage* (referred to as the NED Manual) includes utility loses for individuals within the section discussing temporary relocation costs.

> *"Temporary relocation costs include: 1) the costs of motel rooms or apartment rentals; 2) the extent that costs of restaurant or prepared food exceed ordinary grocery costs; 3) additional costs of commuting to work and school; and, 4) the opportunity costs of the time spent in making household repairs, contracting for repairs, and purchasing new furnishings and personal effects. The net difference in <u>utility expenses</u> should also be considered*."[49]

As a regional cost, the manual includes utility losses in the context of relocation costs of railroads and utility lines. For highways, the analysis can base relocation costs on the replacement that reflects the volume of traffic and may include "*justified improvement over the configuration of the current roadway*."[50] FEMA considers utility loss a component of more typical services, which include public services, "*like law enforcement, fire rescue, medical, general government administrative operations, and public library, as well as utilities like electricity and water treatment.*"[51]

Debris Removal Costs

Widespread debris, including silt, is another condition specified in the NED Manual.[52] The benefit of inundation reduction includes not having to pay for cleanup costs and restoration. Those costs include the costs in labor and materials of removing silt and debris from buildings and outside property. The costs may also include the value of time for the cleanup.

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[49] National Economic Development Procedures Manual – Urban Flood Damage, IWR Report 88-R-2, March 1988, VII-13.

[50] Economic and Environmental Principles. In accordance with section 103 of the Water and Guidelines for Water and Related Land Resources Planning Act, as amended (42 U.S.C. Resources Implementation Studies), 1983

[51] Appendix B: Understanding the FEMA Benefit-Cost Analysis Process

[52] National Economic Development Procedures Manual – Urban Flood Damage, IWR Report 88-R-2, VII-13

Location Benefits

Location benefits accrue when a reduction in the level of flood risk makes it profitable for new activities to locate in the floodplain. USACE recommends determining location benefits by the increase in net income or property values brought on by the new use.

Intensification Benefits

Intensification benefits are increases in net income where land use or type of economic activity does not change under with-project conditions. Analysts have most often applied Intensification benefits to agricultural areas, realized through increased net income from crop production. [53]

Employment Benefits

Employment benefits, such as additional jobs to those building levees, etc. can come because of the mitigation projects. Employment benefits come from utilization of unemployed labor in designated depressed areas.[54]

[53] National Economic Development Procedures Manual – Urban Flood Damage, IWR Report 88-R-21: p. X-8
[54] National Economic Development Procedures Manual – Urban Flood Damage, IWR Report 88-R-2: p. II-14

Appendix B – DATA REVIEW AND GAP ANALYSIS – QUESTIONS FOR THE USACE

August 16, 2016
File: 174316203

Attention: Michael D. Pniewski, P.E., P.S., PMP
U.S. Army Corps of Engineers, Buffalo District
Toledo Project Office
3906 North Summit Street
Toledo, OH 43611-5003

Reference: Western Diversion of Eagle Creek Project
City of Findlay, Hancock County, Ohio
Phase I – Data Review - Questions for Clarification

Dear Mr. Pniewski,

Stantec has recently been contracted by the Hancock County Commissioners (Hancock County) to continue the design of the referenced project. The U.S. Army Corps of Engineers, Buffalo District (USACE) proposed a 9.2 mile flood diversion channel outside Findlay to the south and west of the city. The recommended plan (Alternative 13) calls for a diversion structure to convey flow from Eagle Creek and discharge into the Blanchard River approximately 1,500 feet west of Township Road 130. The project has advanced through the planning stages resulting in a Draft Feasibility Study and Environmental Impact Statement (USACE Feasibility Report – March 2016) for the proposed diversion channel.

Stantec reviewed existing data associated with the analysis completed by the USACE. A majority of the data reviewed was provided by the USACE on July 14, 2016 via external hard drive. The hard drive contained information related to the USACE Feasibility Study analysis including:

- Base Map Data
- Hydrology and Hydraulics (H&H)
- Design and Engineering
- Geotechnical
- Environmental
- Mitigation Plan
- Real Estate
- Cost Analysis
- Economics
- Cost and Schedule Risk Analysis
- Other reports compiled for the project

Stantec developed questions that can best be answered through coordination with the USACE. Some of these questions were first brought up during a conference call with USACE, Stantec and the Hancock County Engineer’s Office on August 9th, 2016. This document formalizes those questions and lists additional questions in which Stantec is requesting clarification.

Reference: Western Diversion of Eagle Creek Project
City of Findlay, Hancock County, Ohio
Phase I – Data Review - Questions for Clarification

BASE MAP DATA

- Is documentation and metadata available for the GIS information?
- What is the source of the provided DEM – "blan_dem"?
- What is the source of the GIS utilities data? Is it available for the area around Findlay outside of the footprint of the proposed alternative?

ALTERNATIVES

- Does documentation exist on the extent of analysis for other alternatives reviewed (model runs, data or other documentation)?
  - What type of data/documentation exists on other scenarios such as detention/storage?
  - What is the extent of the analysis performed on the diversion channel extension to the Blanchard River?
  - What is the extent of the analysis performed on the alignment through Aurand Run?

HYDROLOGY & HYDRAULICS

- It isn't clear what happens when the discharge on Eagle Creek exceeds a 25-year event for the recommended plan. Presumably, the diversion structure would be designed to allow the excess flow (beyond the diversion channel capacity) to continue downstream along Eagle Creek, but that isn't clearly described in the reports provided. Does flow exceeding the capacity of the diversion channel continue downstream of the diversion structure into Eagle Creek?
- The results of the provided HEC-FDA models are inconsistent with the reported values in Final w/ Project runs in HEC-RAS and the reported results in the H&H Report and Feasibility Study for Alternative 13. The HEC-RAS model has the "Flow Optimization" option activated for the lateral structure on Eagle Creek. This leads to correct discharges along the diversion channel, but reduces discharges along the Blanchard River. The HEC-FDA model uses a profile that has a drop in water surface elevation in downtown Findlay of approximately 2 feet, while the floodplain figures appear to show a drop of approximately 4.5 feet.
  - In other words, is the actual reduction in water surface elevation for the Blanchard River in downtown Findlay approximately 4.5 feet or 2 feet for the 100-year event? Figures are attached for clarification.

Reference: Western Diversion of Eagle Creek Project
City of Findlay, Hancock County, Ohio
Phase I – Data Review - Questions for Clarification

- Were there any statistical analyses performed to determine the likelihood of Eagle Creek being able to reduce flood impacts from the Lye Creek or Blanchard River watersheds? A multi-variate analysis that considers storms of multiple durations, sizes, and center locations could help characterize this uncertainty.

- If the Eagle Creek Diversion Channel (Alt. 13) only has capacity for a 25-year event, what is the combined probability for a given event of the Blanchard River flooding downtown Findlay after the channel is constructed. In other words, what is the aggregate risk reduction or effective return period reduction in Findlay for the proposed channel?

- Was connecting diversions between Eagle Creek, Lye Creek, and the Blanchard River considered to further reduce the risk in Findlay?

  - What types of analyses were performed in screening this alternative?

- The digital data includes some gage frequency analyses using Bulletin 17B, but it is unclear how/if this was used and how it compares to the HMS model results. The H&H Report doesn't mention gage analyses.

- Climate change is discussed in the H&H Report, but it is unclear how that was accounted for in the model. Were the Frequency Storm based runs that add 10% to the rainfall depths intended to account for climate change? How were those results applied to the hydraulic model?

- The Feasibility Study mentions consideration of options other than flood diversion channels (like inline detention), but the hydrologic model does not appear to include those options. Are there model runs for these other options?

- The linkage between the hydrograph peaks predicted by the HEC-HMS model and the steady state discharges entered into the HEC-RAS model is not well documented and it cannot be determined if the discharge values in the HEC-RAS model are consistent because there's not a one-to-one match between junction nodes in the HMS model and cross sections in the RAS model.

- Additional documentation on calibration and parameter sensitivity/accuracy would help clarify the H&H Report.

- The source of the geometry for the HEC-RAS model is not fully documented. The H&H Report alludes to OGRIP LiDAR (2-foot contours) being used to supplement a previous model

Reference: Western Diversion of Eagle Creek Project
City of Findlay, Hancock County, Ohio
Phase I – Data Review - Questions for Clarification

developed by USACE Buffalo. It is unclear if current channel and bridge surveys were incorporated. Is the geometry of the Blanchard River through Findlay (including all the structures) based on a current or recent survey?

- Hydraulic results for various alternatives considered are not presented in the H&H Report, other than tables 17-22 which only consider the diversion channel and its derivatives. Are results of other alternatives documented?

- Will there be a new FEMA regulatory floodplain and floodway along the diversion channel alignment (and potentially overland to Aurand Run) for the 1% ACE (100-year) flood event? Figures or exhibits that present the residual/resulting floodplain for this alternative other than Figure 39 in the H&H Report and Figure 8.5 in the Feasibility Report are not available.

- Sections 7.3 and 8.5 of the Feasibility Report indicates an increase in discharge at the confluence of the diversion channel and the Blanchard River of approximately 250 cfs. This is referenced to the 1% ACE, and Section 7.3 indicates it will be resolved during the Planning, Engineering and Design (PED) phase. A potential mitigation strategy is not presented or discussed. Did USACE have a conceptual approach they were going to investigate?

COST/ECONOMICS

- NED Benefits associated with transportation and agricultural damages were planned for the project, but not included in the analysis. Is documentation available on these draft analyses that were not included in the report?

- It is unclear how USACE defined the project objective in terms of Benefit/Cost Determination related specifically to flooding. Any of these flood risk reduction objectives could apply and would/should result in different benefit calculations.

  – Any solution that results in reduced flooding and a B/C > 1. This could result in considerable residual flood risk to Findlay although the net benefit is favorable.

  – Reduce WSE in downtown Findlay by X amount for a given return period.

  – The optimal project to maximize flood reduction for all areas considered.

- The final EIS states that while some of the flood risk management measures may have met the criteria for completeness, effectiveness, efficiency, and acceptability, they were subsequently screened from further evaluation because they were implemented using another source of funding.

- – Are measures implemented through other sources of funding needing to be incorporated into the H&H modeling to account for flood reduction and control?

- – Do the benefits of the recommended plan overlap any benefits of other measures using other sources of funding?

- The O&M spreadsheet mentions O&M costs for sluice gate crossings and drainage, tide flex backflow replacement costs, mowing, and the Obermeyer weir structure. Are there other operations and maintenance costs that were not considered?

  - – The following O&M activities were listed in the report, but not broken out in the costing: Removing vegetation, obstructions, and encroachments (trash, debris, unauthorized structures, excavations, or other obstructions present within the easement area); repairing erosion; repairing or replacing riprap; and repairing or replacing revetments other than riprap.

    - o Is there documentation on how O&M costs were derived for the diversion channel?

    - o The Final EIS mentions three aqueduct crossings that need to be maintained to ensure proper flow during non-flood events. Are these the sluice gate crossings?

- Is the ending date of November 2021 the latest schedule considered?

- The HEC-FDA data suggests a discount rate of 7.5% was used for the benefit analysis. Is there documentation supporting this value?

- The HEC-FDA profile data used for benefits does not appear to match the final HEC-RAS results for Alt. 13.

DESIGN/ENGINEERING

The following assumptions were made by Stantec based on the diversion channel as recommended in the Feasibility Report. The following items need to be discussed with Hancock County and/or USACE to confirm our interpretation.

- The Interstate I-75 crossing will remain on the existing grade.

- The Norfolk Southern RR crossing will remain on the existing grade.

- CR 313 (between the RR and I-75) will remain on the existing grade.

**Reference: Western Diversion of Eagle Creek Project
City of Findlay, Hancock County, Ohio
Phase I – Data Review - Questions for Clarification**

- Utility coordination will be completed for the project.
- Roadway/bridge improvements will follow ODOT PDP, Path 3 and will be designed to meet the County and ODOT standards.
- Lengths of roadway improvements will be based on a 2.5 foot levee for the State Route 12 crossing and the other local roadways.
- The USACE Feasibility Report Section 9.3 discusses and makes recommendations for each of the crossings, and breaks them down into five categories. These are Dry Crossings, Local Road Bridges, State Road Bridge, Interstate Highway Bridge and Railroad Bridge. It should be noted that this section of the report indicated that bridge type studies had been completed. Is this the case?

Thank you for reviewing these questions and assisting Stantec in the transition to make this a successful project. We look forward to receiving your responses.

Respectfully,

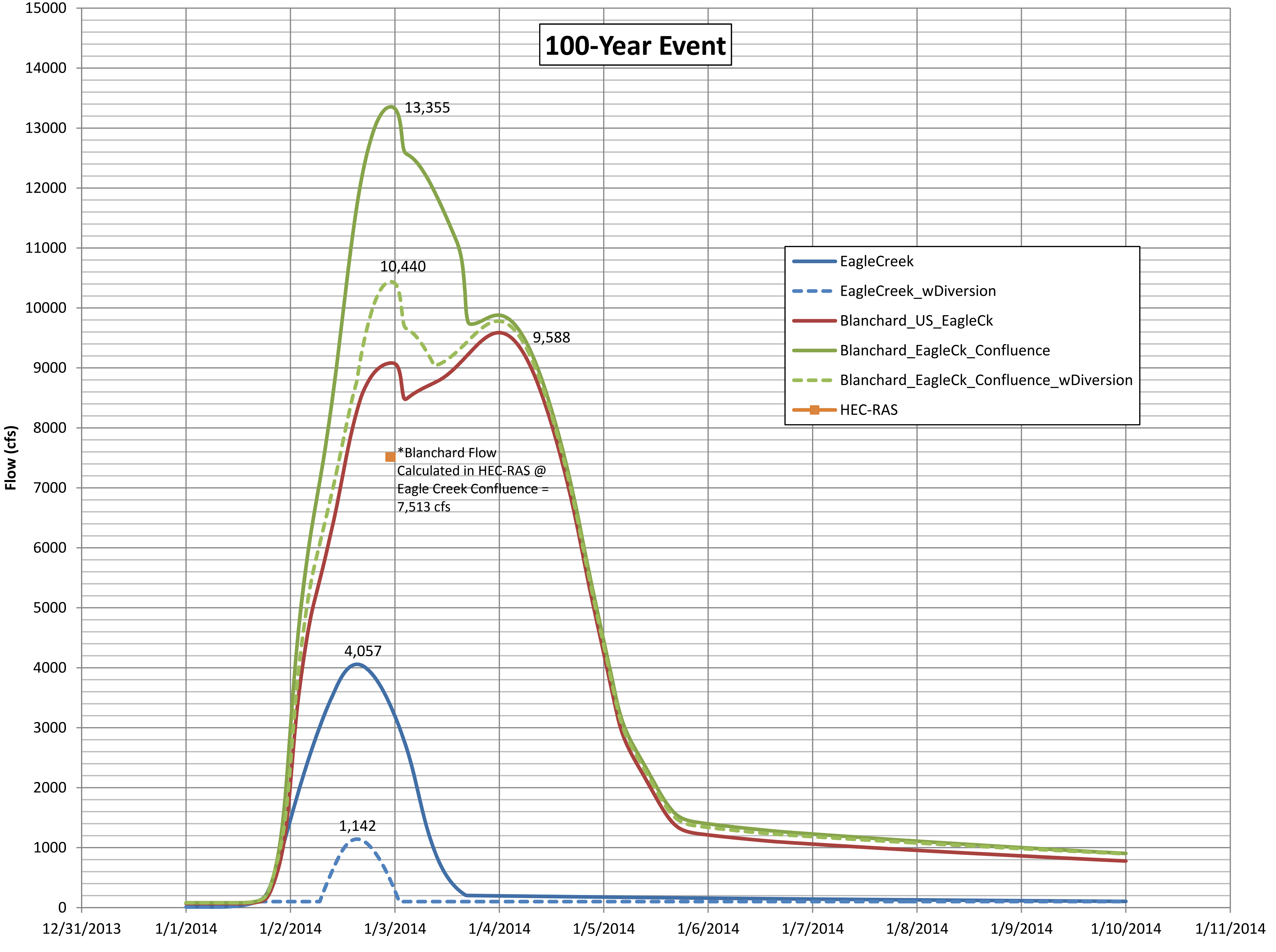
Stantec Consulting Services Inc.

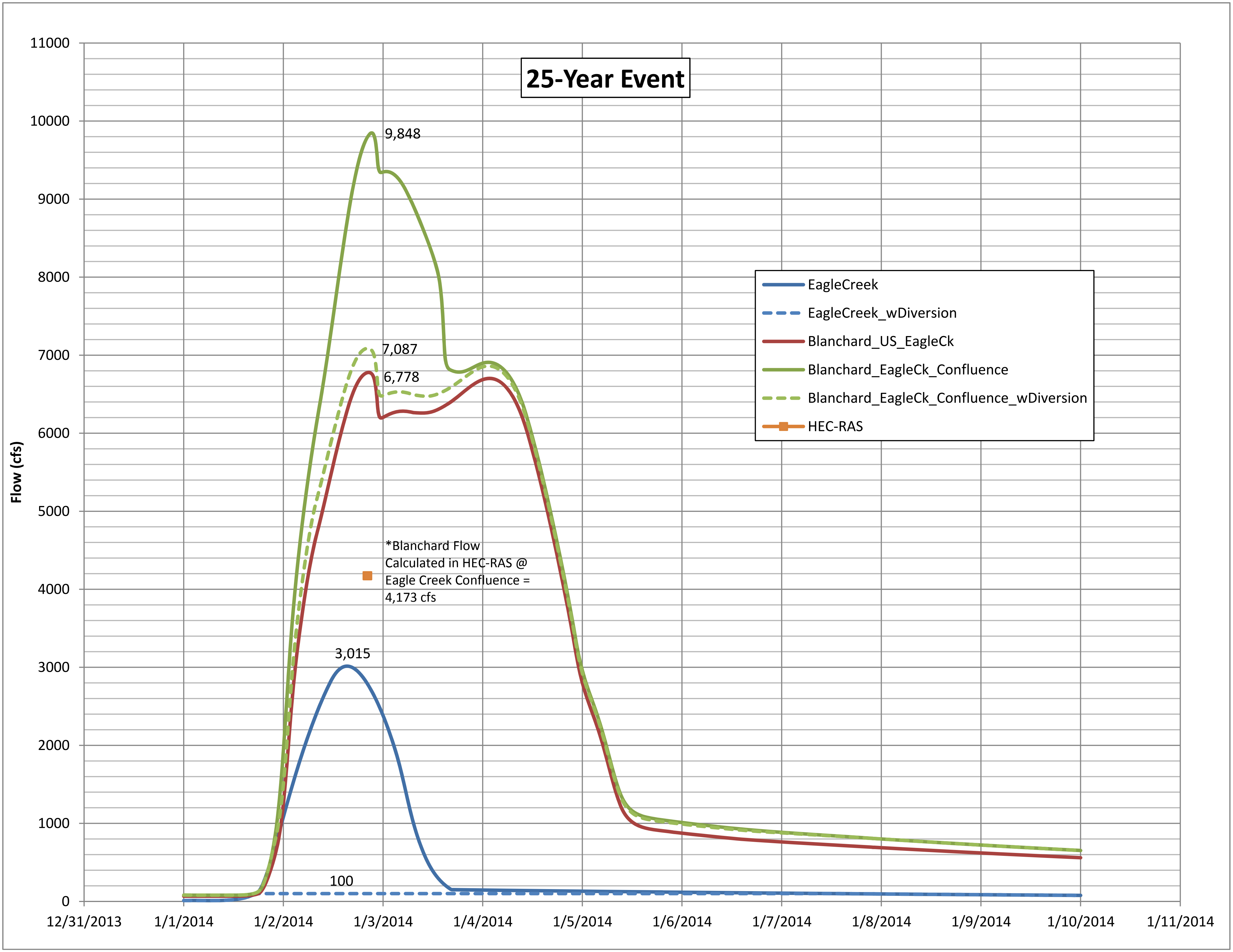
Scott D. Peyton, P.E.
Senior Principal
Phone: 513-842-8200
Scott.Peyton@Stantec.com

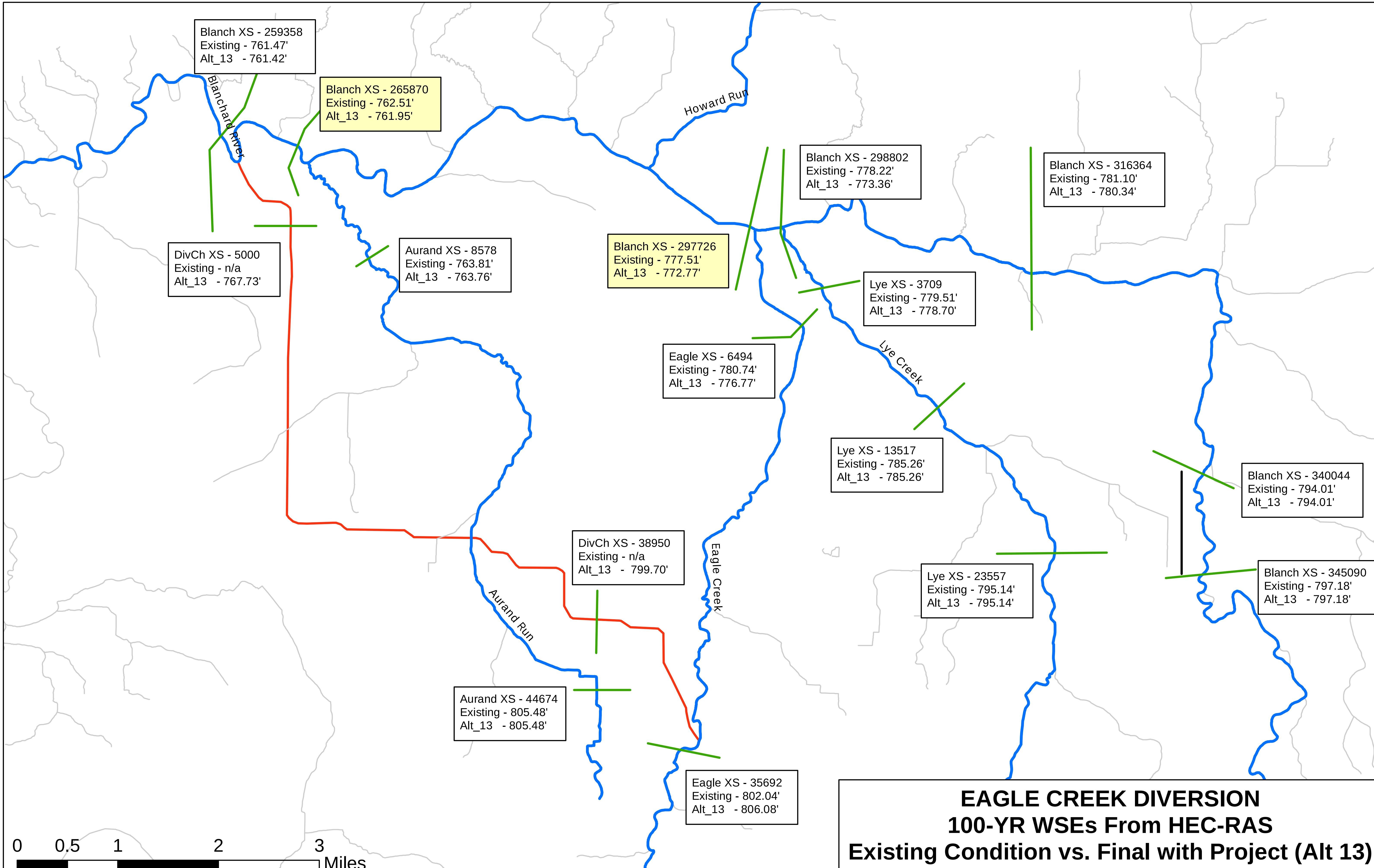
Attachment: H&H Schematics

c. Adam Hoff, John Menninger and Bryon Ringley, Stantec

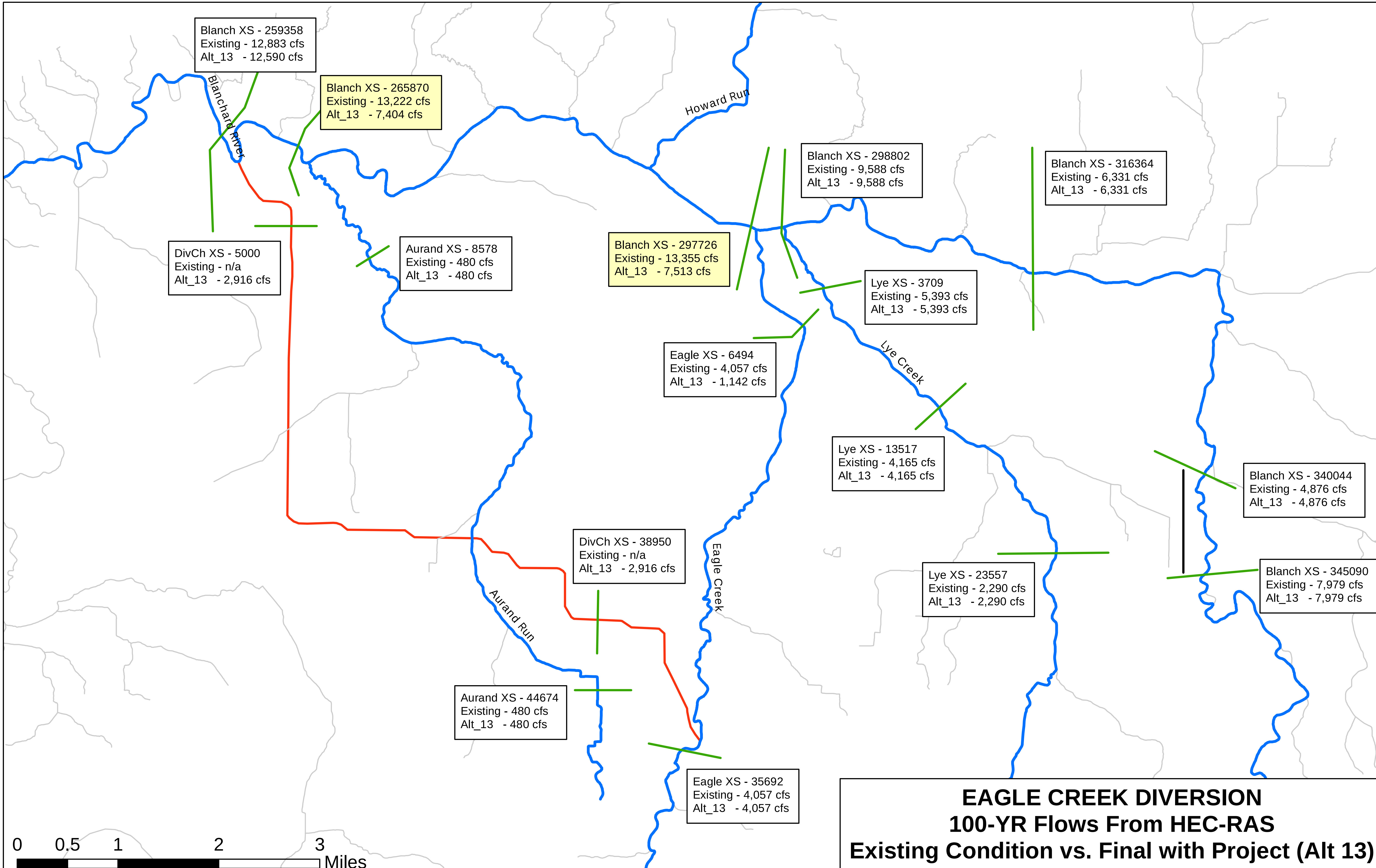
dth u:\1743\174316203\record\let_eagle_creek_questionsforusace_081116.docx


100-Year Event
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
12/31/2013
1/1/2014
1/2/2014
1/3/2014
1/4/2014
1/5/2014
1/6/2014
1/7/2014
1/8/2014
1/9/2014
1/10/2014
1/11/2014
13,355
10,440
9,588
4,057
1,142
*Blanchard Flow
Calculated in HEC-RAS @
Eagle Creek Confluence =
7,513 cfs
EagleCreek
EagleCreek_wDiversion
Blanchard_US_EagleCk
Blanchard_EagleCk_Confluence
Blanchard_EagleCk_Confluence_wDiversion
HEC-RAS


25-Year Event
Flow (cfs)
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
12/31/2013
1/1/2014
1/2/2014
1/3/2014
1/4/2014
1/5/2014
1/6/2014
1/7/2014
1/8/2014
1/9/2014
1/10/2014
1/11/2014
EagleCreek
EagleCreek_wDiversion
Blanchard_US_EagleCk
Blanchard_EagleCk_Confluence
Blanchard_EagleCk_Confluence_wDiversion
HEC-RAS
9,848
7,087
6,778
3,015
100
*Blanchard Flow
Calculated in HEC-RAS @
Eagle Creek Confluence =
4,173 cfs



Blanch XS - 259358
Existing - 761.47'
Alt_13 - 761.42'
Blanch XS - 265870
Existing - 762.51'
Alt_13 - 761.95'
Blanchard River
Howard Run
Blanch XS - 298802
Existing - 778.22'
Alt_13 - 773.36'
Blanch XS - 316364
Existing - 781.10'
Alt_13 - 780.34'
DivCh XS - 5000
Existing - n/a
Alt_13 - 767.73'
Aurand XS - 8578
Existing - 763.81'
Alt_13 - 763.76'
Blanch XS - 297726
Existing - 777.51'
Alt_13 - 772.77'
Lye XS - 3709
Existing - 779.51'
Alt_13 - 778.70'
Eagle XS - 6494
Existing - 780.74'
Alt_13 - 776.77'
Lye Creek
Lye XS - 13517
Existing - 785.26'
Alt_13 - 785.26'
Blanch XS - 340044
Existing - 794.01'
Alt_13 - 794.01'
DivCh XS - 38950
Existing - n/a
Alt_13 - 799.70'
Eagle Creek
Lye XS - 23557
Existing - 795.14'
Alt_13 - 795.14'
Blanch XS - 345090
Existing - 797.18'
Alt_13 - 797.18'
Aurand Run
Aurand XS - 44674
Existing - 805.48'
Alt_13 - 805.48'
Eagle XS - 35692
Existing - 802.04'
Alt_13 - 806.08'
0
0.5
1
2
3
Miles
EAGLE CREEK DIVERSION
100-YR WSEs From HEC-RAS
Existing Condition vs. Final with Project (Alt 13)


Blanch XS - 259358
Existing - 12,883 cfs
Alt_13 - 12,590 cfs
Blanch XS - 265870
Existing - 13,222 cfs
Alt_13 - 7,404 cfs
Blanchard River
Howard Run
Blanch XS - 298802
Existing - 9,588 cfs
Alt_13 - 9,588 cfs
Blanch XS - 316364
Existing - 6,331 cfs
Alt_13 - 6,331 cfs
DivCh XS - 5000
Existing - n/a
Alt_13 - 2,916 cfs
Aurand XS - 8578
Existing - 480 cfs
Alt_13 - 480 cfs
Blanch XS - 297726
Existing - 13,355 cfs
Alt_13 - 7,513 cfs
Lye XS - 3709
Existing - 5,393 cfs
Alt_13 - 5,393 cfs
Eagle XS - 6494
Existing - 4,057 cfs
Alt_13 - 1,142 cfs
Lye Creek
Lye XS - 13517
Existing - 4,165 cfs
Alt_13 - 4,165 cfs
Blanch XS - 340044
Existing - 4,876 cfs
Alt_13 - 4,876 cfs
DivCh XS - 38950
Existing - n/a
Alt_13 - 2,916 cfs
Eagle Creek
Lye XS - 23557
Existing - 2,290 cfs
Alt_13 - 2,290 cfs
Blanch XS - 345090
Existing - 7,979 cfs
Alt_13 - 7,979 cfs
Aurand Run
Aurand XS - 44674
Existing - 480 cfs
Alt_13 - 480 cfs
Eagle XS - 35692
Existing - 4,057 cfs
Alt_13 - 4,057 cfs
0 0.5 1 2 3
Miles
EAGLE CREEK DIVERSION
100-YR Flows From HEC-RAS
Existing Condition vs. Final with Project (Alt 13)

Appendix C – DATA REVIEW AND GAP ANALYSIS – WRITTEN RESPONSE FROM USACE

DEPARTMENT OF THE ARMY
BUFFALO DISTRICT, CORPS OF ENGINEERS
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207-3199

September 14, 2016

Mr. Scott Peyton, P.E.
Stantec Consulting Services, Inc.
11687 Lebanon Road
Cincinnati, Ohio 45241

RE: Response to Questions for Clarification dated August 16, 2016
Blanchard River Watershed Study, Hancock County, Ohio.

Dear Mr. Peyton;

As requested in your letter dated August 16, 2016 regarding clarification of several issues encountered during a review of data provided by the Buffalo District of the U.S. Army Corps of Engineers for the Blanchard River Watershed Study, the following responses have been prepared to address the questions presented in the referenced letter.

BASE MAP DATA

Q1: Is documentation and metadata available for the GIS information?

A1: This depends. Some of the layers we created in-house from DEMs, CADD, and other sources as needed. If they were created from other layers (such as NWI, OWI, NHD) then the metadata is contained in the previous layers. A more specific question on actual data files would be more helpful. With regards to utility data USACE had to digitize them from pdf's received from the utility companies.

Q2: What is the source of the provided DEM - "blan_dem"?

A2: The data came from 2006 OSIP data. The metadata for this set is : "The 2006 OSIP bare-earth Digital Elevation Model (DEM) was derived from digital LiDAR data was collected during the months of March and May (leaf-off conditions)..."

Q3: What is the source of the GIS utilities data? Is it available for the area around Findlay outside of the footprint of the proposed alternative?

A3: The pipeline data was digitized from topographic maps and then verified with the pipeline companies with very specific areas. We do not have pipeline data for the entire pipeline; however, a good estimate of pipelines in the area can be found online at the National Pipeline Mapping System (https://www.npms.phmsa.dot.gov/PublicViewer/composite.jsf).

The well data was acquired through the Ohio Oil & Gas Well locator (http://oilandgas.ohiodnr.gov/well-information/oil-gas-well-locator).

Water well data was acquired from the ODNR database but can be viewed online at this website: https://gis.ohiodnr.gov/MapViewer/?config=waterwells.

The aqueduct layer was digitized from topographic maps.

The overhead lines layer was digitized from NAIP imagery and only includes overhead lines visual from imagery. Finally, Hancock Woods Electric, Benton Ridge Fiber Cable, Benton Ridge Copper Cable, CNI Fiber Optics, and Ohio Power utilities were all digitized from engineering plans provided by the different service providers.

ALTERNATIVES

Q1: Does documentation exist on the extent of analysis for other alternatives reviewed (model runs, data or other documentation)?

- What type of data/documentation exists on other scenarios such as detention/storage?

- What is the extent of the analysis performed on the diversion channel extension to the Blanchard River?

- What is the extent of the analysis performed on the alignment through Aurand Run?

A1: The Blanchard River Flood Risk Management Study was performed using a tiered process of increasing level of detail. The Feasibility Scoping Report (FSR) dated December 2011 considered the broadest array of alternatives. These analyses were supported by preliminary HEC-HMS and steady state HEC-RAS models and preliminary layouts, cost, benefit, and environmental assessments. The Feasibility Scoping Report has been provided under separate cover.

The FSR recommended continued analysis of a limited number of alternatives which are documented in the Report Synopsis - Final Array of Plans dated March 2013. This report used an unsteady HEC-RAS model to evaluate the Eagle Creek diversion channel and several other alternatives. Again this assessment was based on preliminary hydrology which was revised for the 2015 Feasibility Report. The diversion alternative analysis includes Civil 3-D layouts and excavation quantity analyses. Concept bridge designs and cost estimates are a part of the Cost Appendix support documentation. Detailed supporting documentation is available for use if a re-analysis of alternatives is to be performed.

No detailed analysis of extending the diversion channel to either Lye Creek or the Blanchard River was conducted. A qualitative assessment indicated the length of the channel would increase dramatically as a result of likely blasting of rock as a potential diversion channel extended eastward; the construction of additional diversion structures on both the Blanchard River and Lye Creek; and the additional sizing required to accommodate additional flows from Lye Creek and the Blanchard River. This qualitative analysis indicated the potential costs of an extension would exceed the potential benefit pool after implementation of the Eagle Creek Diversion channel. In addition, the concept of extending the channel to Lye Creek to the Blanchard River was considered in the Value Engineering Study but discarded as being cost prohibitive. Formal costs were not developed; however, general per foot costs were considered in the assessment.

The Aurand Run diversion alignment was included in the Report Synopsis - Final Array of Plans dated March 2013, included HEC-RAS models and preliminary layouts/quantity takeoffs in Civil -

3D. This alternative was screened from consideration primarily for environmental reasons as this alternative would not be the Least Environmentally Damaging Practicable Alternative (LEDPA). As a replacement, this alternative would include significantly more stream and wetland impacts than the selected alternative. In addition, an offset of the diversion channel along Aurand Run was also considered, but was also not selected due to several factors including the impacts to the existing stream and wetlands as a result of groundwater disruption as well as increased cost due to significantly more rock excavation.

HYDROLOGY AND HYDRAULICS

Q1: It isn't clear what happens when the discharge on Eagle Creek exceeds a 25-year event for the recommended plan. Presumably, the diversion structure would be designed to allow the excess flow (beyond the diversion channel capacity) to continue downstream along Eagle Creek, but that isn't clearly described in the reports provided. Does flow exceeding the capacity of the diversion channel continue downstream of the diversion structure into Eagle Creek?

A1: Yes. The intent of the diversion structure design is to pass any flows down Eagle Creek that exceed the diversion channel capacity.

Q2. The results of the provided HEC-FDA models are inconsistent with the reported values in Final w/ Project runs in HEC-RAS and the reported results in the H&H Report and Feasibility Study for Alternative 13. The HEC-RAS model has the "Flow Optimization" option activated for the lateral structure on Eagle Creek. This leads to correct discharges along the diversion channel, but reduces discharges along the Blanchard River. The HEC-FDA model uses a profile that has a drop in water surface elevation in downtown Findlay of approximately 2 feet, while the floodplain figures appear to show a drop of approximately 4.5 feet. In other words, is the actual reduction in water surface elevation for the Blanchard River in downtown Findlay approximately 4.5 feet or 2 feet for the 100-year event? Figures are attached for clarification.

A2: It appears the 4.5 feet drop in water surface elevation in downtown Findlay is based on a model run where the flow optimization feature did not properly converge on an internally consistent result.

Q3: Were there any statistical analyses performed to determine the likelihood of Eagle Creek being able to reduce flood impacts from the Lye Creek or Blanchard River watersheds? A multi-variate analysis considered storms of multiple durations, sizes, and center locations could help characterize this uncertainty.

A3: The precipitation scenario analyzed was one of uniform rainfall over the entire drainage basin. The Eagle Creek diversion provides flood reduction to the extent there is flow in Eagle Creek to divert and only up to the capacity of the diversion channel (equivalent to a 25-year flow on Eagle Creek minus 100 cfs). For a geographically skewed rainfall event that generated 100-year flows in the Lye Creek and the upper Blanchard, and a 25-year flow in Eagle Creek, the project could still deliver a level of control equivalent to that for a 100-year flood throughout the entire basin.

Q4: If the Eagle Creek Diversion Channel (Alt. 13) only has capacity for a 25-year event, what is the combined probability for a given event of the Blanchard River flooding downtown Findlay after the channel is constructed. In other words, what is the aggregate risk reduction or effective return period reduction in Findlay for the proposed channel?

A4: The FDA analysis we performed assessed expected damages for both existing and with-project conditions for a range of flow frequencies.

USACE policy does not evaluate alternatives in terms obtaining a level of reduction of flood risk as particular flow frequencies. USACE evaluated alternatives in terms of providing the highest benefits from flood risk less the project costs. As with any flood risk management project, there will be a level of residual risk from the without project condition. As demonstrated in Section 6.4 of the Draft Final EIS, Plan 13 provided a 66% reduction in expected annual damages from the without project condition, leaving 34% in residual risk.

Q5: Was connecting diversions between Eagle Creek, Lye Creek, and the Blanchard River considered to further reduce the risk in Findlay? What types of analyses were performed in screening this alternative?

A5: No detailed analysis of extending the diversion channel to either Lye Creek or the Blanchard River was conducted which would involve preparing hydraulic or economic models. A qualitative assessment indicated that the length of the channel would increase dramatically as a result of likely blasting of rock as a potential diversion channel extended eastward, the construction of additional diversion structures on both the Blanchard River and Lye Creek, and the additional sizing of the proposed Eagle Creek diversion channel required to accommodate additional flows from Lye Creek and the Blanchard River. This qualitative analysis indicated the potential costs of an extension would easily exceed the potential benefit pool after implementation of the Eagle Creek Diversion channel. In addition, the concept of extending the channel to Lye Creek and to the Blanchard River was considered in the Value Engineering study but discarded as cost prohibitive. Formal costs were not developed; however, general per foot costs were considered in the assessment based on the formal costs prepared for the Eagle Creek Diversion channel.

Q6. The digital data includes some gage frequency analyses using Bulletin 17B, but it is unclear how/if this was used and how it compares to the HMS model results. The H&H Report doesn't mention gage analyses.

A6: The HMS model was used to generate the flow frequencies used in the feasibility study. The Bulletin 17B analysis was performed as part of the evaluation of the potential impact of climate change on the Blanchard watershed hydrology. The climate change white paper discusses a mismatch between the Bulletin 17B and HMS flow frequencies and was proposing to update flow frequencies starting from the Bulletin 17B flow frequencies and then adjusting them to account for an observed trend in annual peak flows.

Q7. Climate change is discussed in the H&H Report, but it is unclear how that was accounted for in the model. Were the Frequency Storm based runs that add 103 to the rainfall depths intended to account for climate change? How were those results applied to the hydraulic model?

A7: Climate change was assessed in the feasibility report but was not incorporated in any of the modeling associated with the feasibility report as at this stage of the project such an incorporation would not be required. The climate change white paper proposed accounting for an observed trend in annual peak flows by adjusting the flow frequencies using a statistical technique to account for the trend. The white paper did not consider adjusting precipitation frequencies.

Q8: The Feasibility Study mentions consideration of options other than flood diversion channels (such as inline detention), but the hydrologic model does not appear to include those options. Are there model runs for these other options?

A8: Other options such as inline detention were considered earlier in the project. The files associated with any model runs performed to simulate these other options are not readily available. Model runs for these alternatives would be available by contacting AECOM who prepared the modelling. However in t reports documenting the alternative selection, , there are few alternatives where retention could be considered feasible and this is contributed to the flat terrain in the area. Where retention was found to be feasible, other alternatives were determined to be more efficient at managing flood risk.

Q9. The linkage between the hydrograph peaks predicted by the HEC-HMS model and the steady state discharges entered into the HEC-RAS model is not well documented and it cannot be determined if the discharge values in the HEC-RAS model are consistent because there's not a one-to-one match between junction nodes in the HMS model and cross sections in the RAS model.

A9: The flow change locations in RAS can be verified by overlaying the basin shapefile from HMS with the cross-section coverage from RAS.

Q10: Additional documentation on calibration and parameter sensitivity/accuracy would help clarify the H&H Report.

A10: The full extent of our documentation on calibration and parameter sensitivity for the models is included in the feasibility report. The model developer has since left the Buffalo District. His contact information could be provided if needed.

Q11. The source of the geometry for the HEC-RAS model is not fully documented. The H&H Report alludes to OGRIP LiDAR (2-foot contours) being used to supplement a previous model developed by USACE Buffalo. It is unclear if current channel and bridge surveys were incorporated. Is the geometry of the Blanchard River through Findlay (including all the structures) based on a current or recent survey?

A11: USACE Buffalo District originally built a RAS model that was later transferred to URS. The latest version of the RAS model is based on the RAS geometry developed during the original modeling effort prior to 2010 with bridge and structure geometries added to the model by AECOM in 2011.

The following text from the H&H appendix summarizes how the bridges and structures were input into the HEC-RAS models AECOM received initially from the USACE:

"Field survey measurements were also obtained to supplement the topographic information derived from the DEM of the watershed and to obtain additional information on the structures in the reaches of the HEC-RAS model. In addition, "as-built" and plan information of bridges, inline structures (such as "low-head" dams), culverts, private foot bridges, public roadway bridges, and railroad bridges were obtained from county and local municipality bridge and culverts plans, county bridge and culvert inventory records, Ohio Department of Transportation bridge and culvert plans, and National Resource Conservation Service (NRCS)bridge data."

We have numerous CD's (15-20) with bridge and geometry related data, apparently from the original model development effort, which we could provide copies of if needed.

Q12: Hydraulic results for various alternatives considered are not presented in the H&H Report, other than tables 17-22 which only consider the diversion channel and its derivatives. Are results of other alternatives documented?

A12: See A1 under Alternatives section.

Q13: Will there be a new FEMA regulatory floodplain and floodway along the diversion channel alignment (and potentially overland to Aurand Run) for the 1% ACE (100-year) flood event? Figures or exhibits that present the residual/resulting floodplain for this alternative other than Figure 39 in the H&H Report and Figure 8.5 in the Feasibility Report are not available.

A13: A feature of the diversion structure design was that it would allow all flows greater than the Eagle Creek 25-year flood minus 100 cfs, to continue down Eagle Creek. The diversion structure gates would be operated to divert flows into the diversion channel only up to the maximum capacity of the channel. Operation of the diversion channel inlet structure would need to take into account any additional lateral flows along the length of the diversion channel. The intersections of Aurand Run and the Unnamed Tributary with the diversion channel include gates on the downstream side of the diversion channel that are meant to be controlled to allow outflows equivalent to tributary inflows, resulting in no net gain or loss of flow in the tributaries or diversion channel. As such, there should be no need to define a floodplain for the diversion channel. However, FEMA requirements may require outlining a floodplain within the diversion channel footprint. However, for the intersection of two streams with the diversion channel, the water surface in the diversion channel exceeds that of the estimated 100-year water surface in the two tributaries, and thus would result in an increased backwater, thus affecting floodplain boundaries for Aurand Run and the Unnamed Tributary.

Floodplain mapping, including floodplain analysis, and subsequent submission to FEMA is typically performed during the design phase of the project. The purpose of preliminary floodplain mapping during feasibility is primarily for use in performing an economic analysis for alternative comparison.

Q14. Sections 7.3 and 8.5 of the Feasibility Report indicates an increase in discharge at the confluence of the diversion channel and the Blanchard River of approximately 250 cfs. This is referenced to the 1% ACE, and Section 7.3 indicates it will be resolved during the Planning, Engineering and Design [PED) phase. A potential mitigation strategy is not presented or discussed. Did USACE have a conceptual approach they were going to investigate?

A14: Potential resolutions considered were: 1) enhancing Ottawa's flood risk management project; or 2) legal/policy decision that impact was inconsequential enough to not require mitigation. This is a legal analysis that is performed during the PED phase once the impact is known based on the final design of the project. A final real estate plan is then prepared which analyzes the impacts of the increase in discharge and whether the impacts rise to the level of a legal taking of property rights which require mitigation or compensation.

COST/ECONOMICS

Q1: NED Benefits associated with transportation and agricultural damages were planned for the project, but not included in the analysis. Is documentation available on these draft analyses that were not included in the report?

A1: Yes documentation is available. See the following zip file: “Transportation & Agricultural Benefits.zip”

Q2: Il is unclear how USACE defined the project objective in terms of Benefit/Cost Determination related specifically to flooding. Any of these flood risk reduction objectives could apply and would/should result in different benefit calculations.

1) Any solution that results in reduced flooding and a B/C > 1.0 . This could result in considerable residual flood risk to Findlay although the net benefit is favorable.

2) Reduce WSE in downtown Findlay by X amount for a given return period.

3) The optimal project to maximize flood reduction for all areas considered.

A2: The objective from the economic perspective was to mitigate flood risk, including physical damages associated with flooding. The predominant benefit category in any flood risk management study is damages avoided to industrial/commercial/residential buildings (structure and content damage). These benefits are calculated using HEC-FDA, by comparing existing damages (without project condition), to the damages that occur given a proposed structural or non-structural alternative. Using this framework you are able to estimate project benefits, and residual damages.

The overall economic framework, including benefit estimation, was developed pursuant to ER1105-2-100 (Planning Guidance Notebook), and the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.

Q3: The final EIS states that while some of the flood risk management measures may have met the criteria for completeness, effectiveness, efficiency, and acceptability, they were subsequently screened from further evaluation because they were implemented using another source of funding.

Are measures implemented through other sources of funding needing to be incorporated into the H&H modeling to account for flood reduction and control?

A3 -1: Yes, if measures currently exist, they are part of the existing or without project condition, and should be incorporated as such into the H&H modeling.

Do the benefits of the recommended plan overlap any benefits of other measures using other sources of funding?

A3-2: No, there should be no overlap if the measures were taken into account under the existing or without project condition.

Q4: The O&M spreadsheet mentions O&M costs for sluice gate crossings and drainage, tide flex backflow replacement costs, mowing, and the Obermeyer weir structure. Are there other operations and maintenance costs that were not considered?

The following O&M activities were listed in the report, but not broken out in the costing: Removing vegetation, obstructions, and encroachments (trash, debris, unauthorized structures, excavations, or other obstructions present within the easement area); repairing erosion; repairing or replacing riprap; and repairing or replacing revetments other than riprap. Is there documentation on how O&M costs were derived for the diversion channel? The Final EIS mentions three aqueduct crossings that need to be maintained to ensure proper flow during non-flood events. Are these the sluice gate crossings?

A4: There may be other O&M costs that could be considered. However, the O&M costs provided in the final report are cursory in nature and were determined either through a percentage of construction costs or from professional opinion based on similar projects. As the O&M costs are relatively small portion of total project costs, performance of a detailed O&M cost analysis was not performed as such costs would not have a significant impact on alternative selection. The aqueduct crossings are the sluice gate crossings.

Q5: Is the ending date of November 2021 the latest schedule considered?

A5: November 2021 is the latest date considered for economic analysis reasons. Later dates would require cost escalation and interest during construction, likely resulting in a lower benefit to cost ratio.

Q6: The HEC-FDA data suggests a discount rate of 7.5% was used for the benefit analysis. Is there documentation supporting this value?

A6: A discount rate of 7.5% was not in the benefit analysis. Expected annual damages avoided (benefits) are estimated based on probability of flood occurrence. More details related to benefit estimation can be found in:

1/ HEC-FDA Flood Damage Reduction Analysis User Manual Version 1.2.4,
2/ ER1105-2-100 (Planning Guidance Notebook),
3/Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.

The Office of Management and Budget (OMB) requires projects be evaluated utilizing two discount rates. The present discount rate (3.125% for FY2016) is used to evaluate a project for

USACE Chief's Report approval and Congressional Authorization. The OMB evaluates projects using a 7.5% discount rate for inclusion in the President's Budget each year.

Q7: The HEC-FDA profile data used for benefits does not appear to match the final HEC-RAS results for Alt. 13.

A7: See H&H A9.

DESIGN/ENGINEERING

Q1: The following assumptions were made by Stantec based on the diversion channel as recommended in the Feasibility Report. The following items need to be discussed with Hancock County and/or USACE to confirm our interpretation.

- The Interstate I-75 crossing will remain on the existing grade.
- The Norfolk Southern RR crossing will remain on the existing grade.
- CR 313 (between the RR and 1-75) will remain on the existing grade.
- Utility coordination will be completed for the project.
- Roadway/bridge improvements will follow ODOT PDP; Path 3 and will be designed to meet the County and ODOT standards.
- Lengths of roadway improvements will be based on a 2.5 foot levee for the Stale Route 12 crossing and the other local roadways.
- The USACE Feasibility Report, Section 9.3 discusses and makes recommendations for each of the crossings, and breaks them down into five categories: These are Dry Crossings, Local Road Bridges, Slate Road Bridge, Interstate Highway Bridge and Railroad Bridges. It should be noted that this section of the report indicated that a bridge type studies had been completed. Is this the case?

A1: The Norfolk Southern Rail Crossing was assumed to be designed to remain at existing grade. However, it was assumed that there would be availability for changes in grade for all other road crossings, including Interstate 75 if required. Final grade requirements for new bridges including I-75, Norfolk and Southern RR Crossing, CR 313, and SR 12 will depend on the selected channel capacity, vertical alignment, and design cross section.

Utility coordination for the project included requesting utility location information via a design ticket with OUPS. The purpose of utility information at a feasibility stage is to determine the extent of the need for utility relocation, the potential for utility avoidance, and to determine preliminary costs for such relocations. Further coordination will be necessary as the final design progresses. The types of structures used in costing was based on the pertinent ODOT standards.

The approach to implementing roadway / bridge improvements should be coordinated directly with the County and/or ODOT. For the USACE project, it was assumes that bridge and roadway improvements were to be contracted separately by the non-Federal sponsor as these costs are a 100% responsibility of the non-Federal sponsor. A report providing conceptual bridge designs was prepared and is available. The preliminary bridge improvement designs used to develop the feasibility-level quantities and costs are included in the Engineering and Design Appendix. The complete report will be provided if requested

Thank you for your questions. We are able to provide additional clarifications or answering any questions you may have and look forward to making a successful transition of the project. If you have additional questions, please contact the undersigned at michael.d.pniewski@usace.army.mil or via phone at 419-726-9121.

Respectfully,

Michael D. Pniewski, P.E., P.S., PMP
Project Manager

Appendix D – REPORT OF GEOTECHNICAL EXPLORATION

Report of Geotechnical Exploration Hancock County Flood Diversion Project, Phase 1

Hancock County, Ohio

Prepared for:
Maumee Watershed Conservancy District

Prepared by:
Stantec Consulting Services Inc.
Cincinnati, Ohio

November 10, 2016

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

The Maumee Watershed Conservancy District (MWCD) is planning the construction of a flood diversion channel in Hancock County, Ohio, southwest of the city of Findlay, Ohio. The proposed channel is approximately 9.2 miles in length, starting at Eagle Creek (approximately 5.0 miles south of Findlay) and ending at the Blanchard River (approximately 4.7 miles west of Findlay). Stantec Consulting Services Inc. (Stantec) was contracted by MWCD to perform engineering and design services for the project, including the Phase 1 geotechnical exploration.

Twelve borings were advanced by TTL Associates and supervised by Stantec to provide geotechnical data at the roadway crossings of the proposed diversion channel. Terracon conducted laboratory testing of selected soil and bedrock samples at Stantec's request. The existing surface materials consisted of 0.5 to 0.8 feet of asphalt with 0.4 to 0.6 feet of granular base or 0.3 to 0.5 feet of topsoil. In general, the soils encountered below the surface materials were fine-grained, classifying as sandy silt (A-4a), silt and clay (A-6a), silty clay (A-6b and clay (A-7-6). Thin seams of granular materials classifying as gravel (A-1-a), gravel with sand (A-1-b), gravel with sand and silt (A-2-4), and coarse and find sand (A-3a) were encountered within the fine-grained deposits in several borings. In general, granular materials were more common near the top of bedrock. N_{60}-values typically ranged from 7 to 50 and generally increased with depth. Groundwater was encountered in eight of the twelve borings, with the depth to groundwater ranging from 4.8 feet to 22.5 feet. Groundwater was typically encountered when advancing through the granular soil pockets within the fine-grained glacial till. Four borings contained perched groundwater near the top of bedrock.

Soil sampling was performed until bedrock was encountered. The depth to the top of rock ranged from 8.5 feet to 30.0 feet. Bedrock coring was performed in ten of the twelve borings. The encountered bedrock was described as gray dolomite that is moderately strong to strong, very thin to medium bedded, highly fractured to slightly fractured, and slightly rough. Recovery of the rock cores ranged from 87 to 100 percent, with an average of 96 percent. Rock Quality Designation (RQD) ranged from 0 to 87 percent, with an average of 42 percent. The bedrock was more fractured near the top of bedrock, becoming less fractured with depth.

The potential for scour was evaluated for soil samples within six feet below the proposed channel bottom elevation. D_{50}-values were obtained from the particle size analysis from laboratory testing and can be used for further scour analysis, once design channel velocities are known. D_{50} is the diameter of the particle at which 50% of a sample's mass is smaller. Suggested maximum permissible mean channel velocities were determined from Table 2-5 in USACE, 1991 based on the channel material. Suggested maximum velocities range from 2.0 feet per second (fps) for sandy silt and fine sand to 10.0 fps for bedrock.

The suitability of the encountered soil for roadway embankment fill material was estimated using ODOT Geotechnical Bulletin 6 (GB 6). According to GB 6, roadway embankments are typically constructed with silts and clays (A-4a, A-4b, A-6a, A-6b, and A-7-6) in Ohio. Approximately 83

percent of soils encountered in this exploration were classified as typical embankment soils. The procedure to estimate shear strength parameters of proposed embankments outlined in GB 6 was performed with the encountered silts and clays. The following estimated shear strength parameters were calculated for the overall alignment:

- short term cohesion = 1,900 pounds per square foot (psf)
- short term friction angle = 0 degrees
- long term cohesion = 400 psf
- long term friction angle = 30 degrees

Sulfate testing was performed on two samples from borings where cul-de-sacs are planned. The sulfate contents of the tested samples ranged from 81 to 93 parts per million (ppm). According to ODOT Geotechnical Bulletin 1, chemical stabilization is not recommended in areas where sulfate contents are greater than 3,000 ppm. Additional investigation is recommended to determine the necessary subgrade treatment, prior to construction of the pavement sections at the proposed cul-de-sac locations.

Previous geotechnical reports for the proposed diversion channel (URS/Baird, 2013 and USACE, 2015) made recommendations for bedrock excavation. These recommendations included a range of excavation effort from ripping to blasting, with ripping more common near the top of bedrock. The findings in this investigation are consistent with these recommendations. The RQD values indicate the rock may be rippable to a depth of approximately 3 to 5 feet below the top of rock. High unconfined compressive strength of intact dolomite samples indicate that the bedrock would likely require blasting for excavation of less fractured zones.

An interpreted top of bedrock surface was developed using boring information from this investigation along with available data from previous exploration boring logs. A figure showing the proposed alignment and the interpreted top of bedrock surface is provided in Appendix D.

1.0 INTRODUCTION

The Maumee Watershed Conservancy District (MWCD) is planning the construction of a diversion channel in Hancock County, Ohio, southwest of the city of Findlay, Ohio. The proposed channel is approximately 9.2 miles in length, starting at Eagle Creek approximately 5.0 miles south of Findlay and ending at the Blanchard River approximately 4.7 miles west of Findlay. The proposed channel shape is trapezoidal with 4H:1V side slopes. The depth of the proposed channel is 11 to 12 feet deep (on average) with a bottom width of 25 to 52 feet (USACE, 2016).

Stantec Consulting Services Inc. (Stantec) was contracted by MWCD to perform engineering and design services for the project, including the Phase 1 geotechnical exploration. Figure 1 shows the proposed channel alignment with the borings completed by Stantec as part of this exploration. The proposed channel alignment crosses multiple roads and existing streams. Bridges, cul-de-sacs, or dry channel crossings are proposed at the road and stream crossings to accommodate the diversion channel.

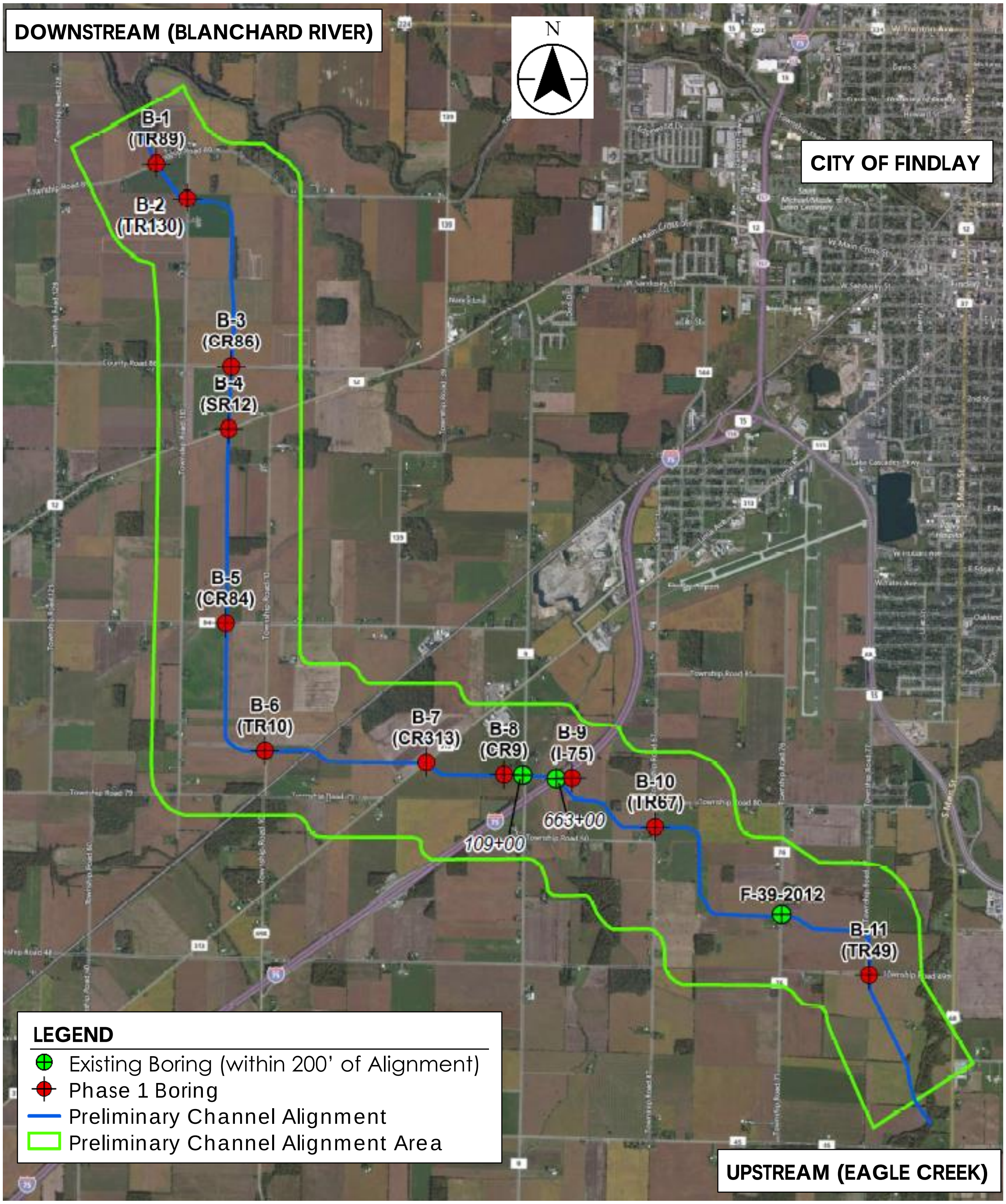


Figure 1 Site Vicinity Map

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 GENERAL

The Physiographic Regions of Ohio map (Ohio Department of Natural Resources (ODNR), 1998) indicates that approximately the downstream third of the alignment is in the Maumee Lake Plains Region, near the intersection with the Findlay Embayment. The Maumee Lake Plains Region is described as a flat-lying Ice-Age lake basin with beach ridges, bars, dunes, deltas, and clay flats. This region is dissected by modern streams and has very low relief (5 feet) with elevations of 570 to 800 feet.

Approximately two thirds of the alignment (upstream) is located in the Central Ohio Clayey Till Plain. The Central Ohio Clayey Till Plain has a surface of clayey till, and contains well-defined moraines with intervening flat-lying ground moraine and intermorainal lake basins. This region contains a few large streams and has moderate relief (100 feet) with elevations of 700 to 1,150 feet.

According to the physiographic regions map, the Columbus Escarpment crosses the alignment in the general area between where the alignment intersects SR 12 and TR 10.

2.2 SOIL GEOLOGY

According to the Quaternary Geology of Ohio map (ODNR, 1999), the site is predominately underlain by clayey till deposited during the Late Wisconsinan Age. The clayey till originates as flat to gently undulating ground moraine in the portion of the channel alignment upstream of State Route (SR) 12. Downstream of SR 12, the clayey till originates as lake-plane moraine and may contain small patches of sand, silt, or clay on the surface. The map indicates that a small portion of the channel alignment near SR 12 is underlain by beach ridges deposited along the shore of former glacial lakes during the Late Wisconsinan Age.

The soil survey (Web Soil Survey of Hancock County, Ohio, United States Department of Agriculture (USDA), 2016) indicates that the site is underlain predominantly by Blount silt loam (0 to 2 percent slopes) and Pewamo silty clay loam (0 to 1 percent slopes). These soils consist of silt loam, silty clay, and clay loam with low to moderately high capacities to transmit water.

The Drift Thickness Map of Ohio (ODNR, 2004) suggests a range of soil cover along the project site between 0 and 50 feet.

2.3 BEDROCK GEOLOGY

Bedrock mapping (Bedrock Geology of the Findlay, OH Quadrangle, ODNR, 1994 and Bedrock Geology of the Arlington, OH Quadrangle, ODNR, 1999) and Descriptions of Geologic Map Units

(ODNR, 2000) indicate that overburden soils along the channel alignment are underlain by sedimentary bedrock from the Salina Undifferentiated Formation (downstream of County Road (CR) 9) or the Tymochtee Dolomite Formation (upstream of CR 9) of the Silurian System. The Salina Undifferentiated Formation is composed of gray to brown dolomite. Bedrock is described as thin bedded, with thicknesses ranging from 235 to 335 feet. The Tymochtee Dolomite Formation is composed of olive gray to yellowish brown dolomite with shale laminae. This bedrock is described as thin to massive bedded, with thicknesses ranging from 0 to 140 feet.

According to the Abandoned Underground Mine Locator (ODNR, 2015), mapped underground mines have not been identified within the project footprint. An active surface mine (National Lime and Stone Co.) is located approximately 0.75 miles north of the middle of the channel alignment, north of the intersection of CR 9 and CR 313.

The Ohio Karst Areas map (ODNR, 2007) does not indicate known karst areas within the project footprint. Probable karst areas are located approximately 10 to 15 miles east of the upstream end of the channel alignment.

2.4 SEISMIC

A review of the seismic data available in the project vicinity included the OhioSeis database developed by the ODNR, Division of Geological Survey. The review was performed using the internet mapping service (rev. 2012) at the following website: https://gis.ohiodnr.gov/website/dgs/earthquakes/.

Overall, Ohio has a relatively limited amount of seismic activity. However, within a 20-mile radius of the proposed channel alignment, there have been six earthquake epicenters with magnitudes ranging between 2.0 to 3.0. The available data reviewed included events that occurred from 1804 to present day.

2.5 HYDROLOGY

The project is located in the Blanchard River Watershed. Eagle Creek flows south to north and flows into the Blanchard River in the eastern portion of the City of Findlay. The Blanchard River flows east to west through the City of Findlay. The proposed channel starts at Eagle Creek, approximately 5.0 miles south of Findlay, diverting flow to the Blanchard River approximately 4.7 miles west of Findlay. The proposed channel alignment crosses Aurund Run and three unnamed tributaries/ditches.

2.6 HYDROGEOLOGY

Groundwater migrates by both primary and secondary porosity at the site. The soils in the area range from silts and clays to zones with sands and gravels. Surface water seeps into the soil overburden, particularly within the coarser zones. Perched water will often concentrate in the coarser soils and along the soil-top of bedrock interface. The groundwater will then primarily migrate downward through secondary porosity features as the existing fractures, joints, and bedding planes, and to a lesser extent by primary porosity through the bedrock matrix. Groundwater follows the path of greater transmissivity downward and laterally until it intercepts the ground surface at seeps or springs, or intercepts the primary water table at varying depths within the bedrock. Regionally, groundwater generally flows in the direction of the surface drainage and intercepts channels and streams at lower elevations in the surrounding watersheds.

2.7 RECONNAISSANCE

Stantec representatives visited the site on September 14, 2016. The land usage around the project is primarily rural, with some residences nearby. The areas immediately surrounding the boring locations can be described as rural, with some residential and commercial structures in the vicinity. In general, the existing pavement appeared to be in good condition.

Some boring locations were modified due to access concerns and overhead and/or underground utility conflicts. The borings were proposed on the existing pavement or just beyond the pavement of eleven roads. The road information associated with the geotechnical borings is summarized in Table 1. The functional classes of the routes were determined from the Hancock County Functional Class Map (ODOT, 2015). Traffic counts were obtained from the most recent data (2015 or 2016) on the ODOT Traffic Data Management System.

Table 1 Road Information

Boring No.	Road Intersecting with Proposed Channel	Functional Class Route	Annual Average Daily Traffic Volume (AADT), Both Directions
B-1	Township Road 89	Local	86-201 (2016)[1]
B-2	Township Road 130	Local	71 (2015)[1]
B-3	County Road 86	Minor Collector	647 (2015)
B-4	State Route 12	Major Collector	2,560-7,073 (2016)[1]
B-5	County Road 84	Local	437 (2016)
B-6	Township Road 10	Local	208 (2015)[1]
B-7	County Road 313	Major Collector	3,163 (2016)
B-8	County Road 9	Minor Collector	803-2,521 (2016)[1]
B-9	Interstate 75	Interstate	47,305 (2015)
B-10	Township Road 67	Local	207 (2016)[1]
B-11	Township Road 49	Local	333 (2016)

[1]Traffic data was not available for the segment of the route where the boring was performed. Data shown is from the traffic count on the same route, closest to the boring.

3.0 EXPLORATION

3.1 HISTORIC EXPLORATION PROGRAMS

The ODOT Geotechnical Data Management System (GeoMS) indicates that several explorations were performed in the vicinity of the proposed channel alignment. Within 200 feet of the proposed channel alignment, geotechnical explorations were performed for the existing alignments of CR 12 (HAN-12-8.58, 1980), CR 9 (HAN-75-8.90,1959), and Interstate-75 (HAN-75-8.90, 1959). An additional exploration was performed for a proposed water line on CR 9 near the proposed channel alignment (HAN-CR 9, 2000). These explorations indicated that dolomite bedrock was relatively shallow (typically 6.5 to 12.0 feet below ground surface). Soil was generally cohesive, with classifications consisting of clay (A-7-6), silty clay (A-6b), silt and clay (A-6a), sandy silt (A-4a), coarse and fine sand (A-3a), and gravel with sand and silt (A-2-4). Groundwater was encountered in some of the borings at inconsistent depths.

A geotechnical exploration was performed in 2012 by URS/Baird to obtain subsurface information in support of a flood prevention alternatives analysis in Hancock County (URS/Baird, 2013). The possible flood prevention measures included diversion channels, levees in downtown Findlay, and a detention dam of Eagle Creek. A total of forty-eight borings were advanced for this exploration. Soils typically classified as lean clay (CL), silty clay (CL-ML), silt (ML), clayey or silty sand (SC or SM), poorly graded sand (SP), clayey or silty gravel (GC or GM) or well graded gravel (GW). Groundwater was found in forty-four borings, ranging from 4.7 to 24.5 feet below the ground surface. Bedrock was encountered between 5 to 25 feet below the ground surface. Bedrock was described as gray-dolomite, slightly weathered and medium strong to strong. RQD ranged between 33 to 95 percent. Additional information on this exploration is found in URS/Baird, 2013.

An additional three borings were performed in 2015 by DLZ, Inc. under contract with USACE. Information on these borings is found in USACE, 2015.

A search of the ODNR Ohio Oil & Gas Well Locator (2016) indicates that many wells have been drilled in the project vicinity. Approximately five active oil wells are within a 200-foot buffer of the proposed channel alignment, four of which are northeast of the intersection of Township Road (TR) 10 and CR 84. Several hundred inactive oil wells are within a 200-foot buffer of the proposed channel alignment, a majority of which are located downstream of the proposed channel intersection with CR 313. The inactive wells are typically plugged and abandoned. Most wells are located in the Trenton Play Oil Field, which contains 849 wells with an average producing depth of 1,240 feet. The well reports contain little to no information on subsurface conditions.

A search was also performed using the ODNR Ohio Water Wells Map (2016). According to the map, approximately 45 water wells have been drilled within a 200-foot buffer of the proposed channel alignment. The water wells indicate that the overburden materials are typically clay.

Bedrock was typically encountered at a depth of 15 to 25 feet, and water was typically encountered 10 to 20 feet below the top of bedrock (static water level typically 5 to 15 feet below surface).

3.2 PROJECT EXPLORATION PROGRAM

Twelve borings were advanced by TTL Associates and supervised by Stantec to obtain preliminary geotechnical data for use in the design and construction of the proposed diversion channel. A summary of the borings advanced for this project is shown in Table 2. A complete set of boring logs are provided in Appendix A.

Table 2 Boring Summary

Boring No.	Current Design Structure	Road	Northing (feet)[1]	Easting (feet)[1]	Ground Surface Elevation (feet)[2]	Top of Bedrock Elevation (feet)[2]	Bottom of Boring Elevation (feet)[2]
B-1	Cul-de-sac	TR 89	505,208.0	1,626,356.5	764.1	745.4	745.4
B-2	Bridge	TR 130	504,110.9	1,627,337.2	764.7	746.7	740.7
B-2 (Alt)	Bridge	TR 130	504,101.0	1,627,337.4	764.8	746.8	726.8
B-3	Bridge	CR 86	499,003.8	1,628,675.3	772.7	755.4	735.4
B-4	Bridge	SR 12	497,066.6	1,628,619.2	788.4	758.4	737.4
B-5	Bridge	CR 84	491,129.2	1,628,435.9	785.0	772.1	751.5
B-6	Dry Channel Crossing	TR 10	487,202.6	1,629,728.1	795.0	777.8	772.0
B-7	Bridge	CR 313	486,810.2	1,634,615.9	797.6	789.1	769.1
B-8	Bridge	CR 9	486,450.5	1,637,674.7	797.5	785.0	764.5
B-9	Bridge	I-75	486,361.5	1,638,678.8	798.0	785.0	765.0
B-10	Bridge	TR 67	484,872.6	1,641,671.0	804.5	779.5	759.5
B-11	Cul-de-sac	TR 49	480,343.5	1,648,241.2	799.7	781.7	780.9

[1]Ohio SPC North Zone 3401 Grid Coordinates
[2]NAVD 88 Datum

The borings were advanced in accordance with the Ohio Department of Transportation (ODOT) Specifications for Geotechnical Exploration (SGE). The borings were completed with a CME 75 truck-mounted drill rig using 3¼-inch inside diameter (ID) hollow stem augers to advance the borings through soil. Standard penetration test (SPT) sampling was typically performed at 2.5-foot intervals until bedrock was encountered in the borings. Continuous SPT sampling was performed in the upper six feet of the cul-de-sac borings and for a depth of 6 feet below the proposed channel bottom elevation (or until bedrock was encountered) in the borings. The energy ratio (ER) of the automatic hammer and drill rod system was measured to be 74.5 percent on December 29, 2015.

The SPT is performed by advancing a split-spoon sampler, 18 inches in length, with a 140-pound automatic hammer dropping 30 inches at select depth intervals in the boring. The number of hammer blows needed to advance the sampler each 6-inch increment is recorded. The blow count from the first 6-inch increment is discarded due to ground disturbance at the bottom of the borehole. The sum of the blow counts from the last two 6-inch increments is called the field N-value (N_{field}). The field N-value is corrected to an equivalent rod energy ratio of 60 percent (N_{60}) according to the equation below.

$$N_{60} = N_{field}\left(\frac{ER}{60}\right)$$

The depths/elevations of the SPTs with the corresponding N_{60}-values are shown on the boring logs in Appendix A.

Upon encountering bedrock, rock coring was performed in the bridge (20 feet) and dry channel crossing (5 feet) borings using NQ2-size equipment. Recovery, core loss, and rock quality designation (RQD) values were recorded as percentages for each coring run. The recovery is a measurement of the core sample obtained from a core run. The loss is the difference between the core run and the recovery length. The RQD is measured by dividing the sum of all pieces of intact rock core longer than four inches in a run by the total length of the core run. These values are shown on the boring logs contained in Appendix A.

The materials encountered were logged by a geotechnical engineer, with particular attention given to soil type, consistency, and moisture content. The borings were checked for the presence of groundwater during and after drilling with the depth of water recorded.

Borings were backfilled or sealed according the ODOT SGE. Borings were sealed with bentonite and/or backfilled with a mixture of soil cuttings and bentonite. Borings that were advanced through the existing pavement were capped with asphalt cold patch.

The soil samples obtained from the borings were returned to the laboratory for visual classification and tested for water content. Engineering classification testing was performed on samples reflecting the main soil horizons. The engineering classification tests conducted on the samples included sieve and hydrometer analysis (ASTM D 422) and Atterberg limits (ASTM D 4318). The samples were classified according to the ODOT classification method. Unconfined compression testing (ASTM D 7012) was performed on rock core samples from eight borings. One near-surface SPT sample from the cul-de-sac borings (B-1 and B-11) was subjected to sulfate content testing (ODOT Supplement 1122) to identify potentially expansive soils. The results of the laboratory testing are provided in Appendix B.

4.0 FINDINGS

4.1 GENERAL

The profile of the borings completed during this exploration is shown in Figure 2. The approximate stationing is based on the drawings of the proposed channel alignment in USACE, 2016. A complete set of boring logs is provided in Appendix A.

4.2 SOIL

The existing surface materials in borings advanced through the existing pavement consisted of 0.5 to 0.8 feet of asphalt with 0.4 to 0.6 feet of granular base. Borings drilled off the pavement (B-1, B-7, and B-9) encountered 0.3 to 0.5 feet of topsoil. In general, the soils encountered below the surface materials were fine-grained, classifying as sandy silt (A-4a), silt and clay (A-6a), and silty clay (A-6b). Clay (A-7-6) was encountered only in B-1. Thin seams of granular materials classifying as gravel (A-1-a), gravel with sand (A-1-b), gravel with sand and silt (A-2-4), and coarse and find sand (A-3a) were encountered within fine-grained soil deposits in some of the borings. In general, granular materials were more common near the top of bedrock. A 2.5- to 2.7-foot layer of gray and black gravel and sand (A-1-a, A-1-b, or A-3a) was encountered above the top of bedrock in B-5, B-6, B-10, and B-11.

N_{60}-values typically ranged from 7 to 50 and generally increased with depth. A summary of laboratory testing results on the soil samples is shown in Table 3.

Table 3 Soil Laboratory Testing Results

Boring No.	Number of Laboratory Classifications	ODOT Classifications	Moisture Content Range (percent)	Sulfate Content (ppm)
B-1	3	A-6a (2), A-7-6	11 to 28	81
B-2	2	A-6a, A-6b	14 to 22	N/A
B-3	3	A-4a, A-6a, A-6b	10 to 23	N/A
B-4	4	A-1-b, A-4a, A-6a (2)	6 to 21	N/A
B-5	4	A-3a, A-6a, A-6b (2)	17 to 24	N/A
B-6	4	A-1-a, A-6a, A-6b (2)	11 to 23	N/A
B-7	1	A-6b	4 to 23	N/A
B-8	2	A-4a, A-6a	13 to 19	N/A
B-9	1	A-6b	12 to 22	N/A
B-10	4	A-1-b, A-2-4, A-6a, A-6b	10 to 23	N/A
B-11	4	A-1-a, A-6a (2), A-6b	2 to 23	93

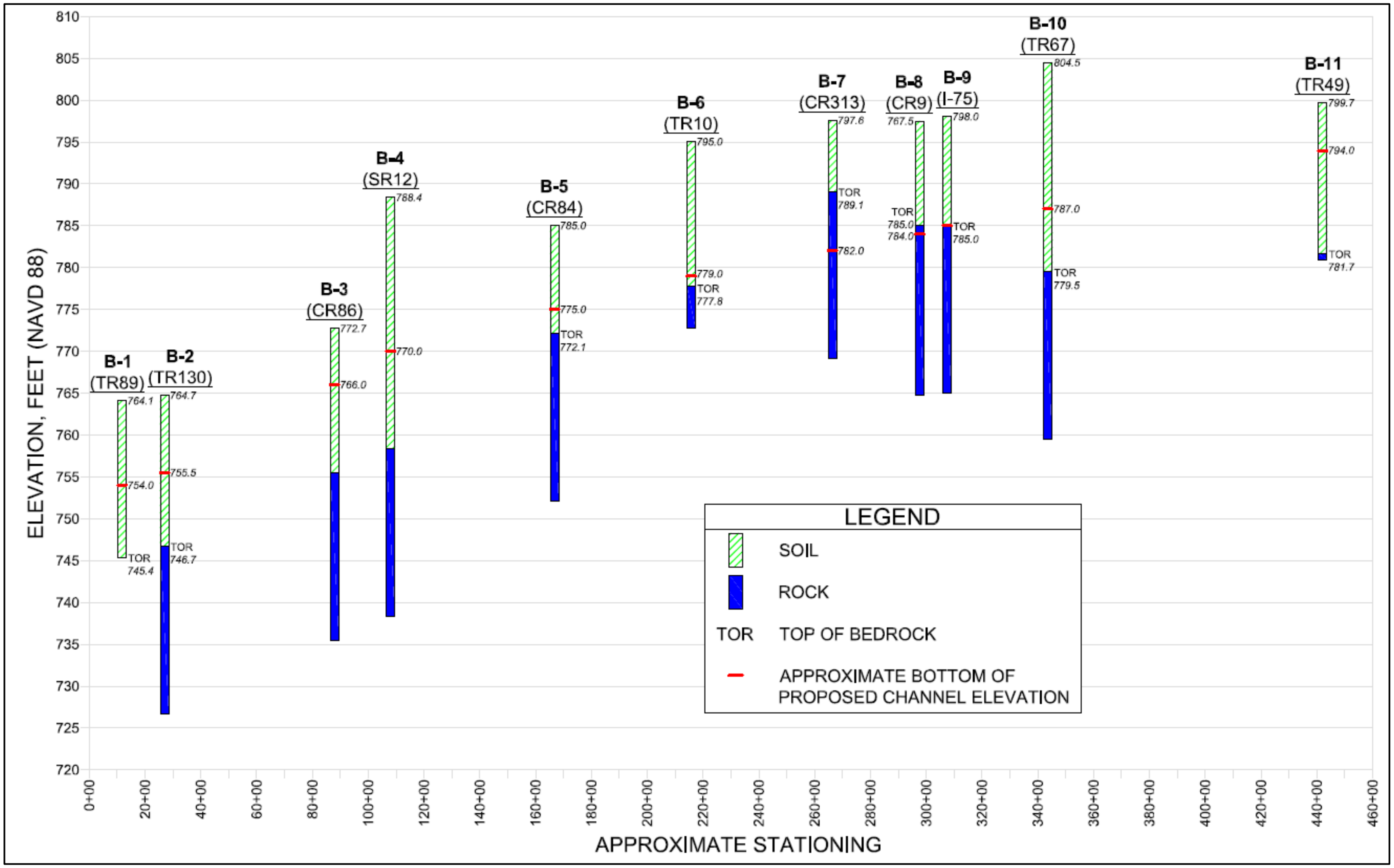


Figure 2 Phase 1 Boring Profile

Groundwater was encountered in nine borings (not encountered in B-3, B-7, or B-9). The depth to groundwater ranged from 4.8 feet (B-1) to 22.5 feet (B-10). The elevation of the groundwater ranged from 747.2 feet (B-2) to 788.5 feet (B-8) and is generally lower as the proposed channel progresses downstream. Groundwater was typically documented after granular soils were encountered. Four borings encountered perched groundwater near the top of bedrock. These findings are consistent with USACE, 2015 and Smith, 1994 which indicate that bedrock serves as the principal aquifer for Hancock County. Glacial till can serve as a source of recharge for the underlying bedrock aquifer; therefore, the depth to water can be "extremely variable" (Smith, 1994).

4.3 BEDROCK

Coring of the bedrock was performed in the bridge and dry channel crossing borings. A minimum of twenty feet of rock core was obtained for the bridge borings, and five feet of rock core was obtained for the dry channel crossing boring (B-6). The cul-de-sac borings (B-1 and B-11) were advanced to the top of bedrock and did not include rock coring. The depth to the top of rock ranged from 8.5 feet (B-7) to 30.0 feet (B-4). Top of rock elevation ranged from 745.4 feet (B-1) to 789.1 feet (B-7). The encountered bedrock was described as gray dolomite that is moderately strong to strong, very thin to medium bedded, highly fractured to slightly fractured, and slightly rough. Recovery of the rock cores ranged from 87 to 100 percent, with an average of 96 percent. Table 4 shows the top of rock elevation, the Rock Quality Designation (RQD) of the rock cores, and the results of the unconfined compressive strength (UCR) testing. Table 3

Table 4 Bedrock Findings

Boring No.	Top of Rock Elevation (feet)	Rock Quality Designation (percent)					UCR Test Sample Elevation (feet)	Unconfined Compressive Strength (psi)
		Run 1	Run 2	Run 3	Run 4	Run 5		
B-1	745.4	-	-	-	-	-	-	-
B-2	746.8	33	43	68	68	-	733.7	24,500
B-3	755.4	53	53	58	N/A[1]	-	755.4	23,200
B-4	758.4	23	38	50	60	-	748.4	13,900
B-5	772.1	17	N/A[1]	57	87	-	760.0	11,300
B-6	777.8	25	-	-	-	-	-	-
B-7	789.1	15	0	25	52	-	773.8	20,700
B-8	785.0	15	33	11	38	50	765.7	21,300
B-9	785.0	0	20	15	68	-	769.7	17,600
B-10	779.5	70	52	67	80	-	763.8	20,400
B-11	781.7	-	-	-	-	-	-	-

[1]Rock core measurements were unreliable due to sampling complications

Photographs of the rock core samples were taken immediately after drilling and are shown in Appendix C. The encountered bedrock was typically more fractured near the top of bedrock, becoming less fractured with depth. Table 4 shows that RQD generally increases with depth.

Borings B-2 and B-7 experienced water loss during rock coring. When compared to the remaining bridge borings, coring operations during advancement of B-2 and B-7 required approximately four times and two times more water, respectively.

5.0 ANALYSIS AND RECOMMENDATIONS

5.1 GENERAL

The recommendations that follow are based on the information discussed in this report and the interpretation of the subsurface conditions encountered at the site during fieldwork. If future design changes are made, Stantec should be notified so that such changes can be reviewed and the recommendations amended as necessary.

These conclusions and recommendations are based on data and subsurface conditions from the borings advanced during this exploration using the degree of care and skill ordinarily exercised under similar circumstances by competent members of the engineering profession. No warranties can be made regarding the continuity of conditions.

5.2 SOIL

5.2.1 Scour

The potential for scour was evaluated for soil samples within six feet below the proposed channel bottom. The approximate bottom elevation of the proposed channel was estimated from the drawings in USACE, 2016. Suggested maximum permissible mean channel velocities were determined from Table 2-5 in USACE, 1991. Table 5 provides the approximate proposed channel bottom elevation and suggested maximum velocity at the boring locations. The tabulated maximum velocity represents the lowest value of the encountered soils. It was assumed that the diversion channel will be grass-lined with Kentucky bluegrass where fine-grained soil is present. USACE, 1991 suggests to “keep velocities less than 5.0 fps unless good cover and proper maintenance can be obtained” for grass-lined earth channels.

Table 5 Suggested Channel Velocities

Boring No.	Approx. Bottom of Proposed Channel Elevation (ft)	Material Type	Suggested Maximum Permissible Mean Channel Velocity (fps)
B-1	754.0	A-6a	7.0
B-2	755.5	A-6a	7.0
B-3	766.0	A-6a (2.9'), A-4a (3.1')	5.0
B-4	770.0	A-6a (3.1'), A-1-b (2.9')	6.0
B-5	775.0	A-4a (0.3'), A-6a (1.1'), A-3a (1.5'), Rock (3.1')	2.0[1]
B-6	779.0	A-1-a (1.2'), Rock (4.8')	6.0
B-7	782.0	Rock	10.0
B-8	784.0	Rock	10.0
B-9	785.0	Rock	10.0
B-10	787.0	A-2-4 (5.0'), A-1-b (1.0')	6.0
B-11	794.0	A-6a	7.0

[1]Suggested maximum velocity based on 1.5-foot A-3a layer (fine sand in USACE, 1991). A higher maximum velocity would be suggested if the A-3a material were removed near the proposed channel bottom.

D_{50}-values were obtained from the particle size analysis from laboratory testing for soil samples within six feet below the proposed channel bottom elevation. D_{50} is the diameter of the particle at which 50% of a sample's mass is smaller. These values can be used for further scour analysis, once design channel velocities are known. Table 6 shows the low, high, and weighted average D_{50}-values for the evaluated borings. Appendix E shows the calculations performed to obtain weighted average D_{50}-values.

Table 6 D_{50}-values

Boring No.	D_{50} (mm)		
	Low	High	Weighted Average
B-1	<0.0040	0.0781	<0.0250
B-2	0.0071	0.0103	0.0084
B-3	<0.0040	0.0238	<0.0144
B-4	0.0065	0.5533	0.1893
B-5	0.0070	0.2240	0.1322
B-6	2.0116	2.0116	2.0116
B-7	N/A[1]		
B-8	N/A[1]		

Boring No.	D_{50} (mm)		
	Low	High	Weighted Average
B-9	N/A[1]		
B-10	1.0404	3.1978	2.8382
B-11	0.0119	0.0119	0.0119

[1]Proposed channel bottom elevation is in rock

5.2.2 Suitability for Roadway Embankments

ODOT Geotechnical Bulletin 6 (GB 6) was used as a reference to estimate the suitability of the soils encountered in this exploration as roadway embankment material. According to GB 6, silts and clays (A-4a, A-4b, A-6a, A-6b, and A-7-6) are typically used in the construction of roadway embankments. Approximately 83 percent of the soil encountered during this exploration classify as silts and clays as listed above. Granular materials are also considered acceptable embankment materials, but are not as commonly used. Table 7 shows the estimated shear strengths of the fine-grained soils encountered based on the recommended values and methodology outlined in GB 6. Encountered fine-grained soils classifying as A-4a, A-4b, A-6a, A-6b, and A-7-6 were considered in the calculations. Calculations are shown in Appendix E.

Table 7 Estimated Shear Strengths Based on GB 6

Boring No.	Classifications (ODOT)	Short Term Cohesion, C (psf)	Short Term Friction Angle, Φ (psf)	Long Term Cohesion, C' (psf)	Long Term Friction Angle, Φ' (psf)
B-1	A-1-b (V), A-6a, A-7-6	1900	0	400	31
B-2	A-6a, A-6b	1900	0	400	30
B-3	A-4a, A-6a, A-6b	1900	0	450	31
B-4	A-1-b, A-4a, A-6a	2000	0	450	32
B-5	A-3a, A-6a, A-6b	1800	0	450	30
B-6	A-1-a, A-6a, A-6b	1800	0	400	30
B-7	A-1-a (V), A-6b	1700	0	400	28
B-8	A-4a, A-6a	2000	0	450	31
B-9	A-6b	1700	0	400	29
B-10	A-1-b, A-2-4, A-6a, A-6b	1900	0	400	30
B-11	A-1-a, A-6a, A-6b	1950	0	400	31
Weighted Average from Evaluated Borings:		**1900**	**0**	**400**	**30**

5.2.3 Subgrade Treatment

According to ODOT Geotechnical Bulletin 1 (GB 1), chemical stabilization is not recommended in areas where sulfate contents are greater than 3,000 ppm. This condition was not observed in either the SPT sample from B-1 (81 ppm) or from B-11 (93 ppm) that were tested for sulfate content. Additional investigation is recommended to determine the necessary subgrade treatment, prior to construction of the pavement sections at the proposed cul-de-sac locations.

5.3 BEDROCK

5.3.1 Excavatability

The descriptions of the bedrock encountered in this investigation were similar to those in the Blanchard River Watershed Study (URS/Baird, 2013). According to URS/Baird, 2013, local quarry operators are generally able to remove the upper 4 to 5 feet of bedrock with minimal to no blasting. Blasting is considered the most efficient and cost-effective method for bedrock below 5 feet in depth. The bedrock encountered in this exploration complements this description, as lower RQD values and more fracturing were noted near the top of bedrock.

URS/Baird, 2013 provides the following recommendations for excavation of the bedrock:

> "Based on local quarry experience, available rock core data, and existing rock excavatability charts (Tsiambaos and Saroglou, 2010), we conclude that dolomite excavation will require techniques ranging from hard to very hard ripping (e.g., CAT D8-D9) to extremely hard ripping (e.g., CAT D11 or CAT D9+hydraulic breaking) to blasting depending upon the dolomite strength, joint/fracture frequency, and joint/fracture surface roughness and weathering. Dolomite that is moderately strong with closely spaced fractures that are moderately weathered typically will require hard ripping, whereas dolomite that is strong to very strong with widely spaced fractures that are slightly weathered or fresh will require blasting."

Additionally, USACE, 2015 provides further recommendations:

> "Between stations 207+00 and 233+00 and between station 277+00 and 317+00, the depth of bedrock excavation is estimated to be less than 4 feet. For cost estimating purposes it should be assumed that half of the excavated rock volume from these reaches will require ripping and half will require blasting. Between stations 233+00 and 277+00, the depth of bedrock excavation is estimated to be between 4 and 6.5 feet. For the rock volume above a depth of 4 feet below the bedrock surface, it should be assumed that half of the excavated rock volume will require ripping and half will require blasting. Below a depth of 4 feet below the bedrock surface, it should be assumed that blasting will be required to excavate the entire volume."

The findings in this investigation are consistent with these recommendations. The RQD values indicate the rock may be rippable to a depth of approximately 3 to 5 feet below the top of rock. High unconfined compressive strength of intact dolomite samples indicate that the bedrock would require blasting for deeper excavation needs.

5.3.2 Interpreted Top of Bedrock Surface

An interpreted top of bedrock surface was developed using boring information from this investigation along with available data from previous exploration boring logs. This top or bedrock surface should be used to inform the design of the proposed channel in order to minimize rock excavation requirements. A figure showing the proposed alignment and the interpreted top of bedrock surface is provided in Appendix D.

6.0 REFERENCES

Smith, K. C., 1994. Groundwater Pollution Potential of Hancock County, Ohio." Ground Water Pollution Report No. 14. September, 1994.

Tsiambaos, G. and Saroglou, H., 2010. "Excavatability Assessment of Rock Masses Using the Geological Strength Index (GSI)." Bulletin of Engineering Geology and the Environment, Vol. 69, pp. 13-27. June 30, 2009.

URS/Baird, 2013. "Blanchard River Watershed Study, Geotechnical Report." March 2013.

U.S. Army Corps of Engineers (USACE), 2016. "Blanchard River Watershed Study – Draft Interim Feasibility Study. Appendix E, Engineering and Design." January 2016.

U.S. Army Corps of Engineers (USACE), 2015. "Blanchard River Flood Risk Management Feasibility Study – Draft Geotechnical Engineering Appendix." August 31, 2015.

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APPENDIX A
BORING LOGS

PROJECT: HANCOCK CO DIVERSION	DRILLING FIRM / OPERATOR: TTL / N. WIKTOR	DRILL RIG: CME 75 TRUCK	STATION / OFFSET: 11+74, 76' LT.
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA	HAMMER: CME AUTOMATIC	ALIGNMENT: PROP. CHANNEL (TR 89)
PID: N/A SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 12/29/15	ELEVATION: 764.1 (MSL) EOB: 18.7 ft.
START: 10/3/16 END: 10/3/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 74.5	COORD: 505208.0 N, 1626356.5 E

EXPLORATION ID: B-1

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 764.1
TOPSOIL	763.8
LOOSE, BROWN, **GRAVEL WITH SAND**, SOME CLAY, DAMP	762.6
STIFF TO VERY STIFF, BROWN AND GRAY, **CLAY**, TRACE GRAVEL, TRACE SAND, TRACE SILT, MOIST	759.6
VERY STIFF, BROWN, **SILT AND CLAY**, TRACE GRAVEL, "AND" SAND, 2" - 4" SAND SEAMS, WET	758.5
HARD, GRAY, **SILT AND CLAY**, TRACE GRAVEL, LITTLE SAND, DAMP TO MOIST SS-8: LOWER GRAVEL AND SAND CONTENTS, HIGHER CLAY CONTENT 1" SAND SEAM AT 14.3' SS-9: HIGHER GRAVEL AND SAND CONTENT, LOWER CLAY CONTENT SS-10: LESS GRAVEL AND SAND	745.4
AUGER REFUSAL AT 18.7'	EOB

W (water) at approx. 5 ft depth.

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
3-3-5	10	33	SS-1	-	-	-	-	-	-	-	-	-	12	A-1-b (V)	
3-5-8	16	67	SS-2	3.00	5	5	3	9	78	56	24	32	28	A-7-6 (19)	
3-5-7	15	50	SS-3	3.25	5	5	3	9	78	56	24	32	24	A-7-6 (19)	
7-9-9	22	100	SS-4A	-	4	9	26	31	30	27	15	12	26	A-6a (6)	
			SS-4B	4.00	-	-	-	-	-	-	-	-	14	A-6a (V)	
16-17-20	46	61	SS-5	4.50	-	-	-	-	-	-	-	-	13	A-6a (V)	
12-15-23	47	100	SS-6	4.50	7	6	11	35	41	26	14	12	12	A-6a (9)	
15-30-35	81	50	SS-7	4.50	5	7	13	34	41	-	-	-	13	A-6a (V)	
11-15-23	47	100	SS-8	4.50	0	0	1	29	70	-	-	-	20	A-6a (V)	
15-20-22	52	100	SS-9	4.50	17	16	17	29	21	-	-	-	12	A-6a (V)	
50/5"	-	100	SS-10	4.50	-	-	-	-	-	-	-	-	11	A-6a (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HANCOCK CO DIVERSION	DRILLING FIRM / OPERATOR: TTL / N. WIKTOR	DRILL RIG: CME 75 TRUCK	STATION / OFFSET: 26+96, 72' RT.
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA	HAMMER: CME AUTOMATIC	ALIGNMENT: PROP. CHANNEL (TR 130)
PID: N/A SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 12/29/15	ELEVATION: 764.7 (MSL) EOB: 24.0 ft.
START: 10/3/16 END: 10/3/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 74.5	COORD: 504110.9 N, 1627337.2 E

EXPLORATION ID B-2

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 764.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
								GRADATION (%)					ATTERBERG					
ASPHALT PAVEMENT	764.5																	
STIFF, BROWN, **SILTY CLAY**, TRACE GRAVEL, LITTLE SAND, MOIST		3	3 3 4	9	0	SS-1	-	-	-	-	-	-	-	-	-	-	A-6b (V)	
		5–6	2 4 6	12	94	SS-2	3.50	1	4	14	30	51	40	20	20	22	A-6b (12)	
VERY STIFF TO HARD, BROWN, **SILT AND CLAY**, TRACE GRAVEL, LITTLE SAND, DAMP TO MOIST	757.7	7–8	7 15 24	48	100	SS-3	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
		10–11	8 11 22	41	100	SS-4	4.50	3	6	12	36	43	31	16	15	15	A-6a (10)	
		12	18 21 25	57	100	SS-5	4.50	4	6	11	34	45	-	-	-	14	A-6a (V)	
1" SAND SEAM AT 13.2'		13–14	4 9 11	25	100	SS-6	4.50	4	4	8	51	33	-	-	-	16	A-6a (V)	
2" SAND SEAM AT 14.5'		15	46 50/4"	-	40	SS-7	4.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
SS-8: STRONG OIL SMELL	746.7	W TR 18	50/2"	-	0	SS-8	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, THIN BEDDED, FRACTURED TO MODERATELY FRACTURED, SLIGHTLY ROUGH.		18–23	62		90	NQ2-1											CORE	
SIGNIFICANT LOSS OF WATER/BLOCKAGES. MOVE TO B-2 (ALT).	740.7	23–24 EOB	0		75	NQ2-2											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/17/17 08:17 - \\US1268-F01\SHARED_PROJECTS\1743\174316204\GEOTECHNICAL\FIELD_DATA\BORING LOGS\174316204_BOF

PROJECT: HANCOCK CO DIVERSION TYPE: STRUCTURE FOUNDATION PID: N/A SFN: N/A START: 10/4/16 END: 10/4/16	DRILLING FIRM / OPERATOR: TTL / N. WIKTOR SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT	DRILL RIG: CME 75 TRUCK HAMMER: CME AUTOMATIC CALIBRATION DATE: 12/29/15 ENERGY RATIO (%): 74.5	STATION / OFFSET: 26+96, 82' RT. ALIGNMENT: PROP. CHANNEL (TR 130) ELEVATION: 764.8 (MSL) EOB: 38.0 ft. COORD: 504101.0 N, 1627337.4 E

EXPLORATION ID B-2 (ALT)

MATERIAL DESCRIPTION AND NOTES	ELEV. 764.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT PAVEMENT	764.6																	
AUGERED TO TOP OF ROCK. AUGER REFUSAL AT 18.0'	746.8	TR 18																
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, THIN BEDDED, FRACTURED TO MODERATELY FRACTURED, SLIGHTLY ROUGH.			33		93	NQ2-1											CORE	
SLIGHTLY LESS FRACTURED IN NQ2-2			43		93	NQ2-2											CORE	

PID: N/A	SFN: N/A	PROJECT: HANCOCK CO DIVERSION	STATION / OFFSET: 26+96, 82' RT.	START: 10/4/16	END: 10/4/16	PG 2 OF 2	B-2 (ALT)

MATERIAL DESCRIPTION AND NOTES	ELEV. 734.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, THIN BEDDED, FRACTURED TO MODERATELY FRACTURED, SLIGHTLY ROUGH. *(continued)* LESS FRACTURED IN NQ2-3 AND NQ2-4		31, 32, 33	68		97	NQ2-3											CORE	
	726.8	34, 35, 36, 37, 38 EOB	68		95	NQ2-4											CORE	

NOTES: LOSS OF WATER DURING ROCK CORING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HANCOCK CO DIVERSION	DRILLING FIRM / OPERATOR: TTL / N. WIKTOR	DRILL RIG: CME 75 TRUCK	STATION / OFFSET: 87+81, 191' LT.
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA	HAMMER: CME AUTOMATIC	ALIGNMENT: PROP. CHANNEL (CR 86)
PID: N/A SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 12/29/15	ELEVATION: 772.7 (MSL) EOB: 37.3 ft.
START: 10/5/16 END: 10/5/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 74.5	COORD: 499003.8 N, 1628675.3 E

EXPLORATION ID B-3

PAGE 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 772.7	DEPTHS	SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT PAVEMENT	772.0																	
STIFF, GRAY TO BROWN AND GRAY, **SILTY CLAY**, LITTLE SAND, MOIST		3	5 4 7	14	72	SS-1	3.50	0	6	14	28	52	37	16	21	21	A-6b (12)	
	765.7	5	3 4 6	12	67	SS-2	4.00	0	6	14	28	52	37	16	21	19	A-6b (12)	
VERY STIFF, BROWN, **SILT AND CLAY**, TRACE GRAVEL, LITTLE SAND, MOIST	763.1	8	3 6 8	17	89	SS-3	4.50	4	3	7	24	62	28	17	11	21	A-6a (8)	
		9	6 12 14	32	100	SS-4A	4.50	4	3	7	24	62	28	17	11	23	A-6a (8)	
HARD, GRAY, **SANDY SILT**, TRACE TO LITTLE GRAVEL, SOME CLAY, DAMP						SS-4B	4.50	8	9	19	35	29	-	-	-	11	A-4a (V)	
		11	12 18 23	51	100	SS-5	4.50	12	9	17	31	31	23	13	10	10	A-4a (5)	
		12	7 12 18	37	83	SS-6	4.50	10	8	14	34	34	-	-	-	11	A-4a (V)	
SS-7: SOME THIN SAND SEAMS	755.4	15	5 8 20	35	100	SS-7	4.50	-	-	-	-	-	-	-	-	13	A-4a (V)	
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, THIN BEDDED, FRACTURED TO MODERATELY FRACTURED, SLIGHTLY ROUGH.		TR 17.3	53		100	NQ2-1											CORE	
		22	53		98	NQ2-2											CORE	
		27	58		100	NQ2-3											CORE	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/17/17 08:17 - \\US1268-F01\SHARED_PROJECTS\174316204\GEOTECHNICAL\FIELD_DATA\BORING LOGS\174316204_BOF

PID: N/A	SFN: N/A	PROJECT: HANCOCK CO DIVERSION	STATION / OFFSET: 87+81, 191' LT.	START: 10/5/16	END: 10/5/16	PG 2 OF 2	B-3

MATERIAL DESCRIPTION AND NOTES	ELEV. 742.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, THIN BEDDED, FRACTURED TO MODERATELY FRACTURED, SLIGHTLY ROUGH. *(continued)*		31, 32																
NQ2-4: ROCK CORE WAS IN OUTER BARREL. WHEN REMOVING CORE FROM BARREL, IT FELL AND WAS SCATTERED. RQD MAY BE LOW AND ROCK MAY NOT BE BOXED IN CORRECT ORDER.	735.4	33, 34, 35, 36, 37 EOB	48		98	NQ2-4											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HANCOCK CO DIVERSION	DRILLING FIRM / OPERATOR: TTL / N. WIKTOR	DRILL RIG: CME 75 TRUCK	STATION / OFFSET: 107+27, 197' LT.
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA	HAMMER: CME AUTOMATIC	ALIGNMENT: PROP. CHANNEL (SR 12)
PID: N/A SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 12/29/15	ELEVATION: 788.4 (MSL) EOB: 51.0 ft.
START: 10/5/16 END: 10/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 74.5	COORD: 497066.6 N, 1628619.2 E

EXPLORATION ID B-4

MATERIAL DESCRIPTION AND NOTES	ELEV. 788.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
ASPHALT PAVEMENT	787.7																
GRANULAR BASE	787.0	1															
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, SOME SILT, SOME CLAY, DAMP		2–3	6 8 8	20	28	SS-1	-	-	-	-	-	-	-	-	-	6	A-1-b (V)
	783.9	4															
STIFF, BROWN, **SILT AND CLAY**, TRACE GRAVEL, SOME SAND, DAMP TO MOIST		5–6	4 4 5	11	56	SS-2	3.50	4	8	25	28	35	28	15	13	21	A-6a (7)
SS-3: SOME VERY THIN SAND SEAMS		7–8	4 5 5	12	89	SS-3	3.75	4	8	25	28	35	28	15	13	12	A-6a (7)
	778.9	9															
STIFF TO HARD, BROWN TO GRAY, **SILT AND CLAY**, TRACE GRAVEL, TRACE TO LITTLE SAND, DAMP TO MOIST GRAY AT 11.0'		10–11	6 8 14	27	94	SS-4	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)
		12–13	6 10 15	31	94	SS-5	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)
		14–16	7 18 18	45	94	SS-6	4.50	-	-	-	-	-	-	-	-	12	A-6a (V)
		17–18 (W)	7 12 14	32	89	SS-7	4.50	5	6	12	35	42	-	-	-	13	A-6a (V)
WET SAND SEAM FROM 19.2' - 19.4'		19–20	4 11 18	36	94	SS-8	4.50	2	3	6	45	44	27	14	13	16	A-6a (9)
	766.9	21	15 20 26	57	100	SS-9A	4.50	2	3	6	45	44	27	14	13	18	A-6a (9)
DENSE, GRAY AND BLACK, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, MOIST TO WET		22				SS-9B	-	23	36	32	6	3	NP	NP	NP	21	A-1-b (0)
SILT AND CLAY SEAMS FROM 23.0' - 23.5'		22–23	3 10 12	27	78	SS-10	4.50	23	36	32	6	3	NP	NP	NP	16	A-1-b (0)
	763.9	24															
HARD, GRAY, **SANDY SILT**, LITTLE GRAVEL, LITTLE CLAY, MOIST		25–26	6 12 22	42	78	SS-11	4.50	12	11	23	37	17	15	12	3	13	A-4a (4)
SS-12: THIN SAND SEAMS		27–28	12 16 29	56	100	SS-12	4.50	12	11	23	37	17	15	12	3	12	A-4a (4)
	758.4	29															

GRADATION (%): GR, CS, FS, SI, CL; ATTERBERG: LL, PL, PI; HOLE SEALED

PID: N/A	SFN: N/A	PROJECT: HANCOCK CO DIVERSION	STATION / OFFSET: 107+27, 197' LT.	START: 10/5/16	END: 10/6/16	PG 2 OF 2	B-4

MATERIAL DESCRIPTION AND NOTES	ELEV. 758.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, VERY THIN TO THIN BEDDED, FRACTURED TO MODERATELY FRACTURED, SLIGHTLY ROUGH.		TR	50/1"	-	0	SS-13	-	-	-	-	-	-	-	-	-	-	Rock (V)	
NQ2-1 HAD SOME FRACTURED POROUS OPENINGS IN VARIOUS SPOTS 31.7' - 32.1' AND 35.5' - 35.7'		31–36	23		90	NQ2-1											CORE	
VERY THIN BEDDED FROM 36.7' - 38.3'		36–41	38		100	NQ2-2											CORE	
LESS FRACTURED IN NQ2-3		41–46	50		98	NQ2-3											CORE	
ROUGH/OPENINGS ON ROCK 49.1' - 49.7'	737.4	46–51 EOB	60		98	NQ2-4											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HANCOCK CO DIVERSION TYPE: STRUCTURE FOUNDATION PID: N/A SFN: N/A START: 10/6/16 END: 10/6/16	DRILLING FIRM / OPERATOR: TTL / N. WIKTOR SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT	DRILL RIG: CME 75 TRUCK HAMMER: CME AUTOMATIC CALIBRATION DATE: 12/29/15 ENERGY RATIO (%): 74.5	STATION / OFFSET: 166+73, 74' LT. ALIGNMENT: PROP. CHANNEL (CR 84) ELEVATION: 785.0 (MSL) EOB: 33.5 ft. COORD: 491129.2 N, 1628435.9 E

EXPLORATION ID B-5

PAGE 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 785.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT PAVEMENT	784.6																	
GRANULAR BASE	784.1																	
STIFF, BROWN, **SILTY CLAY**, TRACE GRAVEL, SOME SAND, MOIST 2" SAND SEAM AT 3.5'		3	3 4 6	12	94	SS-1	3.00	1	5	23	30	41	34	15	19	21	A-6b (11)	
1" SAND SEAM AT 5.7'	778.0	5	2 4 8	15	67	SS-2	3.50	1	5	23	30	41	34	15	19	19	A-6b (11)	
VERY STIFF, BROWN TO GRAY, **SILTY CLAY**, MOIST	776.5	W	3 5 10	19	100	SS-3A	4.50	0	0	0	28	72	40	22	18	23	A-6b (11)	
SOFT TO MEDIUM STIFF, GRAY, **SANDY SILT**, MOIST	774.7					SS-3B	1.50	-	-	-	-	-	-	-	-	24	A-4a (V)	
VERY STIFF, GRAY, **SILT AND CLAY**, TRACE GRAVEL, LITTLE SAND, MOIST	773.6	10	3 6 12	22	100	SS-4	4.50	3	4	12	36	45	26	13	13	17	A-6a (9)	
DENSE, GRAY TO BLACK, **COARSE AND FINE SAND**, SOME GRAVEL, LITTLE SILT, TRACE CLAY, MOIST	772.1	12	13 13 50/5"	-	100	SS-5	-	21	16	43	14	6	NP	NP	NP	17	A-3a (0)	
DOLOMITE, GRAY, MODERATELY WEATHERED, STRONG, VERY THIN TO THIN BEDDED, HIGHLY FRACTURED TO FRACTURED, SLIGHTLY ROUGH.		TR 13	17		87	NQ2-1											CORE	
LESS WEATHERED IN NQ2-2, CORE FROM NQ2-2 WAS DROPPED WHEN REMOVED. THEREFORE, RQD WAS NOT TAKEN, AND CORE MAY NOT BE IN CORRECT ORDER		21	0		100	NQ2-2											CORE	
VERY POROUS FROM 24.7'-24.9' NQ2-3: SOME CRYSTALS IN ROCK. BROKE APART VERY EASILY AS IT WAS REMOVED FROM CORE BARREL. SMALL HOLES/VOIDS/PORES THROUGHOUT		26	57		100	NQ2-3											CORE	

MATERIAL DESCRIPTION AND NOTES	ELEV. 755.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DOLOMITE, GRAY, MODERATELY WEATHERED, STRONG, VERY THIN TO THIN BEDDED, HIGHLY FRACTURED TO FRACTURED, SLIGHTLY ROUGH. *(continued)*	751.5	31 32 33 EOB	87		98	NQ2-4											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/17/17 08:17 - \\US1268-F01\SHARED_PROJECTS\1743\174316204\GEOTECHNICAL\FIELD_DATA\BORING LOGS\174316204_BOF

PROJECT: HANCOCK CO DIVERSION
TYPE: STRUCTURE FOUNDATION
PID: N/A SFN: N/A
START: 10/7/16 END: 10/7/16

DRILLING FIRM / OPERATOR: TTL / N. WIKTOR
SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT

DRILL RIG: CME 75 TRUCK
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 12/29/15
ENERGY RATIO (%): 74.5

STATION / OFFSET: 215+68, 178' RT.
ALIGNMENT: PROP. CHANNEL (TR 10)
ELEVATION: 795.0 (MSL) EOB: 23.0 ft.
COORD: 487202.6 N, 1629728.1 E

EXPLORATION ID B-6

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 795.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT PAVEMENT	794.5																	
GRANULAR BASE	793.8																	
MEDIUM STIFF TO STIFF, BROWN, **SILTY CLAY**, TRACE GRAVEL, LITTLE SAND, MOIST		1–2	3 3 3	7	28	SS-1	2.75	-	-	-	-	-	-	-	-	23	A-6b (V)	
		4–5	3 3 4	9	56	SS-2	2.25	3	4	13	32	48	39	18	21	22	A-6b (12)	
	786.3	6–7	3 3 5	10	94	SS-3	3.25	3	4	13	32	48	39	18	21	18	A-6b (12)	
VERY STIFF, BROWN AND GRAY TO GRAY, **SILT AND CLAY**, TRACE GRAVEL, LITTLE SAND, DAMP		9–10	6 8 10	22	89	SS-4	4.50	6	6	12	31	45	27	14	13	11	A-6a (9)	
	782.0	11–12	6 8 12	25	0	SS-5	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
STIFF, GRAY, **SILTY CLAY**, TRACE GRAVEL, LITTLE SAND, MOIST	779.5	14–15	4 4 6	12	100	SS-6	2.25	5	5	7	24	59	39	19	20	23	A-6b (12)	
DENSE, GRAY AND BLACK, **GRAVEL AND STONE FRAGMENTS**, "AND" SAND, TRACE SILT, TRACE CLAY, MOIST	777.8	W; TR; 16–17	15 35 50/2"	-	86	SS-7	-	50	30	9	7	4	13	11	2	12	A-1-a (0)	
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, LAMINATED TO THIN BEDDED, HIGHLY FRACTURED TO FRACTURED, SLIGHTLY ROUGH.	772.0	18–23; EOB	25		90	NQ2-1											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HANCOCK CO DIVERSION TYPE: STRUCTURE FOUNDATION PID: N/A SFN: N/A START: 10/11/16 END: 10/11/16	DRILLING FIRM / OPERATOR: TTL / N. WIKTOR SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT	DRILL RIG: CME 75 TRUCK HAMMER: CME AUTOMATIC CALIBRATION DATE: 12/29/15 ENERGY RATIO (%): 74.5	STATION / OFFSET: 266+44, 45' RT. ALIGNMENT: PROP. CHANNEL (CR 313) ELEVATION: 797.6 (MSL) EOB: 28.5 ft. COORD: 486810.2 N, 1634615.9 E

EXPLORATION ID B-7 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 797.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
STIFF TO VERY STIFF, BROWN AND GRAY, **SILTY CLAY**, TRACE GRAVEL, SOME SAND, MOIST		1–2	5 4 5	11	56	SS-1	3.50	9	10	14	25	42	38	17	21	23	A-6b (11)	
		4–5	3 6 8	17	89	SS-2	3.50	9	10	14	25	42	38	17	21	21	A-6b (11)	
	791.1	6	48 50/3"	-	78	SS-3A	3.25	-	-	-	-	-	-	-	-	22	A-6b (V)	
DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS**, "AND" SAND, TRACE SILT, TRACE CLAY, DAMP		7				SS-3B	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	
DOLOMITE, LIGHT GRAY, SLIGHTLY TO MODERATELY WEATHERED, MODERATELY STRONG TO STRONG, VERY THIN TO THIN BEDDED, FRACTURED, SLIGHTLY ROUGH.	789.1	TR 8.5–13.5	15		77	NQ2-1											CORE	
VERY FRACTURED FROM 13.5' - 17.0' DARKER GRAY STARTING AT 16.0' LESS FRACTURED FROM 17.0' - 18.5'		13.5–18.5	0		100	NQ2-2											CORE	
MORE INTACT 22.0' - 23.5'		18.5–23.5	25		93	NQ2-3											CORE	
LESS FRACTURED IN NQ2-4	769.1	23.5–28.5 EOB	52		93	NQ2-4											CORE	

NOTES: LOSS OF WATER DURING ROCK CORING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HANCOCK CO DIVERSION
TYPE: STRUCTURE FOUNDATION
PID: N/A SFN: N/A
START: 10/10/16 END: 10/11/16

DRILLING FIRM / OPERATOR: TTL / N. WIKTOR
SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT

DRILL RIG: CME 75 TRUCK
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 12/29/15
ENERGY RATIO (%): 74.5

STATION / OFFSET: 297+56, 107' RT.
ALIGNMENT: PROP. CHANNEL (CR 9)
ELEVATION: 797.5 (MSL) EOB: 33.0 ft.
COORD: 486450.5 N, 1637674.7 E

EXPLORATION ID B-8

MATERIAL DESCRIPTION AND NOTES	ELEV. 797.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT PAVEMENT	796.8																	
GRANULAR BASE	796.4																	
STIFF TO HARD, BROWN AND GRAY, **SILT AND CLAY**, LITTLE GRAVEL, SOME SAND, (FILL), DAMP TO MOIST		1–2	3 5 6	14	78	SS-1	3.25	11	12	14	26	37	28	14	14	19	A-6a (7)	
		4–5	40 13 12	31	28	SS-2	3.50	11	12	14	26	37	28	14	14	16	A-6a (7)	
		6–7	15 15 13	35	0	SS-3	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
	787.0	W 9	5 8 11	24	28	SS-4	-	-	-	-	-	-	-	-	-	13	A-6a (V)	
STIFF, GRAY, **SANDY SILT**, TRACE GRAVEL, SOME CLAY, MOIST	785.0	11–12	7 50/4"	-	100	SS-5	4.25	8	8	16	35	33	22	13	9	13	A-4a (7)	
DOLOMITE, GRAY, MODERATELY WEATHERED, MODERATELY STRONG TO STRONG, VERY THIN TO THIN BEDDED, HIGHLY FRACTURED TO FRACTURED, SLIGHTLY ROUGH.		TR 13–18	15		90	NQ2-1											CORE	
SLIGHTLY LESS FRACTURED IN NQ2-2		18–23	33		100	NQ2-2											CORE	
		23–26	11		100	NQ2-3											CORE	
LESS FRACTURED IN NQ2-4		26–29	38		95	NQ2-4											CORE	

PID: N/A	SFN: N/A	PROJECT: HANCOCK CO DIVERSION	STATION / OFFSET: 297+56, 107' RT.	START: 10/10/16	END: 10/11/16	PG 2 OF 2	B-8

MATERIAL DESCRIPTION AND NOTES	ELEV. 767.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DOLOMITE, GRAY, MODERATELY WEATHERED, MODERATELY STRONG TO STRONG, VERY THIN TO THIN BEDDED, HIGHLY FRACTURED TO FRACTURED, SLIGHTLY ROUGH. *(continued)*		31																
		32	50		92	NQ2-5											CORE	
1" QUARTZ AT 32.5'	764.5	EOB 33																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HANCOCK CO DIVERSION TYPE: STRUCTURE FOUNDATION PID: N/A SFN: N/A START: 10/12/16 END: 10/12/16	DRILLING FIRM / OPERATOR: TTL / N. WIKTOR SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT	DRILL RIG: CME 75 TRUCK HAMMER: CME AUTOMATIC CALIBRATION DATE: 12/29/15 ENERGY RATIO (%): 74.5	STATION / OFFSET: 307+72, 87' LT. ALIGNMENT: PROP. CHANNEL (I-75) ELEVATION: 798.0 (MSL) EOB: 33.0 ft. COORD: 486361.5 N, 1638678.8 E	EXPLORATION ID B-9 PAGE 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 798.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
TOPSOIL	797.5																	
VERY STIFF, BROWN, **SILTY CLAY**, LITTLE GRAVEL, SOME SAND, (FILL), DAMP		1–2.5	6 8 12	25	83	SS-1	4.50	10	8	13	31	38	36	17	19	16	A-6b (10)	
		3.5–5	3 10 10	25	33	SS-2	4.25	10	8	13	31	38	36	17	19	22	A-6b (10)	
		6–6.9	27 50/5"	-	18	SS-3	-	-	-	-	-	-	-	-	-	18	A-6b (V)	
SUSPECTED BOULDER AT 6.9', DIFFICULTY DRILLING FROM 6.9' - 8.5'																		
		8.5–10	13 11 11	27	11	SS-4	-	-	-	-	-	-	-	-	-	12	A-6b (V)	
SS-5: ROCK FRAGMENTS		11–12.2	15 20 50/2"	-	57	SS-5	-	-	-	-	-	-	-	-	-	13	A-6b (V)	
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, MODERATELY STRONG TO STRONG, VERY THIN TO THIN BEDDED, HIGHLY FRACTURED TO FRACTURED, SLIGHTLY ROUGH.	785.0	TR 13–18	0		95	NQ2-1											CORE	
LESS FRACTURED 22.0' - 23.0'		18–23	20		98	NQ2-2											CORE	
		23–28	15		98	NQ2-3											CORE	
LESS FRACTURED IN NQ2-4		28–																

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/17/17 08:17 - \\US1268-F01\SHARED_PROJECTS\1743\174316204\GEOTECHNICAL\FIELD_DATA\BORING LOGS\174316204_BOF

PID: N/A	SFN: N/A	PROJECT: HANCOCK CO DIVERSION	STATION / OFFSET: 307+72, 87' LT.	START: 10/12/16	END: 10/12/16	PG 2 OF 2	B-9

MATERIAL DESCRIPTION AND NOTES	ELEV. 768.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, MODERATELY STRONG TO STRONG, VERY THIN TO THIN BEDDED, HIGHLY FRACTURED TO FRACTURED, SLIGHTLY ROUGH. *(continued)*	765.0	31 32 EOB 33	68		100	NQ2-4											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HANCOCK CO DIVERSION
TYPE: STRUCTURE FOUNDATION
PID: N/A SFN: N/A
START: 10/10/16 END: 10/10/16

DRILLING FIRM / OPERATOR: TTL / N. WIKTOR
SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT

DRILL RIG: CME 75 TRUCK
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 12/29/15
ENERGY RATIO (%): 74.5

STATION / OFFSET: 343+77, 130' RT.
ALIGNMENT: PROP. CHANNEL (TR 67)
ELEVATION: 804.5 (MSL) EOB: 45.0 ft.
COORD: 484872.6 N, 1641671.0 E

EXPLORATION ID
B-10

MATERIAL DESCRIPTION AND NOTES	ELEV. 804.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT PAVEMENT	803.7																	
GRANULAR BASE	803.3																	
STIFF TO HARD, BROWN TO GRAY, **SILT AND CLAY**, TRACE GRAVEL, LITTLE SAND, DAMP TO MOIST		1–2	5 4 5	11	61	SS-1	2.50	-	-	-	-	-	-	-	-	23	A-6a (V)	
		4–5	6 8 10	22	94	SS-2	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
		6–7	3 6 10	20	89	SS-3	4.50	5	7	13	29	46	28	13	15	16	A-6a (10)	
	794.0	9–10	7 12 21	41	89	SS-4	4.50	5	7	13	29	46	28	13	15	15	A-6a (10)	
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, TRACE GRAVEL, LITTLE SAND, DAMP TO MOIST		11–12	5 6 7	16	89	SS-5	3.50	5	6	12	30	47	31	15	16	21	A-6b (10)	
	789.0	14–15	4 3 6	11	100	SS-6	3.50	5	6	12	30	47	31	15	16	14	A-6b (10)	
MEDIUM DENSE TO DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP		16–17	6 9 12	26	33	SS-7	-	52	10	10	18	10	17	13	4	11	A-2-4 (0)	
		17–18	10 11 13	30	44	SS-8	-	52	10	10	18	10	17	13	4	11	A-2-4 (0)	
		19–20	6 8 28	45	28	SS-9	-	52	10	10	18	10	17	13	4	10	A-2-4 (0)	
	782.0	W 20–22	32 20 17	46	0	SS-10	-	-	-	-	-	-	-	-	-	-	A-2-4 (V)	
DENSE, GRAY AND BLACK, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE CLAY, MOIST	779.5	24	6 12 50/4"	-	100	SS-11	-	32	53	10	0	5	NP	NP	NP	16	A-1-b (0)	
DOLOMITE, GRAY, SLIGHTLY WEATHERED, STRONG, THIN TO MEDIUM BEDDED, FRACTURED TO SLIGHTLY FRACTURED, SLIGHTLY ROUGH.		TR 25–29	70		98	NQ2-1											CORE	

MATERIAL DESCRIPTION AND NOTES	ELEV. 774.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DOLOMITE, GRAY, SLIGHTLY WEATHERED, STRONG, THIN TO MEDIUM BEDDED, FRACTURED TO SLIGHTLY FRACTURED, SLIGHTLY ROUGH. *(continued)* SLIGHTLY MORE WEATHERED AND FRACTURED IN NQ2-2		31–35	52		93	NQ2-2											CORE	
SOME DARKER GRAY/BLACK BANDS ABOUT 0.5" THICK IN NQ2-3		35–40	67		100	NQ2-3											CORE	
	759.5	40–45 EOB	80		97	NQ2-4											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HANCOCK CO DIVERSION TYPE: STRUCTURE FOUNDATION PID: N/A SFN: N/A START: 10/7/16 END: 10/7/16	DRILLING FIRM / OPERATOR: TTL / N. WIKTOR SAMPLING FIRM / LOGGER: STANTEC / R. LOPINA DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT	DRILL RIG: CME 75 TRUCK HAMMER: CME AUTOMATIC CALIBRATION DATE: 12/29/15 ENERGY RATIO (%): 74.5	STATION / OFFSET: 442+11, 242' LT. ALIGNMENT: PROP. CHANNEL (TR 49) ELEVATION: 799.7 (MSL) EOB: 18.8 ft. COORD: 480343.5 N, 1648241.2 E

EXPLORATION ID B-11 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 799.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT PAVEMENT	799.2																	
GRANULAR BASE	798.8																	
MEDIUM STIFF TO STIFF, BROWN, **SILTY CLAY**, TRACE GRAVEL, "AND" SAND, MOIST		1–2	4 3 3	7	78	SS-1	2.25	2	9	29	24	36	35	16	19	20	A-6b (9)	
	795.7	3–4	4 4 6	12	56	SS-2	2.50	2	9	29	24	36	35	16	19	23	A-6b (9)	
STIFF TO HARD, BROWN, **SILT AND CLAY**, TRACE GRAVEL, SOME SAND, MOIST		4–5	2 4 7	14	100	SS-3	3.00	-	-	-	-	-	-	-	-	2	A-6a (V)	
		6–7	5 7 8	19	67	SS-4	3.75	6	7	15	36	36	27	14	13	16	A-6a (9)	
		7–8	5 5 7	15	100	SS-5	3.25	6	7	15	36	36	27	14	13	20	A-6a (9)	
		9	4 5 7	15	89	SS-6	4.00	-	-	-	-	-	-	-	-	14	A-6a (V)	
SS-7: SLIGHTLY MORE GRAVEL	787.7	10–11	8 12 14	32	100	SS-7	4.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
VERY STIFF, GRAY, **SILT AND CLAY**, TRACE GRAVEL, LITTLE SAND, MOIST	785.2	12–14	5 5 8	16	83	SS-8	2.25	9	9	16	33	33	24	13	11	14	A-6a (7)	
DENSE, GRAY AND BLACK, **GRAVEL**, "AND" SAND, TRACE SILT, TRACE CLAY, MOIST		W 15–16	12 12 14	32	72	SS-9	-	51	33	7	5	4	17	14	3	11	A-1-a (0)	
	781.7	TR 17–18	2 5 50/3"	-	27	SS-10	-	51	33	7	5	4	17	14	3	10	A-1-a (0)	
	780.9	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

APPENDIX B
LABORATORY TEST RESULTS

TERRACON

TERRACON
Moisture Content ASTM D 2166

Client Name: Stantec **Date:** 10-25-16

Project Location: Hancock County Flood Diversion Ph 1-Project #174316204

Work Order Number: N1165419

LAB NUMBER	7283	7284	7285	7286	7287	7288	7289	
BORING NUMBER	B-1	B-1	B-1	B-1	B-1	B-1	B-1	
DEPTH, (FT.)	0-1.5	1.5-3	3-4.5	4.5-5.6	5.6-6	7.5-9	10-11.5	
WT. OF CUP + WET SOIL	383.04	65.07	92.34	45.98	87.51	107.42	86.31	
WT. OF CUP + DRY SOIL	347.97	54.09	77.27	39.48	78.71	97.09	78.62	
WT. OF CUP	50.89	14.30	14.33	14.44	14.31	14.68	14.01	
WT. OF WATER	35.07	10.98	15.07	6.50	8.80	10.33	7.69	#VALUE!
WATER CONTENT, %	11.8	27.6	23.9	26.0	13.7	12.5	11.9	#VALUE!
BORING NUMBER	7290	7291	7291	7293	7294	7295	7296	
BORING NUMBER	B-1	B-1	B-1	B-1	B-2	B-2	B-2	
DEPTH, (FT.)	11.5-13	13-14.5	14.5-16	17.5-17.9	5-6.5	7.5-9	10-11.5	
WT. OF CUP + WET SOIL	67.53	80.30	103.40	98.56	75.86	73.08	75.65	
WT. OF CUP + DRY SOIL	61.53	69.39	93.63	89.92	64.94	65.93	67.65	
WT. OF CUP	14.71	14.80	14.20	14.33	14.33	14.66	14.31	
WT. OF WATER	6.00	10.91	9.77	8.64	10.92	7.15	8.00	#VALUE!
WATER CONTENT, %	12.8	20.0	12.3	11.4	21.6	13.9	15.0	#VALUE!
BORING NUMBER	7297	7298	7299	7300	7301	7302	7303	
BORING NUMBER	B-2	B-2	B-2	B-3	B-3	B-3	B-3	
DEPTH, (FT.)	11.5-13	13-14.5	14.5-15.3	2.5-4	5-6.5	7.5-9	9-9.6	
WT. OF CUP + WET SOIL	111.29	95.52	97.03	59.62	74.26	88.61	82.41	
WT. OF CUP + DRY SOIL	99.63	84.72	86.35	51.88	64.56	75.88	69.44	
WT. OF CUP	14.45	15.18	14.69	14.07	14.31	14.14	14.01	
WT. OF WATER	11.66	10.80	10.68	7.74	9.70	12.73	12.97	#VALUE!
WATER CONTENT, %	13.7	15.5	14.9	20.5	19.3	20.6	23.4	#VALUE!
BORING NUMBER	7304	7305	7306	7307	7308	7309	7310	
BORING NUMBER	B-3	B-3	B-3	B-3	B-4	B-4	B-4	
DEPTH, (FT.)	9.6-10.5	10.5-12	12-13.5	15-16.5	2.5-4	5-6.5	7.5-9	
WT. OF CUP + WET SOIL	71.38	84.33	76.16	63.58	76.49	66.44	79.95	
WT. OF CUP + DRY SOIL	65.91	78.07	70.00	57.92	72.77	57.46	73.04	
WT. OF CUP	13.91	14.39	14.51	14.24	14.41	14.42	14.78	
WT. OF WATER	5.47	6.26	6.16	5.66	3.72	8.98	6.91	#VALUE!
WATER CONTENT, %	10.5	9.8	11.1	13.0	6.4	20.9	11.9	#VALUE!

TERRACON
Moisture Content ASTM D 2166

TERRACON

Client Name: Stantec **Date:** 10-25-16
Project Location: Hancock County Flood Diversion Ph 1 Page 2
Work Order Number: N1165419

LAB NUMBER	7311	7312	7313	7314	7315	7316	7317	
BORING NUMBER	B-4	B-4	B-4	B-4	B-4	B-4	B-4	
DEPTH, (FT.)	10-11.5	12.5-14	15-16.5	17.5-19	19-20.5	20.5-21.5	21.5-22	
WT. OF CUP + WET SOIL	82.08	74.03	71.61	67.59	77.26	62.13	68.89	
WT. OF CUP + DRY SOIL	73.65	66.81	65.29	61.34	68.68	54.74	59.58	
WT. OF CUP	14.45	14.26	14.19	14.10	14.26	14.27	14.17	
WT. OF WATER	8.43	7.22	6.32	6.25	8.58	7.39	9.31	#VALUE!
WATER CONTENT, %	14.2	13.7	12.4	13.2	15.8	18.3	20.5	#VALUE!

LAB NUMBER	7318	7319	7320	7321	7322	7323	7324	
BORING NUMBER	B-4	B-4	B-4	B-5	B-5	B-5	B-5	
DEPTH, (FT.)	22-23.5	25-26.5	27.5-29	2.5-4	5-6.5	7.5-8.5	8.5-9	
WT. OF CUP + WET SOIL	80.65	77.13	90.92	50.26	57.60	74.22	71.52	
WT. OF CUP + DRY SOIL	71.62	70.04	82.62	44.00	50.61	62.97	60.49	
WT. OF CUP	14.35	14.45	14.58	14.11	14.12	13.97	14.24	
WT. OF WATER	9.03	7.09	8.30	6.26	6.99	11.25	11.03	#VALUE!
WATER CONTENT, %	15.8	12.8	12.2	20.9	19.2	23.0	23.8	#VALUE!

LAB NUMBER	7325	7326	7327	7328	7329	7330	7331	
BORING NUMBER	B-5	B-5	B-6	B-6	B-6	B-6	B-6	
DEPTH, (FT.)	10-11.5	11.5-12.9	1-2.5	3.5-5	6-7.5	8.5-10	13.5-15	
WT. OF CUP + WET SOIL	72.53	69.37	65.80	62.21	70.52	80.39	84.25	
WT. OF CUP + DRY SOIL	64.29	61.34	56.23	53.53	62.12	74.05	70.99	
WT. OF CUP	14.28	13.35	14.24	13.10	14.73	14.17	14.36	
WT. OF WATER	8.24	8.03	9.57	8.68	8.40	6.34	13.26	#VALUE!
WATER CONTENT, %	16.5	16.7	22.8	21.5	17.7	10.6	23.4	#VALUE!

LAB NUMBER	7332	7333	7334	7335	7336	7337	7338	
BORING NUMBER	B-6	B-7	B-7	B-7	B-7	B-8	B-8	
DEPTH, (FT.)	16-17.2	1-2.5	3.5-5	6-6.5	6.5-6.8	1-2.5	3.5-5	
WT. OF CUP + WET SOIL	65.56	63.11	74.06	62.61	72.98	78.25	75.68	
WT. OF CUP + DRY SOIL	60.28	54.09	63.83	53.91	70.74	68.18	67.30	
WT. OF CUP	14.30	14.31	14.31	14.12	14.20	14.22	15.25	
WT. OF WATER	5.28	9.02	10.23	8.70	2.24	10.07	8.38	#VALUE!
WATER CONTENT, %	11.5	22.7	20.7	21.9	4.0	18.7	16.1	#VALUE!

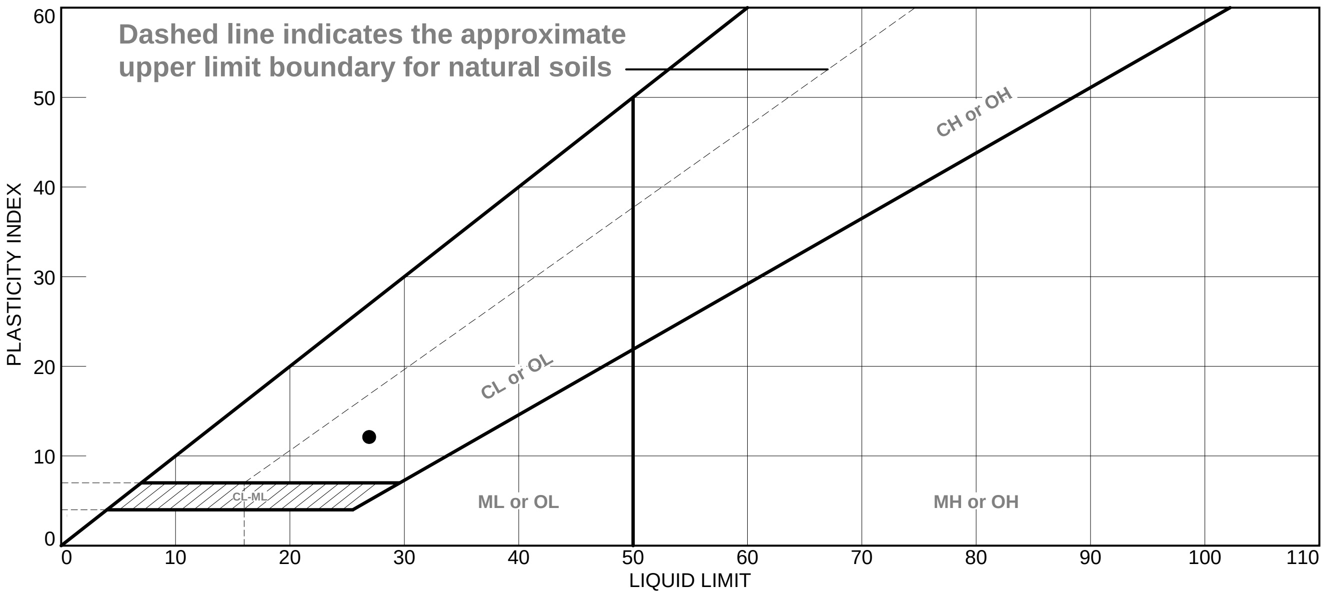
TERRACON
Moisture Content ASTM D 2166

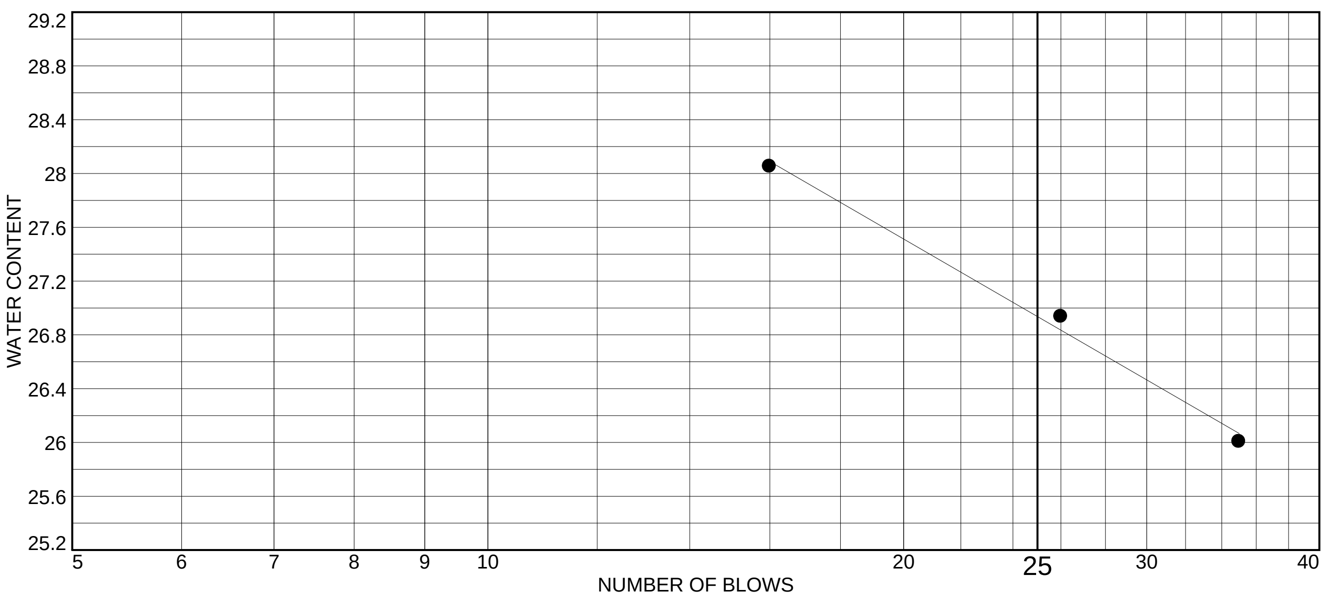
TERRACON

Client Name: Stantec **Date:** 10-25-16
Project Location: Hancock County Flood Diversion Ph 1-Project #174316204
Work Order Number: N1165419

LAB NUMBER	7339	7340	7341	7342	7343	7344	7345	
BORING NUMBER	B-8	B-8	B-9	B-9	B-9	B-9	B-9	
DEPTH, (FT.)	8.5-10	11-11.8	1-2.5	3.5-5	6-6.9	8.5-10	11-12.2	
WT. OF CUP + WET SOIL	69.57	68.47	68.37	66.14	70.42	66.97	72.35	
WT. OF CUP + DRY SOIL	63.36	62.07	61.05	56.75	61.88	61.20	65.77	
WT. OF CUP	14.60	14.08	14.44	14.35	14.30	14.52	14.15	
WT. OF WATER	6.21	6.40	7.32	9.39	8.54	5.77	6.58	#VALUE!
WATER CONTENT, %	12.7	13.3	15.7	22.1	17.9	12.4	12.7	#VALUE!
LAB NUMBER	7346	7347	7348	7349	7350	7351	7352	
BORING NUMBER	B-10	B-10	B-10	B-10	B-10	B-10	B-10	
DEPTH, (FT.)	1-2.5	3.5-5	6-7.5	8.5-10	11-12.5	13.5-15	16-17.5	
WT. OF CUP + WET SOIL	79.36	76.62	73.46	78.84	75.84	69.83	68.12	
WT. OF CUP + DRY SOIL	67.15	68.83	65.07	70.63	65.18	62.84	62.71	
WT. OF CUP	14.29	14.00	13.81	14.25	14.53	14.42	14.16	
WT. OF WATER	12.21	7.79	8.39	8.21	10.66	6.99	5.41	#VALUE!
WATER CONTENT, %	23.1	14.2	16.4	14.6	21.0	14.4	11.1	#VALUE!
LAB NUMBER	7353	7354	7355	7356	7357	7358	7359	7360
BORING NUMBER	B-10	B-10	B-10	B-11	B-11	B-11	B-11	B-11
DEPTH, (FT.)	17.5-19	19-20.5	23.5-24.8	1-2.5	2.5-4	4-5.5	5-5.7	7-8.5
WT. OF CUP + WET SOIL	74.80	65.80	75.83	71.92	68.94	360.93	74.12	43.36
WT. OF CUP + DRY SOIL	68.75	60.93	67.54	62.39	58.74	353.78	65.60	38.59
WT. OF CUP	14.07	14.06	16.10	14.40	14.19	49.91	13.71	14.70
WT. OF WATER	6.05	4.87	8.29	9.53	10.20	7.15	8.52	4.77
WATER CONTENT, %	11.1	10.4	16.1	19.9	22.9	2.4	16.4	20.0
LAB NUMBER	7361	7362	7363	7364	7365			
BORING NUMBER	B-11	B-11	B-11	B-11	B-11			
DEPTH, (FT.)	8.5-10	10-11.5	12.5-14	15-16.5	17.5-19.8			
WT. OF CUP + WET SOIL	74.46	77.00	80.99	69.97	85.36			
WT. OF CUP + DRY SOIL	67.29	68.95	72.69	64.36	78.67			
WT. OF CUP	14.19	14.27	14.05	14.30	14.05			
WT. OF WATER	7.17	8.05	8.30	5.61	6.69	#VALUE!	#VALUE!	#VALUE!
WATER CONTENT, %	13.5	14.7	14.2	11.2	10.4	#VALUE!	#VALUE!	#VALUE!

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILT AND CLAY	27	15	12	87.1	61.1	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-1 **Depth:** 4.5-6'

Remarks:

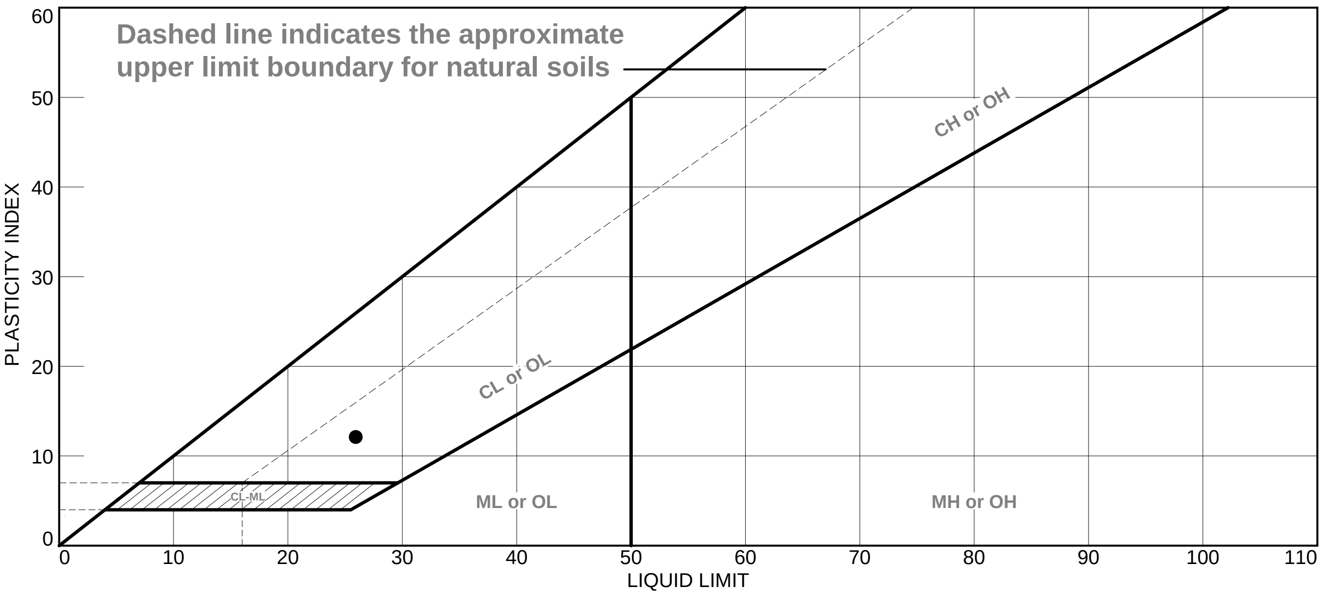
Terracon, Inc.

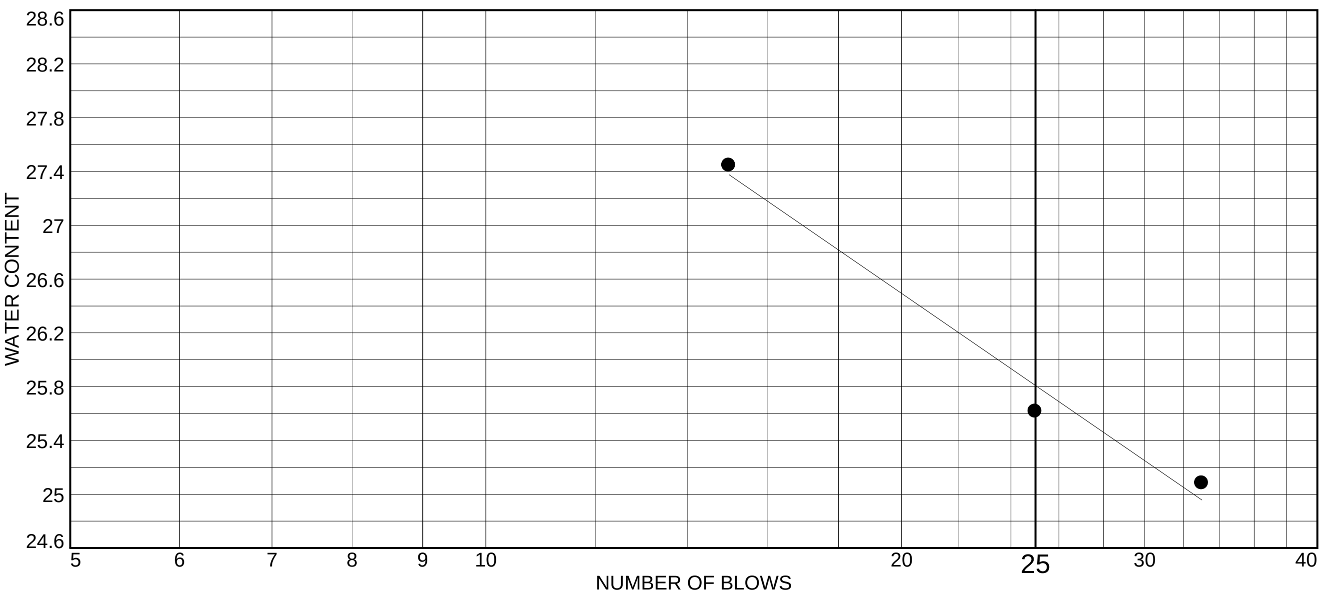
Cincinnati, Ohio

Figure 7286

Tested By: VD **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILT AND CLAY	26	14	12	87.1	75.9	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-1 **Depth:** 10-11.5'

Remarks:

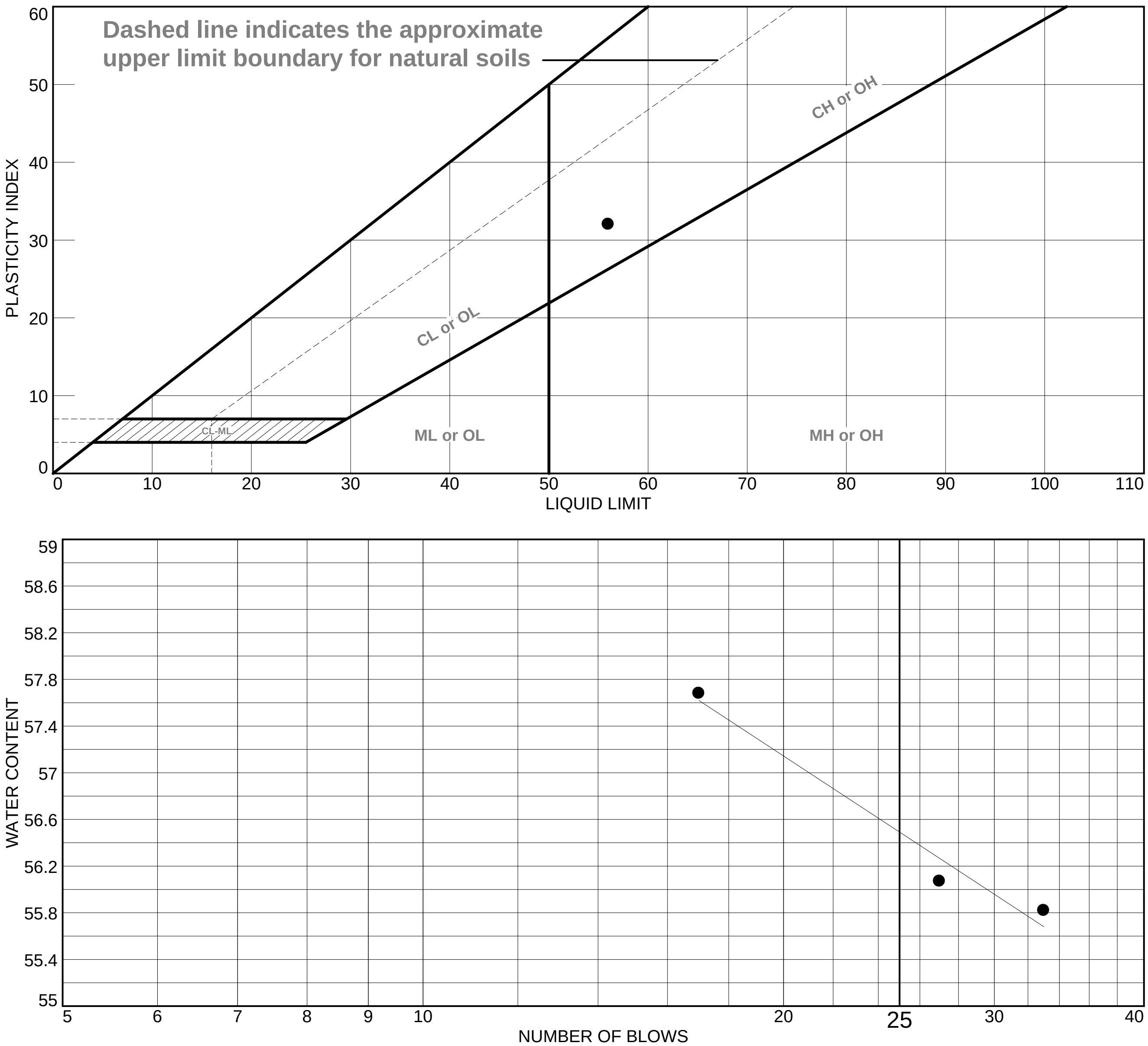
Terracon, Inc.

Cincinnati, Ohio

Figure 7289

Tested By: VD **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN CLAY	56	24	32	89.8	87.2	CH

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-1 **Depth:** 1.5-3 & 3-4.5'

Sample Number: C1

Remarks:

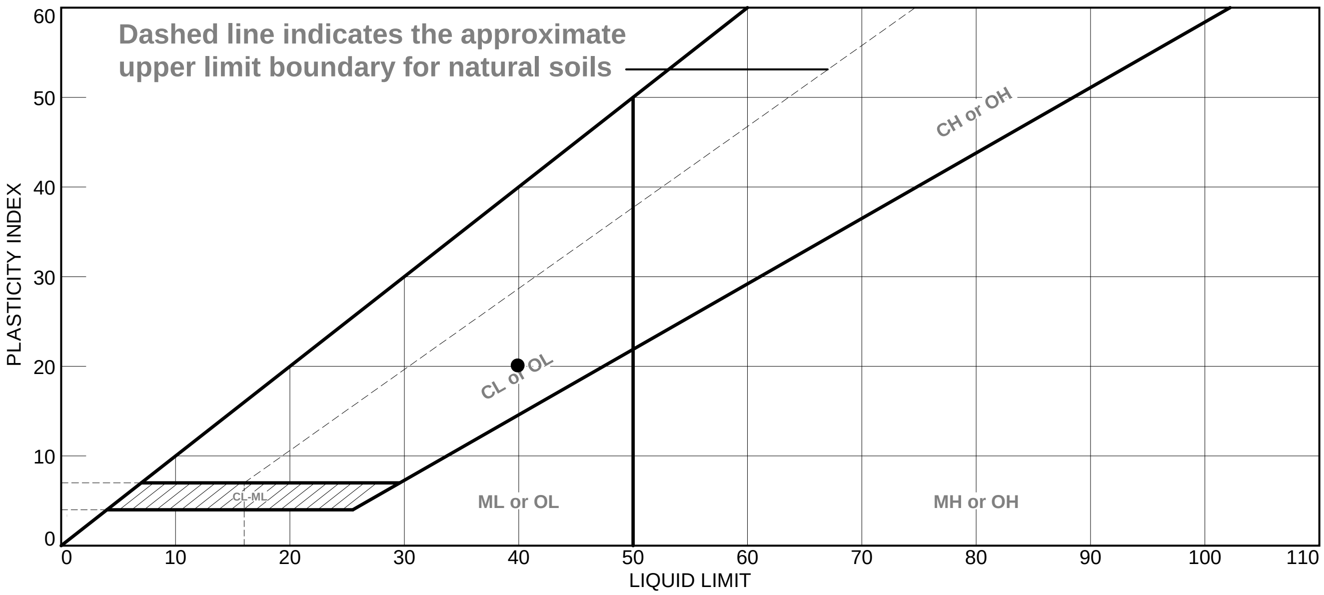
Terracon, Inc.

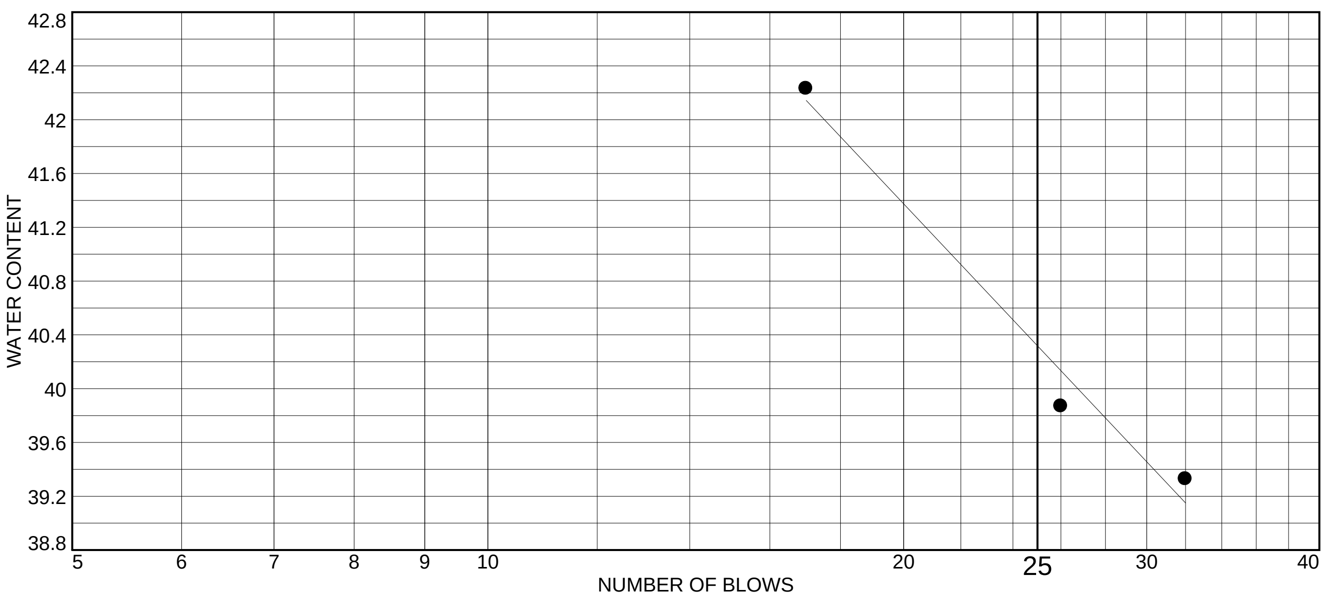
Cincinnati, Ohio

Figure 7284-7285

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILY CLAY	40	20	20	94.5	80.9	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-2 **Depth:** 5-6.5'

Remarks:

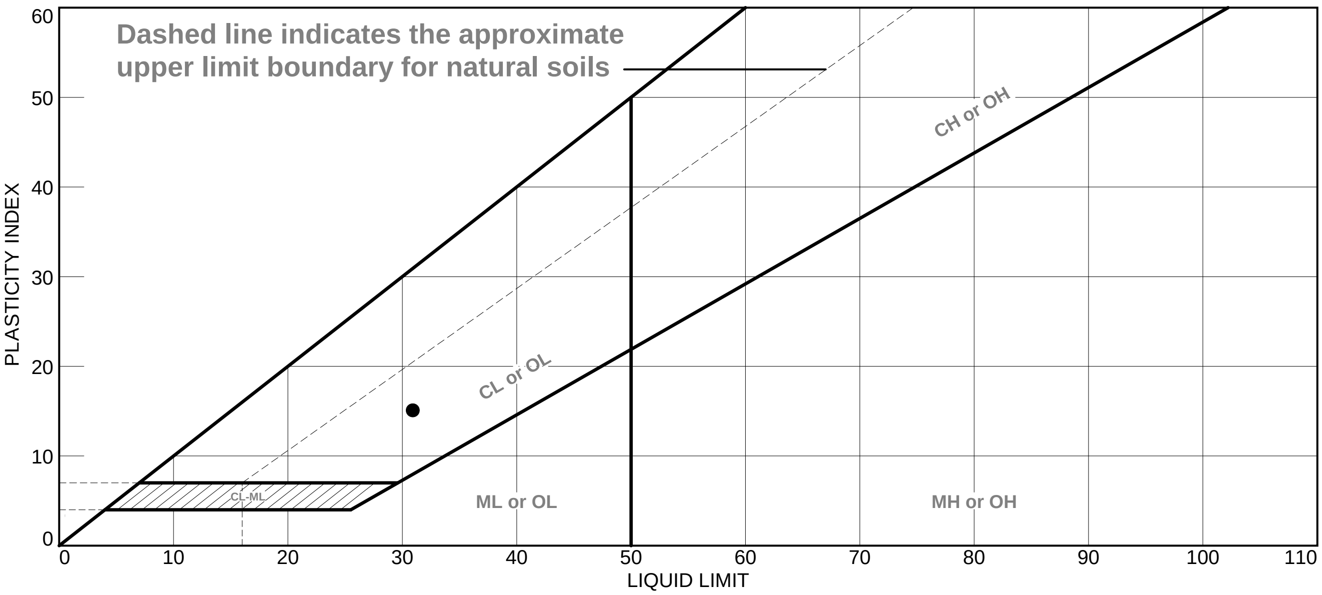
Terracon, Inc.

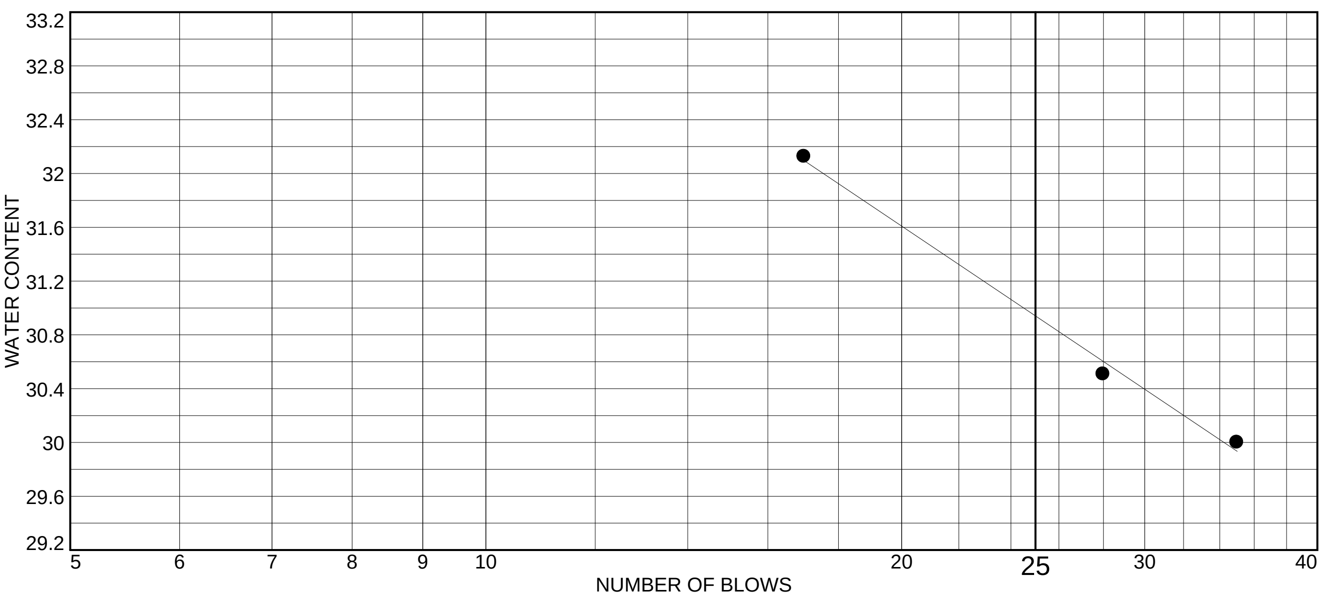
Cincinnati, Ohio

Figure 7294

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILT AND CLAY	31	16	15	91.1	78.8	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-2 **Depth:** 10-11.5'

Remarks:

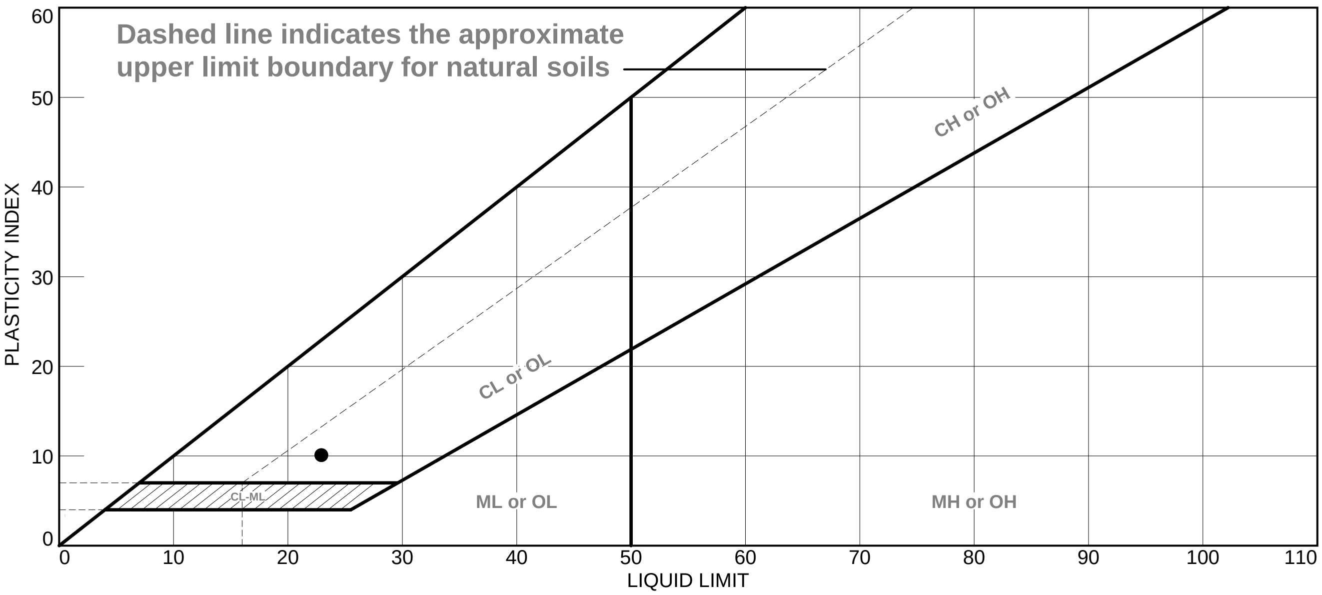
Terracon, Inc.

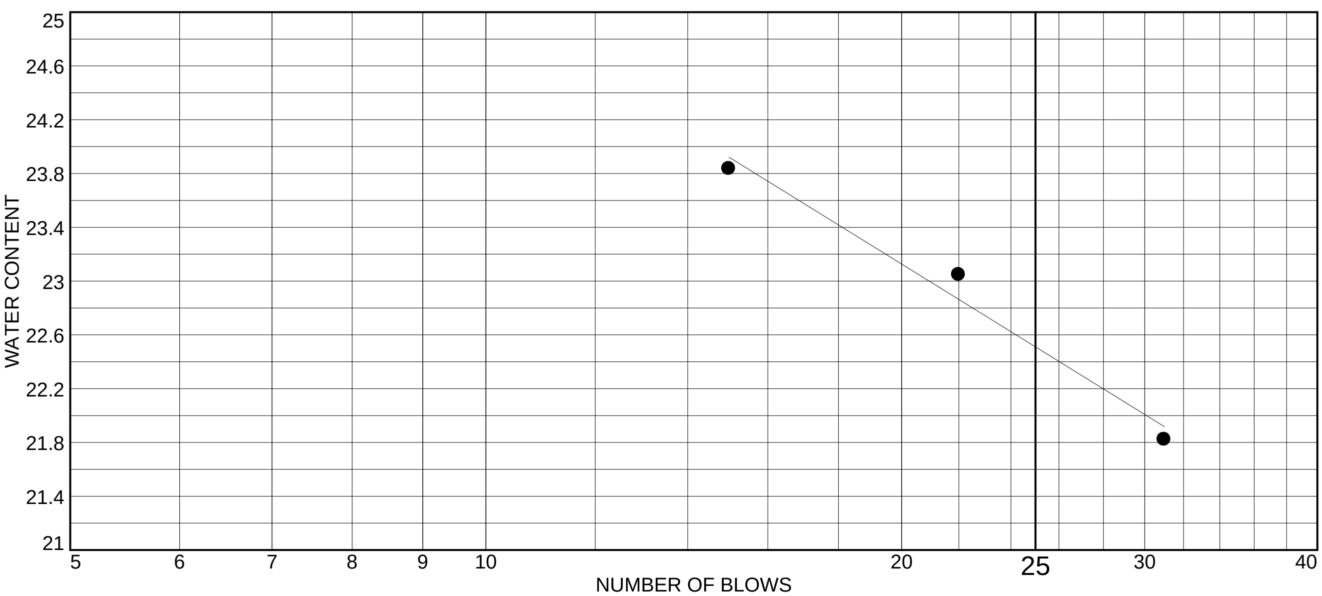
Cincinnati, Ohio

Figure 7296

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY SANDY SILT	23	13	10	78.8	61.5	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-3 **Depth:** 10.5-12'

Remarks:

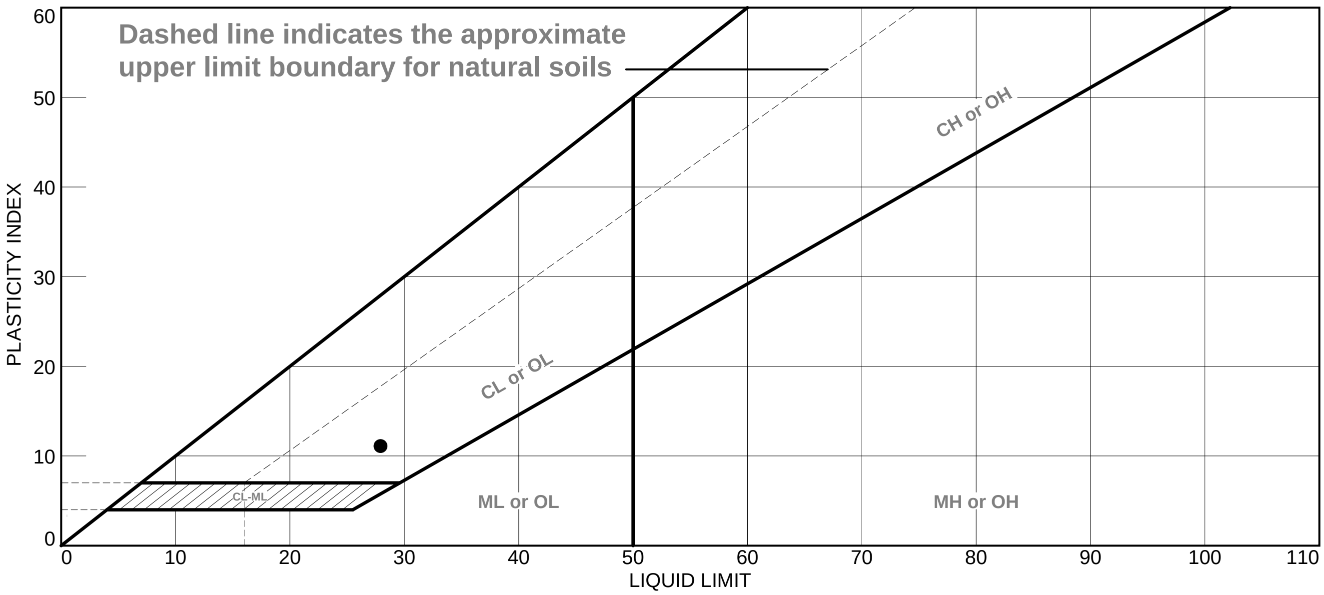
Terracon, Inc.

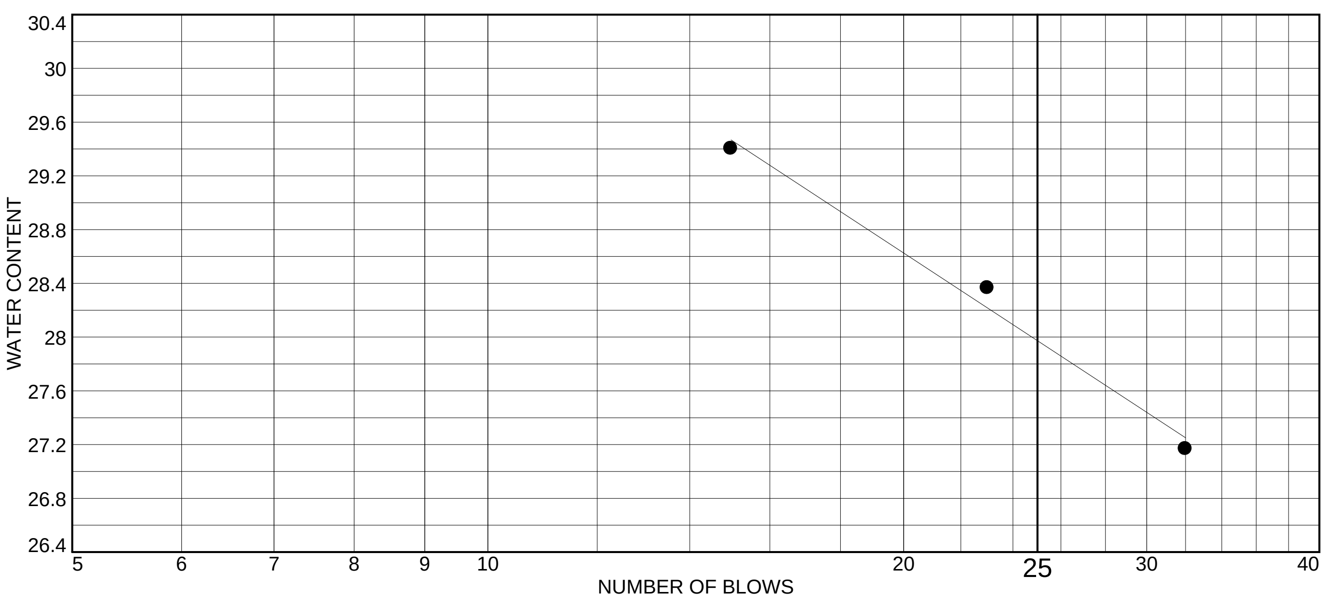
Cincinnati, Ohio

Figure 7305

Tested By: DJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILT AND CLAY	28	17	11	92.5	85.5	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-3 **Depth:** 7.5-9 & 9-9.6'

Sample Number: C3

Remarks:

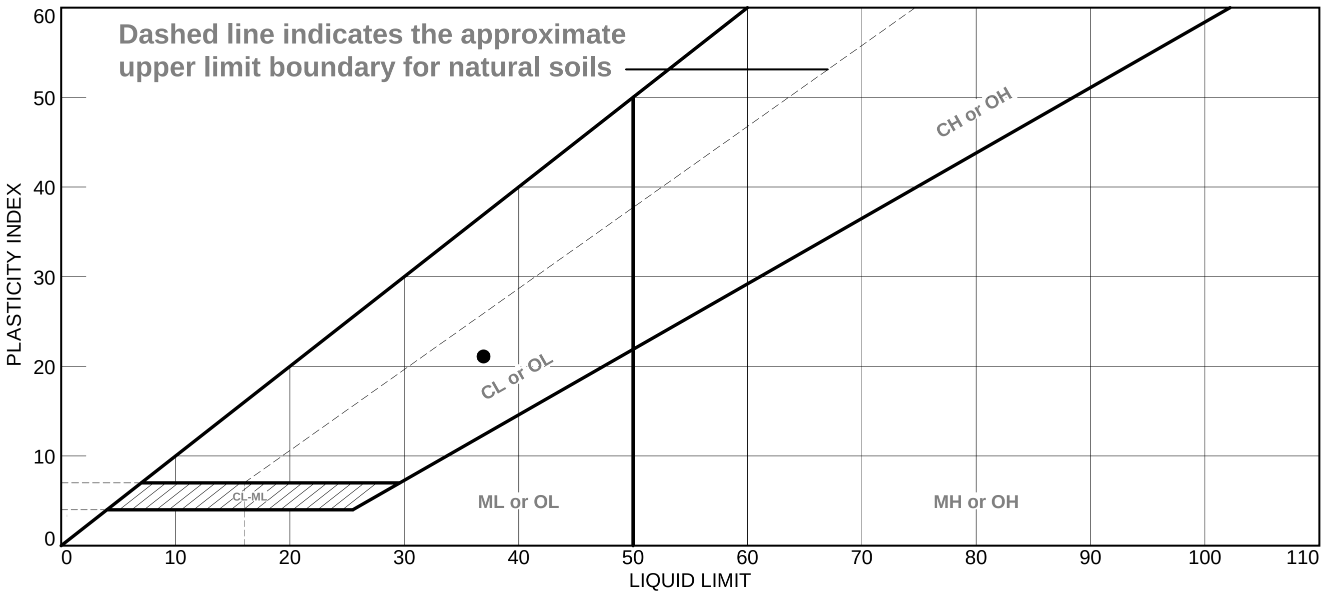
Terracon, Inc.

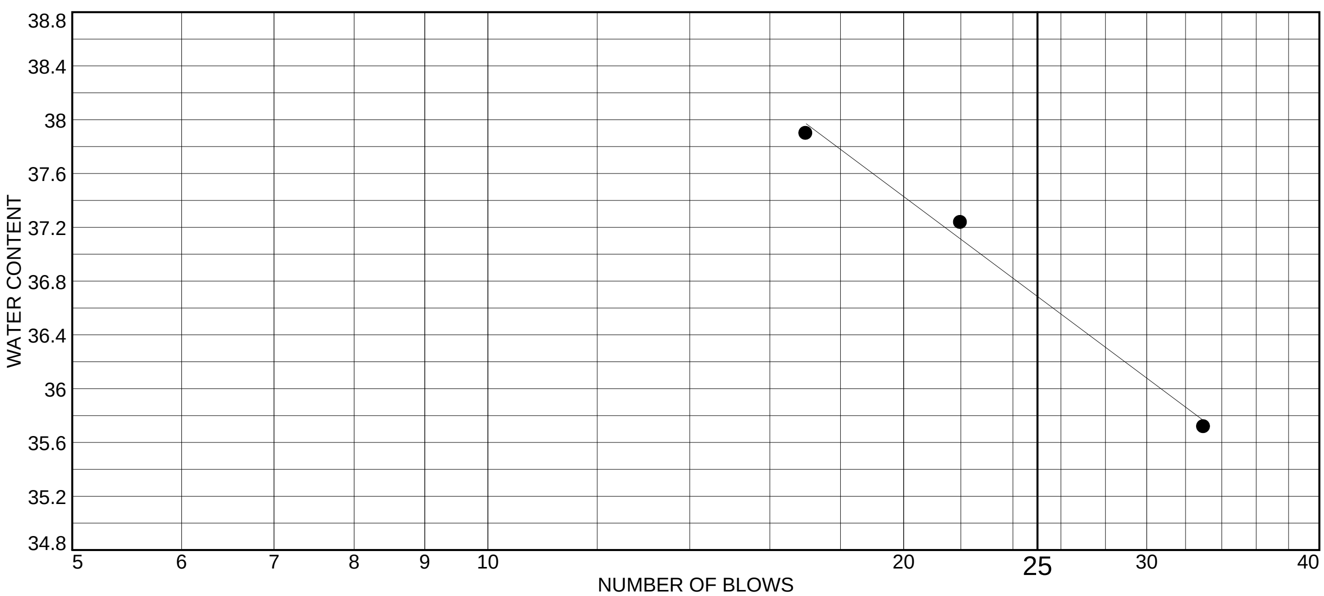
Cincinnati, Ohio

Figure 7302-7303

Tested By: DJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILTY CLAY	37	16	21	94.8	80.4	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-3 **Depth:** 2.5-4 & 5-6.5'

Sample Number: C2

Remarks:

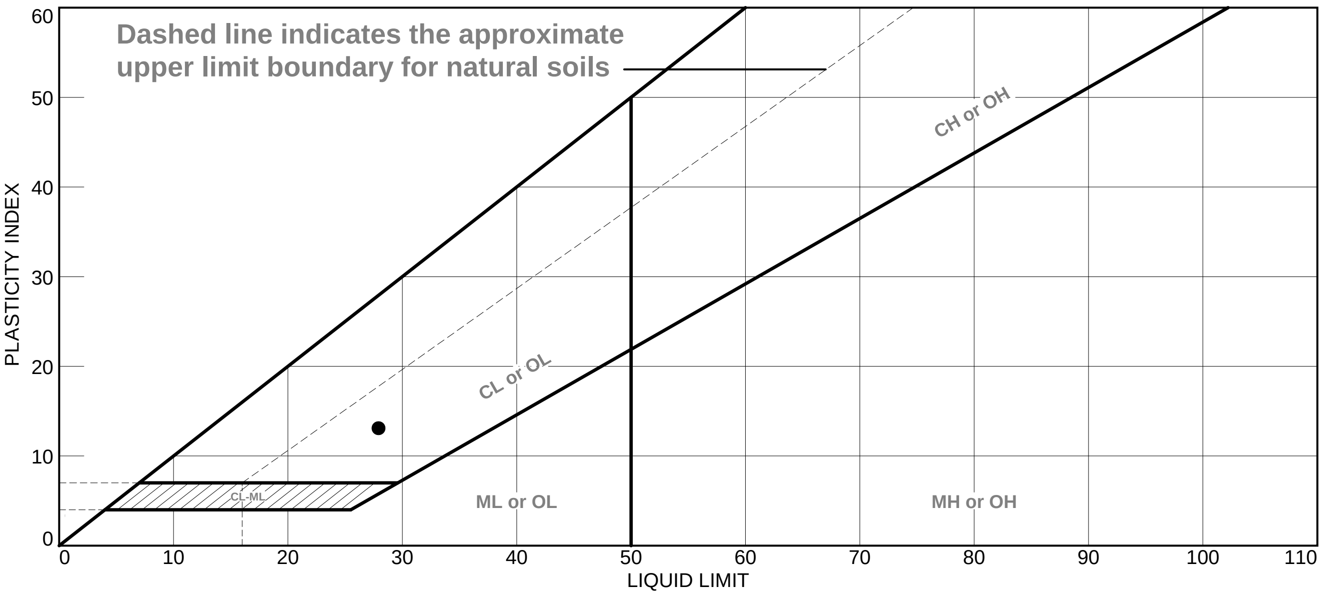
Terracon, Inc.

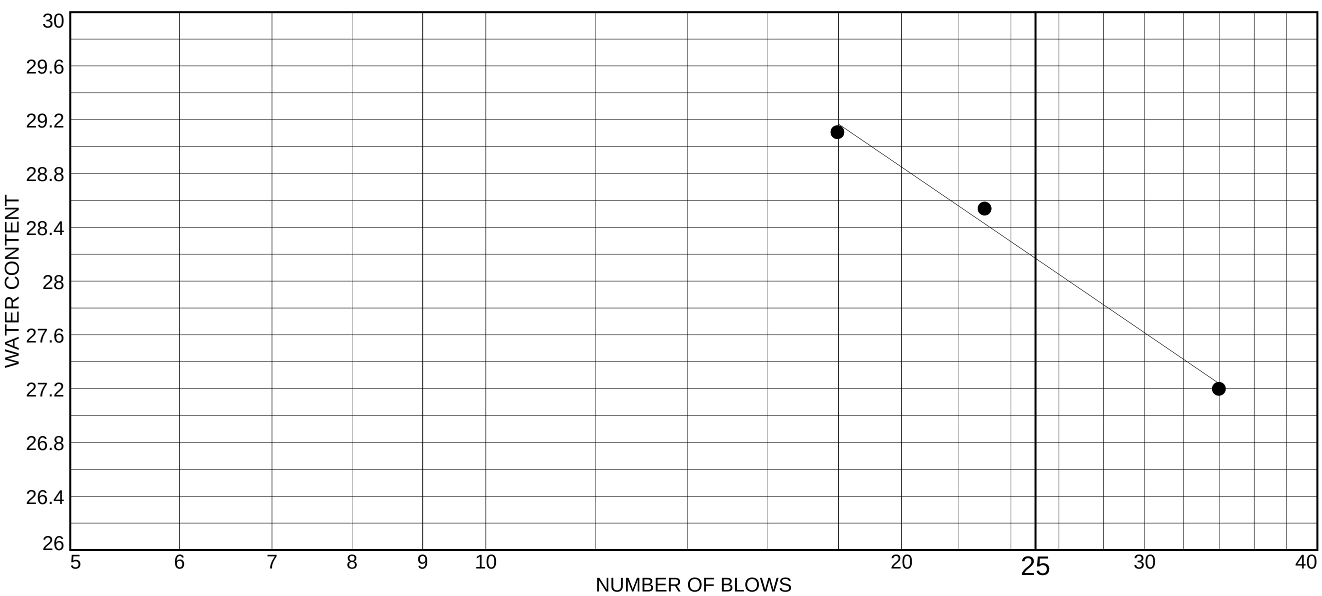
Cincinnati, Ohio

Figure 7300-7301

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILT AND CLAY	28	15	13	88.2	63.0	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-4 **Depth:** 5-6.5 & 7.5-9'

Sample Number: C4

Remarks:

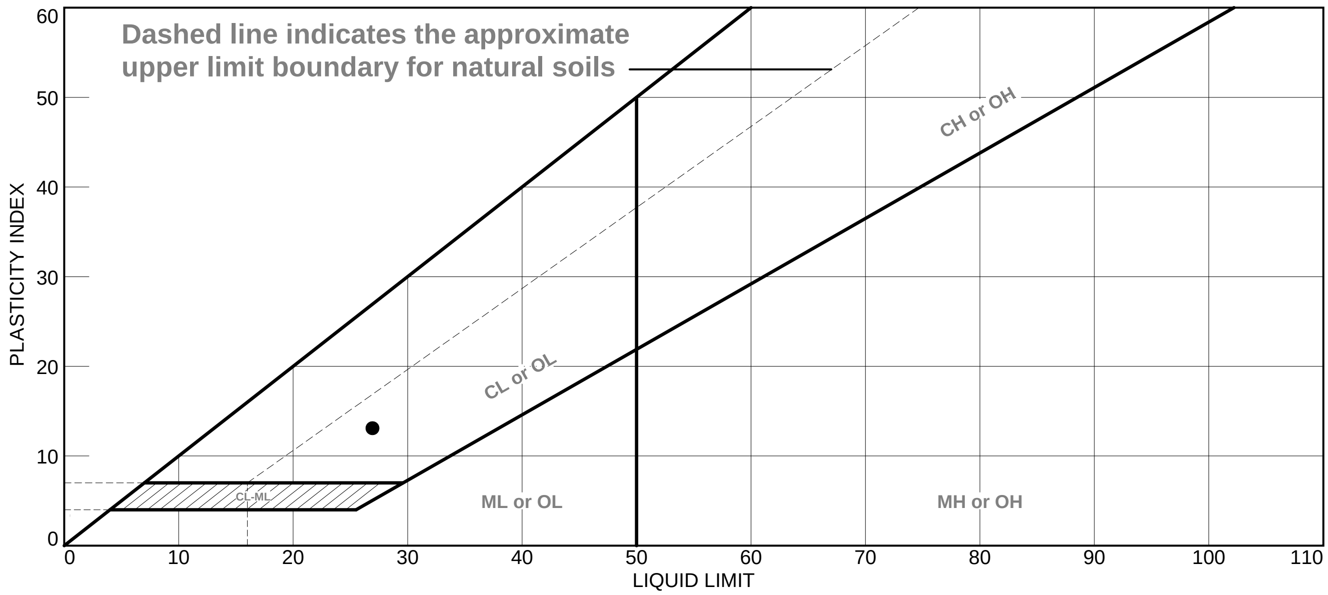
Terracon, Inc.

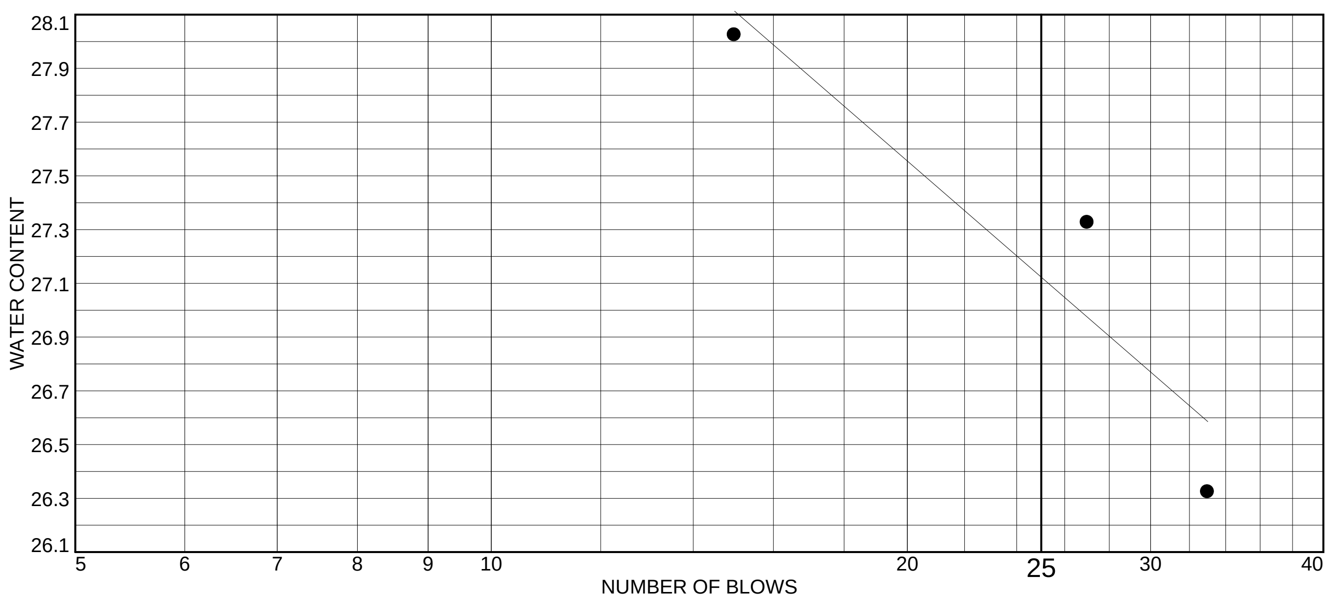
Cincinnati, Ohio

Figure 7309-7310

Tested By: DJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY SILT AND CLAY	27	14	13	95.1	89.3	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-4 **Depth:** 19-20.5 & 20.5-21.5'

Sample Number: C5

Remarks:

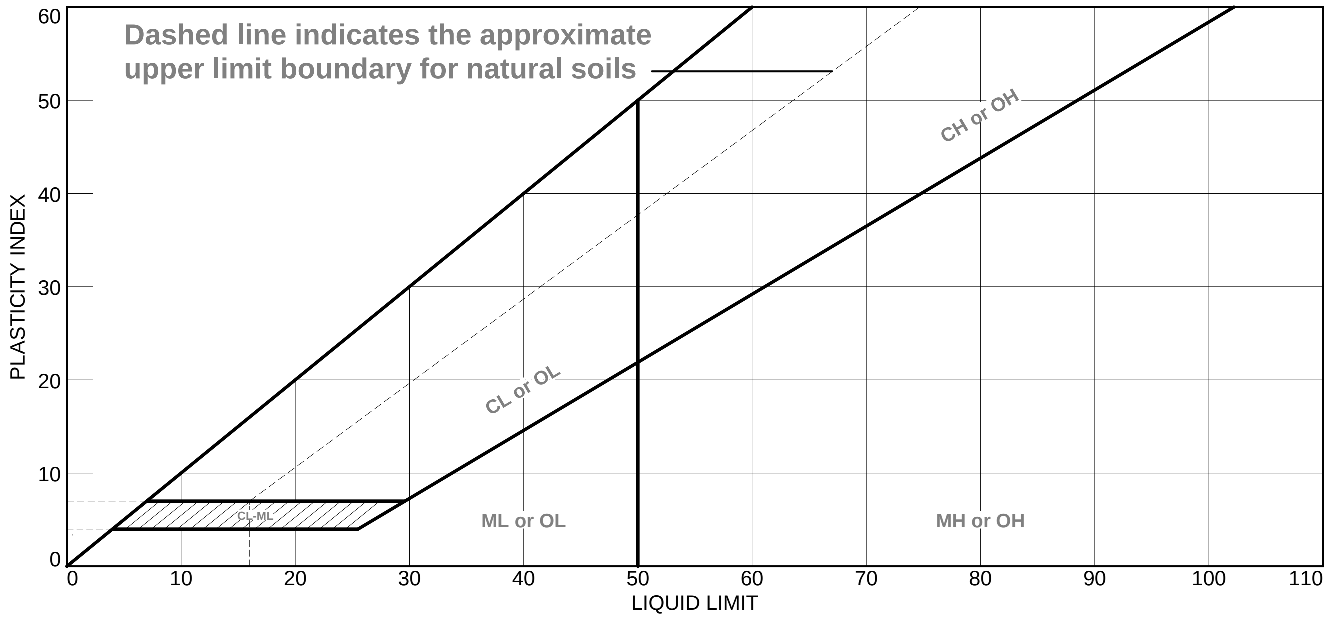
Terracon, Inc.

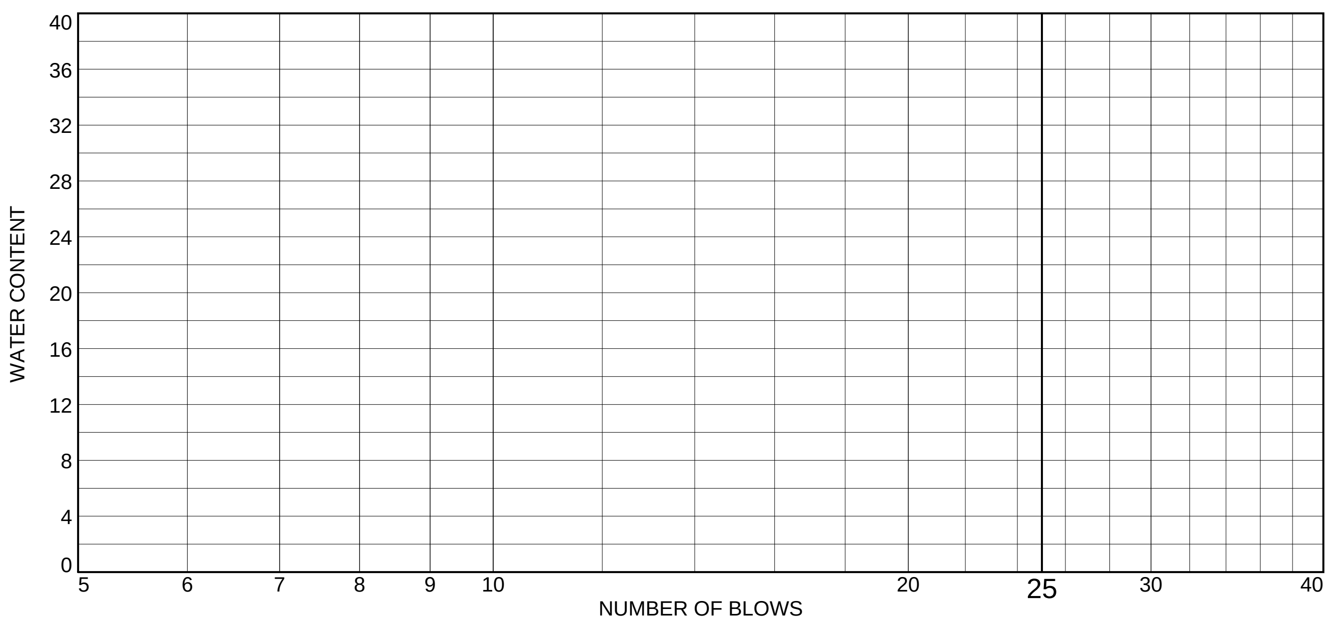
Cincinnati, Ohio

Figure 7315-7316

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY GRAVEL AND/OR STONE FRAG. WITH SAND		NP		41.4	9.3	

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-4 **Depth:** 21.5-22 & 22-23.5'

Sample Number: C6

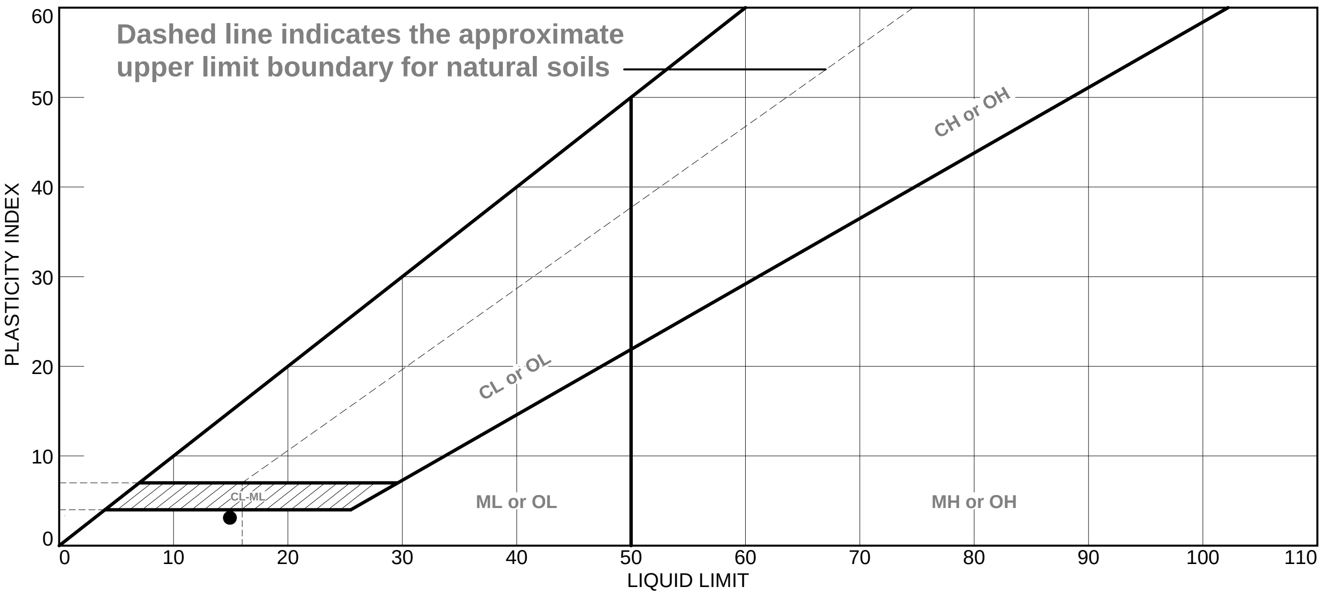
Remarks:

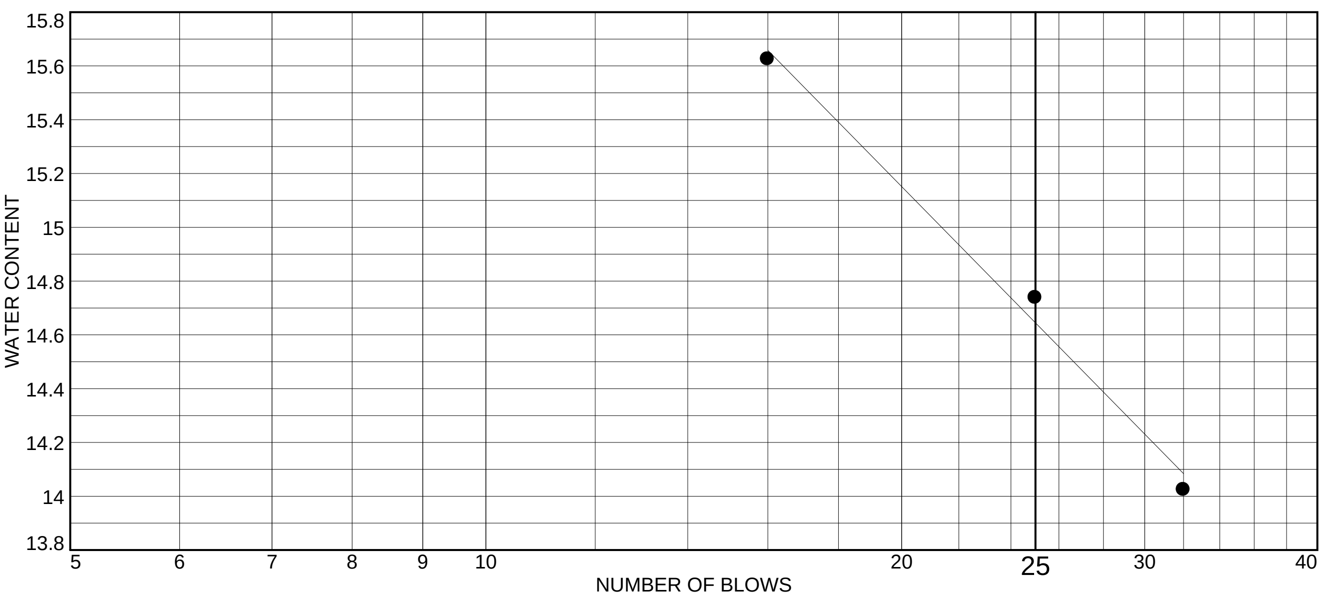
Terracon, Inc.

Cincinnati, Ohio

Figure 7317-7318

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY SANDY SILT	15	12	3	76.7	53.6	ML

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-4 **Depth:** 25-26.5 & 27.5-29'

Sample Number: C7

Remarks:

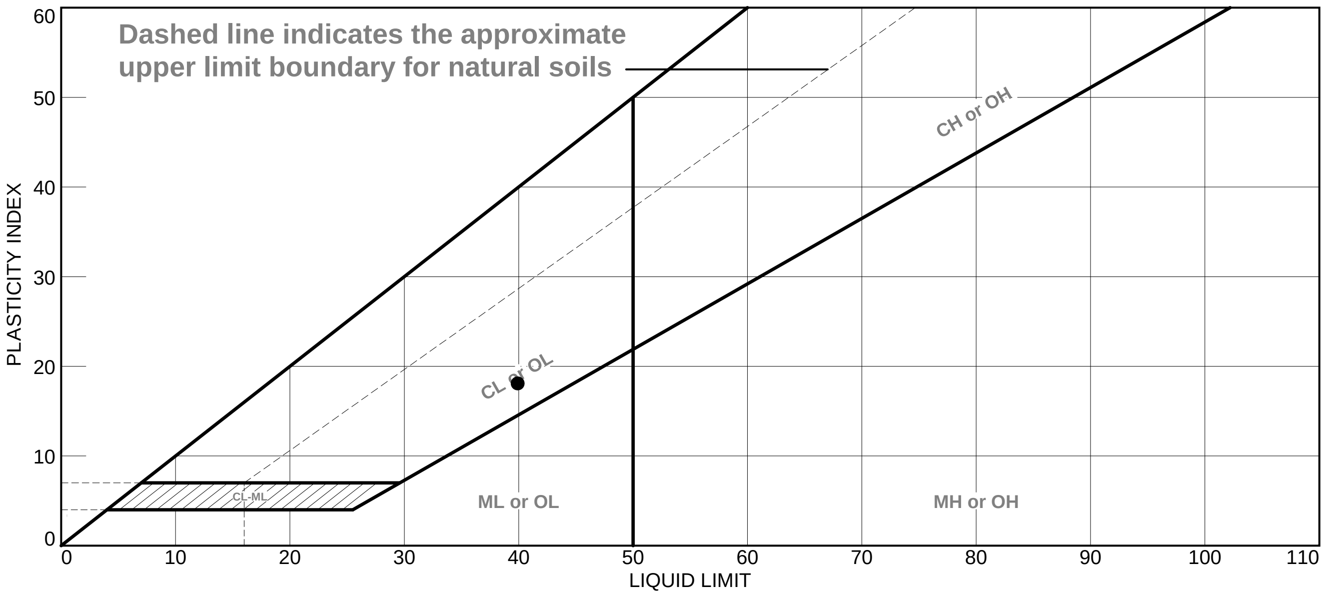
Terracon, Inc.

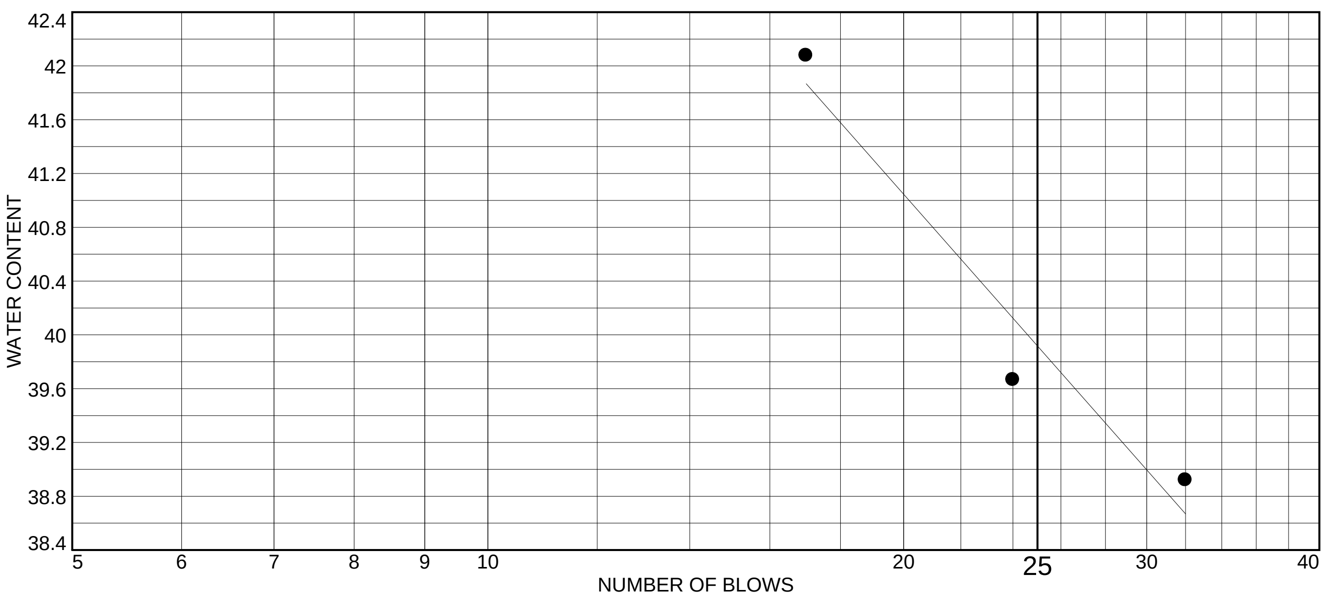
Cincinnati, Ohio

Figure 7319-7320

Tested By: VD **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY SILTY CLAY	40	22	18	99.9	99.5	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-5 **Depth:** 7.5-8.5

Remarks:

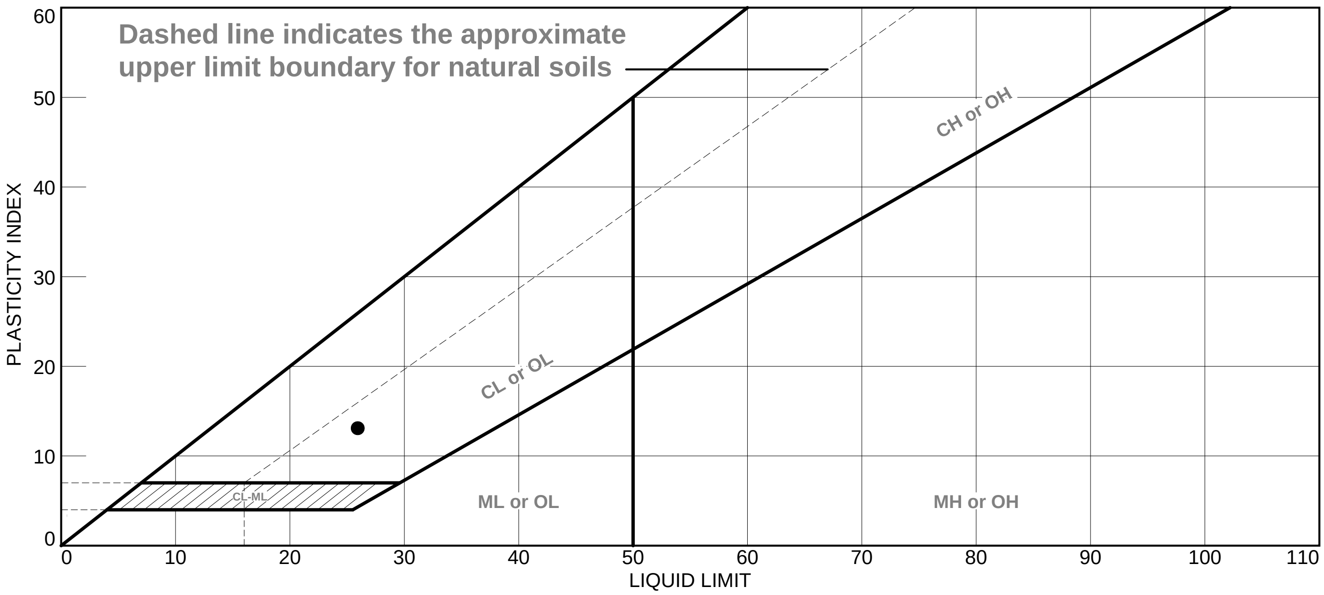
Terracon, Inc.

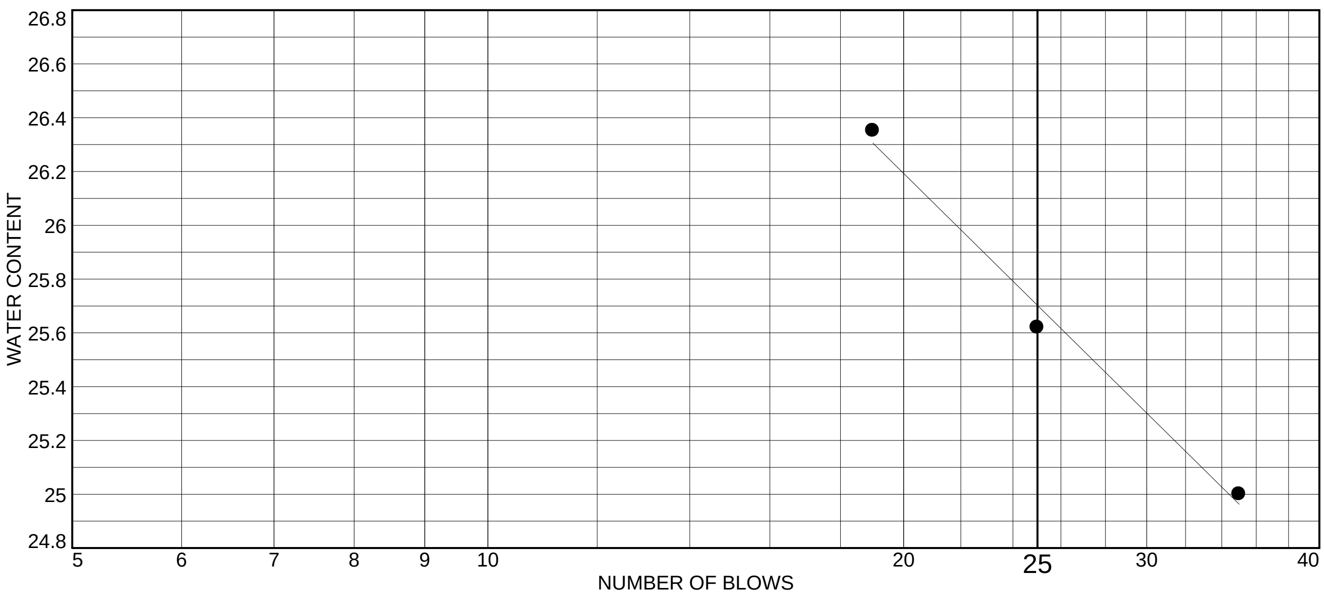
Cincinnati, Ohio

Figure 7323

Tested By: DJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY SILT AND CLAY	26	13	13	93.2	81.3	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-5 **Depth:** 10-11.5'

Remarks:

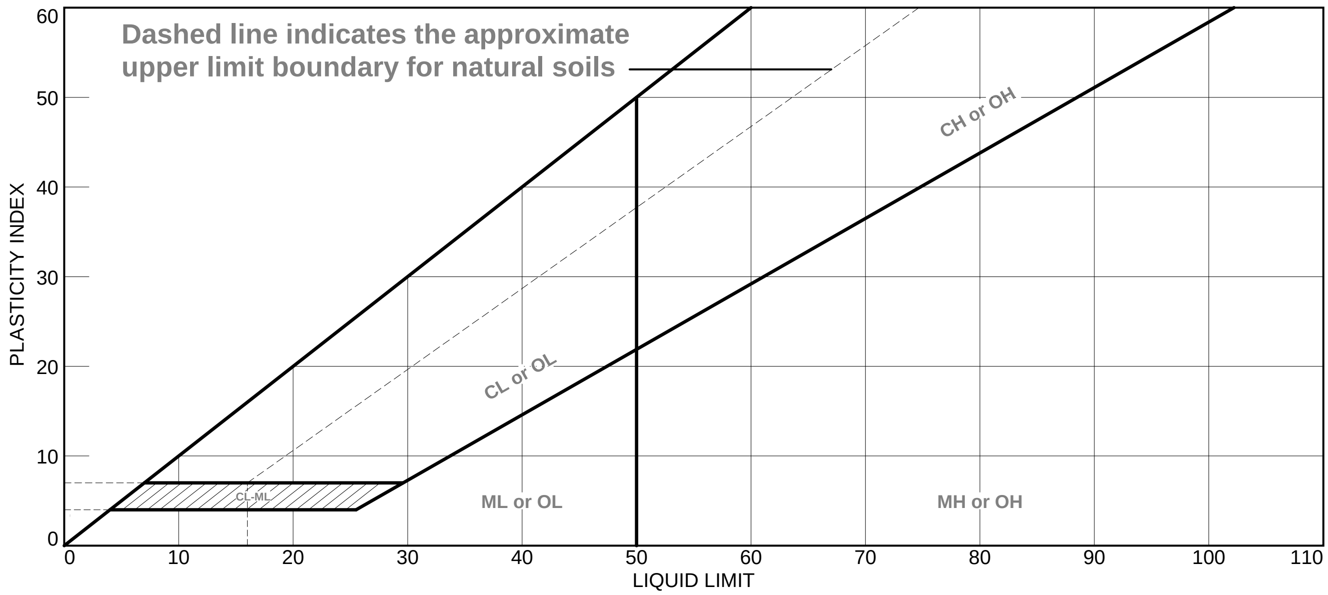
Terracon, Inc.

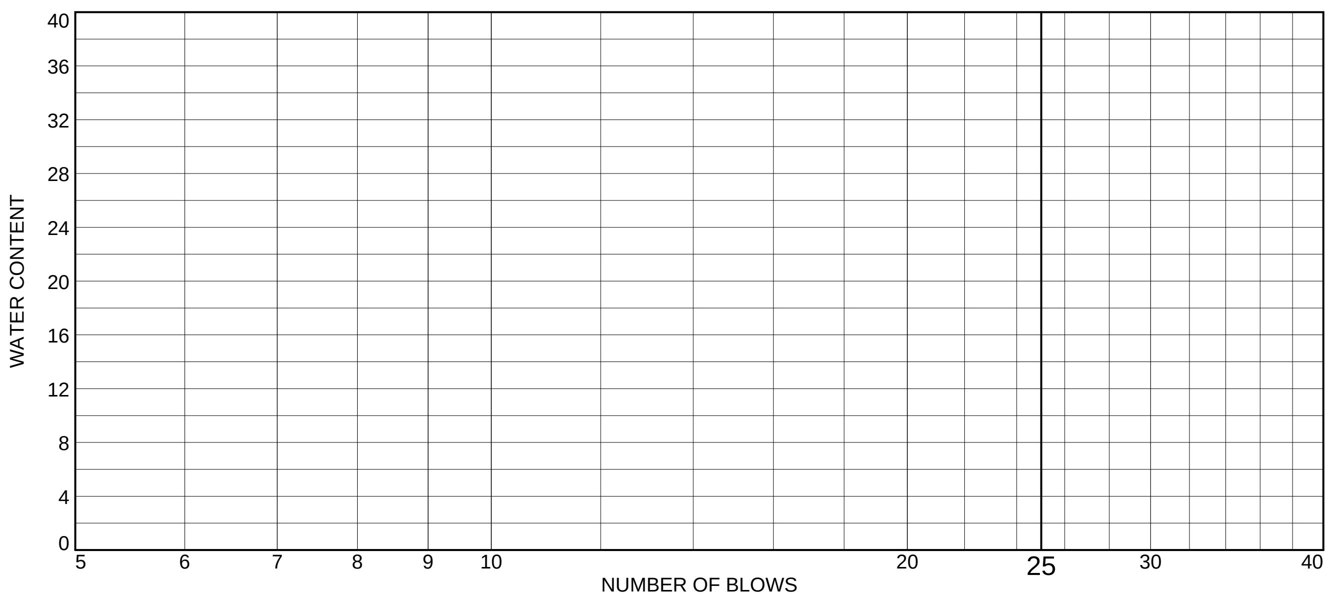
Cincinnati, Ohio

Figure 7325

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY GRAVEL AND/OR STONE FRAGS. WITH SILT AND SAND		NP		62.4	19.5	

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-5 **Depth:** 11.5-12.9'

Remarks:

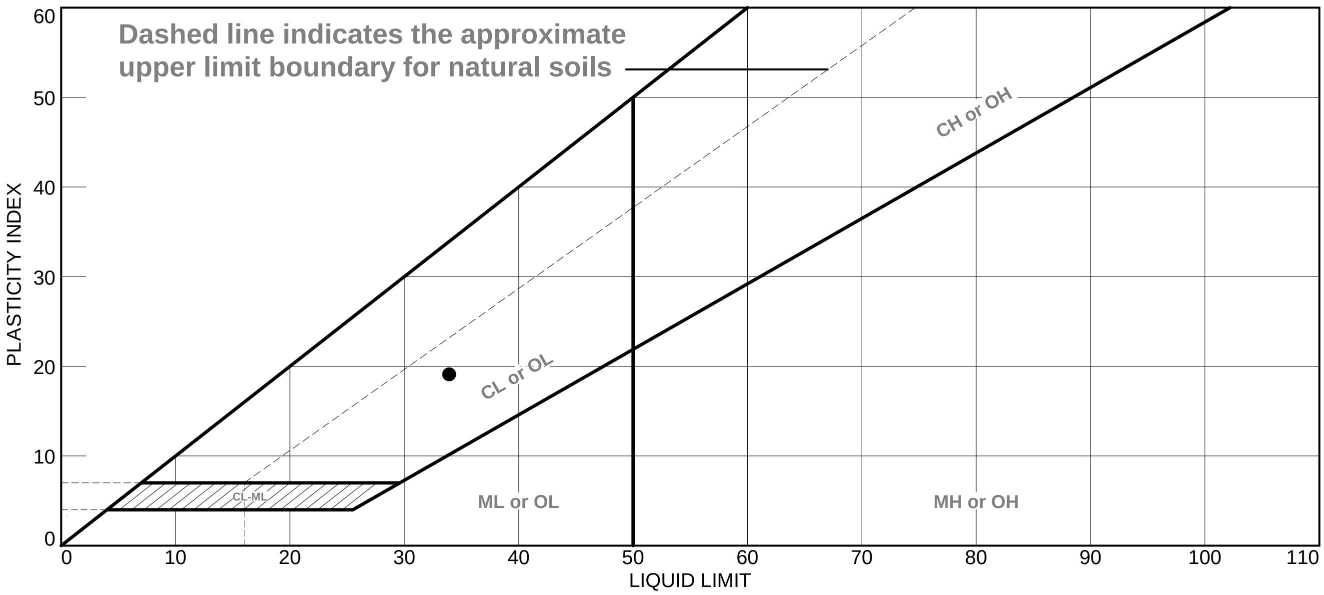
Terracon, Inc.

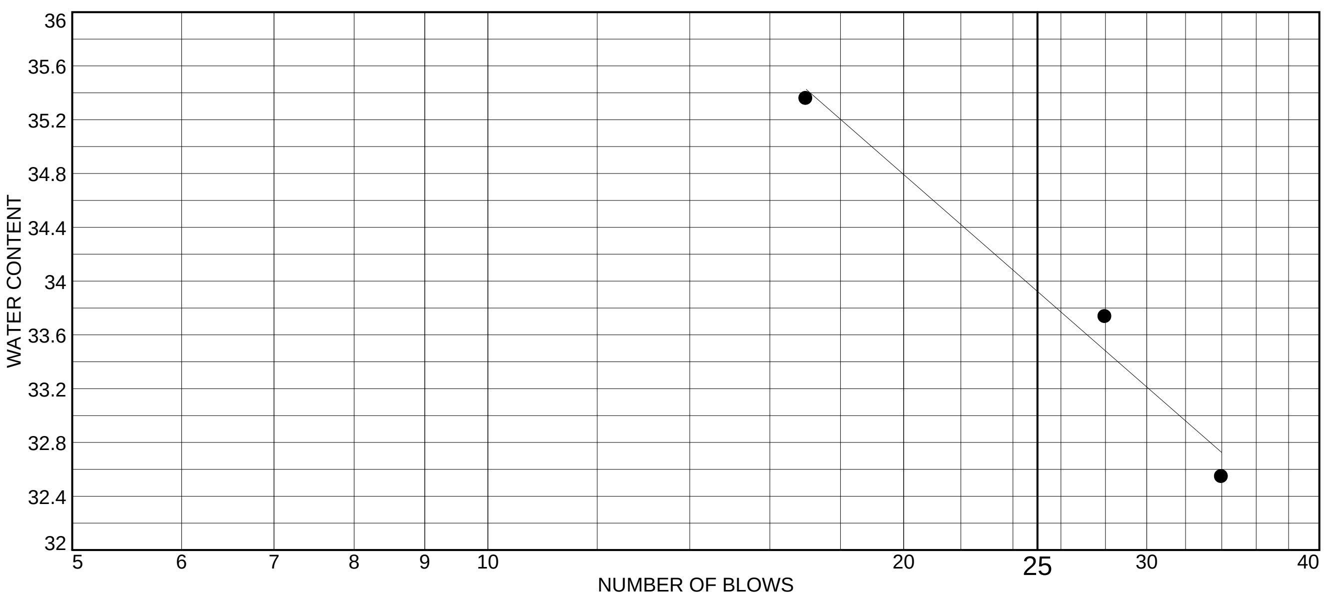
Cincinnati, Ohio

Figure 7326

Tested By: VD **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILTY CLAY	34	15	19	93.5	71.0	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-5 **Depth:** 2.5-4 & 5-6.5'

Sample Number: C8

Remarks:

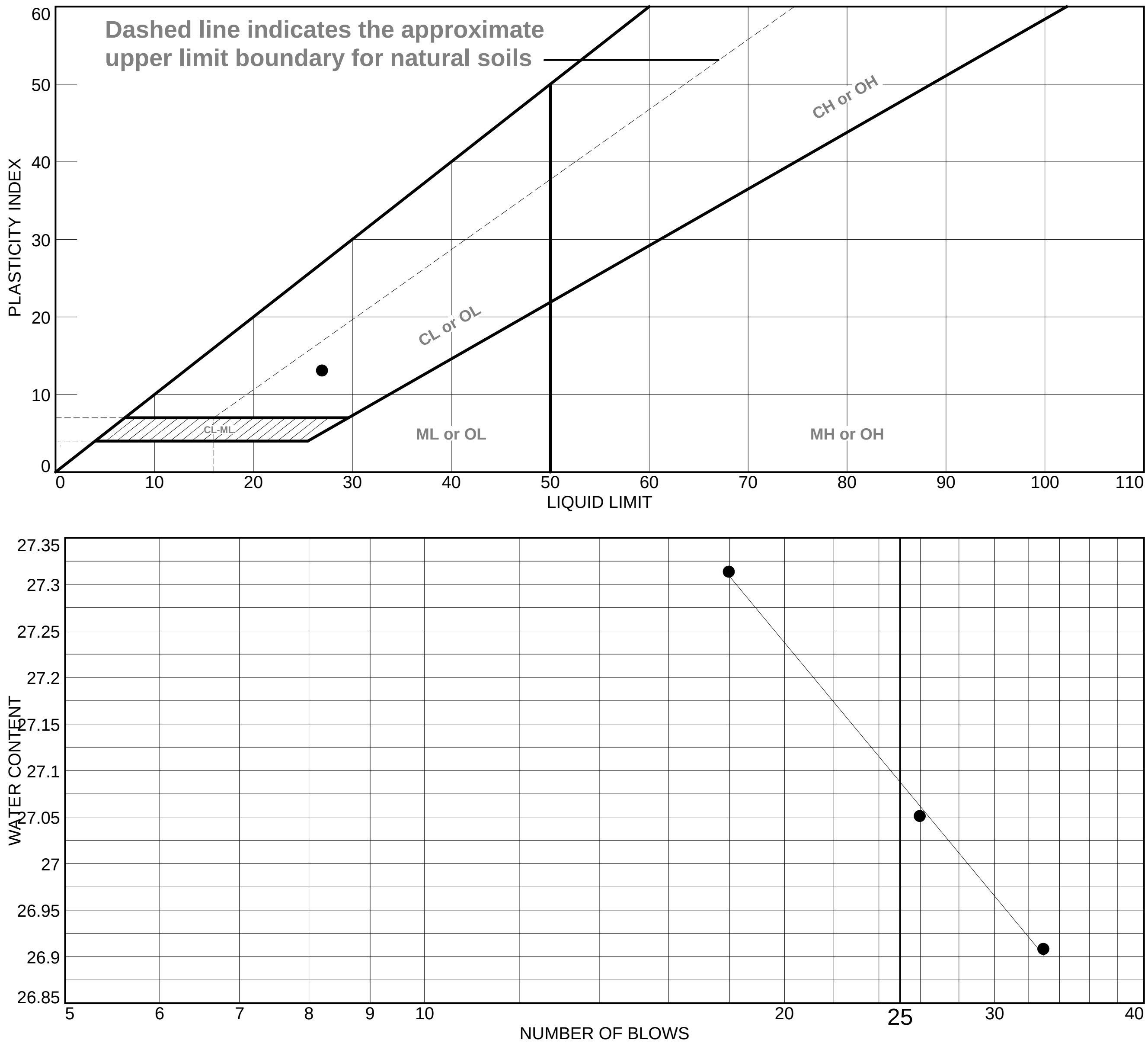
Terracon, Inc.

Cincinnati, Ohio

Figure 7321-7322

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN-GRAY SILT AND CLAY	27	14	13	88.5	76.1	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-6 **Depth:** 8.5-10'

Remarks:

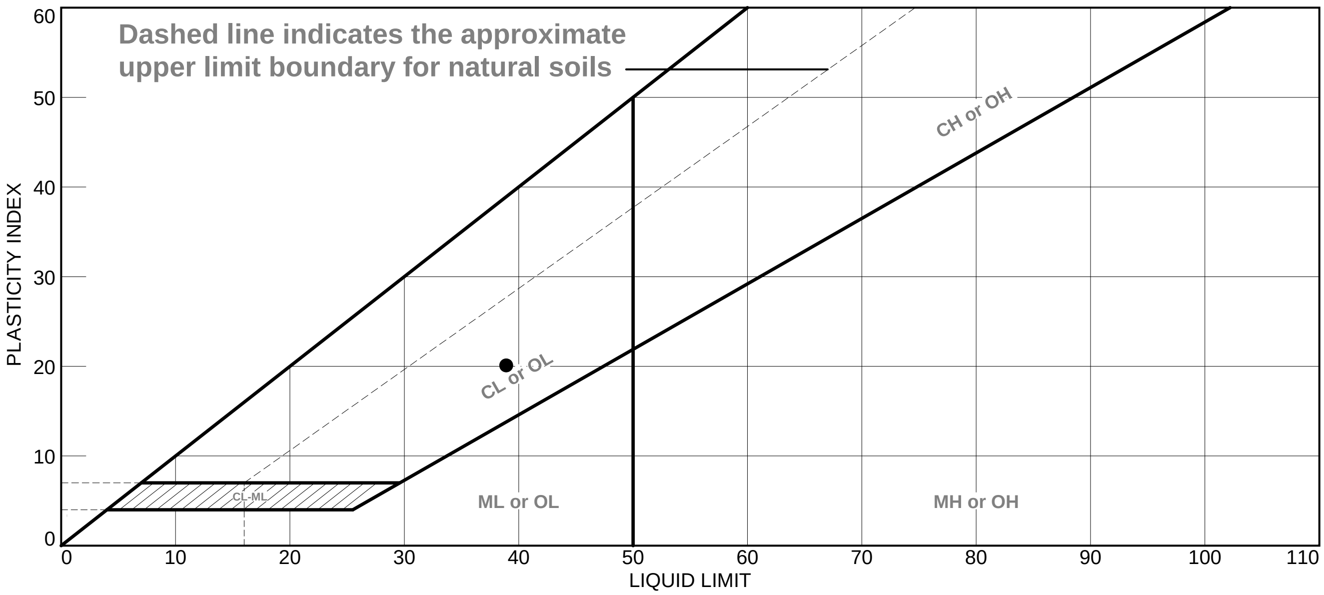
Terracon, Inc.

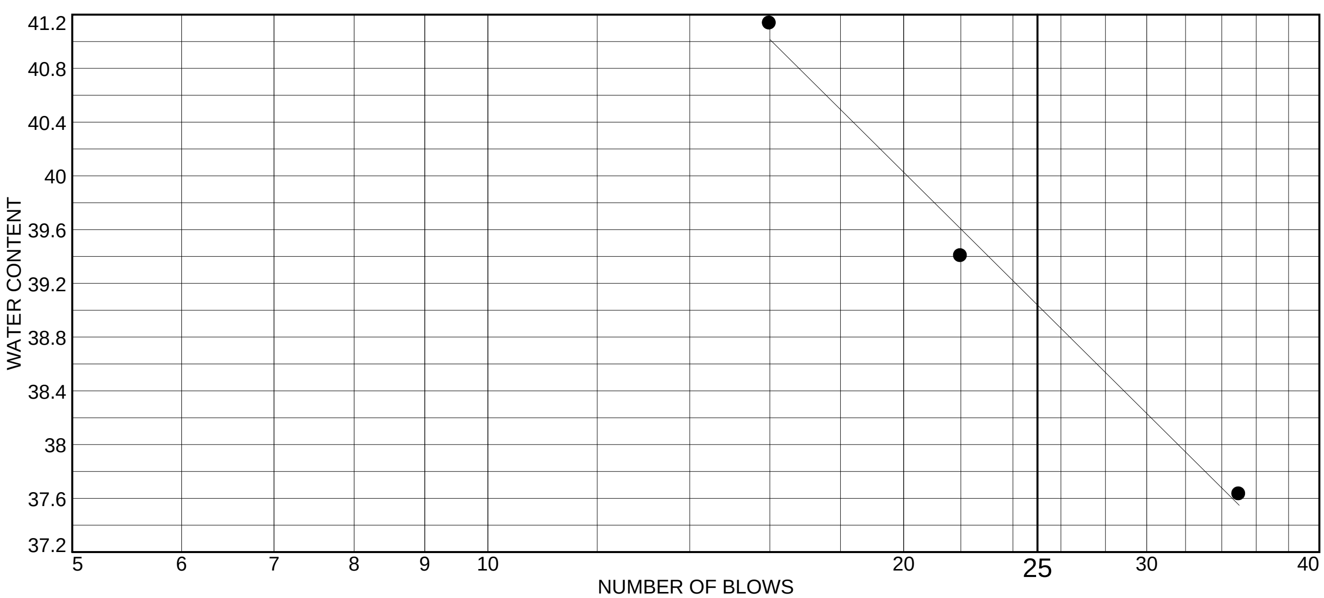
Cincinnati, Ohio

Figure 7330

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY SILT AND CLAY	39	19	20	90.1	82.9	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-6 **Depth:** 13.5-15'

Remarks:

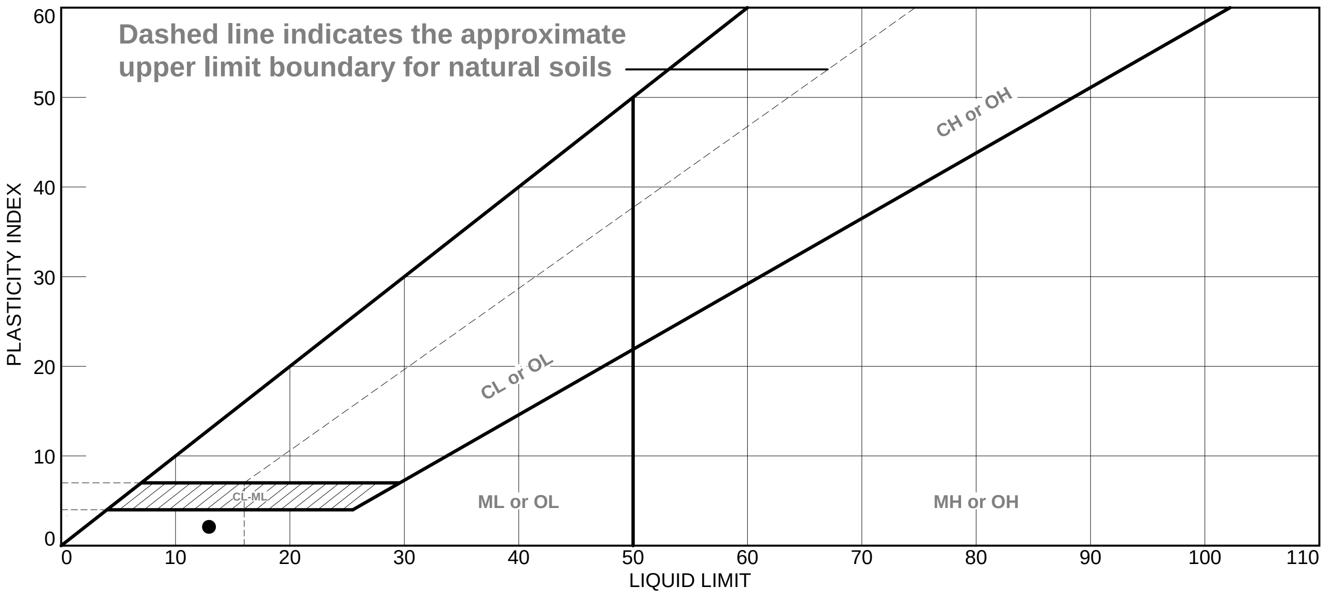
Terracon, Inc.

Cincinnati, Ohio

Figure 7331

Tested By: DJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY GRAVEL AND/OR STONE FRAGS. WITH SAND	13	11	2	19.7	10.7	SP-SM

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-6 **Depth:** 16-17.2'

Remarks:

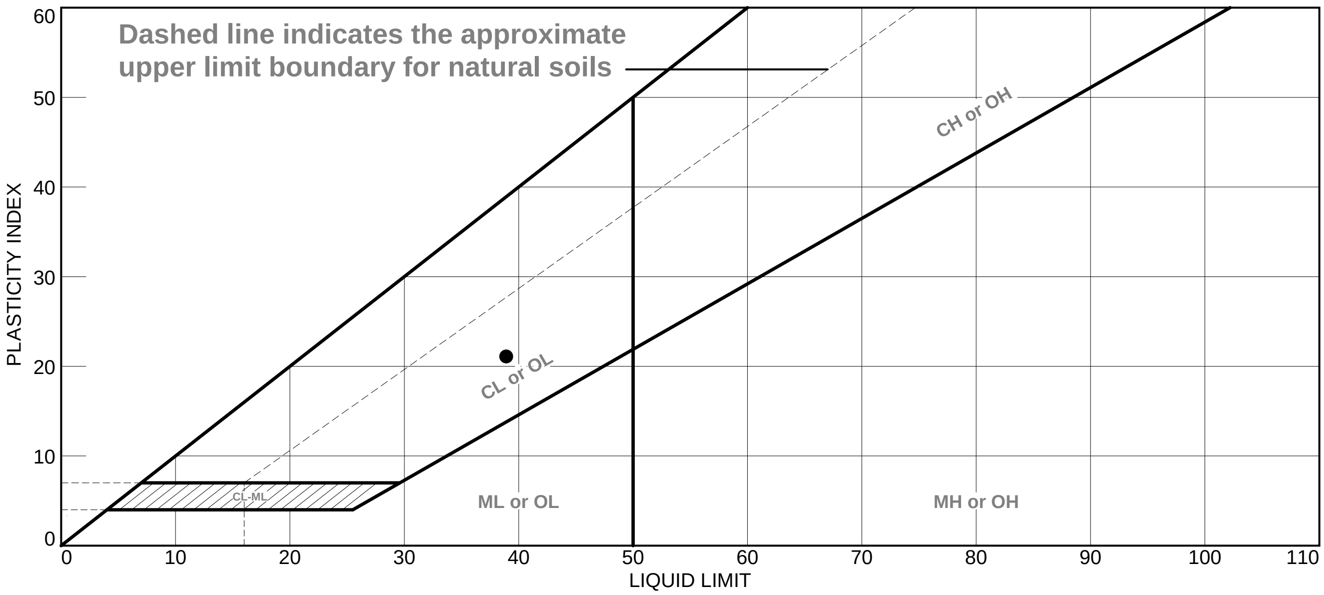
Terracon, Inc.

Cincinnati, Ohio

Figure 7332

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILTY CLAY	39	18	21	92.7	80.0	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-6 **Depth:** 3.5-5 & 6-7.5'

Sample Number: C9

Remarks:

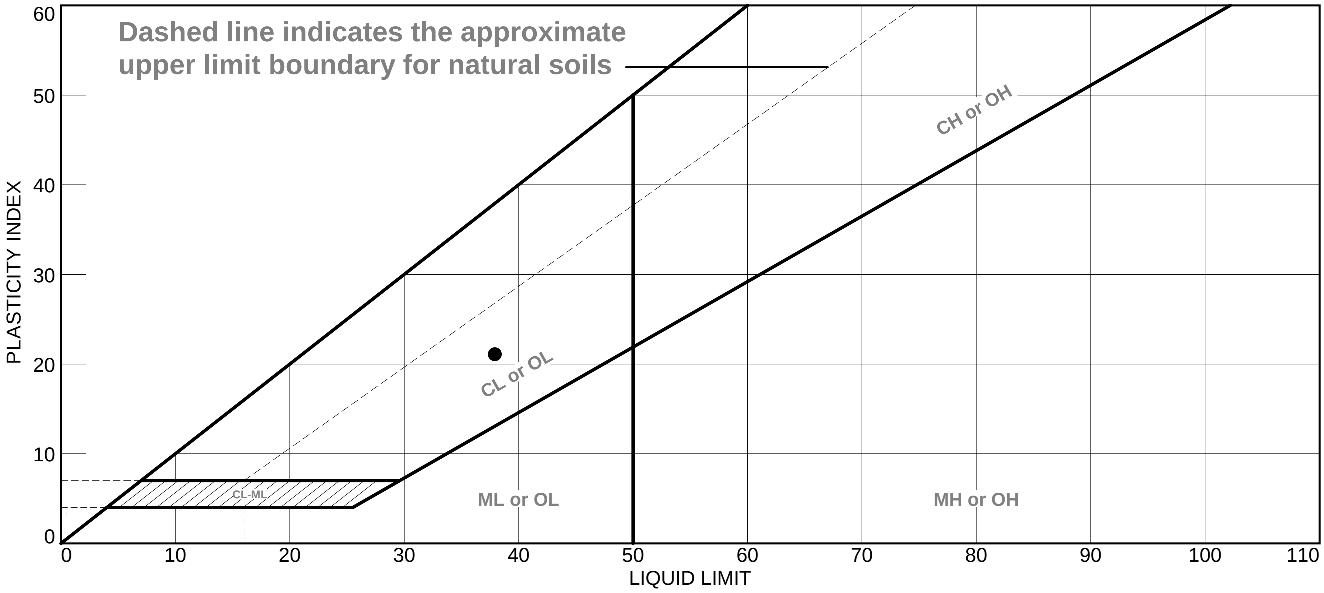
Terracon, Inc.

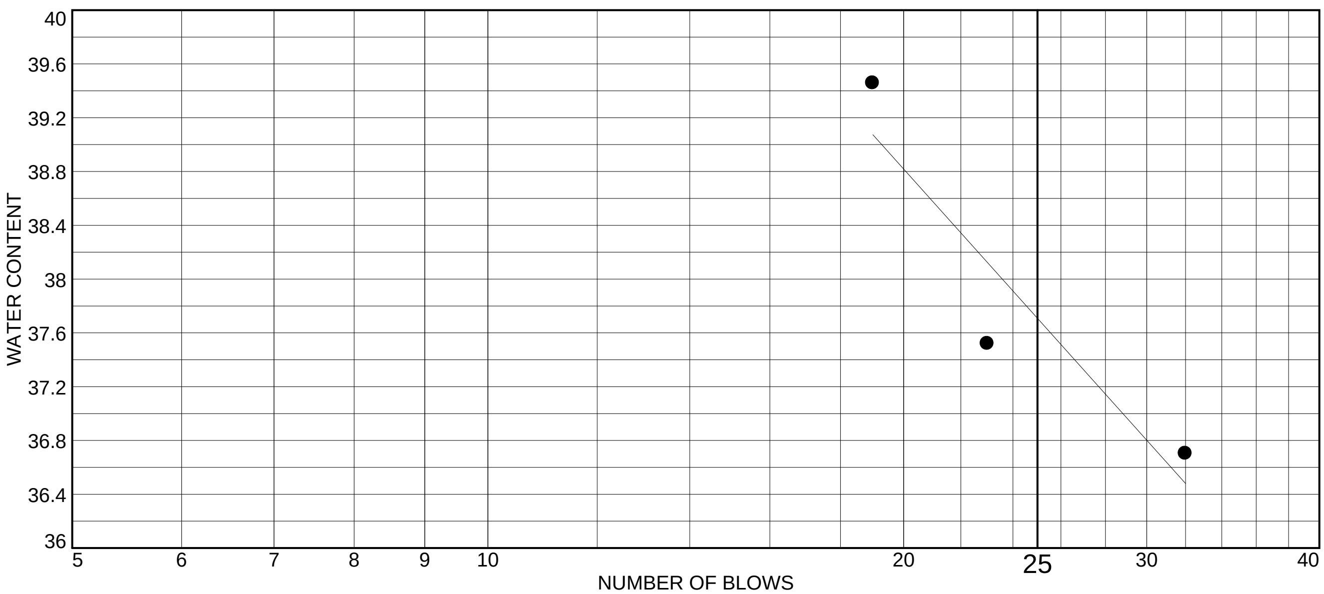
Cincinnati, Ohio

Figure 7328-7329

Tested By: VD **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILTY CLAY	38	17	21	80.4	66.5	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-7 **Depth:** 1-2.5 & 3.5-5'

Sample Number: C10

Remarks:

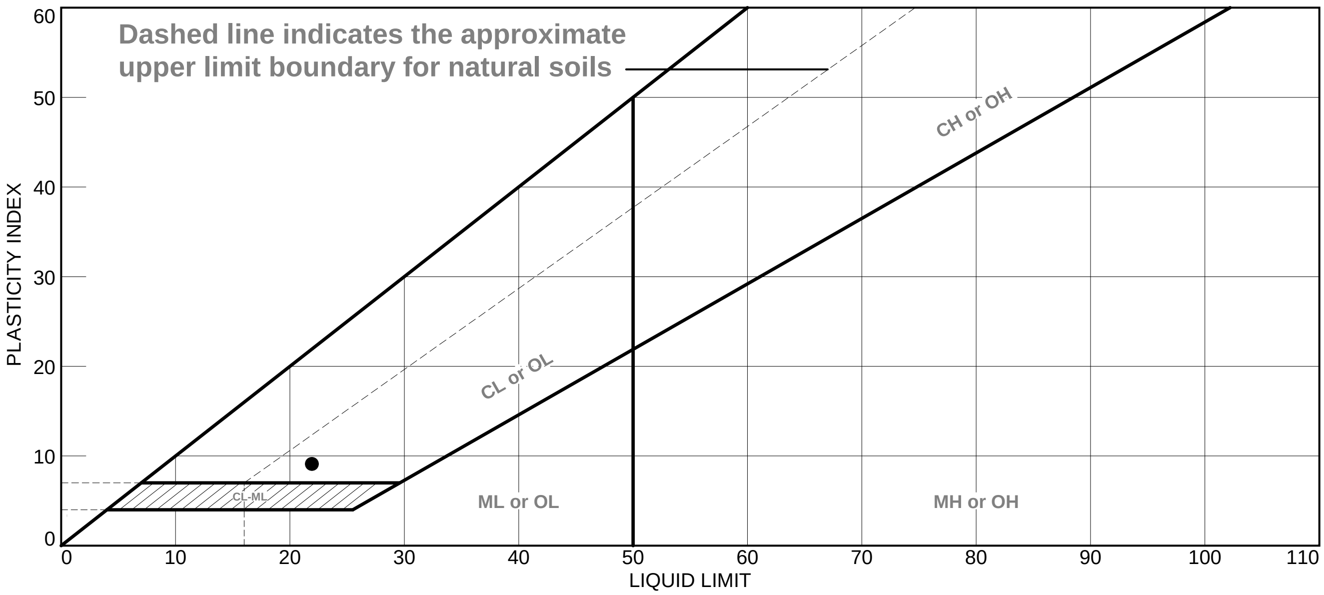
Terracon, Inc.

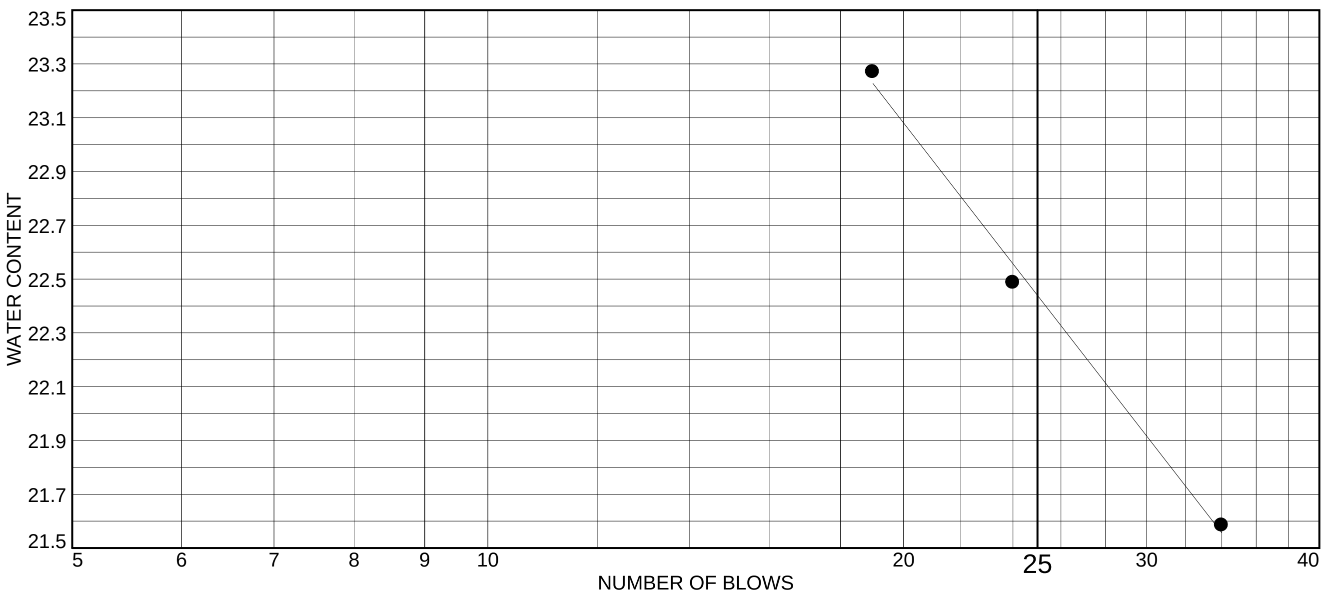
Cincinnati, Ohio

Figure 7333-7334

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY SANDY SILT	22	13	9	84.2	67.9	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-8 **Depth:** 11-11.8'

Remarks:

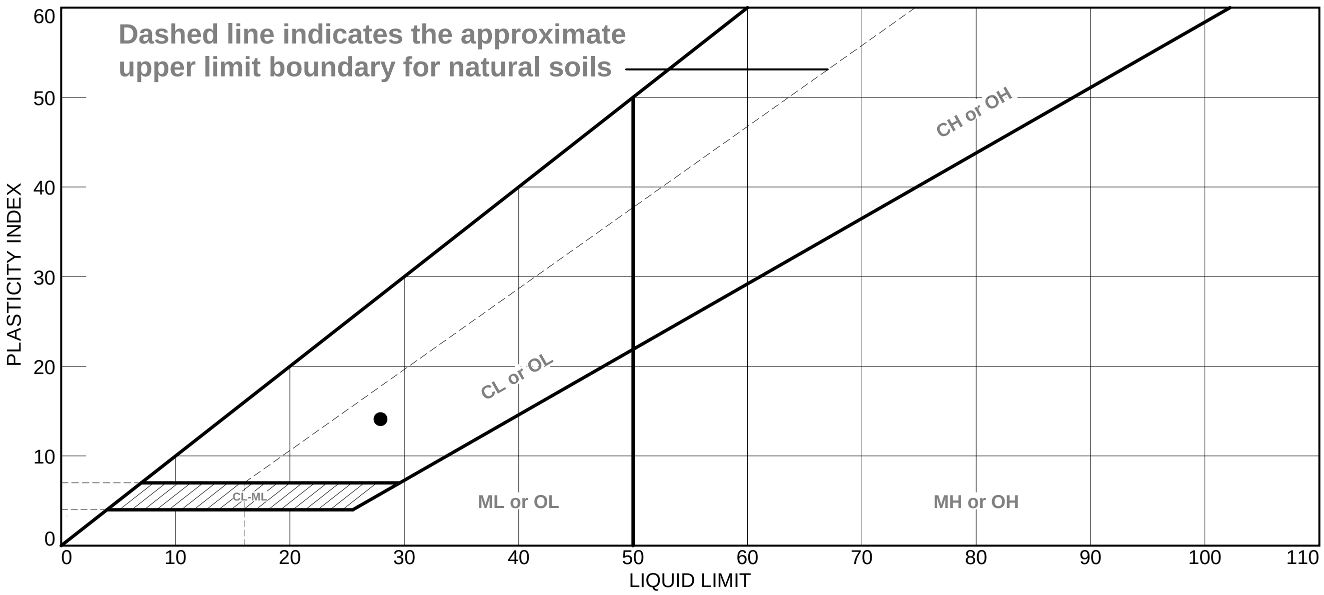
Terracon, Inc.

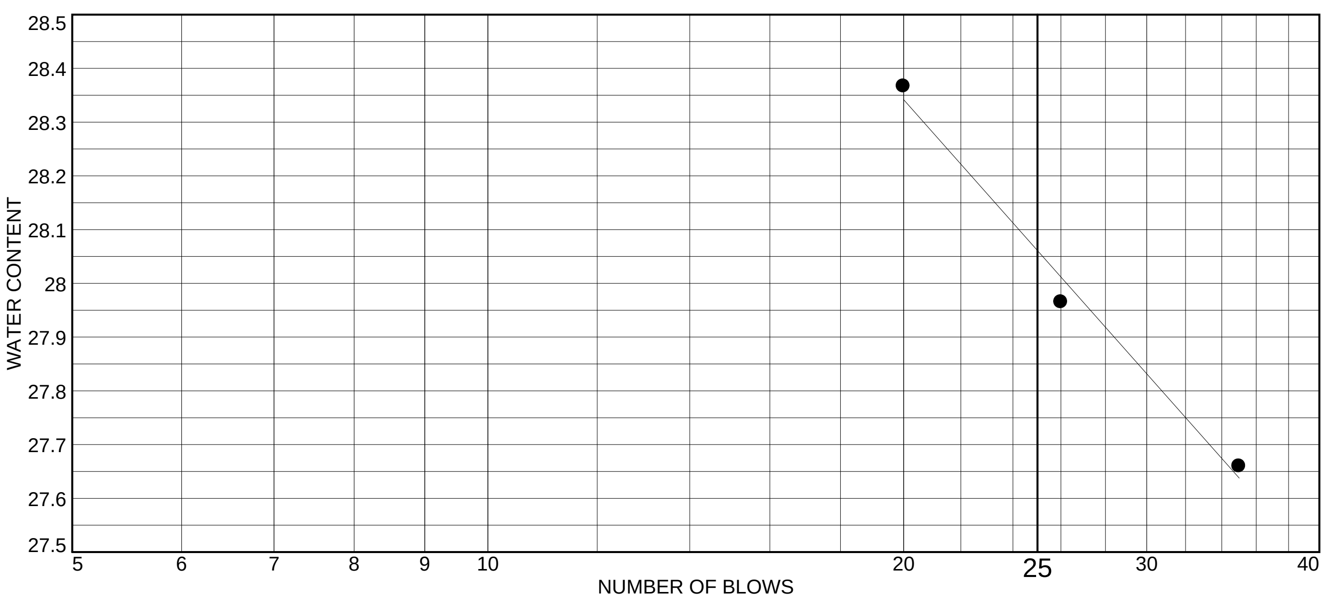
Cincinnati, Ohio

Figure 7340

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN-GRAY SILT AND CLAY	28	14	14	76.2	62.5	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-8 **Depth:** 1-2.5 & 3.5-5'

Sample Number: C11

Remarks:

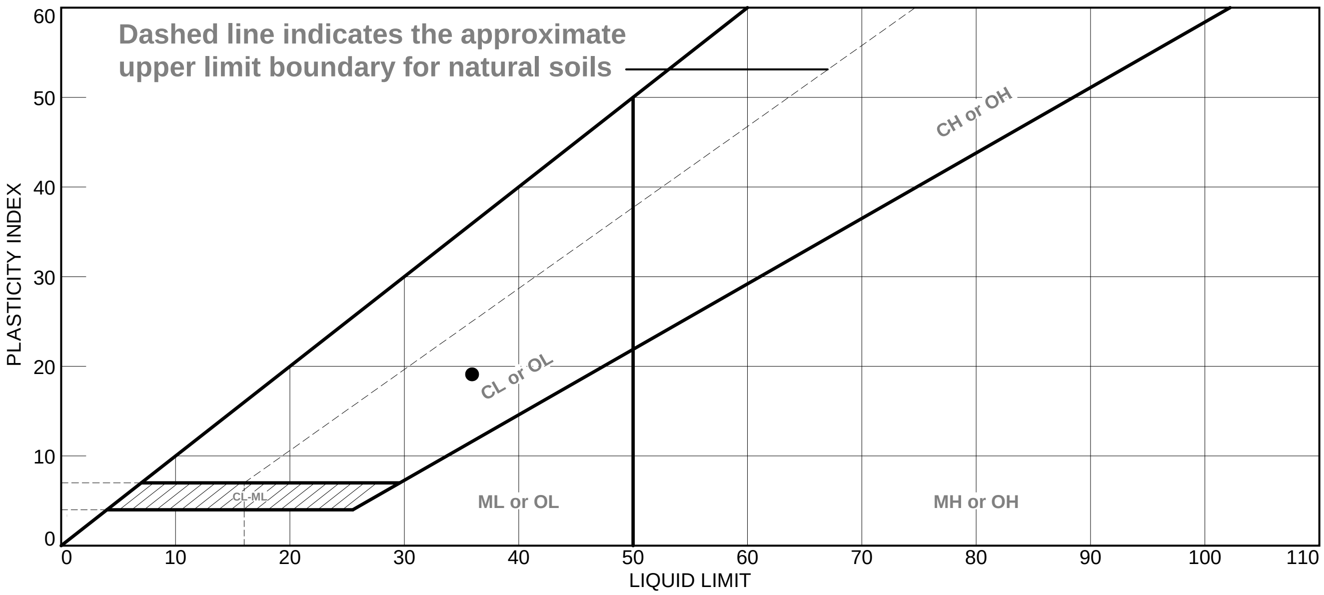
Terracon, Inc.

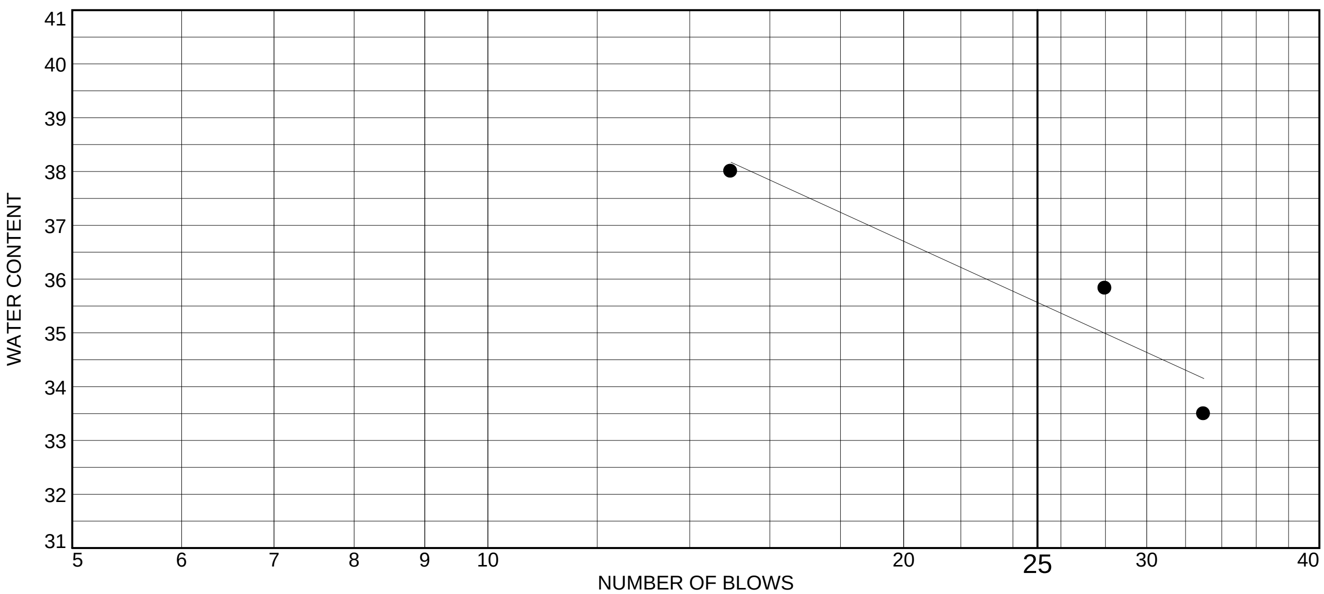
Cincinnati, Ohio

Figure 7337-7338

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILTY CLAY	36	17	19	82.2	69.3	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-9 **Depth:** 1-2.5 & 3.5-5'

Sample Number: C12

Remarks:

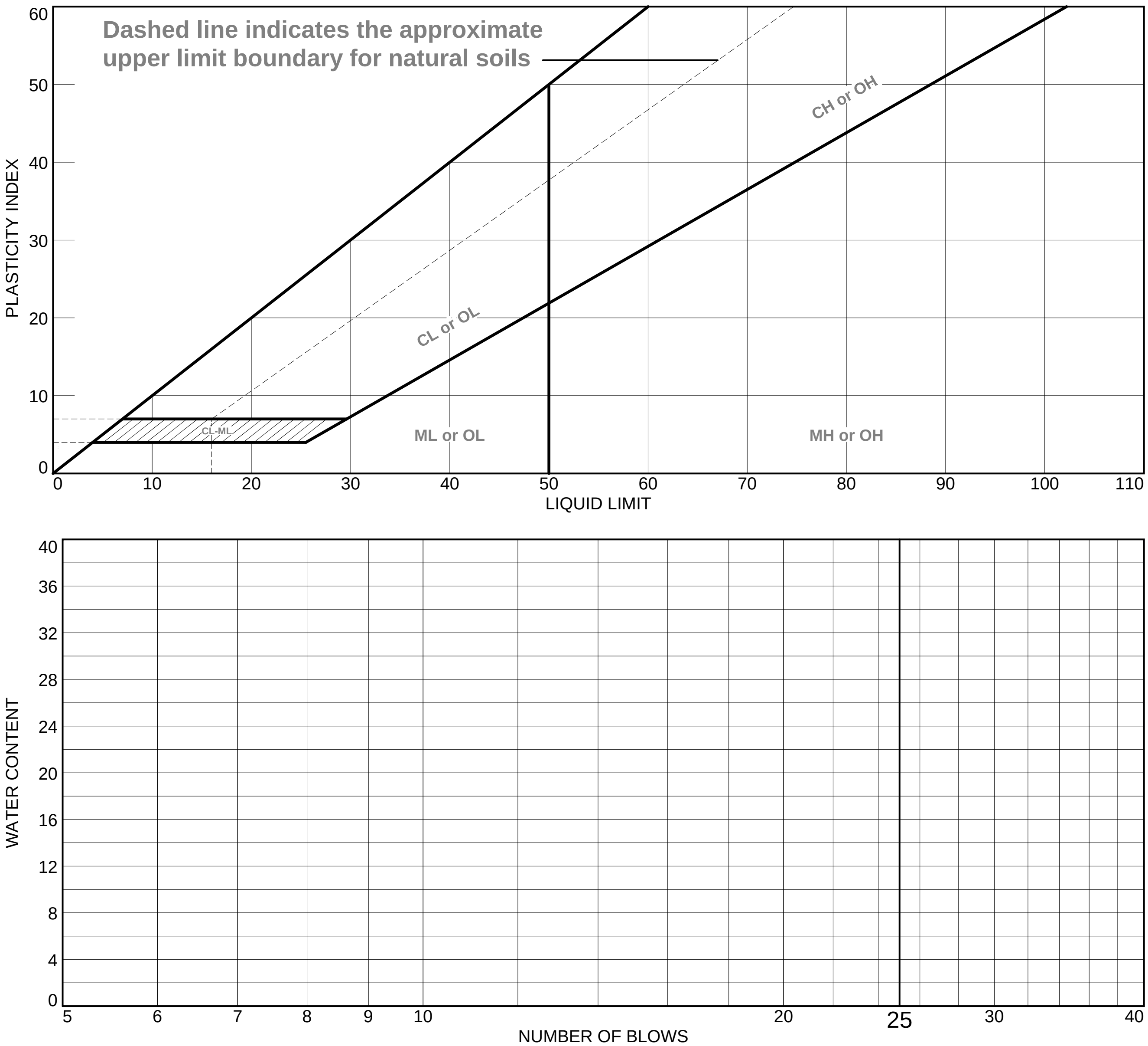
Terracon, Inc.

Cincinnati, Ohio

Figure 7341-7342

Tested By: LP **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY GRAVEL AND/OR STONE FRAGS. WITH SAND		NP		14.6	4.8	SP

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-10 **Depth:** 23.5-24.8'

Remarks:

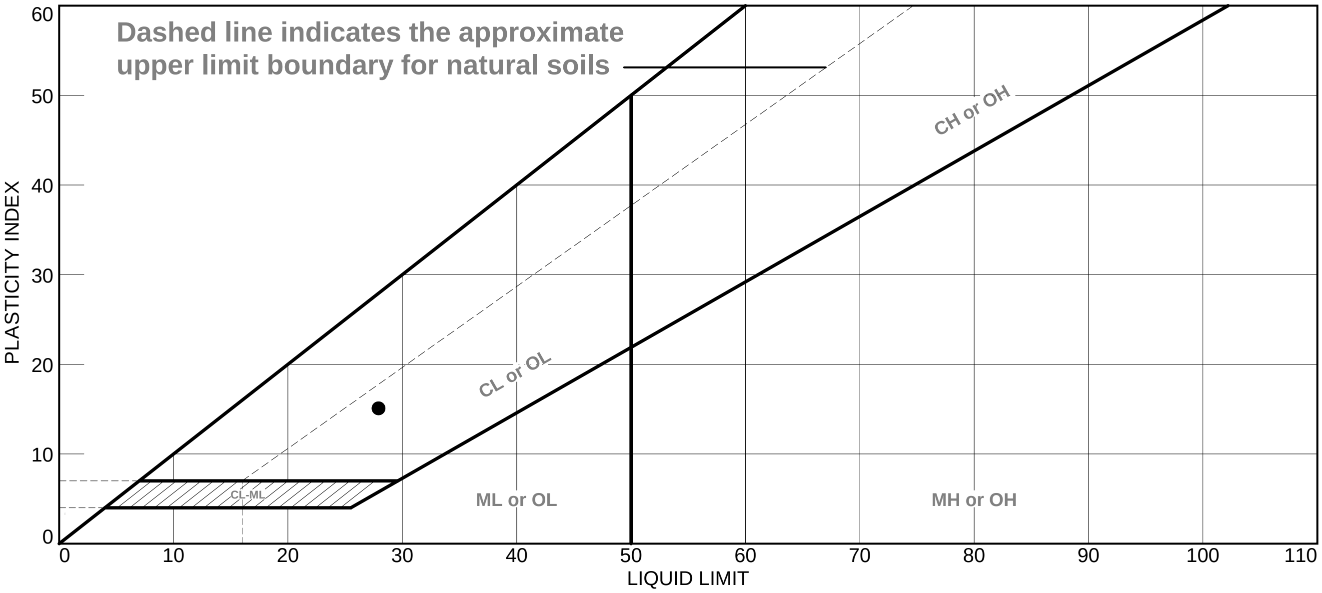
Terracon, Inc.

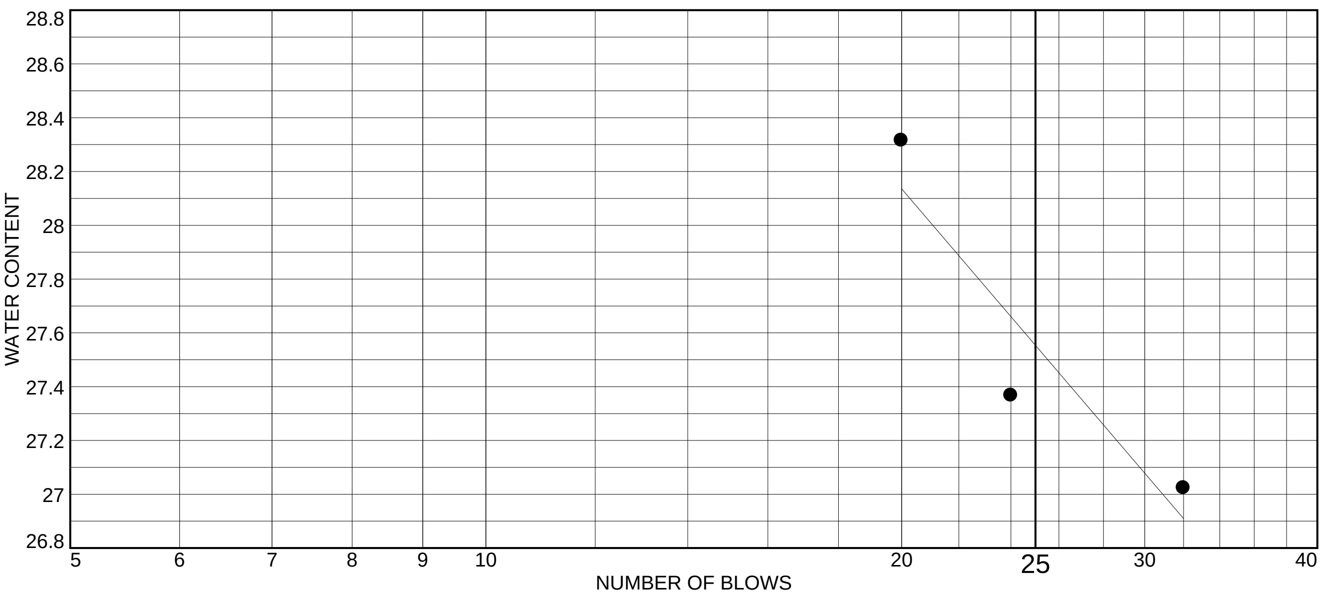
Cincinnati, Ohio

Figure 7355

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILT AND CLAY	28	13	15	87.4	74.5	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-10 **Depth:** 6-7.5 & 8.5-10'

Sample Number: C13

Remarks:

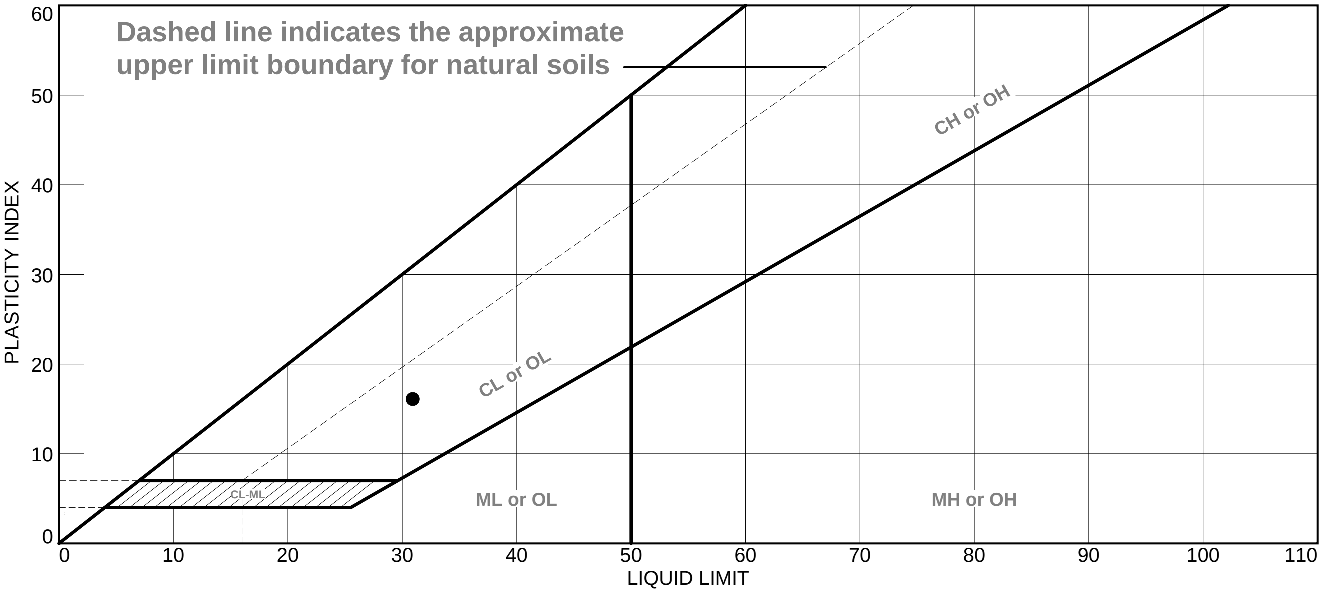
Terracon, Inc.

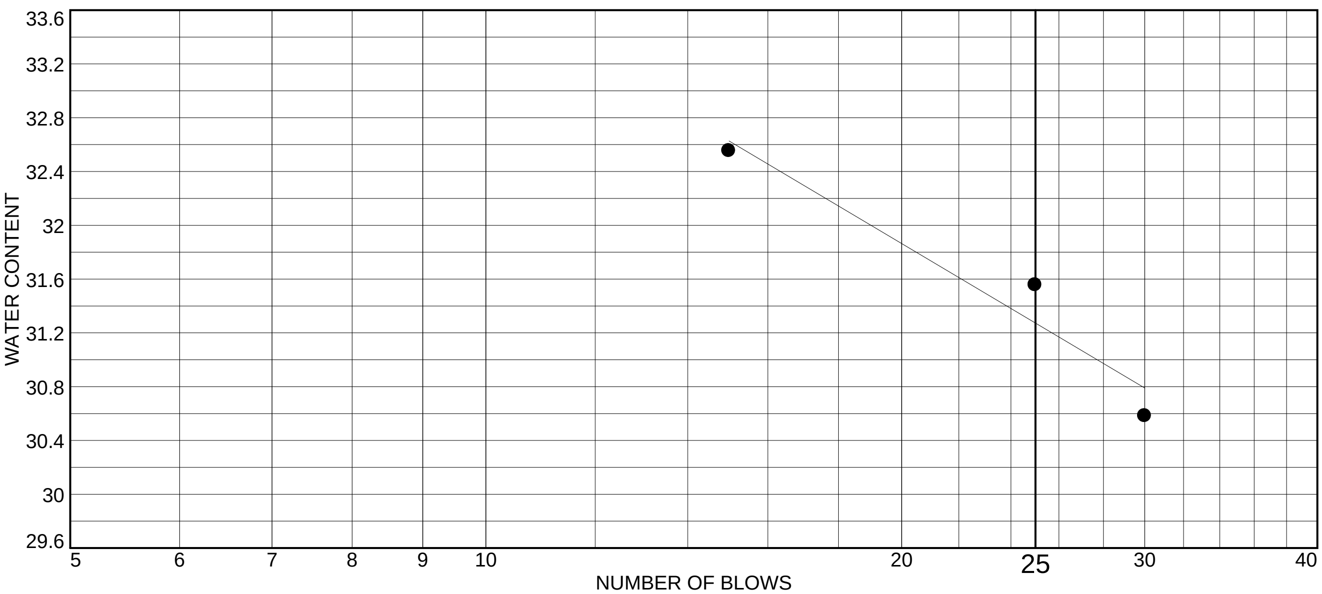
Cincinnati, Ohio

Figure 7348-7349

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY SILTY CLAY	31	15	16	89.2	77.2	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-10 **Depth:** 11-12.5 & 13.5-14'

Sample Number: C14

Remarks:

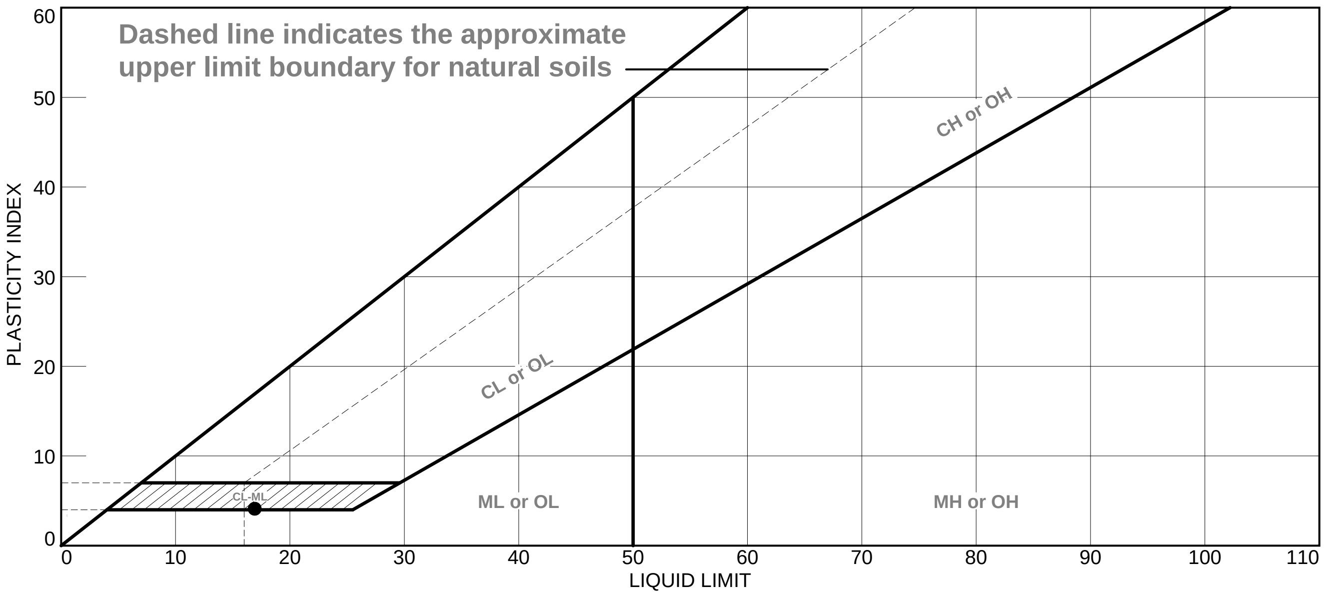
Terracon, Inc.

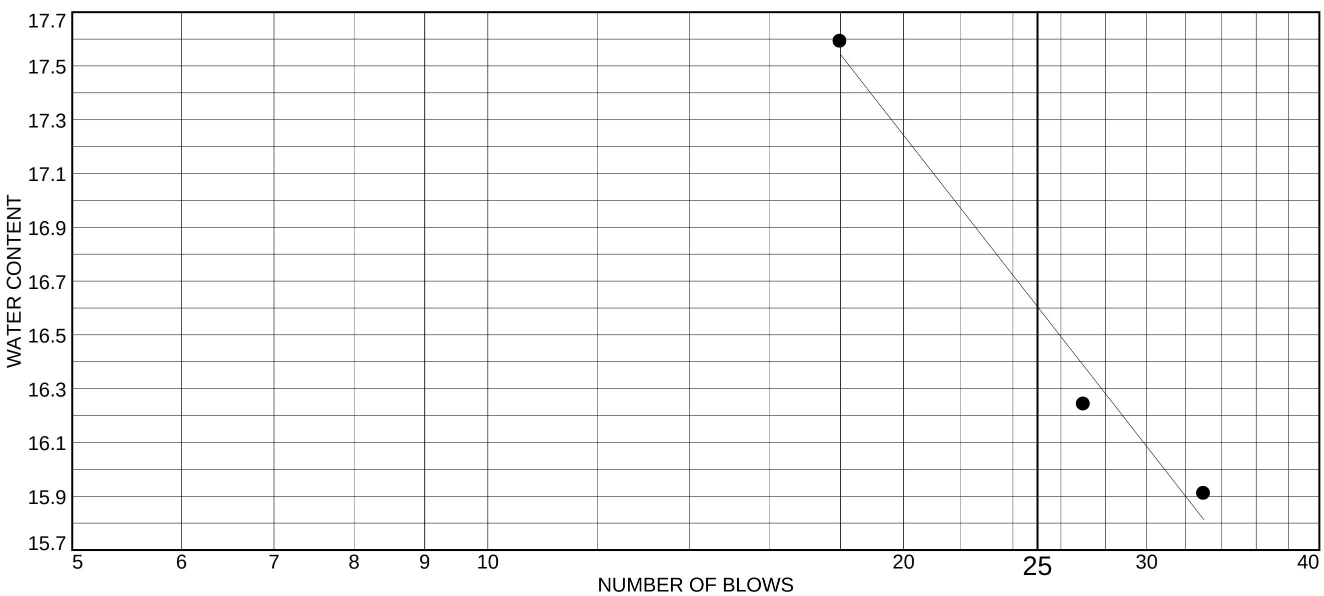
Cincinnati, Ohio

Figure 7350-7351

Tested By: LP **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN GRAVEL AND/OR STONE FRAGS. WITH SAND AND SILT	17	13	4	37.5	27.7	GC-GM

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-10 **Depth:** **

Sample Number: C15

Remarks:

●** Depth: 16-17.5, 17.5-19 & 19-20.5'

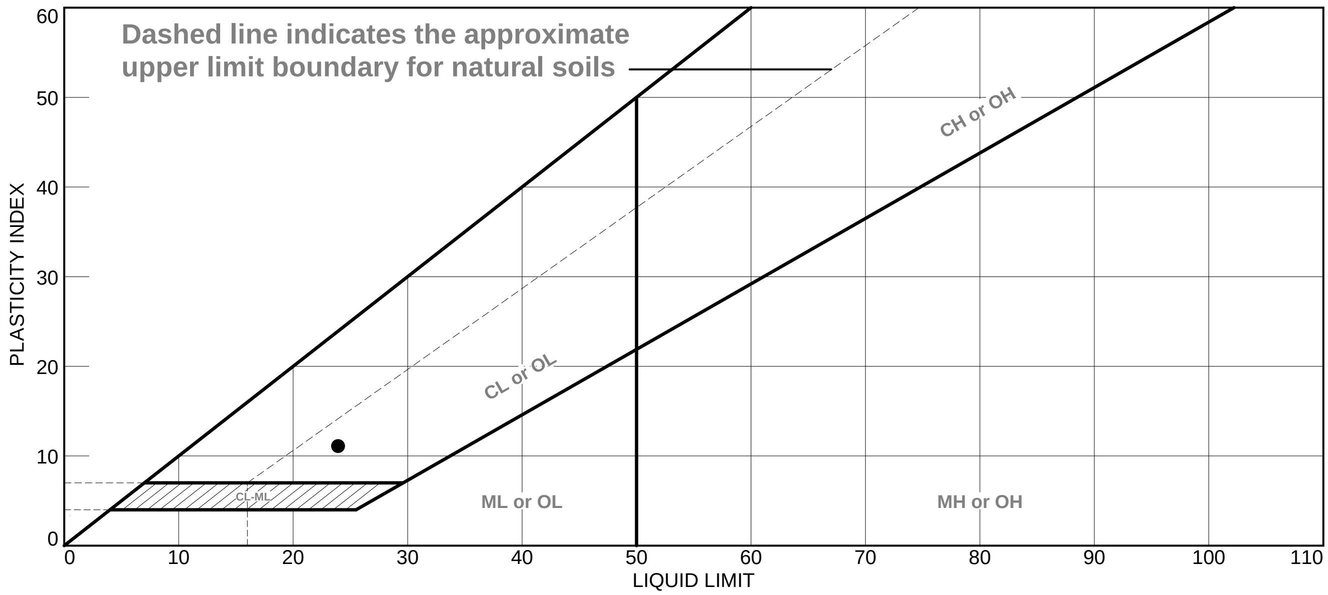
Terracon, Inc.

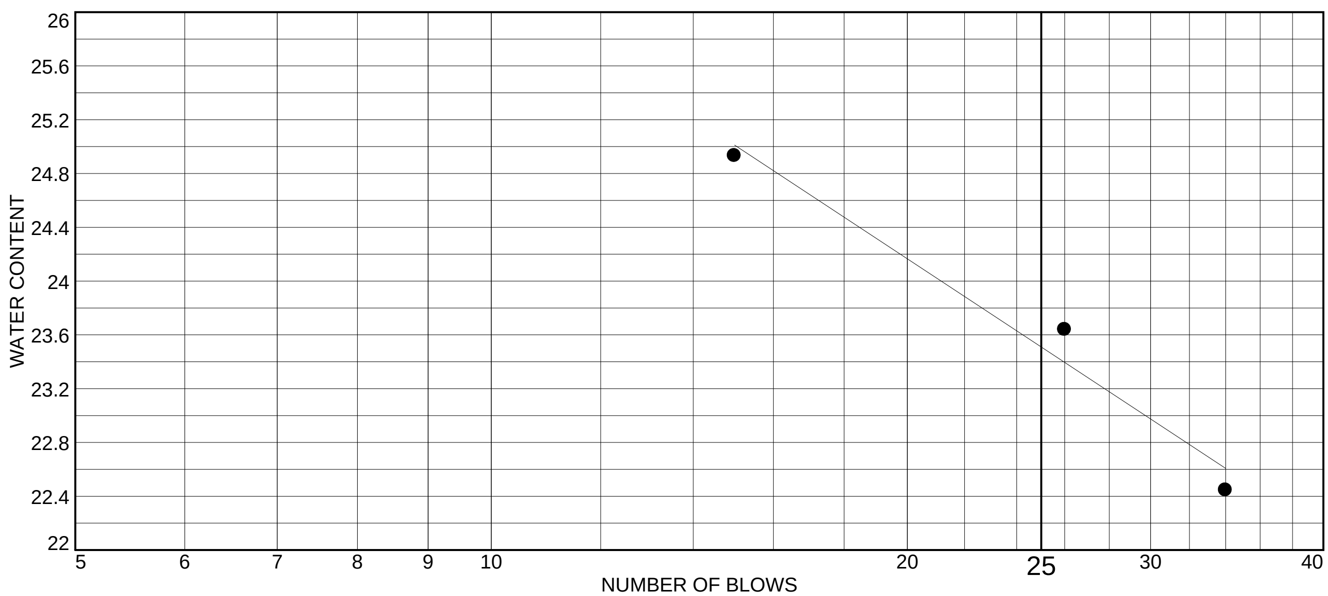
Cincinnati, Ohio

Figure 7352,-7354

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY SILT AND CLAY	24	13	11	81.2	65.6	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-11 **Depth:** 12.5-14'

Remarks:

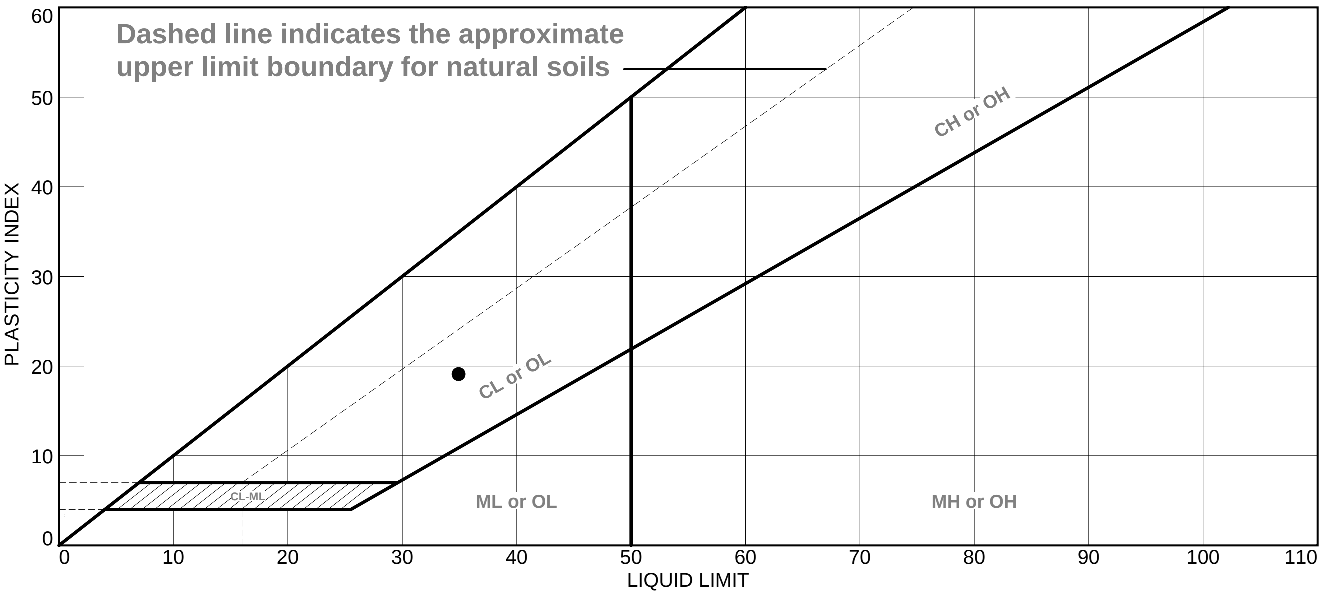
Terracon, Inc.

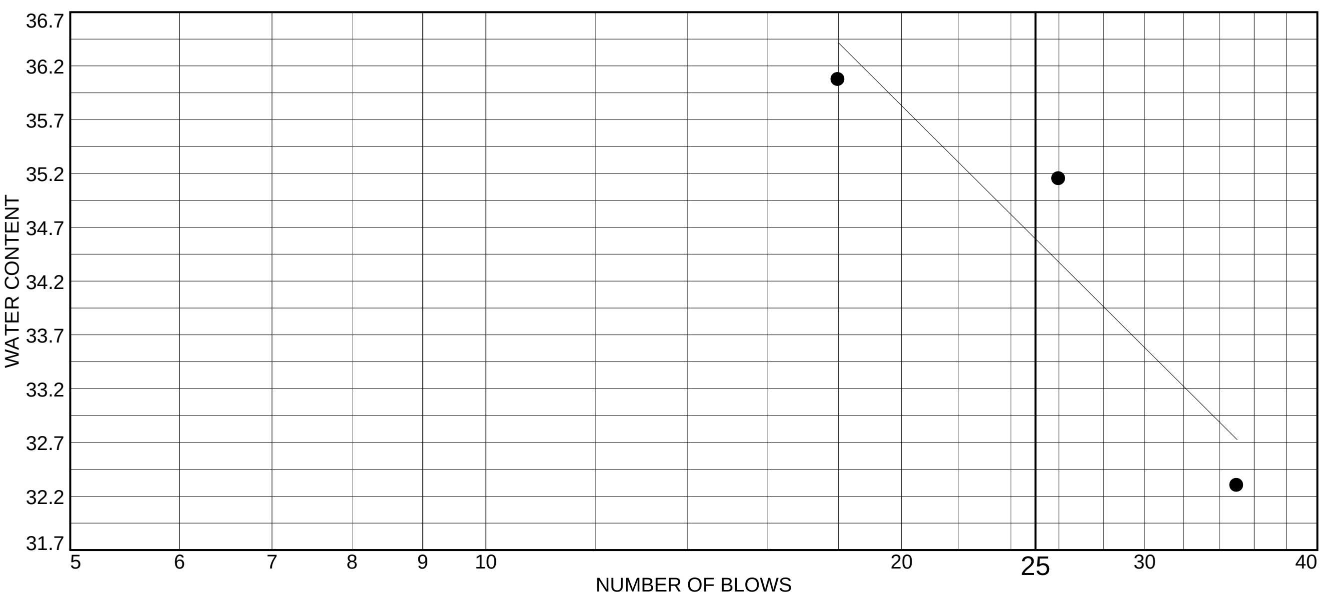
Cincinnati, Ohio

Figure 7363

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILTY CLAY	35	16	19	88.5	59.5	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-11 **Depth:** 1-2.5 & 2.5-4'

Sample Number: C16

Remarks:

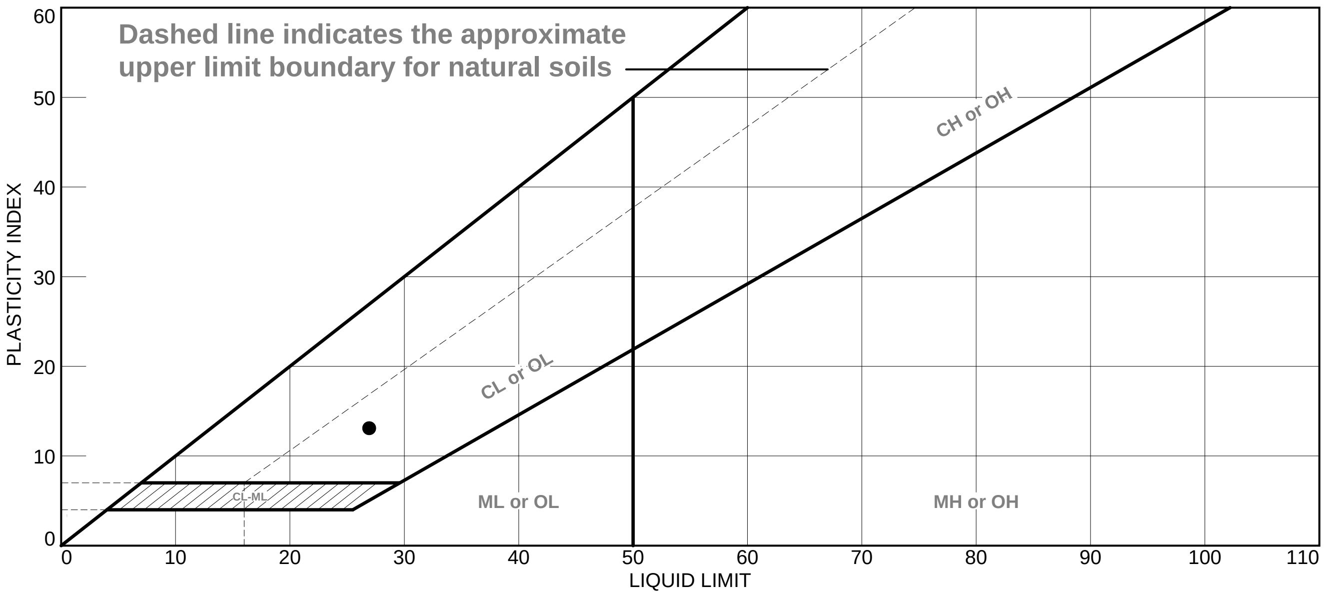
Terracon, Inc.

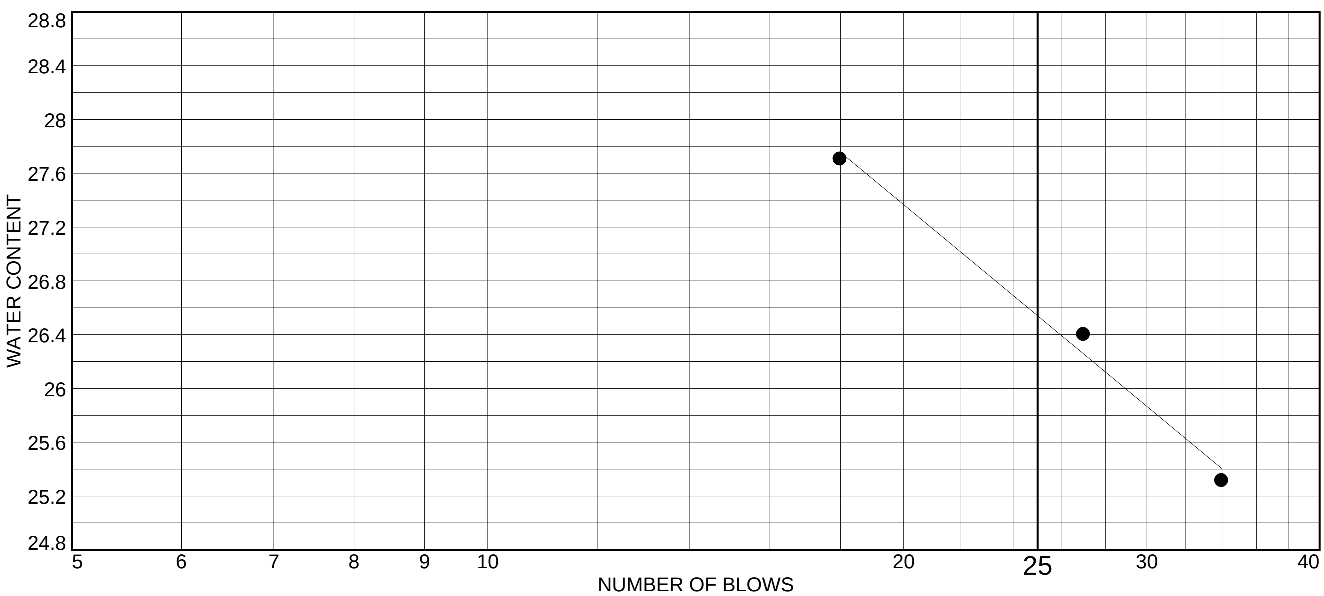
Cincinnati, Ohio

Figure 7356-7357

Tested By: LP **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	BROWN SILT AND CLAY	27	14	13	86.7	72.1	CL

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-11 **Depth:** 5.5-7 & 7-8.5'

Sample Number: C17

Remarks:

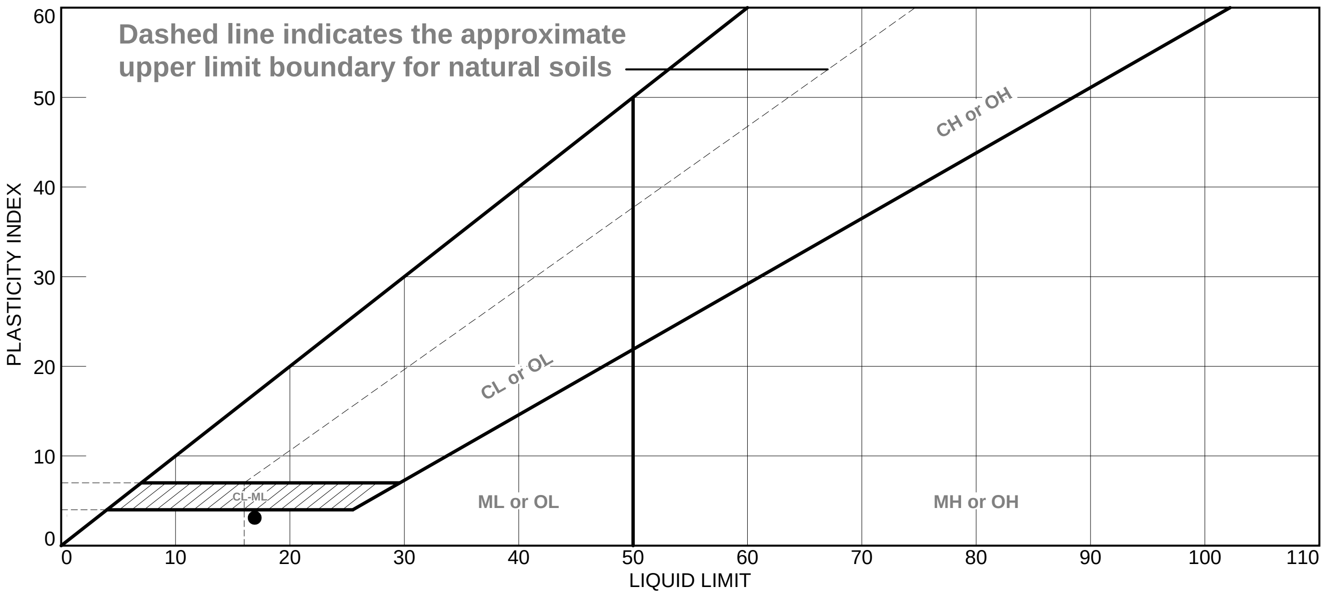
Terracon, Inc.

Cincinnati, Ohio

Figure 7359-7360

Tested By: JJ **Checked By:** GS

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY GRAVEL AND/OR STONE FRAGS. WITH SAND	17	14	3	15.8	8.6	SW-SM

Project No. N1165419 **Client:** STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1

PROJECT NO. 174316204

Source of Sample: B-11 **Depth:** 15-16.5 & 17.5-19.8'

Sample Number: C18

Remarks:

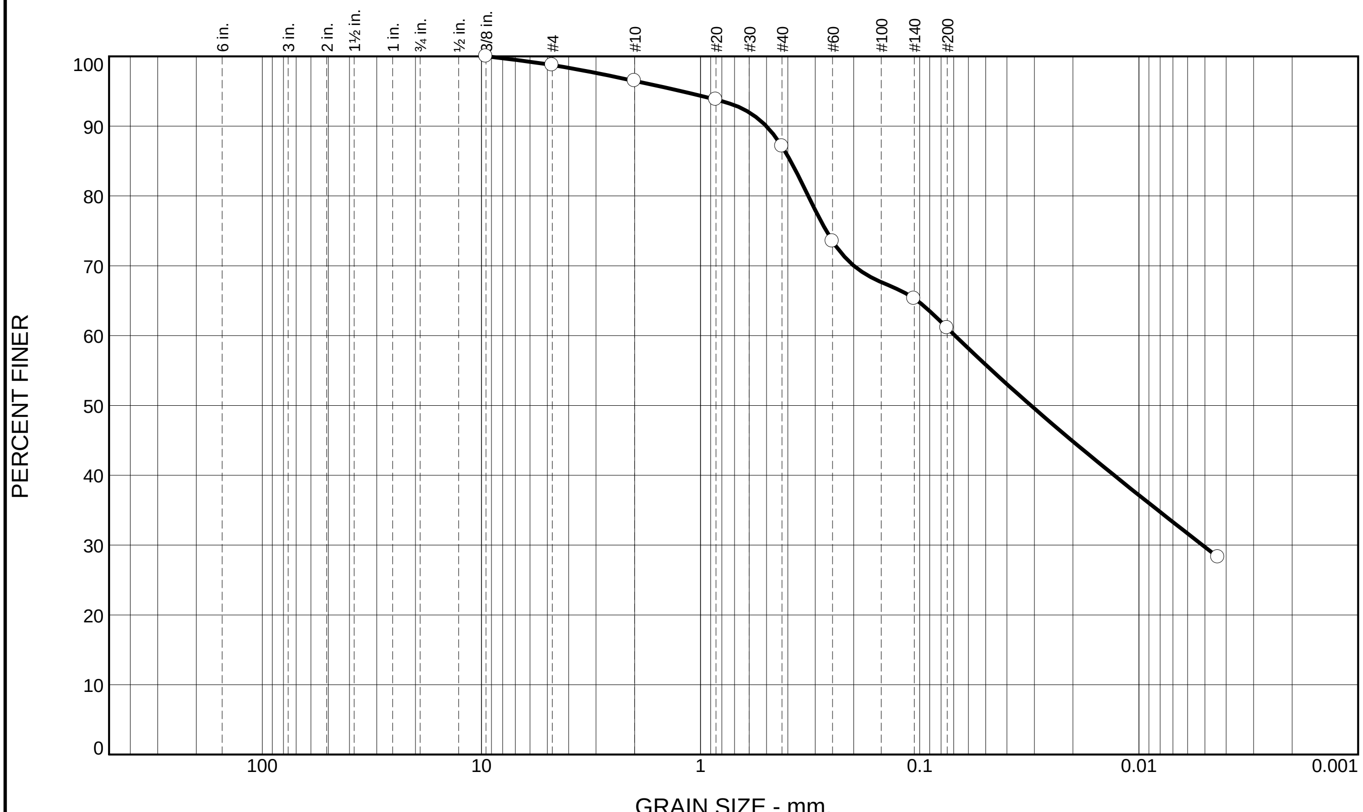
Terracon, Inc.

Cincinnati, Ohio

Figure 7364-7365

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	1.3	37.6	31.4	29.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	98.7		
#10	96.5		
#20	93.8		
#40	87.1		
#60	73.5		
#140	65.3		
#200	61.1		

* (no specification provided)

Material Description

BROWN SILT AND CLAY

Atterberg Limits

PL= 15 LL= 27 PI= 12

Coefficients

D_{90}= 0.5013 D_{85}= 0.3884 D_{60}= 0.0690
D_{50}= 0.0311 D_{30}= 0.0051 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(4)

Remarks

Source of Sample: B-1 **Depth:** 4.5-6'

Date: 10-27-16

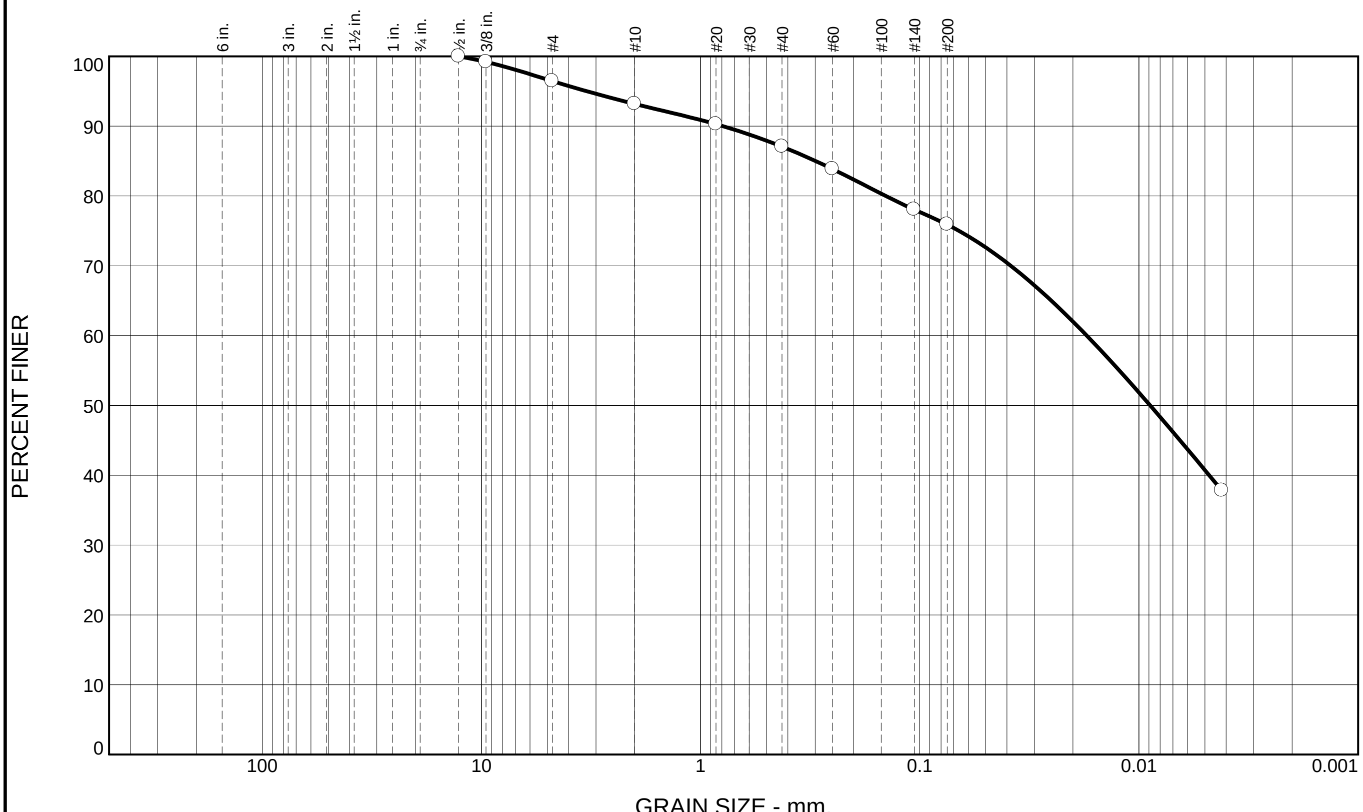
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7286

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	3.5	20.6	35.2	40.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.2		
#4	96.5		
#10	93.2		
#20	90.3		
#40	87.1		
#60	83.9		
#140	78.0		
#200	75.9		

* (no specification provided)

Material Description

BROWN SILT AND CLAY

Atterberg Limits

PL= 14 LL= 26 PI= 12

Coefficients

D_{90}= 0.7924 D_{85}= 0.2986 D_{60}= 0.0173
D_{50}= 0.0089 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(7)

Remarks

Source of Sample: B-1 **Depth:** 10-11.5'

Date: 10-27-16

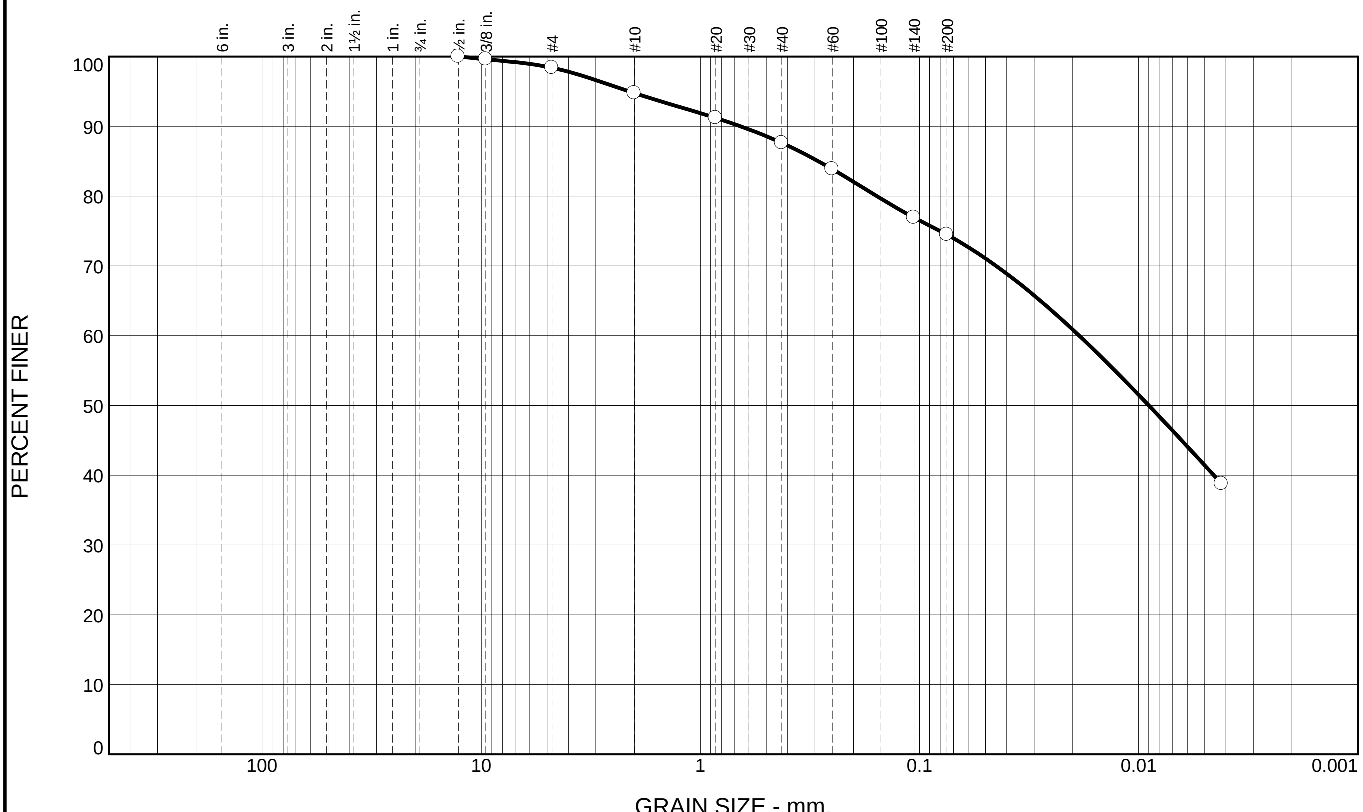
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7289

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	1.6	23.9	33.1	41.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.6		
#4	98.4		
#10	94.8		
#20	91.2		
#40	87.6		
#60	83.9		
#140	76.9		
#200	74.5		

* (no specification provided)

Material Description

GRAY SANDY SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.6560 D_{85}= 0.2897 D_{60}= 0.0187
D_{50}= 0.0090 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO= ODOT: A-4a

Remarks

Source of Sample: B-1 **Depth:** 11.5-13'

Date: 10-26-16

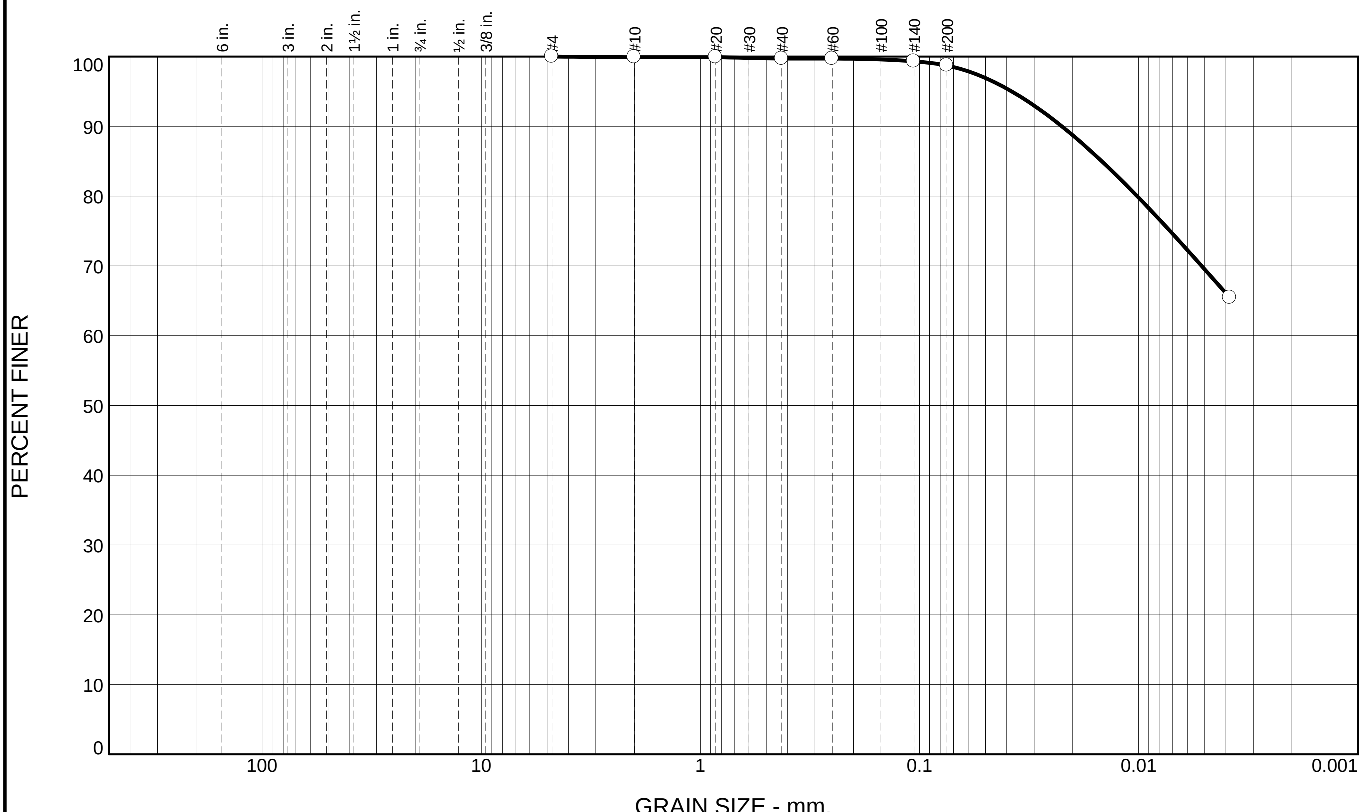
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7290

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	0.0	1.3	29.2	69.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.9		
#20	99.9		
#40	99.7		
#60	99.7		
#140	99.3		
#200	98.7		

* (no specification provided)

Material Description

GRAY SILTY CLAY

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0224 D_{85}= 0.0147 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO= ODOT: A-6b(0)

Remarks

Source of Sample: B-1 **Depth:** 13-14.5'

Date: 11-1-16

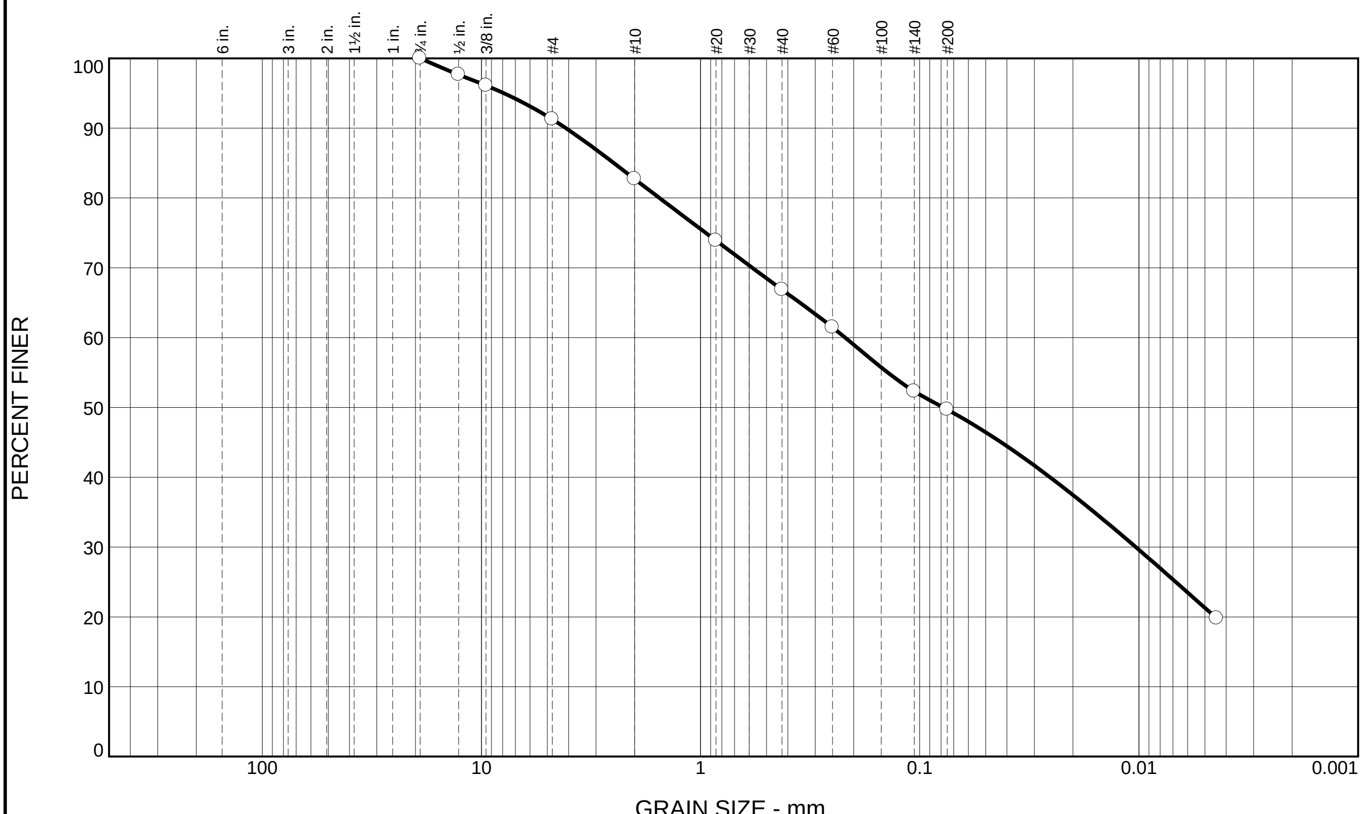
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7291

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	8.7	41.6	28.4	21.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	97.7		
.375	96.1		
#4	91.3		
#10	82.7		
#20	73.9		
#40	66.9		
#60	61.5		
#140	52.3		
#200	49.7		

* (no specification provided)

Material Description

GRAY GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 4.1167 D_{85}= 2.4879 D_{60}= 0.2189
D_{50}= 0.0781 D_{30}= 0.0103 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO= ODOT: A-4a

Remarks

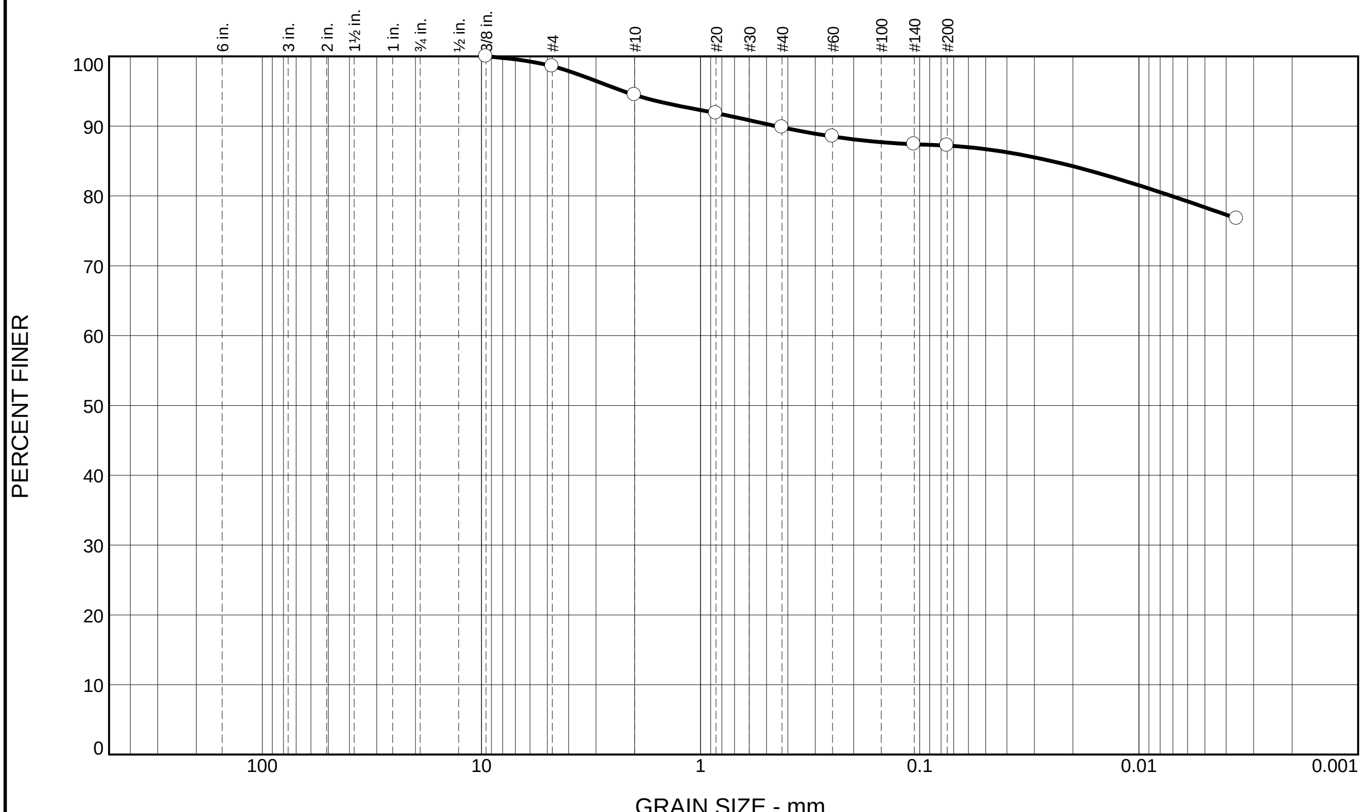
Source of Sample: B-1 **Depth:** 14.5-16'

Date: 10-26-16

Terracon, Inc. Cincinnati, Ohio	**Client:** STANTEC CONSULTING SERVICES, INC **Project:** HANCOCK COUNTY FLOOD DIVERSION Ph. 1 PROJECT NO. 174316204 **Project No:** N1165419 **Figure** 7292

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	1.4	11.4	8.8	78.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	98.6		
#10	94.5		
#20	91.9		
#40	89.8		
#60	88.5		
#140	87.4		
#200	87.2		

* (no specification provided)

Material Description

BROWN CLAY

Atterberg Limits

PL= 24 LL= 56 PI= 32

Coefficients

D_{90}= 0.4524 D_{85}= 0.0251 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(30)

Remarks

Source of Sample: B-1 **Depth:** 1.5-3 & 3-4.5'
Sample Number: C1 **Date:** 10-26-16

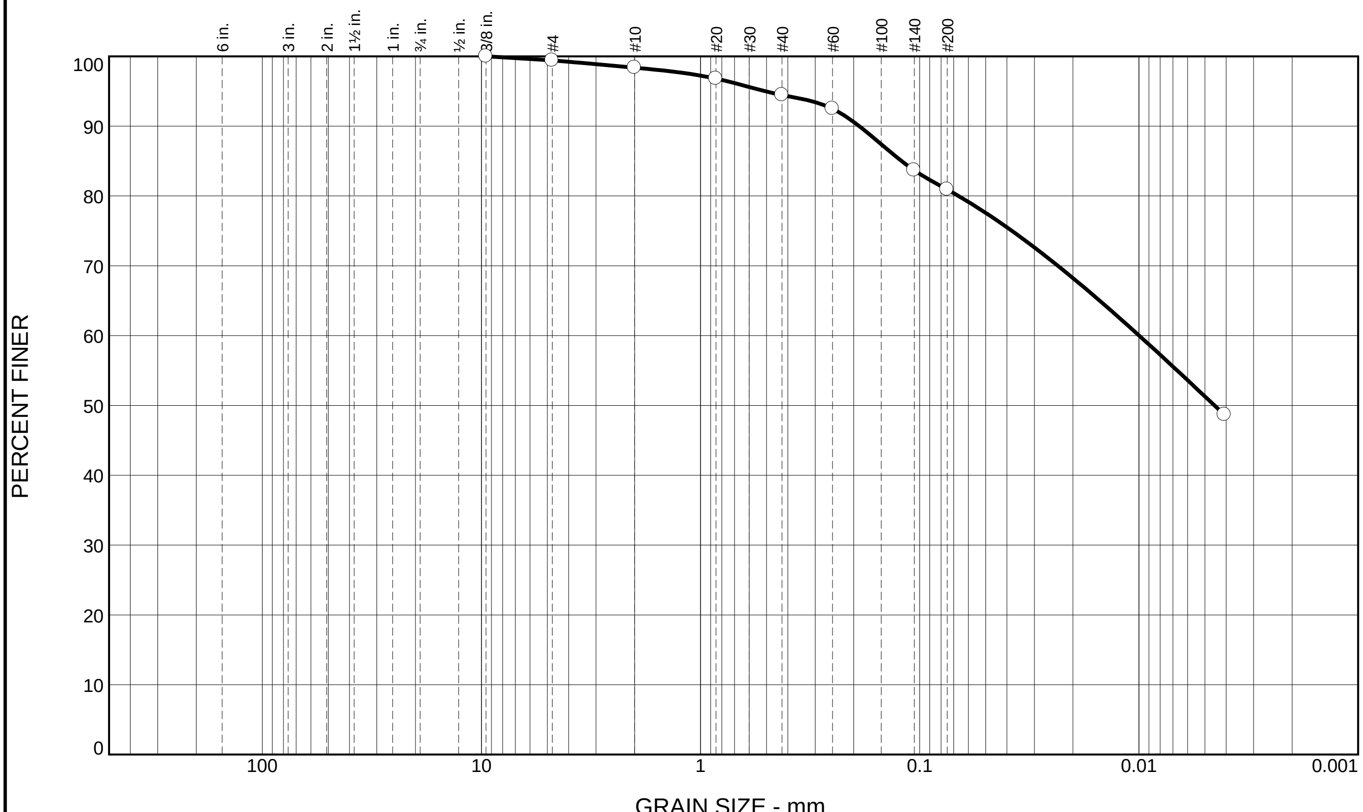
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7284-7285

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	0.6	18.5	29.6	51.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	99.4		
#10	98.4		
#20	96.8		
#40	94.5		
#60	92.5		
#140	83.7		
#200	80.9		

* (no specification provided)

Material Description

BROWN SILY CLAY

Atterberg Limits

PL= 20 LL= 40 PI= 20

Coefficients

D_{90}= 0.1888 D_{85}= 0.1210 D_{60}= 0.0100
D_{50}= 0.0045 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(16)

Remarks

Source of Sample: B-2 **Depth:** 5-6.5'

Date: 10-26-16

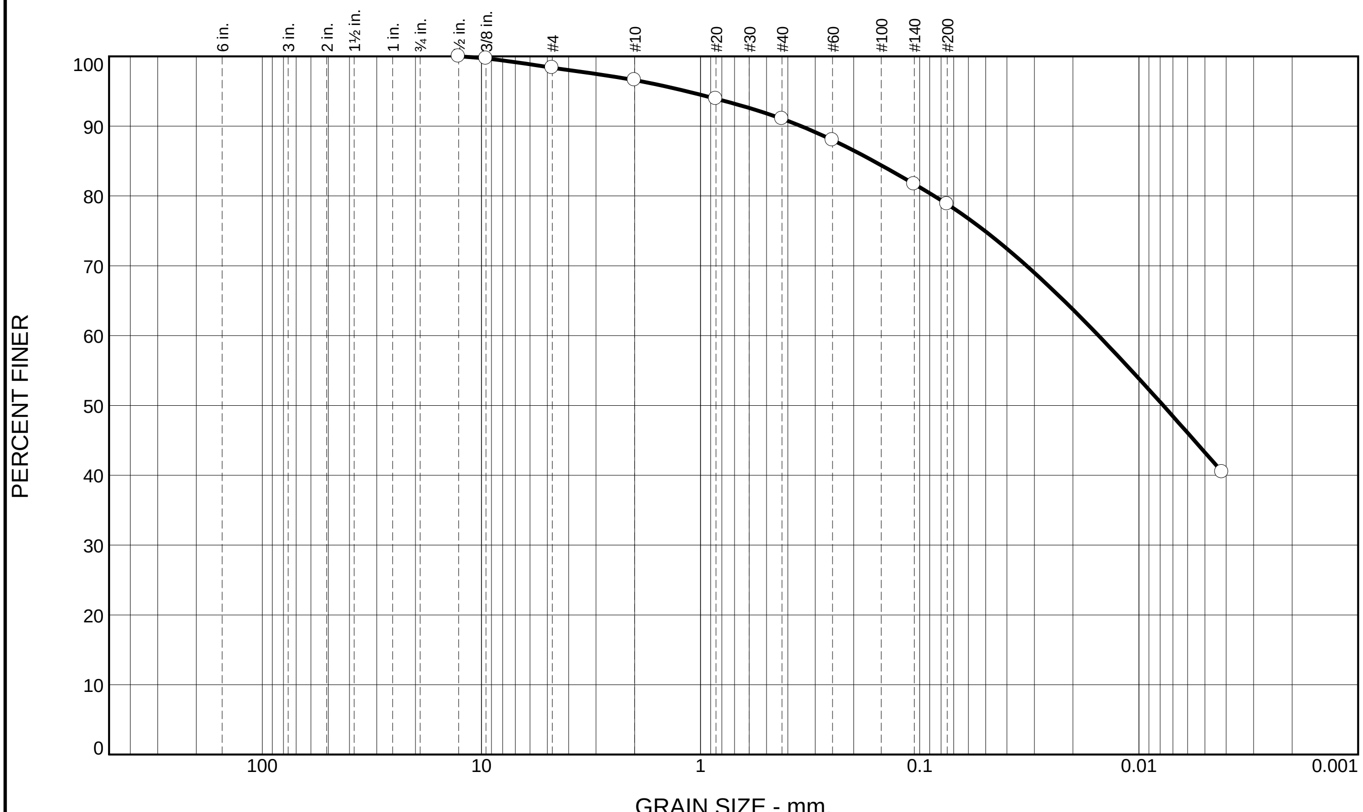
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7294

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	1.6	19.6	35.5	43.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.7		
#4	98.4		
#10	96.6		
#20	93.9		
#40	91.1		
#60	88.0		
#140	81.7		
#200	78.8		

* (no specification provided)

Material Description

BROWN SILT AND CLAY

Atterberg Limits

PL= 16 LL= 31 PI= 15

Coefficients

D_{90}= 0.3478 D_{85}= 0.1626 D_{60}= 0.0153

D_{50}= 0.0078 D_{30}= D_{15}=

D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(10)

Remarks

Source of Sample: B-2 **Depth:** 10-11.5'

Date: 10-26-16

Terracon, Inc.

Cincinnati, Ohio

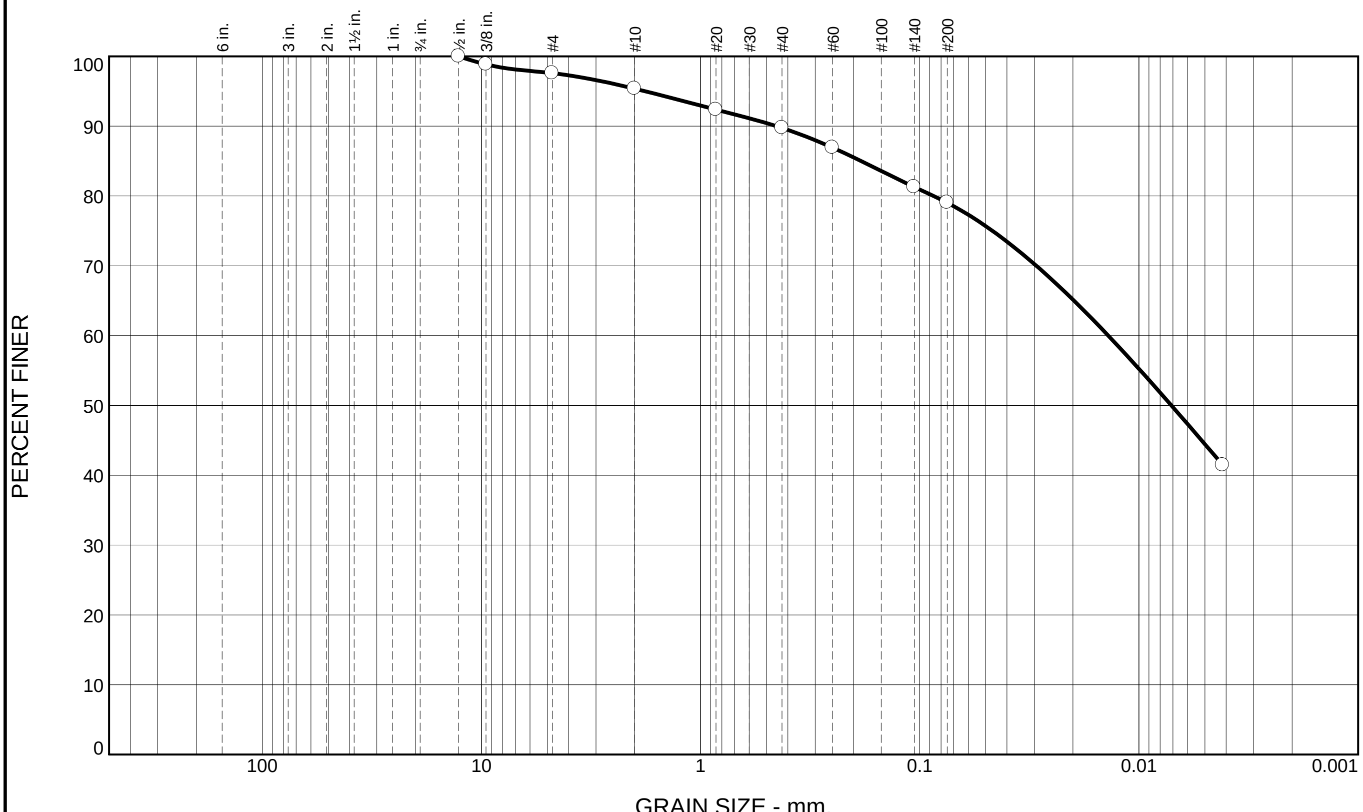
Client: STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204

Project No: N1165419 **Figure** 7296

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	2.4	18.6	34.5	44.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	98.8		
#4	97.6		
#10	95.4		
#20	92.4		
#40	89.7		
#60	86.9		
#140	81.3		
#200	79.0		

* (no specification provided)

Material Description

GRAY SANDY SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.4514 D_{85}= 0.1852 D_{60}= 0.0138
D_{50}= 0.0071 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO= ODOT: A-4a(8)

Remarks

Source of Sample: B-2 **Depth:** 11.5-13'

Date: 10-27-16

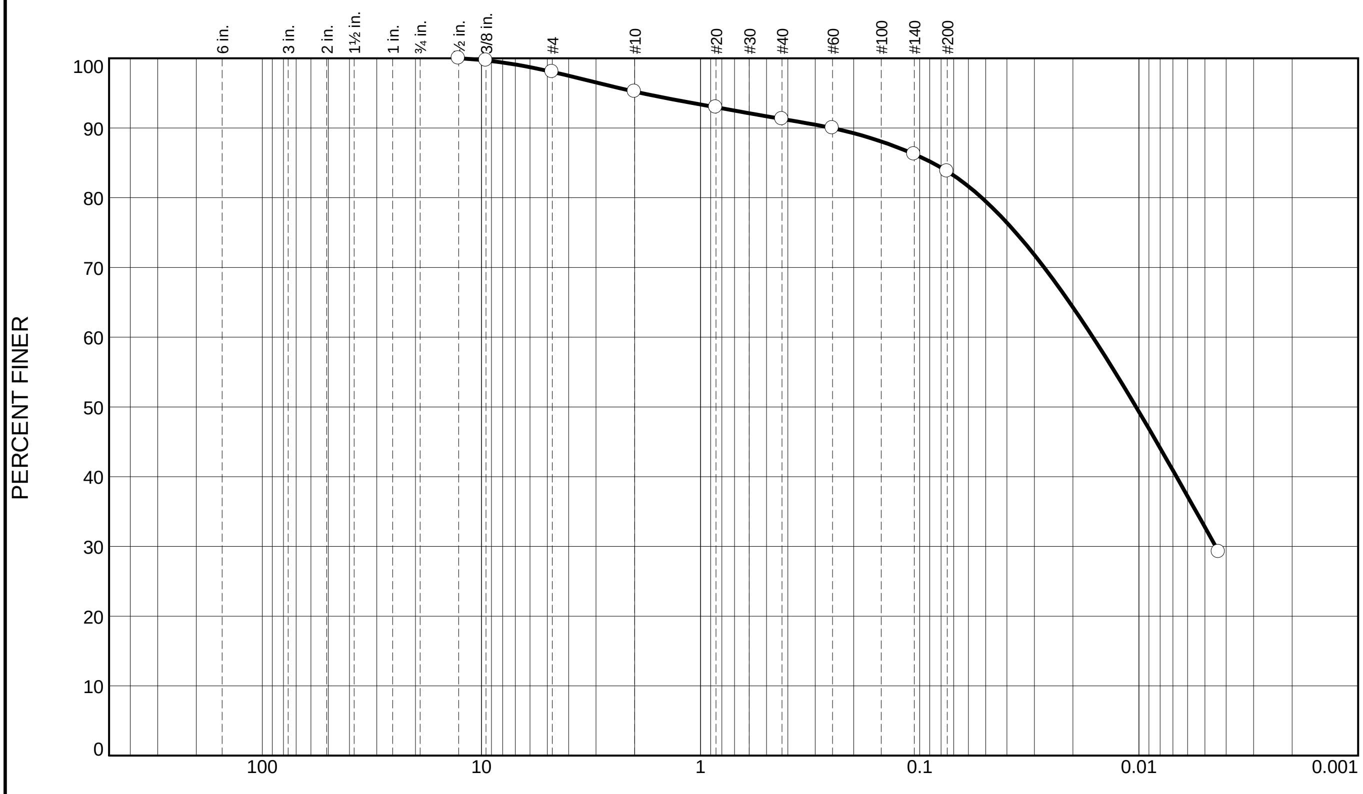
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7297

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	2.0	14.2	51.0	32.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.7		
#4	98.0		
#10	95.2		
#20	93.0		
#40	91.3		
#60	90.0		
#140	86.2		
#200	83.8		

* (no specification provided)

Material Description

GRAY SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.2518 D_{85}= 0.0875 D_{60}= 0.0162
D_{50}= 0.0103 D_{30}= 0.0045 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO= ODOT: A-4b(8)

Remarks

Source of Sample: B-2 **Depth:** 13-14.5'

Date: 10-27-16

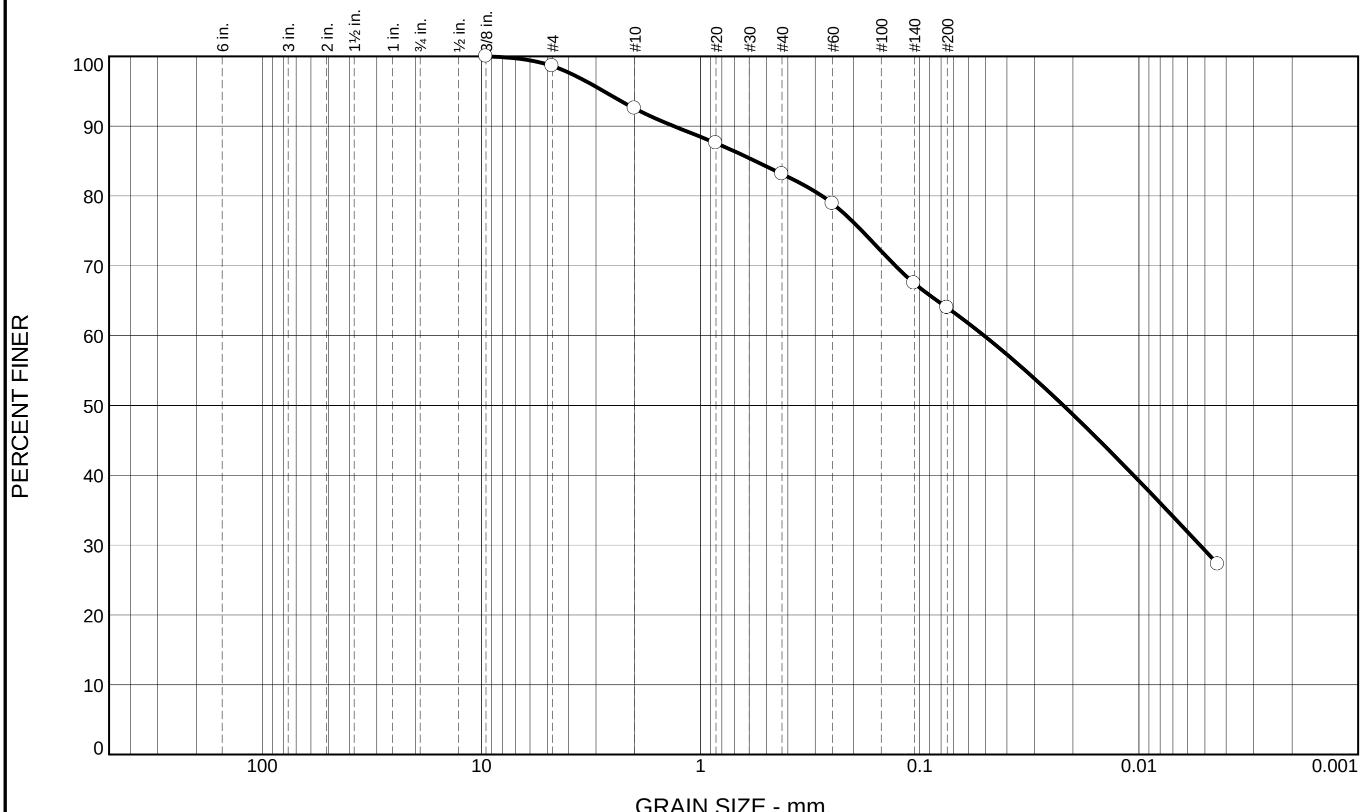
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7298

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	1.4	34.6	34.8	29.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	98.6		
#10	92.5		
#20	87.6		
#40	83.1		
#60	78.9		
#140	67.5		
#200	64.0		

* (no specification provided)

Material Description

GRAY SANDY SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 1.3262 D_{85}= 0.5632 D_{60}= 0.0509
D_{50}= 0.0221 D_{30}= 0.0053 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO= ODOT: A-4a(0)

Remarks

Source of Sample: B-3 **Depth:** 9.6-10.5'

Date: 11-1-16

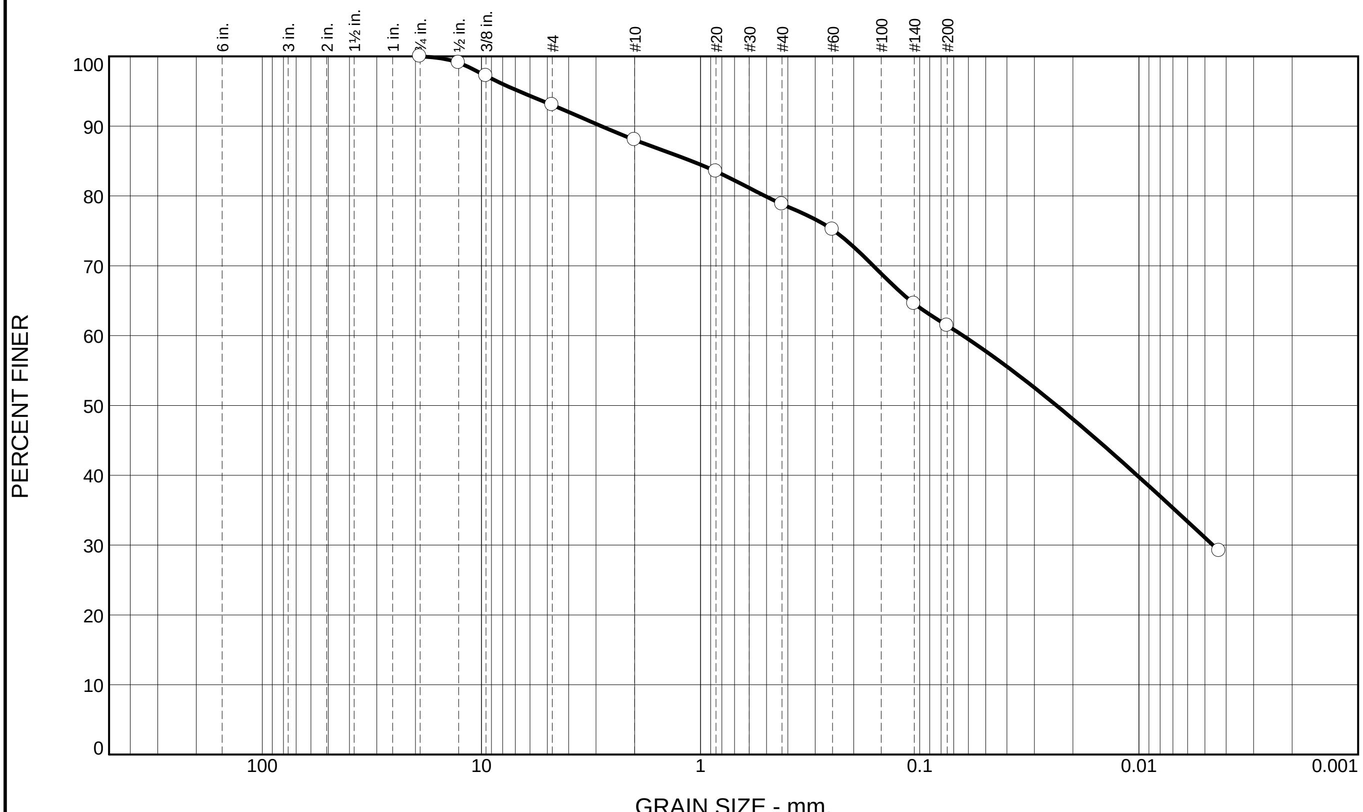
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7304

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	7.0	31.5	30.4	31.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	99.1		
.375	97.2		
#4	93.0		
#10	88.0		
#20	83.5		
#40	78.8		
#60	75.2		
#140	64.6		
#200	61.5		

* (no specification provided)

Material Description

GRAY SANDY SILT

Atterberg Limits

PL= 13 LL= 23 PI= 10

Coefficients

D_{90}= 2.8383 D_{85}= 1.0997 D_{60}= 0.0635
D_{50}= 0.0238 D_{30}= 0.0046 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-4(3)

Remarks

Source of Sample: B-3 **Depth:** 10.5-12'

Date: 11-1-16

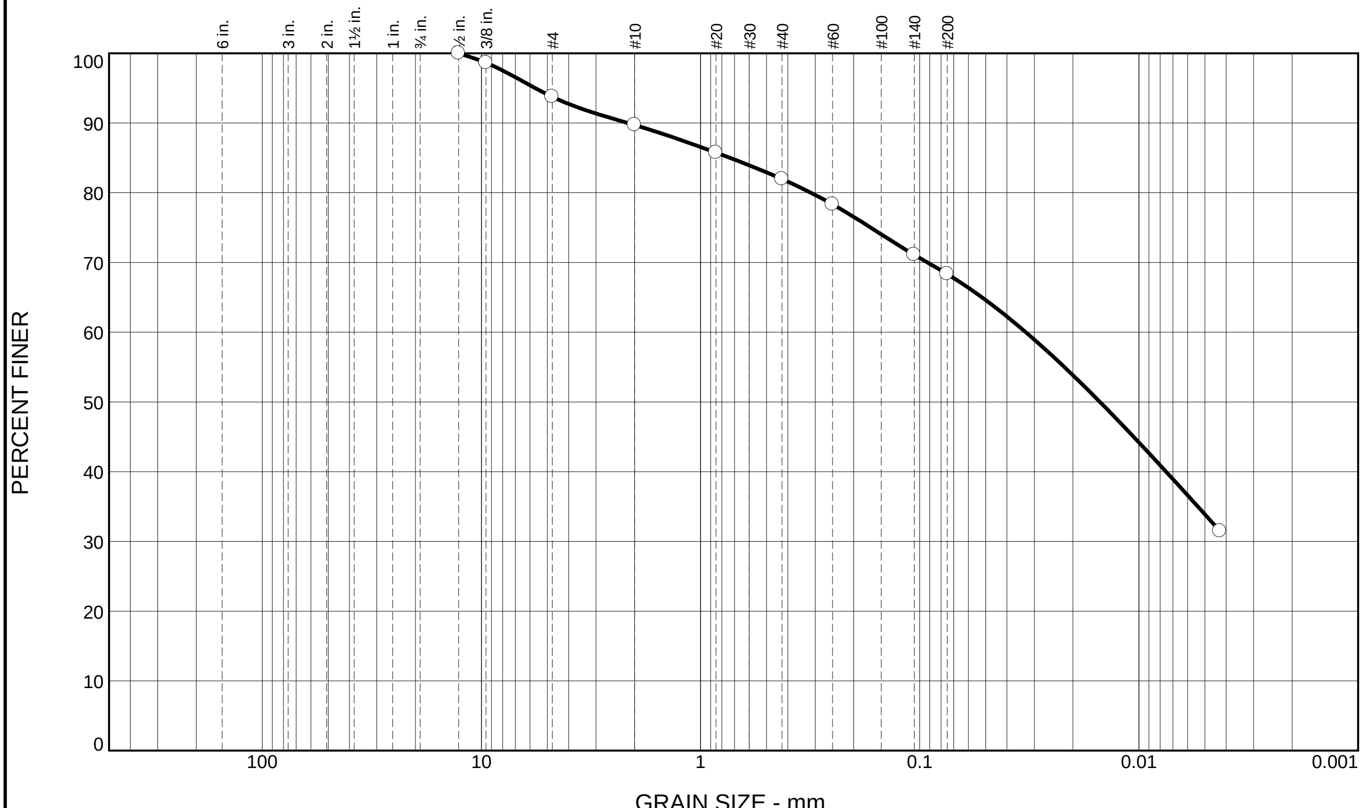
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7305

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	6.2	25.5	34.4	33.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	98.6		
#4	93.8		
#10	89.7		
#20	85.7		
#40	82.0		
#60	78.3		
#140	71.1		
#200	68.3		

* (no specification provided)

Material Description

GRAY SANDY SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 2.1476 D_{85}= 0.7342 D_{60}= 0.0328
D_{50}= 0.0151 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO= ODOT: A-4a(0)

Remarks

Source of Sample: B-3 **Depth:** 12-13.5

Date: 11-1-16

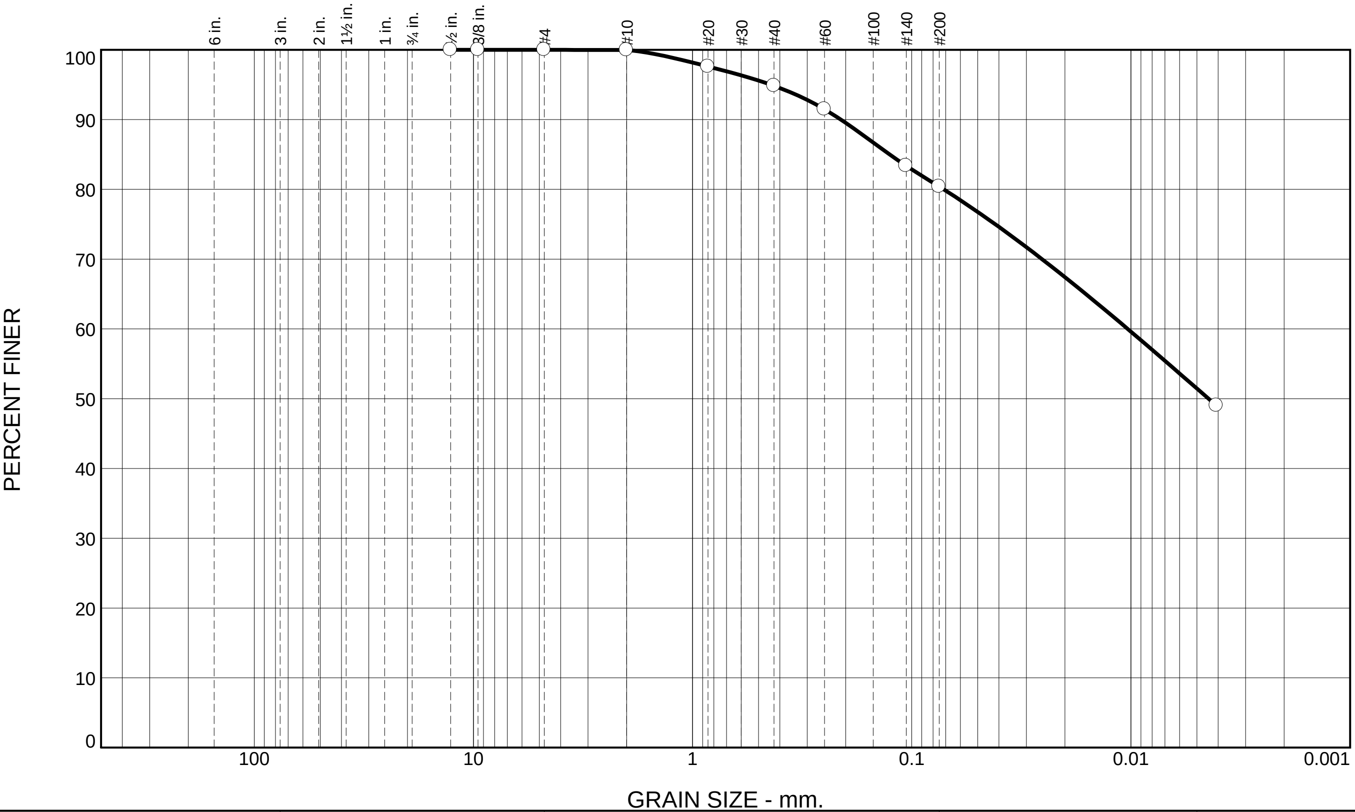
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7306

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	0.0	19.6	28.9	51.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	100.0		
#4	100.0		
#10	100.0		
#20	97.6		
#40	94.8		
#60	91.5		
#140	83.4		
#200	80.4		

* (no specification provided)

Material Description

BROWN SILTY CLAY

Atterberg Limits

PL= 16 LL= 37 PI= 21

Coefficients

D_{90}= 0.2107 D_{85}= 0.1261 D_{60}= 0.0103
D_{50}= 0.0044 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(15)

Remarks

Source of Sample: B-3 **Depth:** 2.5-4 & 5-6.5'
Sample Number: C2

Date: 10-27-16

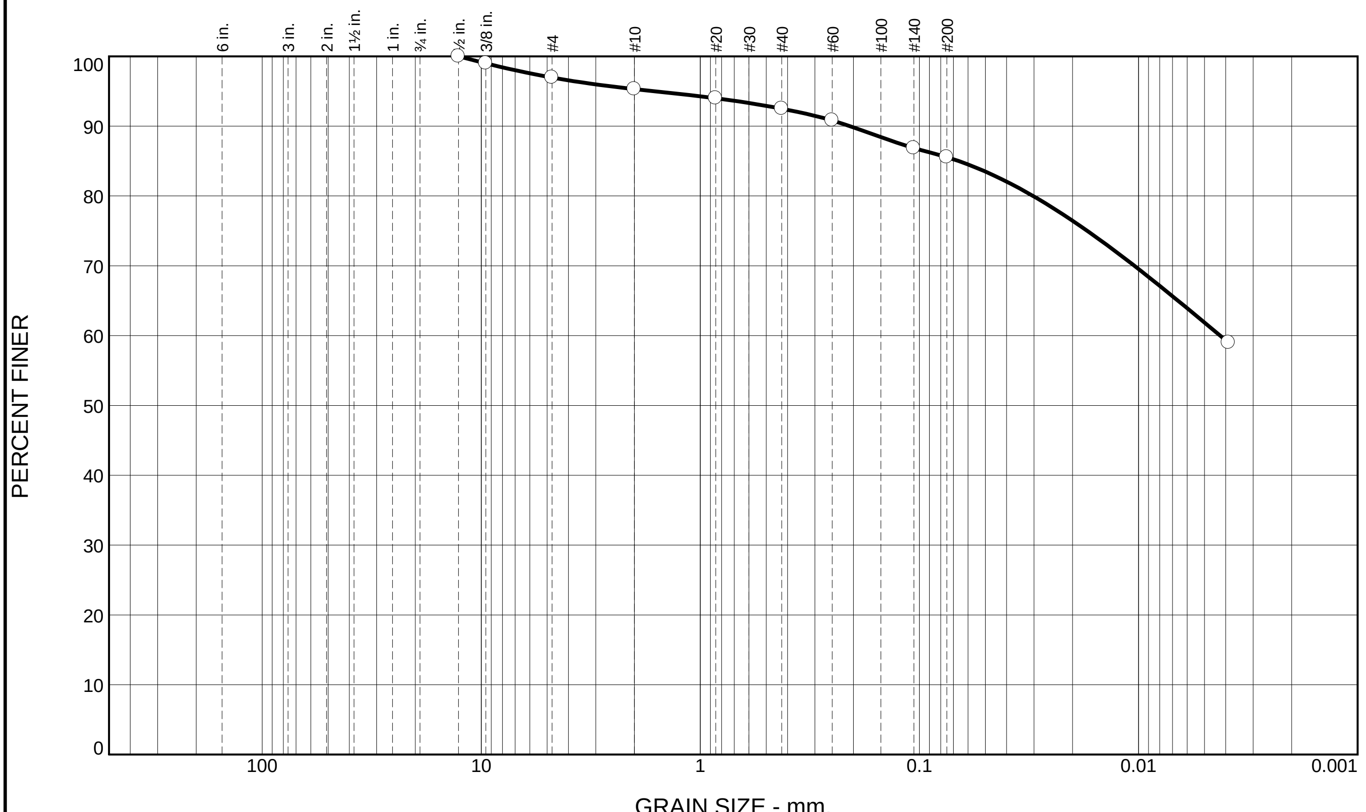
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7300-7301

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	3.0	11.5	23.6	61.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.0		
#4	97.0		
#10	95.3		
#20	94.0		
#40	92.5		
#60	90.8		
#140	86.9		
#200	85.5		

* (no specification provided)

Material Description

BROWN SILT AND CLAY

Atterberg Limits

PL= 17 LL= 28 PI= 11

Coefficients

D_{90}= 0.2077 D_{85}= 0.0662 D_{60}= 0.0042
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(8)

Remarks

Source of Sample: B-3 **Depth:** 7.5-9 & 9-9.6'
Sample Number: C3 **Date:** 11-1-16

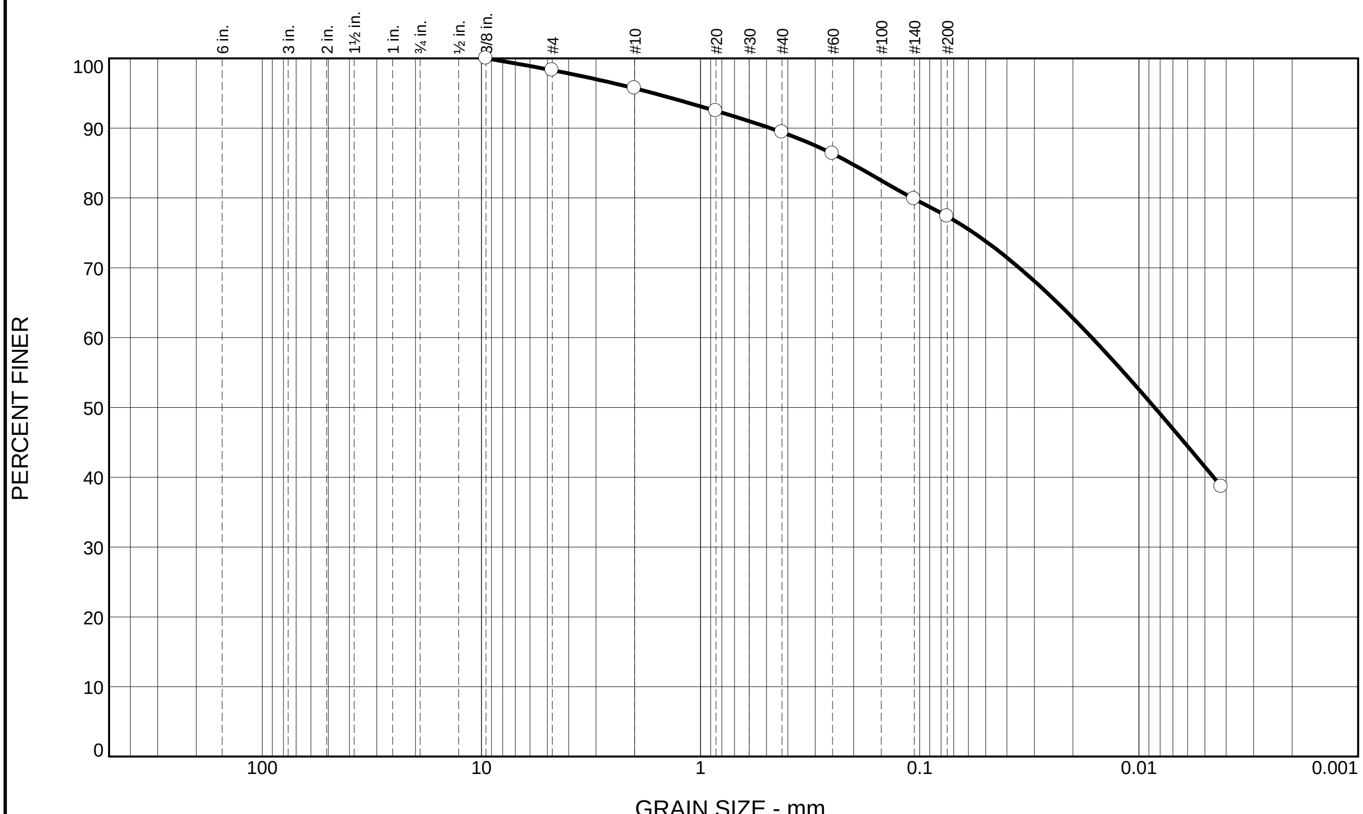
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7302-7303

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	1.7	20.9	35.9	41.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	98.3		
#10	95.7		
#20	92.5		
#40	89.4		
#60	86.4		
#140	79.9		
#200	77.4		

* (no specification provided)

Material Description

GRAY SANDY SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.4807 D_{85}= 0.2069 D_{60}= 0.0164
D_{50}= 0.0085 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO= ODOT: A-4a(0)

Remarks

Source of Sample: B-4 **Depth:** 17.5-19'

Date: 11-1-16

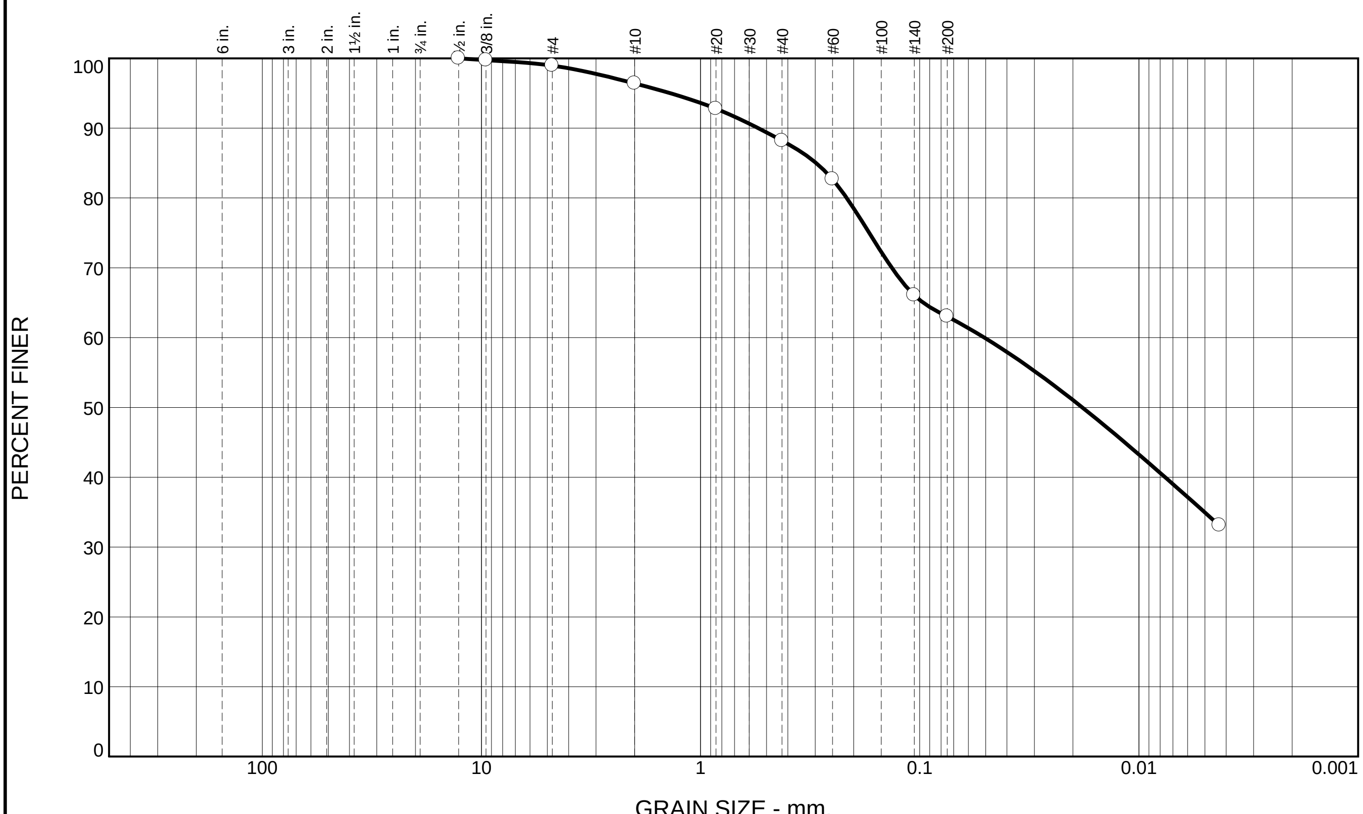
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7314

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	1.0	36.0	28.0	35.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.7		
#4	99.0		
#10	96.4		
#20	92.8		
#40	88.2		
#60	82.7		
#140	66.1		
#200	63.0		

* (no specification provided)

Material Description

BROWN SILT AND CLAY

Atterberg Limits

PL= 15 LL= 28 PI= 13

Coefficients

D_{90}= 0.5457 D_{85}= 0.2967 D_{60}= 0.0507
D_{50}= 0.0181 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(5)

Remarks

Source of Sample: B-4 **Depth:** 5-6.5 & 7.5-9'
Sample Number: C4 **Date:** 11-1-16

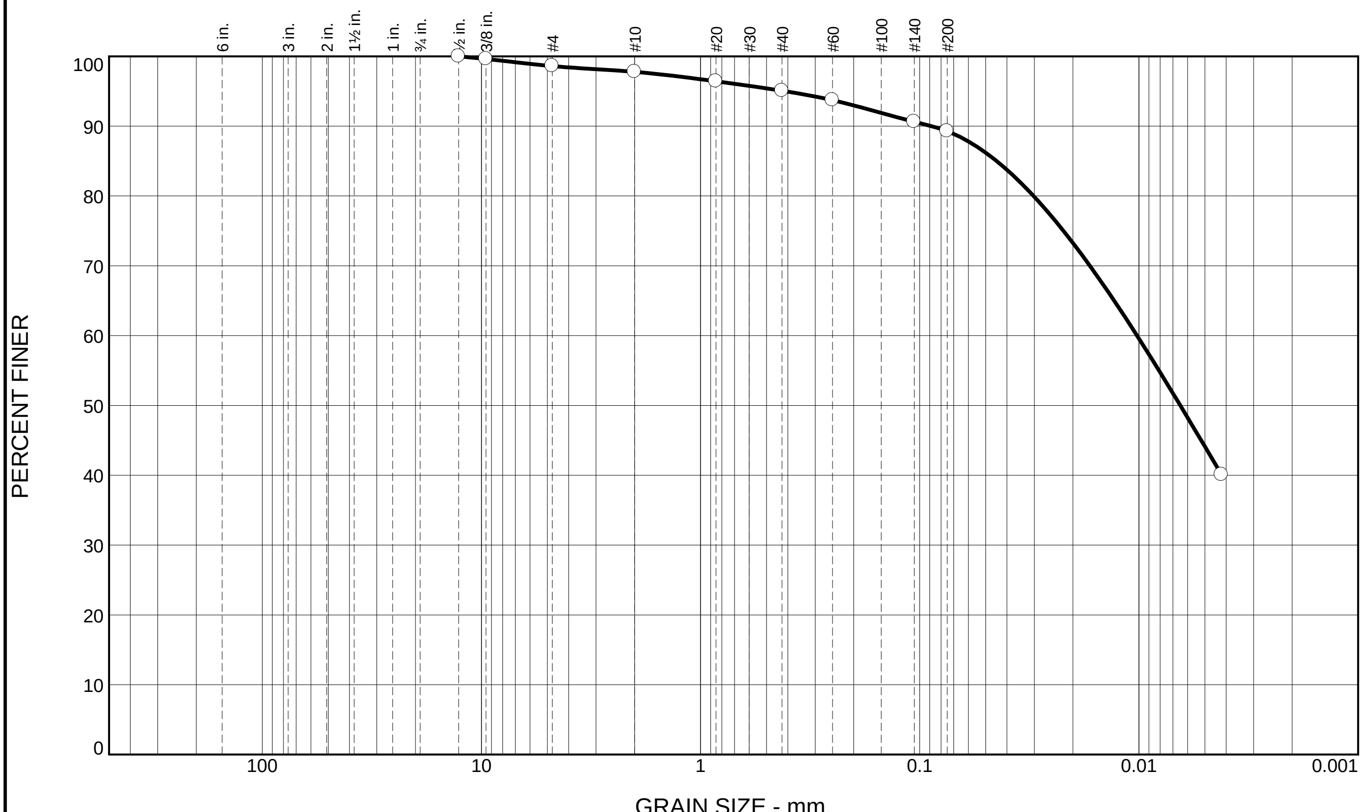
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7309-7310

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	1.4	9.3	45.2	44.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.6		
#4	98.6		
#10	97.8		
#20	96.4		
#40	95.1		
#60	93.7		
#140	90.6		
#200	89.3		

* (no specification provided)

Material Description

GRAY SILT AND CLAY

Atterberg Limits

PL= 14 LL= 27 PI= 13

Coefficients

D_{90}= 0.0885 D_{85}= 0.0446 D_{60}= 0.0102
D_{50}= 0.0065 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(10)

Remarks

Source of Sample: B-4 **Depth:** 19-20.5 & 20.5-21.5'
Sample Number: C5

Date: 11-1-16

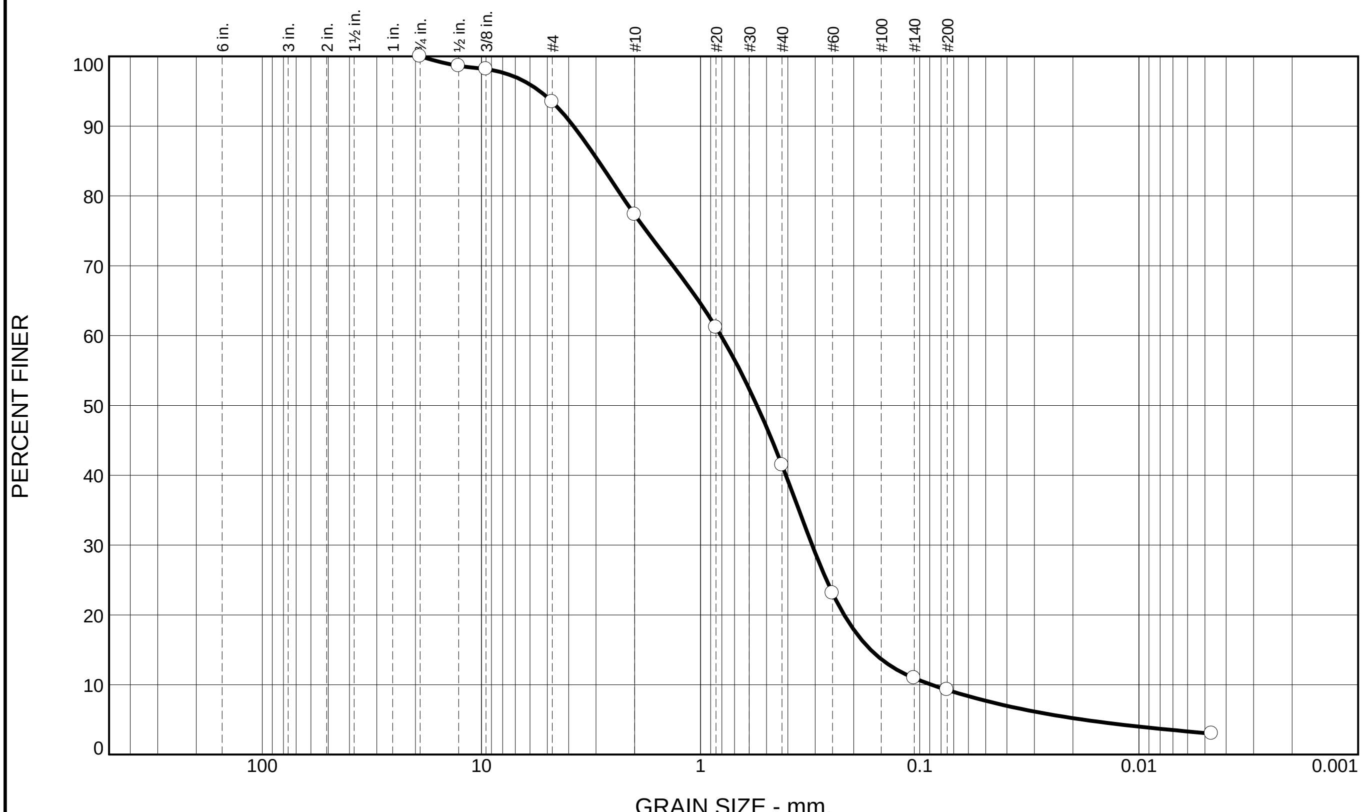
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7315-7316

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	6.5	84.2	6.2	3.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	98.6		
.375	98.2		
#4	93.5		
#10	77.3		
#20	61.2		
#40	41.4		
#60	23.1		
#140	11.0		
#200	9.3		

* (no specification provided)

Material Description

GRAY GRAVEL AND/OR STONE FRAG. WITH SAND

Atterberg Limits

PL= NP LL= PI=

Coefficients

D_{90}= 3.8006 D_{85}= 2.9244 D_{60}= 0.8076
D_{50}= 0.5533 D_{30}= 0.3096 D_{15}= 0.1674
D_{10}= 0.0883 C_u= 9.14 C_c= 1.34

Classification

USCS= AASHTO=

Remarks

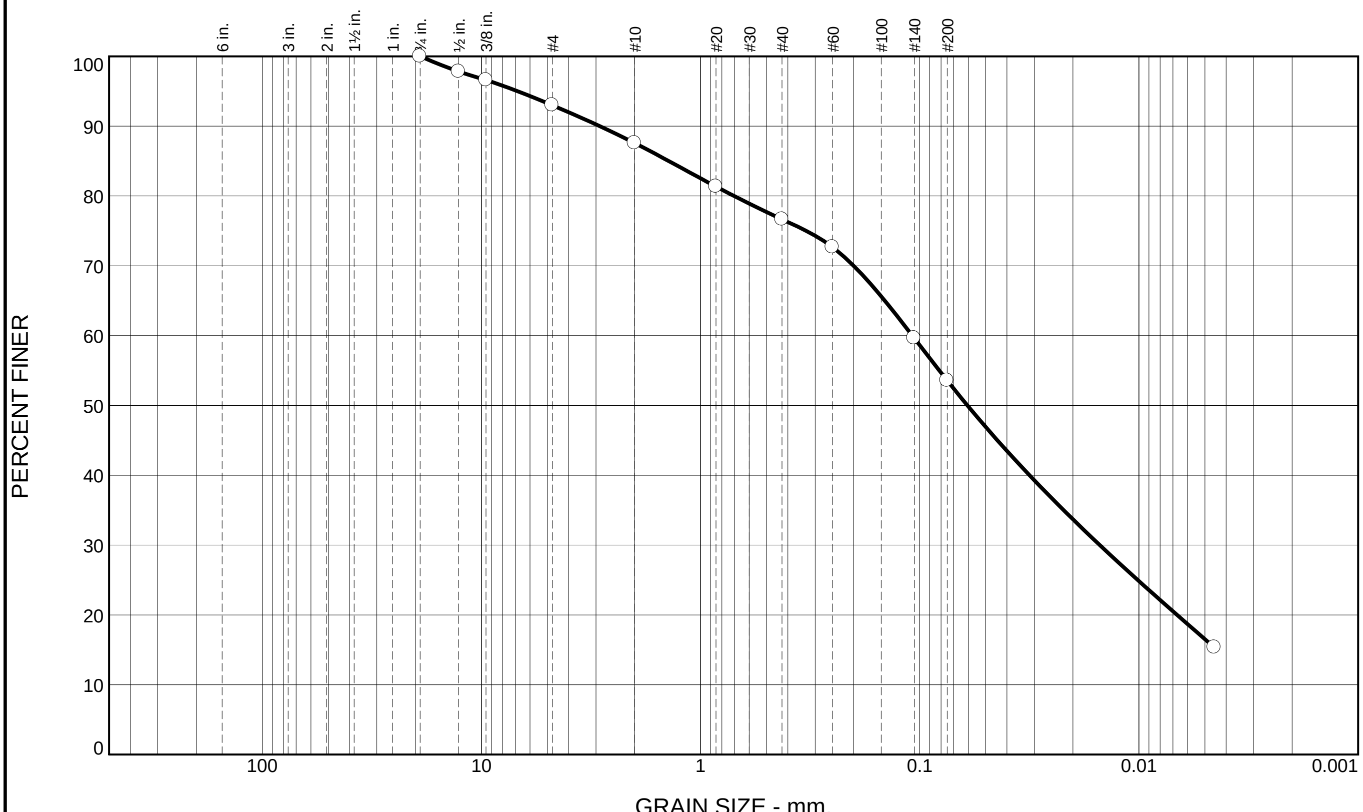
Source of Sample: B-4 **Depth:** 21.5-22 & 22-23.5'
Sample Number: C6 **Date:** 11-1-16

Terracon, Inc.
Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7317-7318

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	7.0	39.4	37.1	16.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	97.8		
.375	96.6		
#4	93.0		
#10	87.6		
#20	81.3		
#40	76.7		
#60	72.7		
#140	59.6		
#200	53.6		

* (no specification provided)

Material Description

GRAY SANDY SILT

Atterberg Limits

PL= 12 LL= 15 PI= 3

Coefficients

D_{90}= 2.8840 D_{85}= 1.3971 D_{60}= 0.1081
D_{50}= 0.0606 D_{30}= 0.0151 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

Source of Sample: B-4 **Depth:** 25-26.5 & 27.5-29'
Sample Number: C7 **Date:** 11-1-16

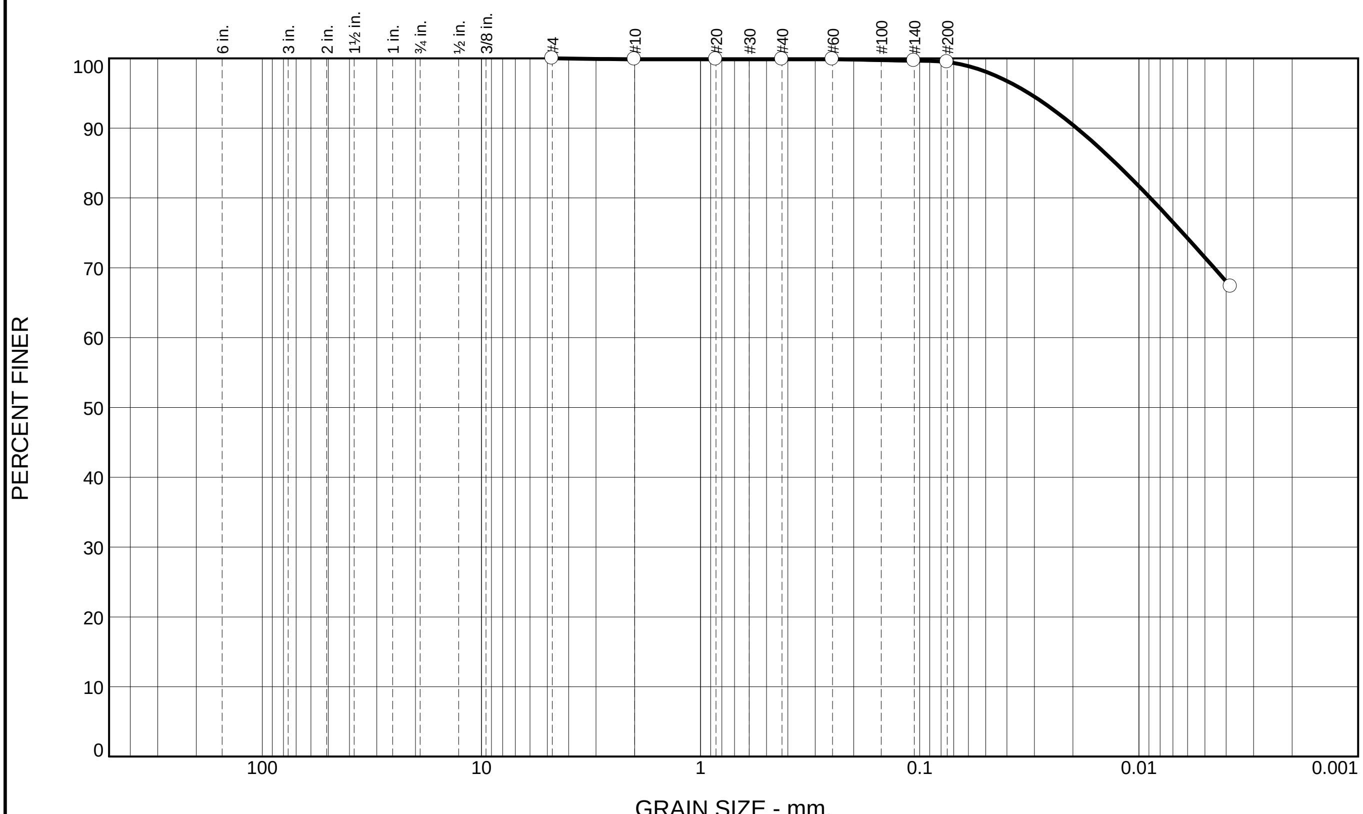
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7319-7320

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	0.0	0.5	28.0	71.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.9		
#20	99.9		
#40	99.9		
#60	99.9		
#140	99.7		
#200	99.5		

* (no specification provided)

Material Description

GRAY SILTY CLAY

Atterberg Limits

PL= 22 LL= 40 PI= 18

Coefficients

D_{90}= 0.0192 D_{85}= 0.0128 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(20)

Remarks

Source of Sample: B-5 **Depth:** 7.5-8.5

Date: 11-1-16

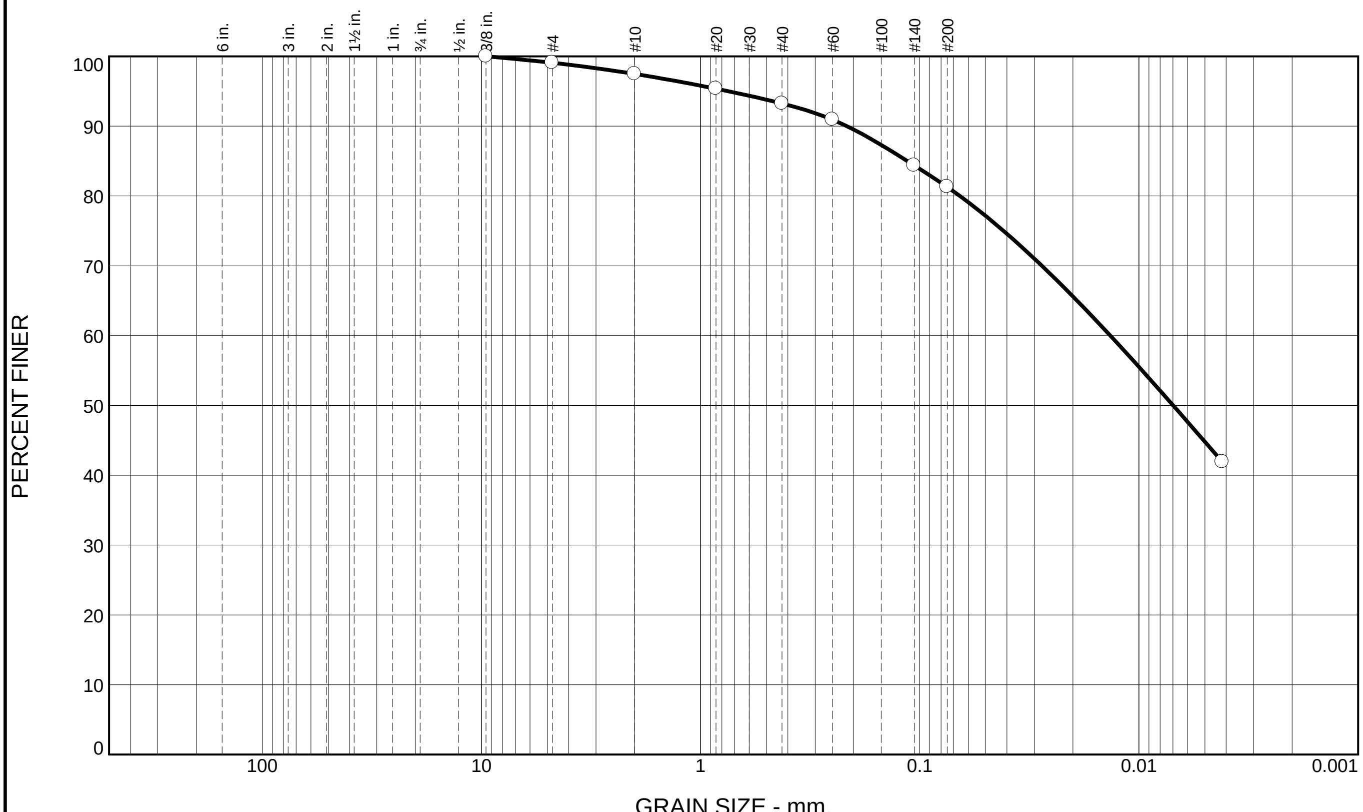
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7323

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	0.9	17.8	36.5	44.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	99.1		
#10	97.5		
#20	95.4		
#40	93.2		
#60	90.9		
#140	84.4		
#200	81.3		

* (no specification provided)

Material Description

GRAY SILT AND CLAY

Atterberg Limits

PL= 13 LL= 26 PI= 13

Coefficients

D_{90}= 0.2152 D_{85}= 0.1140 D_{60}= 0.0135
D_{50}= 0.0070 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(8)

Remarks

Source of Sample: B-5 **Depth:** 10-11.5'

Date: 11-1-16

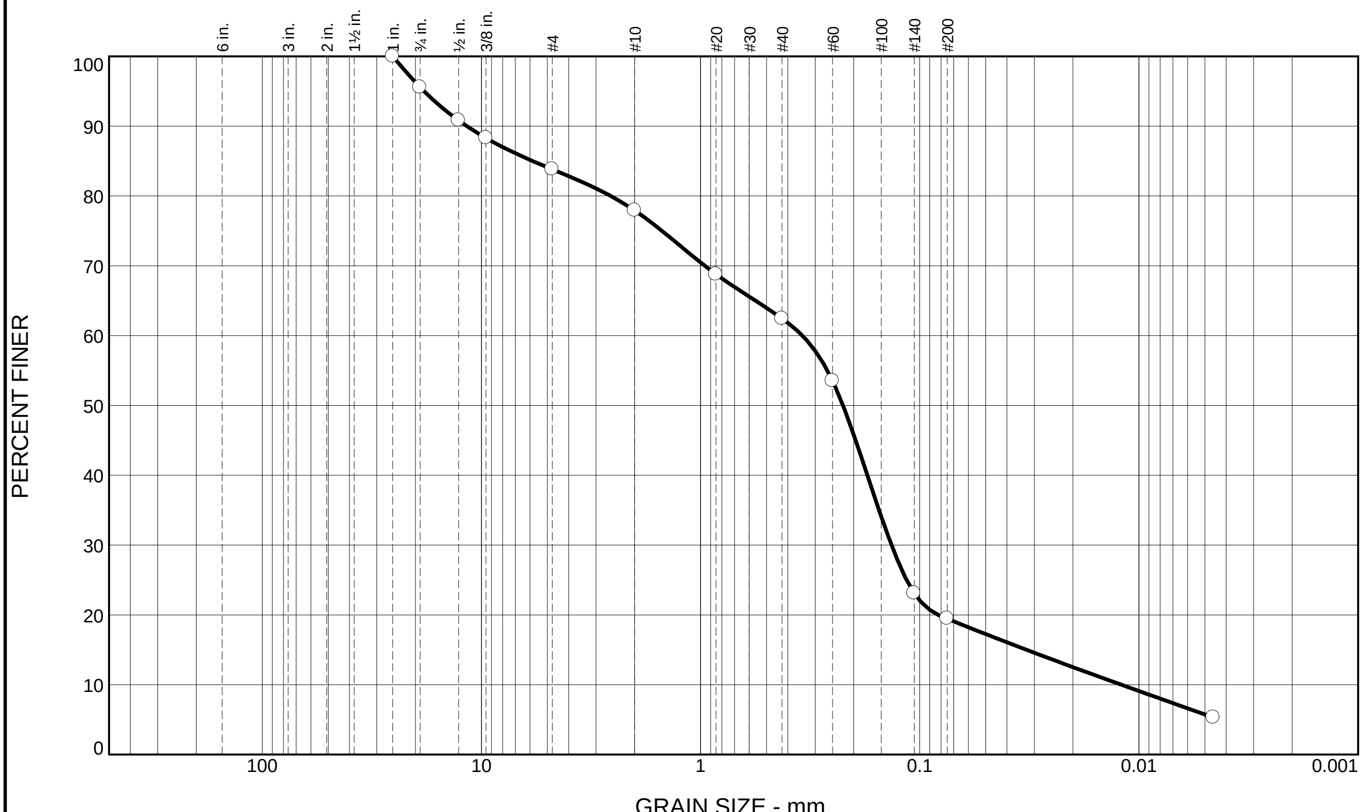
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7325

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	16.2	64.3	13.8	5.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	95.6		
.5	90.8		
.375	88.3		
#4	83.8		
#10	77.9		
#20	68.8		
#40	62.4		
#60	53.5		
#140	23.1		
#200	19.5		

* (no specification provided)

Material Description

GRAY GRAVEL AND/OR STONE FRAGS. WITH SILT AND SAND

Atterberg Limits

PL= NP LL= PI=

Coefficients

D_{90}= 11.6489 D_{85}= 5.8345 D_{60}= 0.3431
D_{50}= 0.2240 D_{30}= 0.1346 D_{15}= 0.0325
D_{10}= 0.0120 C_u= 28.54 C_c= 4.39

Classification

USCS= AASHTO=

Remarks

Source of Sample: B-5 **Depth:** 11.5-12.9'

Date: 11-1-16

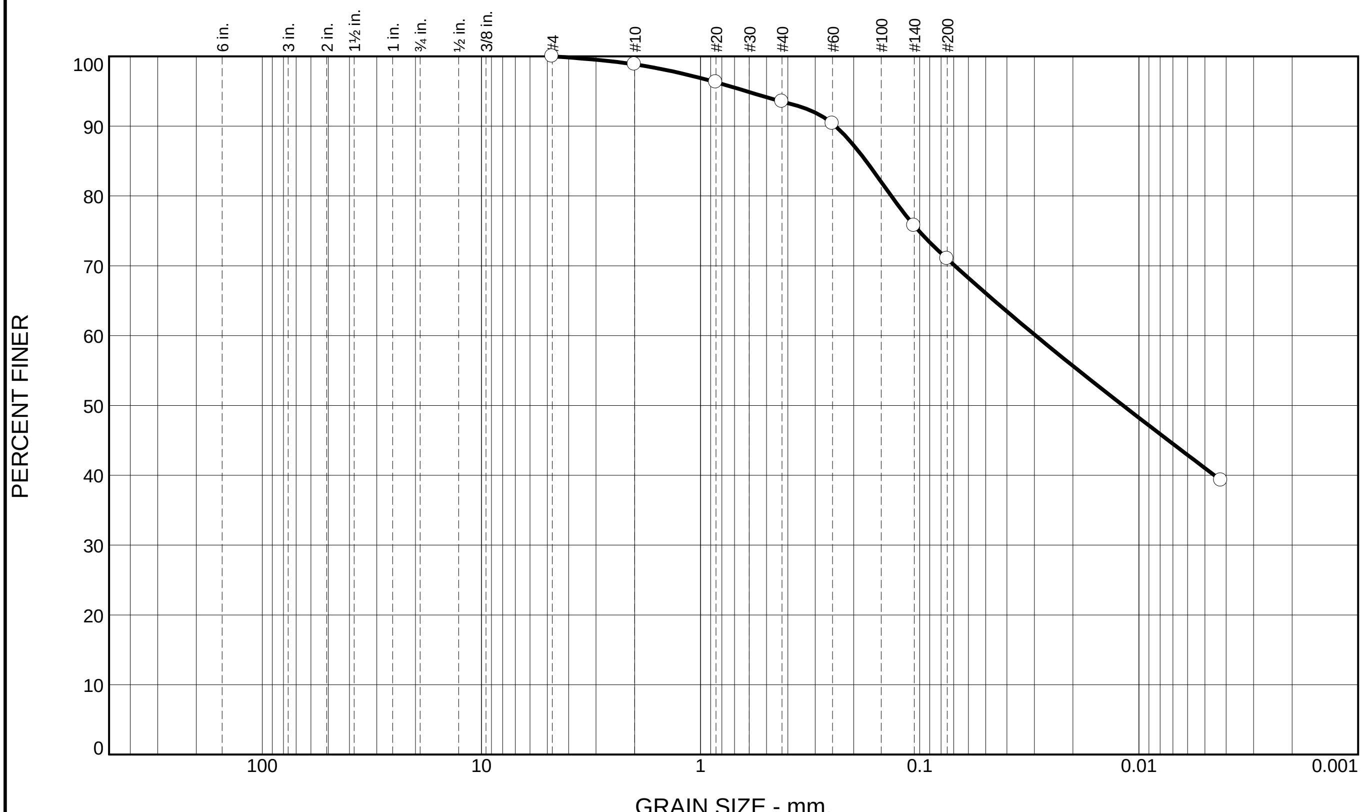
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7326

Tested By: VD **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	0.0	29.0	30.0	41.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	98.8		
#20	96.3		
#40	93.5		
#60	90.4		
#140	75.7		
#200	71.0		

* (no specification provided)

Material Description

BROWN SILTY CLAY

Atterberg Limits

PL= 15 LL= 34 PI= 19

Coefficients

D_{90}= 0.2424 D_{85}= 0.1758 D_{60}= 0.0296
D_{50}= 0.0118 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(11)

Remarks

Source of Sample: B-5 **Depth:** 2.5-4 & 5-6.5'
Sample Number: C8 **Date:** 11-1-16

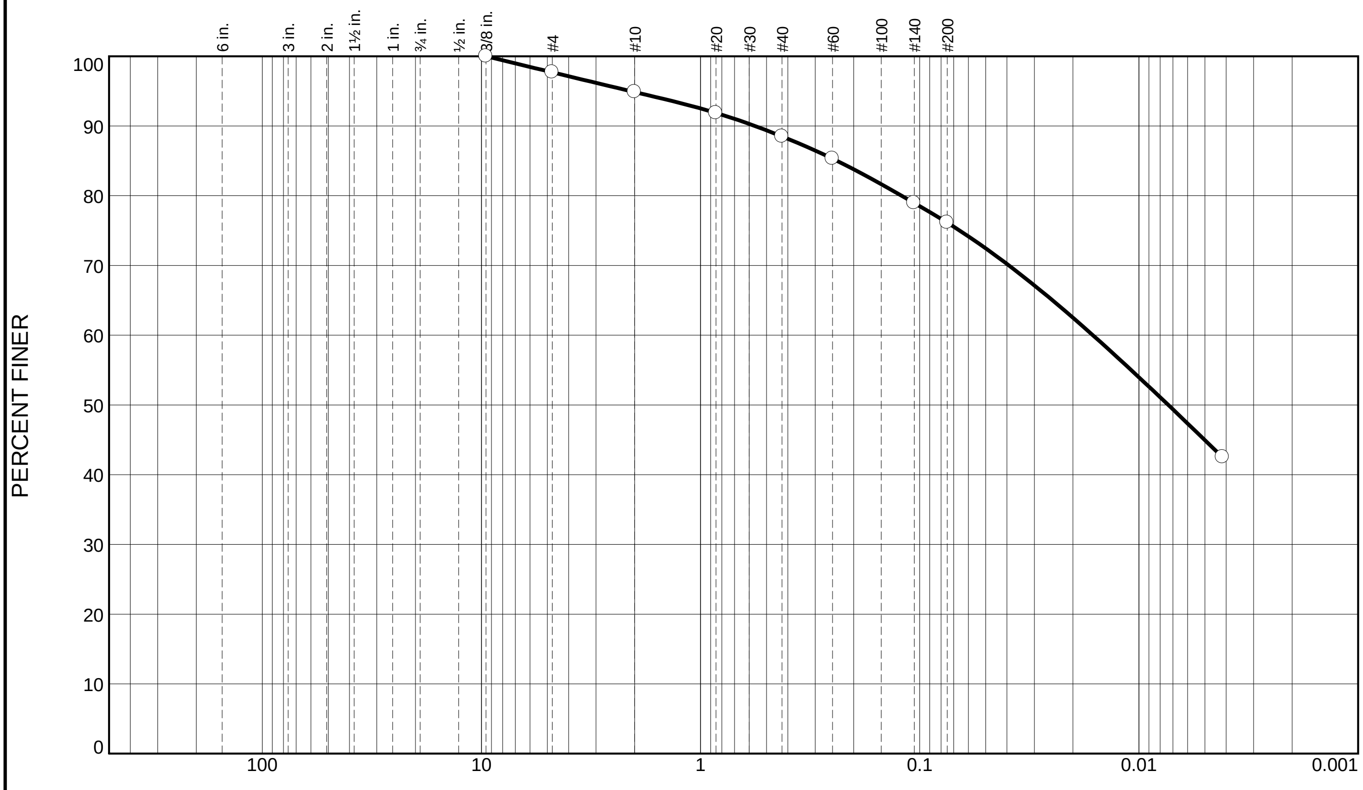
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7321-7322

Tested By: VD **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	2.3	21.6	31.1	45.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	97.7		
#10	94.9		
#20	91.9		
#40	88.5		
#60	85.3		
#140	79.0		
#200	76.1		

* (no specification provided)

Material Description

BROWN-GRAY SILT AND CLAY

Atterberg Limits

PL= 14 LL= 27 PI= 13

Coefficients

D_{90}= 0.5654 D_{85}= 0.2383 D_{60}= 0.0162
D_{50}= 0.0073 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(7)

Remarks

Source of Sample: B-6 **Depth:** 8.5-10'

Date: 11-1-16

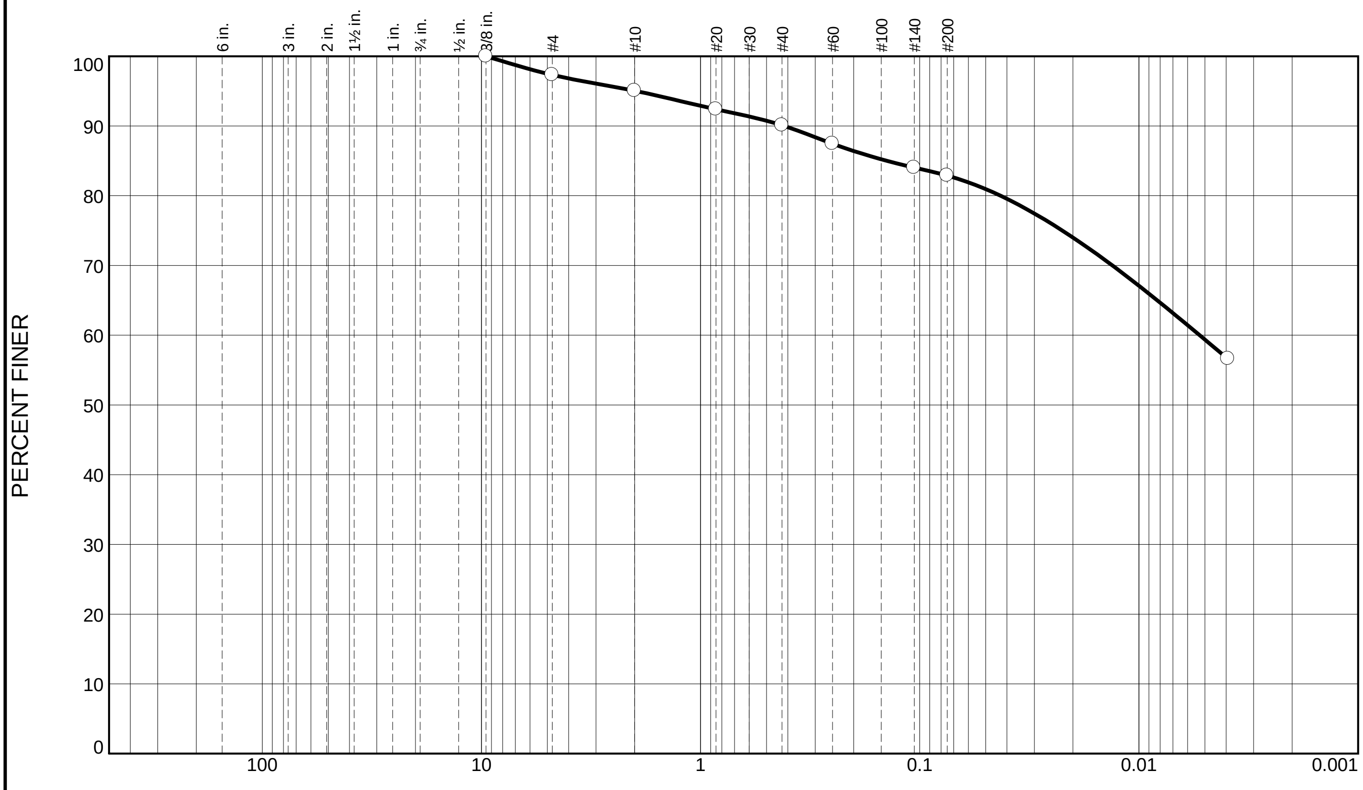
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7330

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	2.7	14.4	23.5	59.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	97.3		
#10	95.0		
#20	92.4		
#40	90.1		
#60	87.5		
#140	84.0		
#200	82.9		

* (no specification provided)

Material Description

GRAY SILT AND CLAY

Atterberg Limits

PL= 19 LL= 39 PI= 20

Coefficients

D_{90}= 0.4146 D_{85}= 0.1409 D_{60}= 0.0053
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(16)

Remarks

Source of Sample: B-6 **Depth:** 13.5-15'

Date: 11-1-16

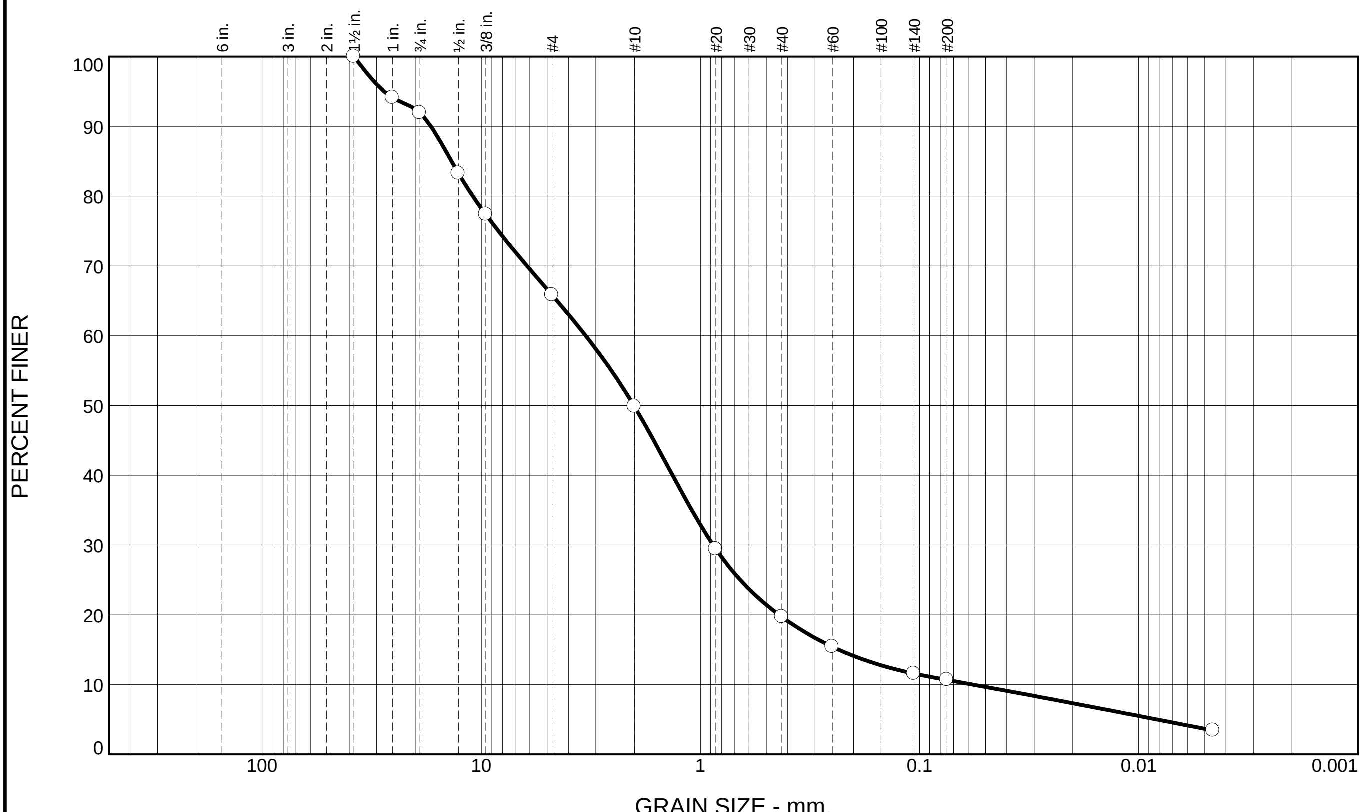
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7331

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	34.2	55.1	7.0	3.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	94.1		
.75	91.9		
.5	83.2		
.375	77.4		
#4	65.8		
#10	49.9		
#20	29.4		
#40	19.7		
#60	15.4		
#140	11.6		
#200	10.7		

* (no specification provided)

Material Description

GRAY GRAVEL AND/OR STONE FRAGS. WITH SAND

Atterberg Limits

PL= 11 LL= 13 PI= 2

Coefficients

D_{90}= 16.9575 D_{85}= 13.6652 D_{60}= 3.3368
D_{50}= 2.0116 D_{30}= 0.8746 D_{15}= 0.2340
D_{10}= 0.0570 C_u= 58.56 C_c= 4.02

Classification

USCS= SP-SM AASHTO= A-1-a

Remarks

Source of Sample: B-6 **Depth:** 16-17.2'

Date: 11-1-16

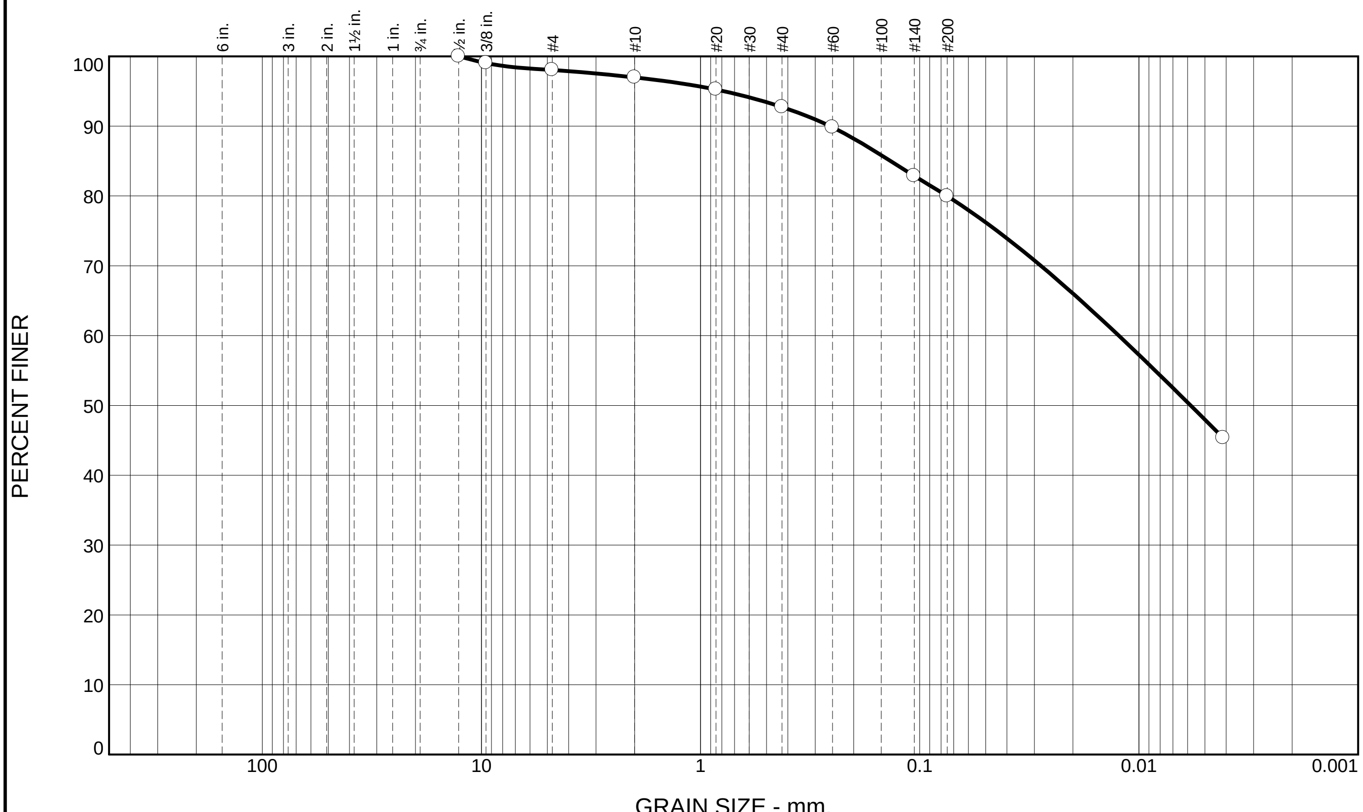
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7332

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	2.0	18.0	32.0	48.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.0		
#4	98.0		
#10	97.0		
#20	95.2		
#40	92.7		
#60	89.8		
#140	82.9		
#200	80.0		

* (no specification provided)

Material Description

BROWN SILTY CLAY

Atterberg Limits

PL= 18 LL= 39 PI= 21

Coefficients

D_{90}= 0.2564 D_{85}= 0.1359 D_{60}= 0.0124
D_{50}= 0.0058 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(16)

Remarks

Source of Sample: B-6 **Depth:** 3.5-5 & 6-7.5'
Sample Number: C9

Date: 11-1-16

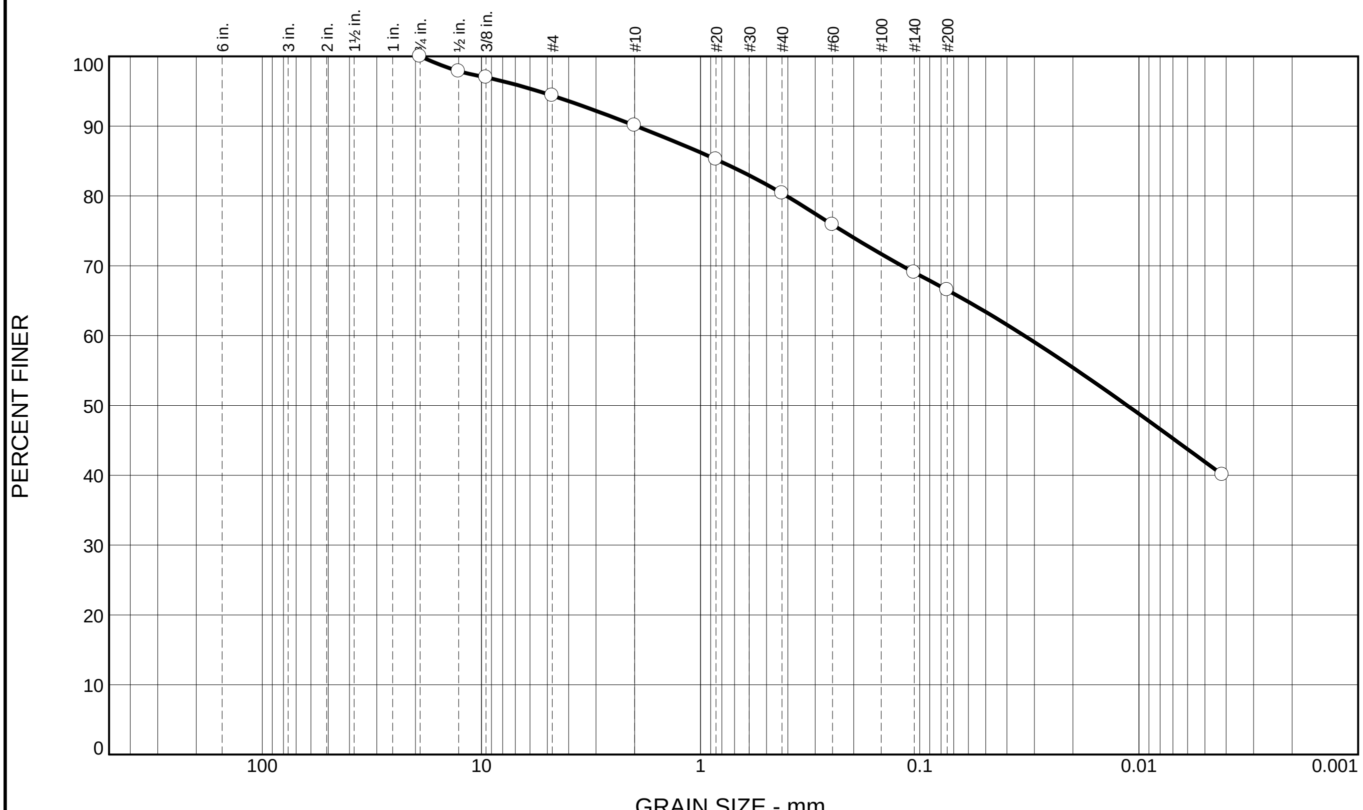
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7328-7329

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	5.6	27.9	24.6	41.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	97.9		
.375	97.0		
#4	94.4		
#10	90.1		
#20	85.2		
#40	80.4		
#60	75.9		
#140	69.1		
#200	66.5		

* (no specification provided)

Material Description

BROWN SILTY CLAY

Atterberg Limits

PL= 17 LL= 38 PI= 21

Coefficients

D_{90}= 1.9677 D_{85}= 0.8190 D_{60}= 0.0334
D_{50}= 0.0113 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(12)

Remarks

Source of Sample: B-7 **Depth:** 1-2.5 & 3.5-5'
Sample Number: C10 **Date:** 11-1-16

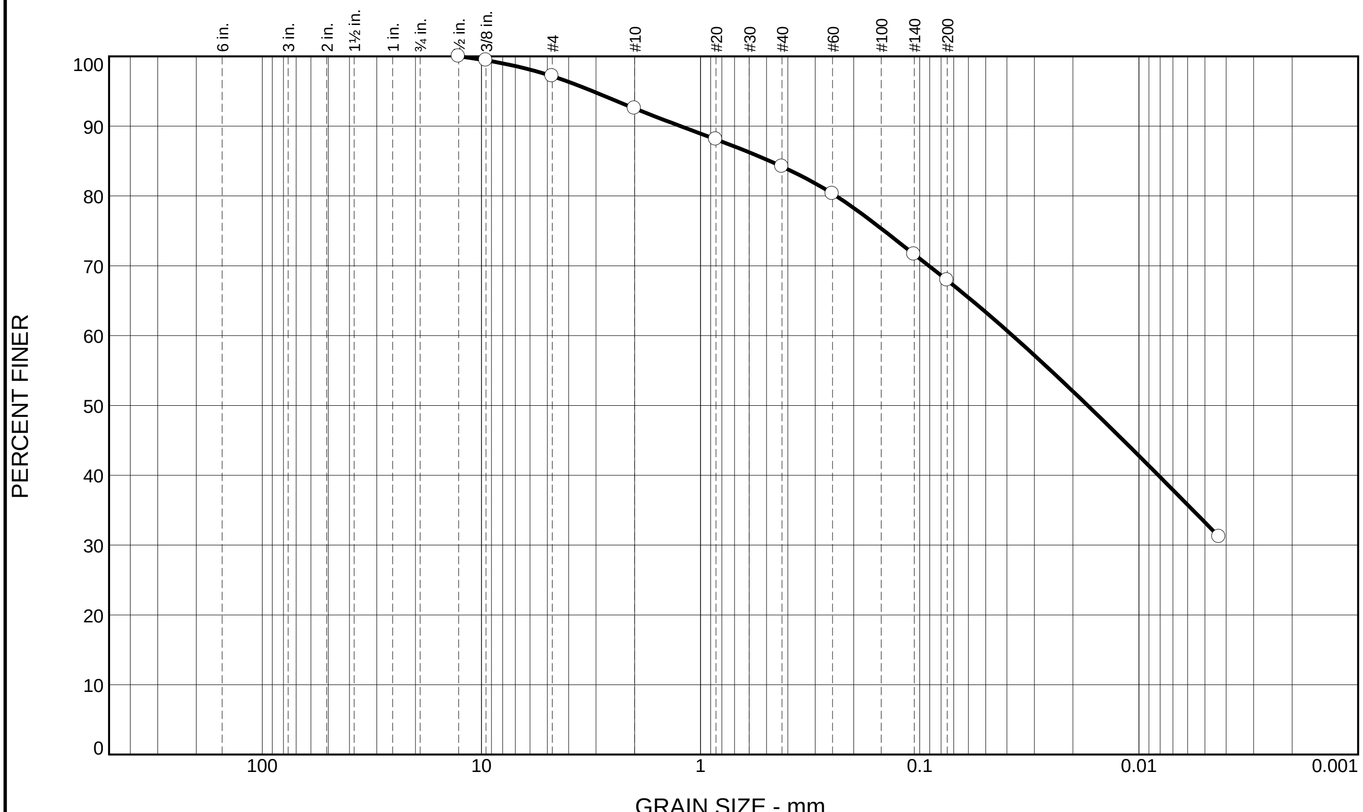
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7333-7334

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	2.8	29.3	34.6	33.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.4		
#4	97.2		
#10	92.5		
#20	88.1		
#40	84.2		
#60	80.3		
#140	71.6		
#200	67.9		

* (no specification provided)

Material Description

GRAY SANDY SILT

Atterberg Limits

PL= 13 LL= 22 PI= 9

Coefficients

D_{90}= 1.2347 D_{85}= 0.4833 D_{60}= 0.0377
D_{50}= 0.0171 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-4(3)

Remarks

Source of Sample: B-8 **Depth:** 11-11.8'

Date: 11-1-16

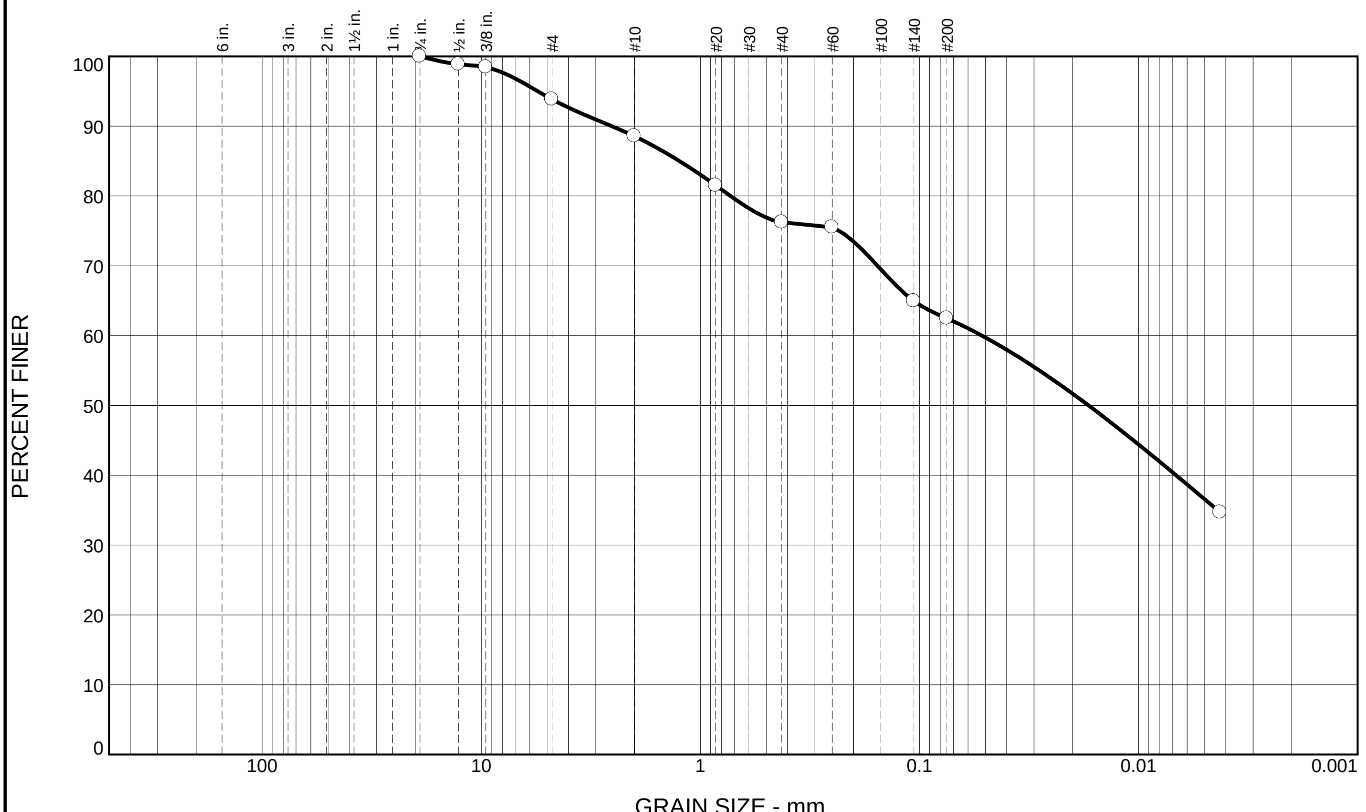
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7340

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	6.2	31.3	25.9	36.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	98.9		
.375	98.4		
#4	93.8		
#10	88.6		
#20	81.5		
#40	76.2		
#60	75.5		
#140	64.9		
#200	62.5		

* (no specification provided)

Material Description

BROWN-GRAY SILT AND CLAY

Atterberg Limits

PL= 14 LL= 28 PI= 14

Coefficients

D_{90}= 2.5365 D_{85}= 1.2455 D_{60}= 0.0518
D_{50}= 0.0169 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(6)

Remarks

Source of Sample: B-8 **Depth:** 1-2.5 & 3.5-5'
Sample Number: C11

Date: 11-1-16

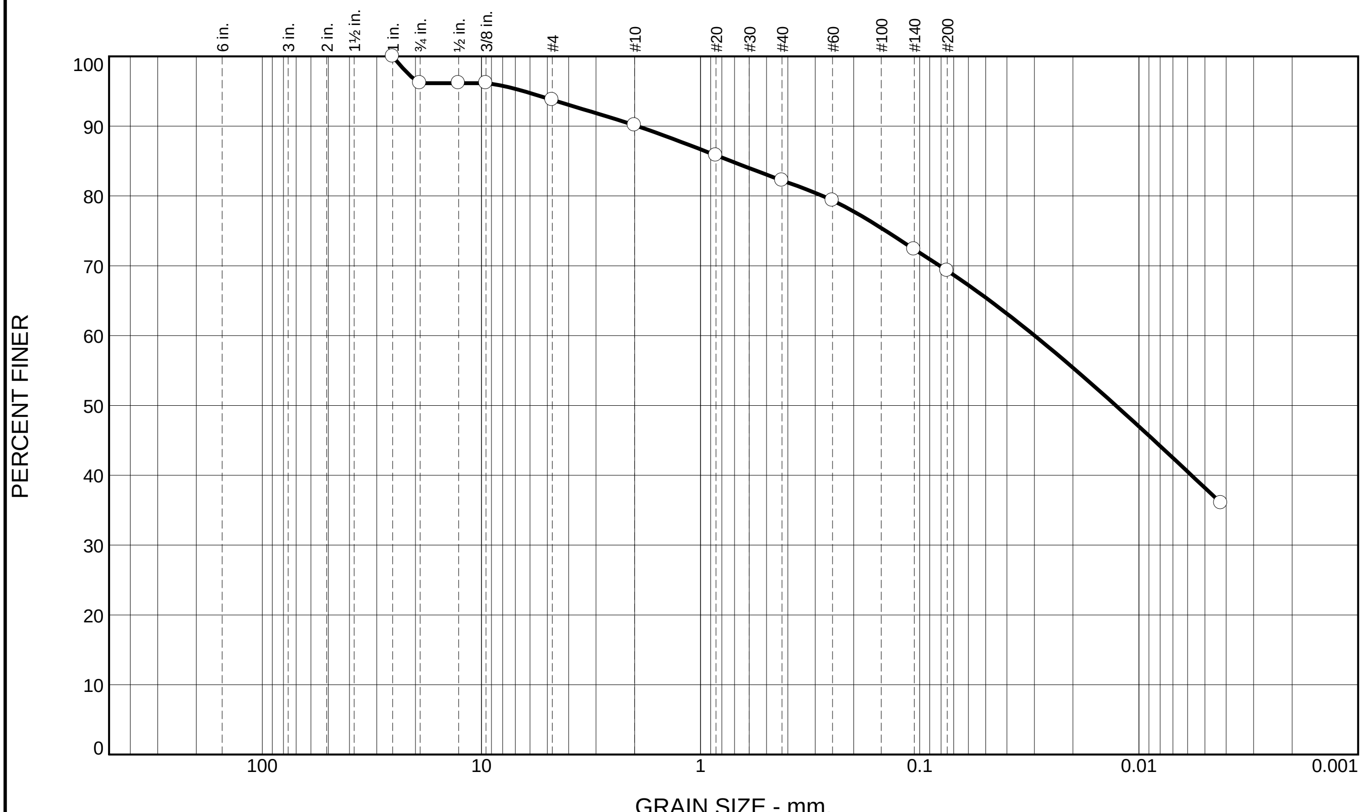
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7337-7338

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	6.2	24.5	31.1	38.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	96.2		
.5	96.2		
.375	96.2		
#4	93.8		
#10	90.1		
#20	85.8		
#40	82.2		
#60	79.4		
#140	72.4		
#200	69.3		

* (no specification provided)

Material Description

BROWN SILTY CLAY

Atterberg Limits

PL= 17 LL= 36 PI= 19

Coefficients

D_{90}= 1.9454 D_{85}= 0.7274 D_{60}= 0.0299
D_{50}= 0.0128 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(11)

Remarks

Source of Sample: B-9 **Depth:** 1-2.5 & 3.5-5'
Sample Number: C12

Date: 11-1-16

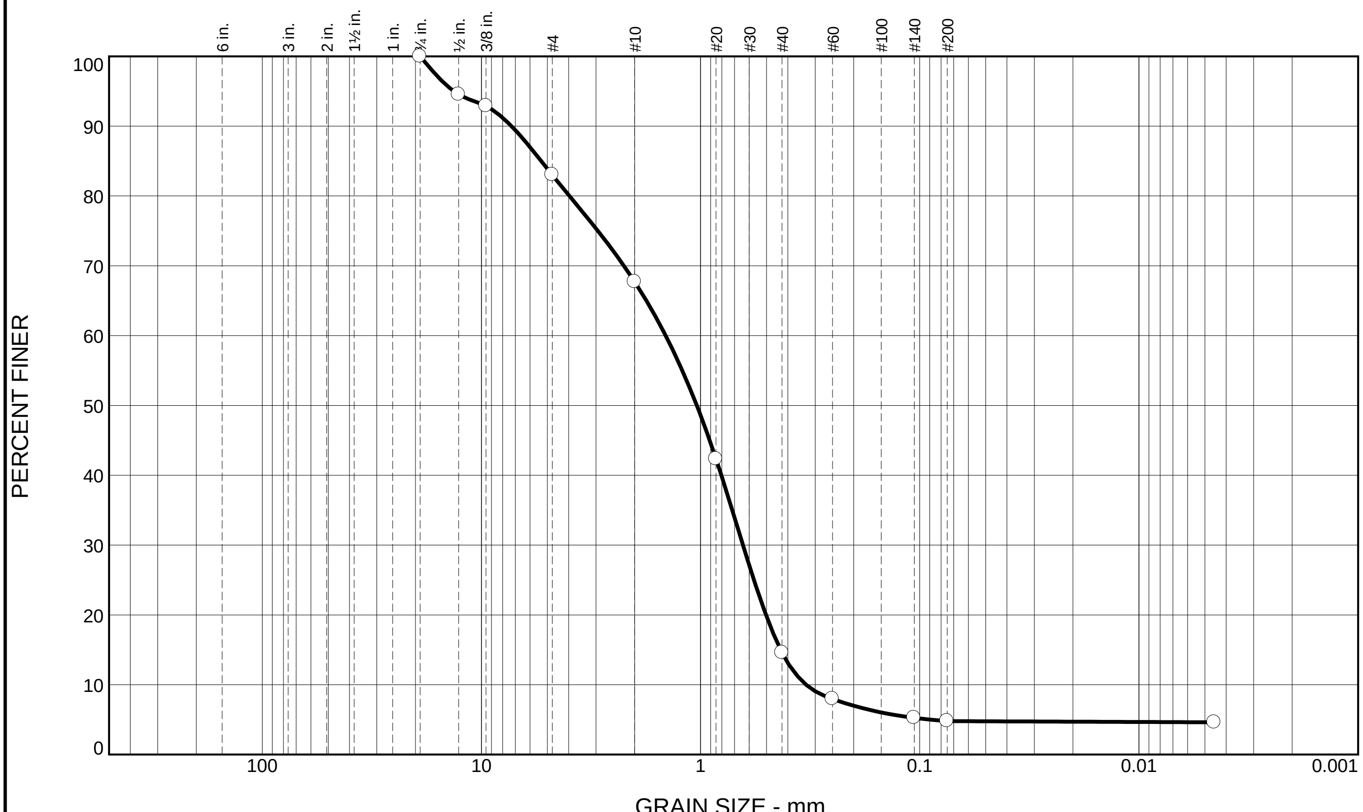
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7341-7342

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	17.0	78.2	0.2	4.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	94.5		
.375	92.9		
#4	83.0		
#10	67.7		
#20	42.3		
#40	14.6		
#60	8.0		
#140	5.3		
#200	4.8		

* (no specification provided)

Material Description

GRAY GRAVEL AND/OR STONE FRAGS. WITH SAND

Atterberg Limits

PL= NP LL= PI=

Coefficients

D_{90}= 7.2930 D_{85}= 5.3333 D_{60}= 1.4431
D_{50}= 1.0404 D_{30}= 0.6409 D_{15}= 0.4313
D_{10}= 0.3299 C_u= 4.37 C_c= 0.86

Classification

USCS= SP AASHTO=

Remarks

Source of Sample: B-10 **Depth:** 23.5-24.8'

Date: 11-2-16

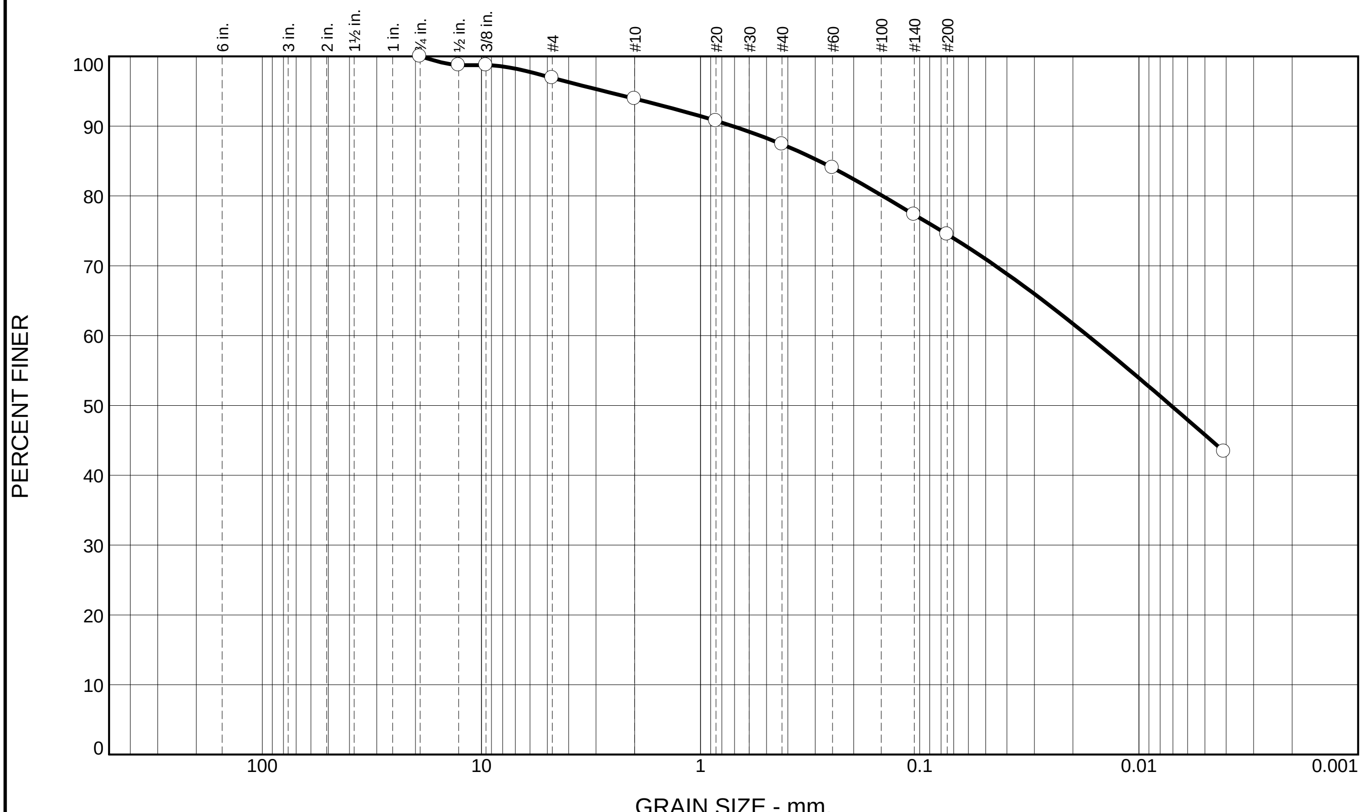
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7355

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	3.1	22.4	28.7	45.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	98.7		
.375	98.7		
#4	96.9		
#10	93.9		
#20	90.8		
#40	87.4		
#60	84.0		
#140	77.3		
#200	74.5		

* (no specification provided)

Material Description

BROWN SILT AND CLAY

Atterberg Limits

PL= 13 LL= 28 PI= 15

Coefficients

D_{90}= 0.7134 D_{85}= 0.2874 D_{60}= 0.0171
D_{50}= 0.0071 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(8)

Remarks

Source of Sample: B-10 **Depth:** 6-7.5 & 8.5-10'
Sample Number: C13

Date: 11-2-16

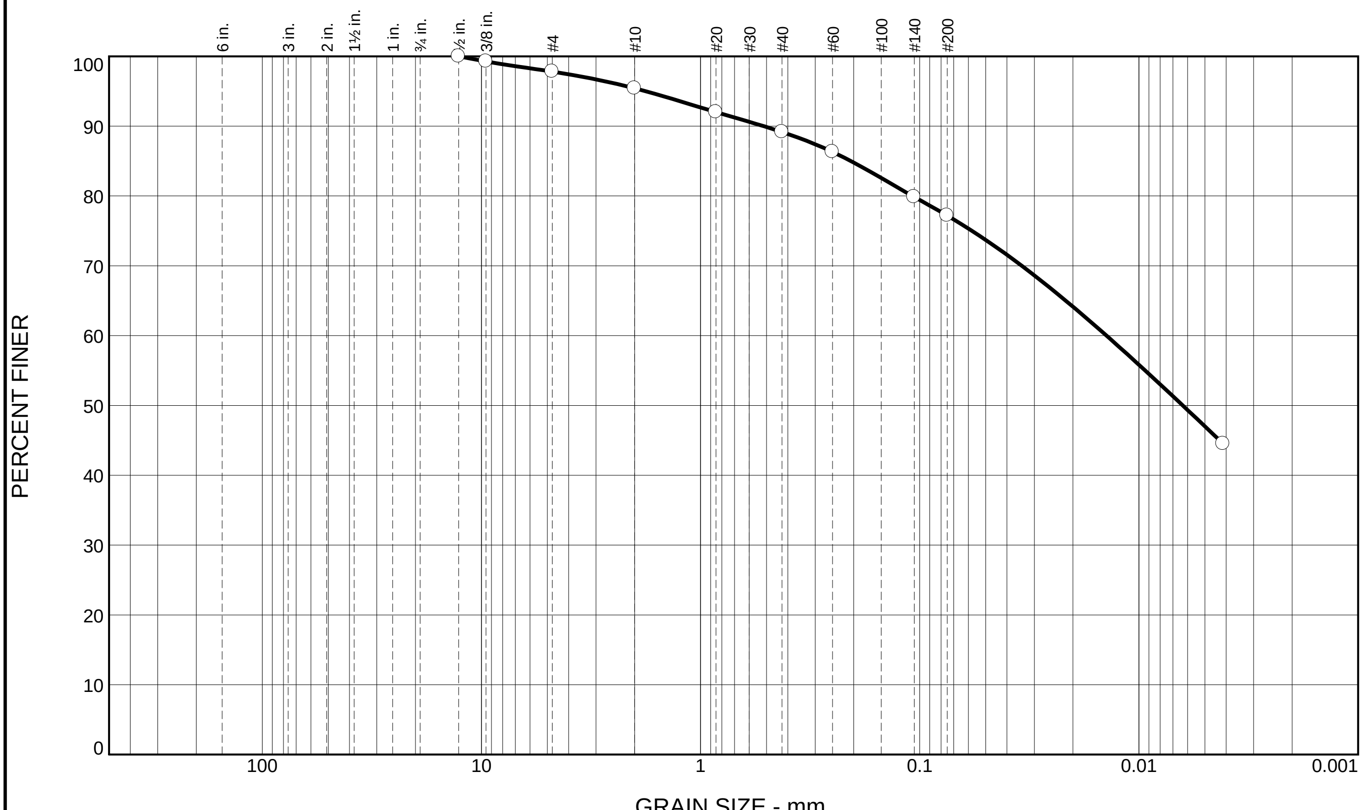
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7348-7349

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	2.2	20.6	30.2	47.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.3		
#4	97.8		
#10	95.4		
#20	92.0		
#40	89.2		
#60	86.3		
#140	79.9		
#200	77.2		

* (no specification provided)

Material Description

GRAY SILTY CLAY

Atterberg Limits

PL= 15 LL= 31 PI= 16

Coefficients

D_{90}= 0.5158 D_{85}= 0.2063 D_{60}= 0.0141
D_{50}= 0.0063 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(10)

Remarks

Source of Sample: B-10 **Depth:** 11-12.5 & 13.5-14'
Sample Number: C14 **Date:** 11-2-16

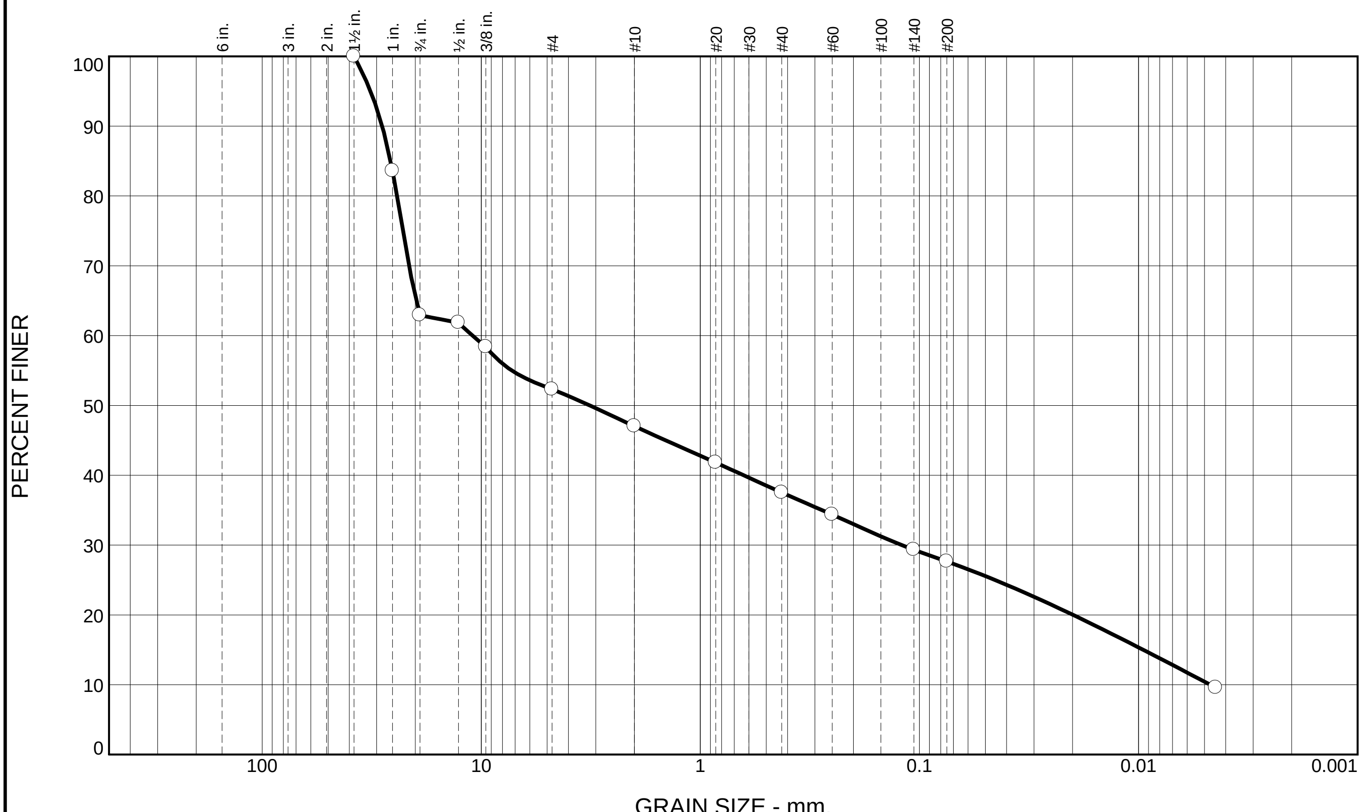
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7350-7351

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	47.7	24.6	17.3	10.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	83.6		
.75	62.9		
.5	61.8		
.375	58.4		
#4	52.3		
#10	47.0		
#20	41.8		
#40	37.5		
#60	34.4		
#140	29.3		
#200	27.7		

* (no specification provided)

Material Description

BROWN GRAVEL AND/OR STONE FRAGS. WITH SAND AND SILT

Atterberg Limits

PL= 13 LL= 17 PI= 4

Coefficients

D_{90}= 28.3060 D_{85}= 25.9326 D_{60}= 10.9616
D_{50}= 3.1978 D_{30}= 0.1203 D_{15}= 0.0095
D_{10}= 0.0047 C_u= 2330.69 C_c= 0.28

Classification

USCS= GC-GM AASHTO= A-2-4(0)

Remarks

** DEPTH: 16-17.5, 17.5-19 & 19-20.5

Source of Sample: B-10 **Depth:** **
Sample Number: C15

Date: 11-2-16

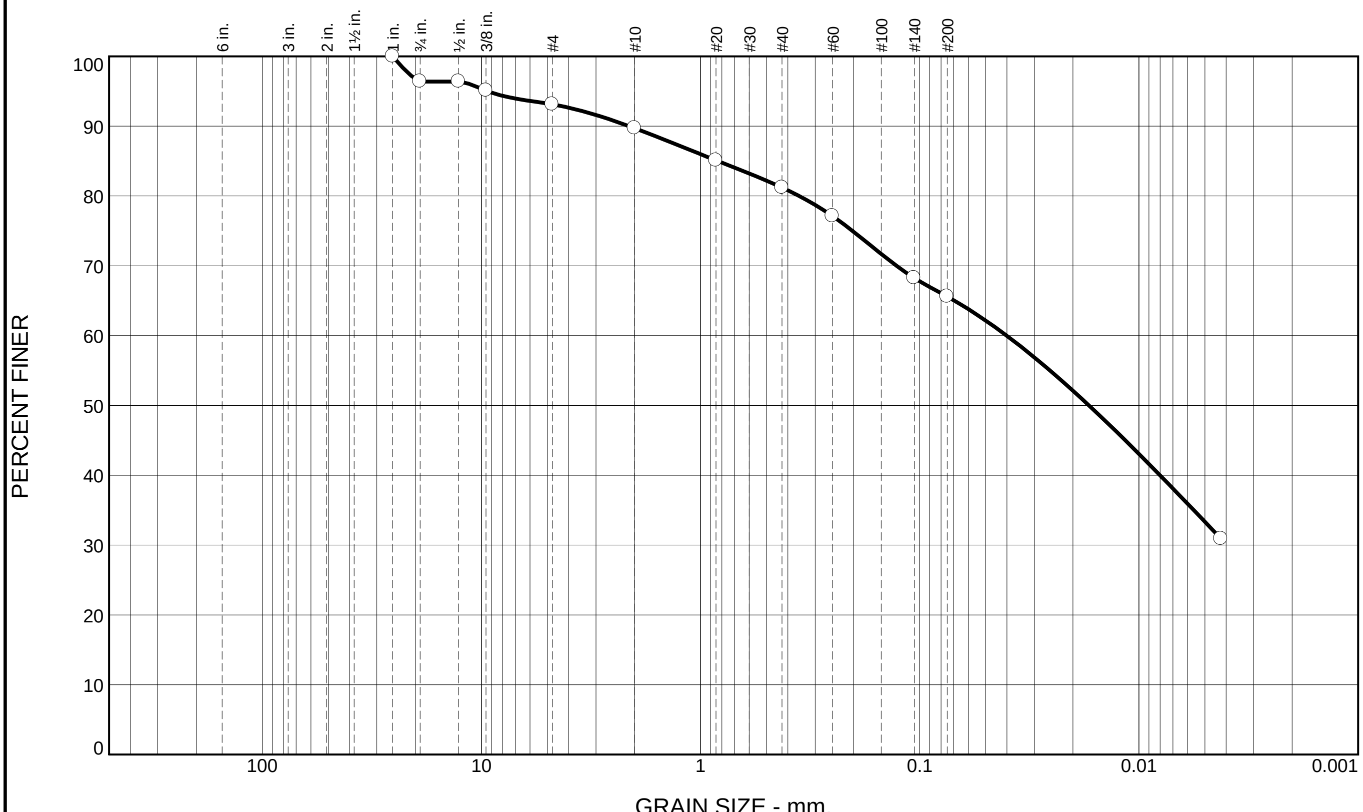
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7352-7354

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	6.9	27.5	32.3	33.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	96.4		
.5	96.4		
.375	95.1		
#4	93.1		
#10	89.7		
#20	85.1		
#40	81.2		
#60	77.1		
#140	68.3		
#200	65.6		

* (no specification provided)

Material Description

GRAY SILT AND CLAY

Atterberg Limits

PL= 13 LL= 24 PI= 11

Coefficients

D_{90}= 2.1211 D_{85}= 0.8348 D_{60}= 0.0402
D_{50}= 0.0169 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(4)

Remarks

Source of Sample: B-11 **Depth:** 12.5-14'

Date: 11-2-16

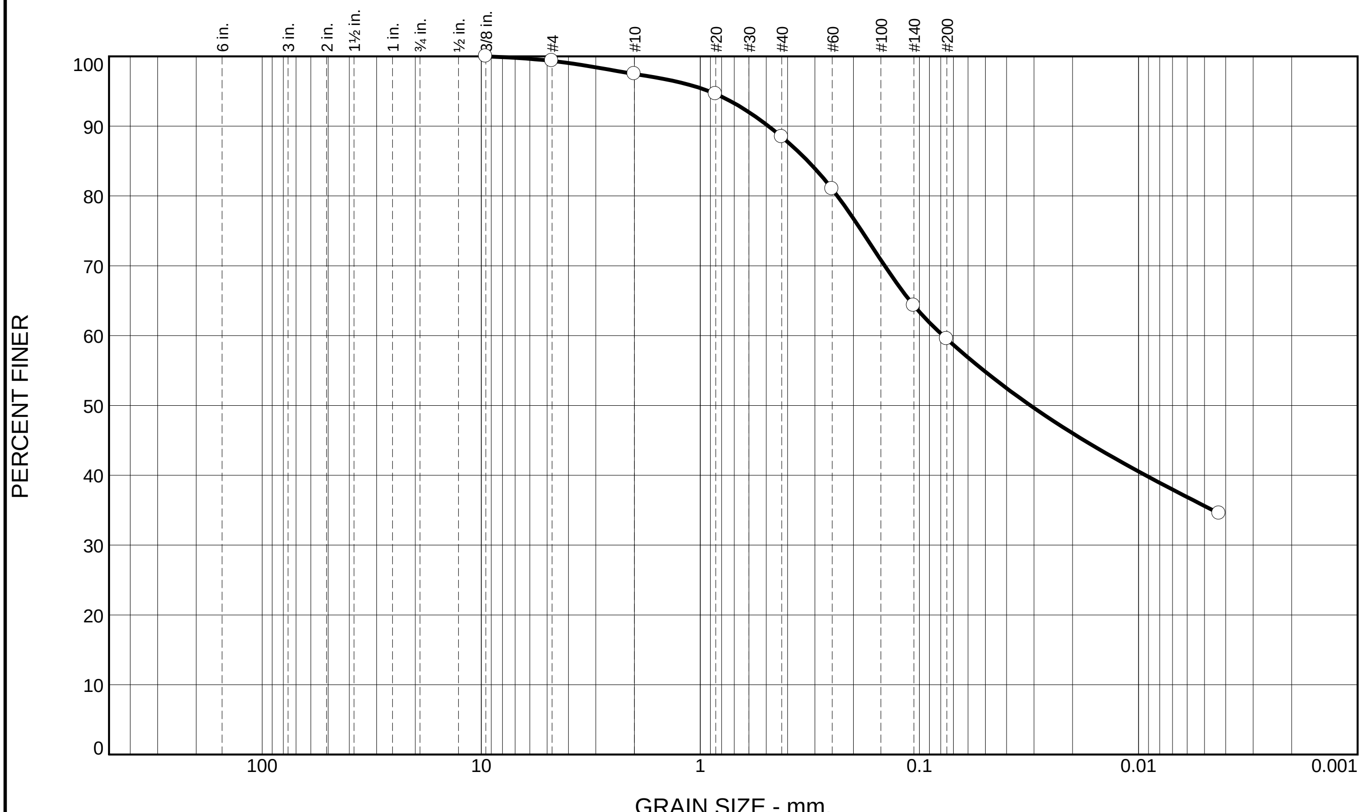
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7363

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	0.7	39.8	23.9	35.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	99.3		
#10	97.5		
#20	94.6		
#40	88.5		
#60	81.0		
#140	64.3		
#200	59.5		

* (no specification provided)

Material Description

BROWN SILTY CLAY

Atterberg Limits

PL= 16 LL= 35 PI= 19

Coefficients

D_{90}= 0.4888 D_{85}= 0.3230 D_{60}= 0.0780
D_{50}= 0.0311 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(8)

Remarks

Source of Sample: B-11 **Depth:** 1-2.5 & 2.5-4'
Sample Number: C16

Date: 11-2-16

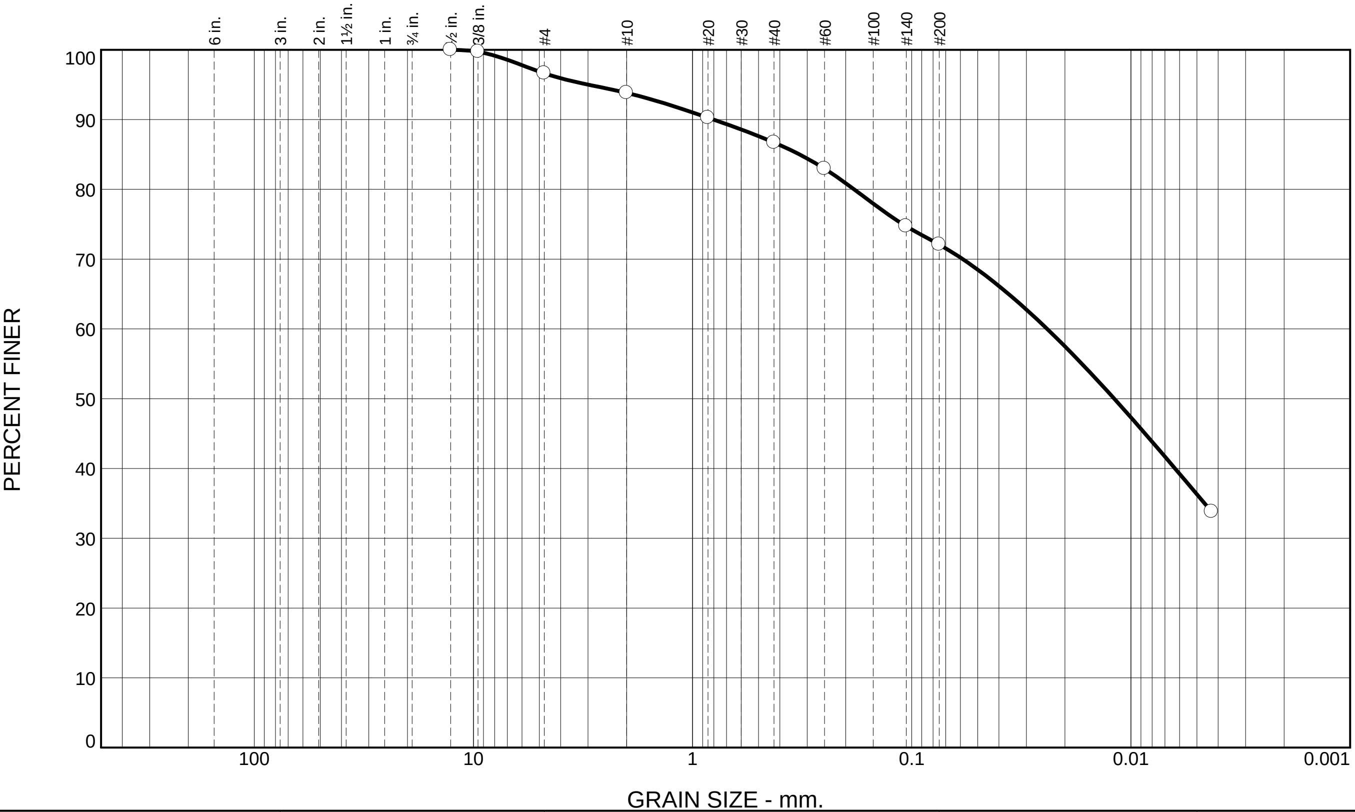
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7356-7357

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	3.4	24.5	35.8	36.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.7		
#4	96.6		
#10	93.8		
#20	90.3		
#40	86.7		
#60	83.0		
#140	74.7		
#200	72.1		

* (no specification provided)

Material Description

BROWN SILT AND CLAY

Atterberg Limits

PL= 14 LL= 27 PI= 13

Coefficients

D_{90}= 0.8040 D_{85}= 0.3252 D_{60}= 0.0241
D_{50}= 0.0119 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(7)

Remarks

Source of Sample: B-11 **Depth:** 5.5-7 & 7-8.5'
Sample Number: C17

Date: 11-2-16

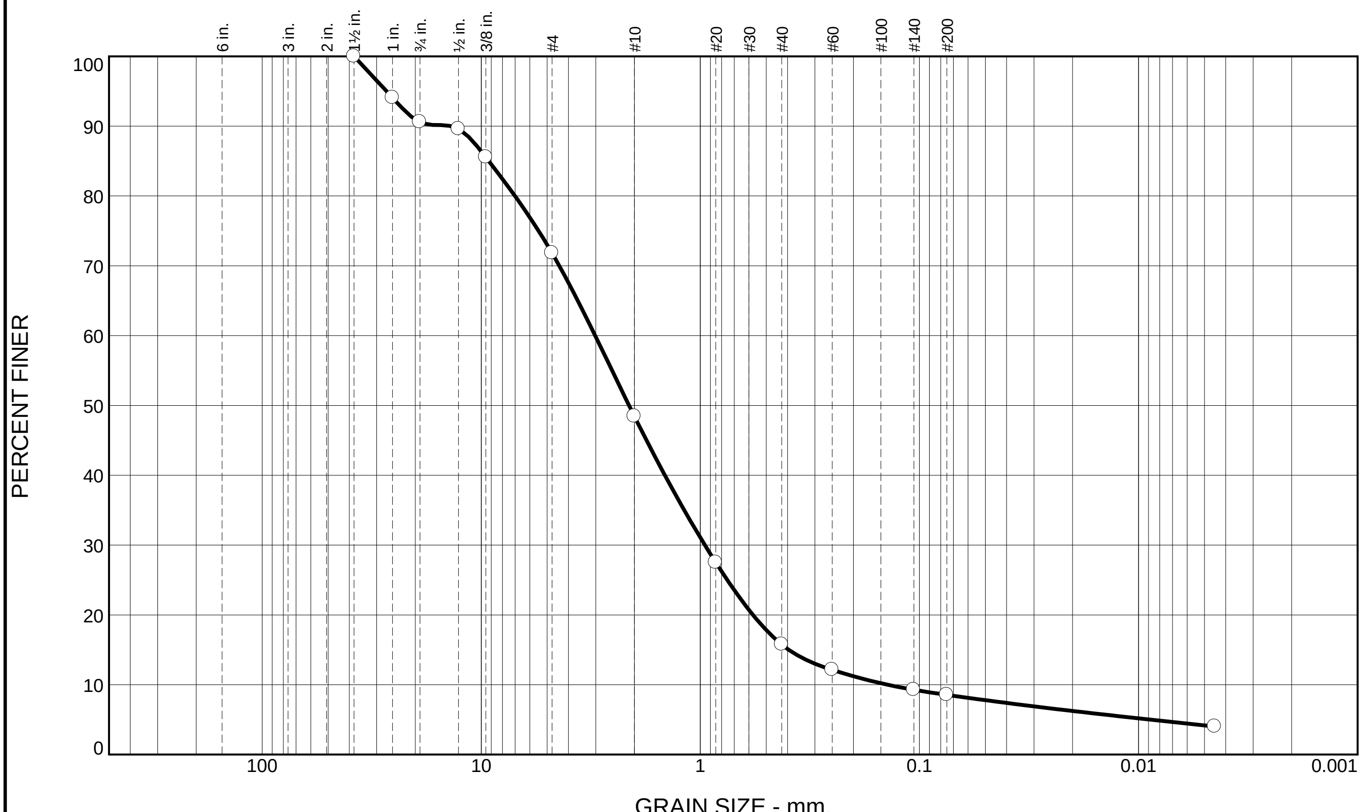
Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7359-7360

Tested By: JJ **Checked By:** GS

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	28.2	63.2	4.4	4.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	94.1		
.75	90.6		
.5	89.6		
.375	85.5		
#4	71.8		
#10	48.5		
#20	27.5		
#40	15.8		
#60	12.1		
#140	9.3		
#200	8.6		

* (no specification provided)

Material Description

GRAY GRAVEL AND/OR STONE FRAGS. WITH SAND

Atterberg Limits

PL= 14 LL= 17 PI= 3

Coefficients

D_{90}= 13.7185 D_{85}= 9.2414 D_{60}= 3.0199
D_{50}= 2.1153 D_{30}= 0.9530 D_{15}= 0.3945
D_{10}= 0.1394 C_u= 21.66 C_c= 2.16

Classification

USCS= SW-SM AASHTO= A-1-a

Remarks

Source of Sample: B-11 **Depth:** 15-16.5 & 17.5-19.8'
Sample Number: C18

Date: 11-2-16

Terracon, Inc.

Cincinnati, Ohio

Client: STANTEC CONSULTING SERVICES, INC
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Project No: N1165419 **Figure** 7364-7365

Tested By: JJ **Checked By:** GS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Road • Dayton, Ohio 45424 Mailing Address: P. O. Box 51 • Dayton, Ohio 45401

AASHTO/ISO 17025 Accredited • USACE Validated ACIL INDEPENDENCE

LABORATORY REPORT

Report To: Terracon
Attn: Tim Goodall
611 Lunken Park Drive
Cincinnati, OH 45226

Report Date: October 26, 2016
Job No.: 177157
Report No.: 418496
No. of Pages: 2

Report On: Laboratory Determination of Sulfate Content in Soils - Turbidimetric Method
Project: Hancock County Flood Diversion PH 1/ODOT - W.O. No. N165419

On October 24, 2016, two samples of soil were submitted for determination of sulfate content in soils from the above referenced source. Testing was performed as specified by the client and in accordance with ODOT Supplement 1122, "Determining Sulfate Content in Soils - Turbidimetric Method".

Results are presented in the following table and detailed on the attached data sheet.

Test Parameter	Lab No. 7283 B-1 (4.0'-5.5')	Lab No. 7358 B-11 (0.0'-1.5')
Water Soluble Sulfate Content, ppm:	**81**	**93**

Should you have any questions, or if we may be of further service, please contact me at (937) 236-8805, extension 322.

Respectfully submitted,

BOWSER-MORNER, INC.

Karl A. Fletcher, Manager
Construction Materials and
Geotechnical Laboratories

KAF/blc
418496
1-File
1-tggoodall@terracon.com

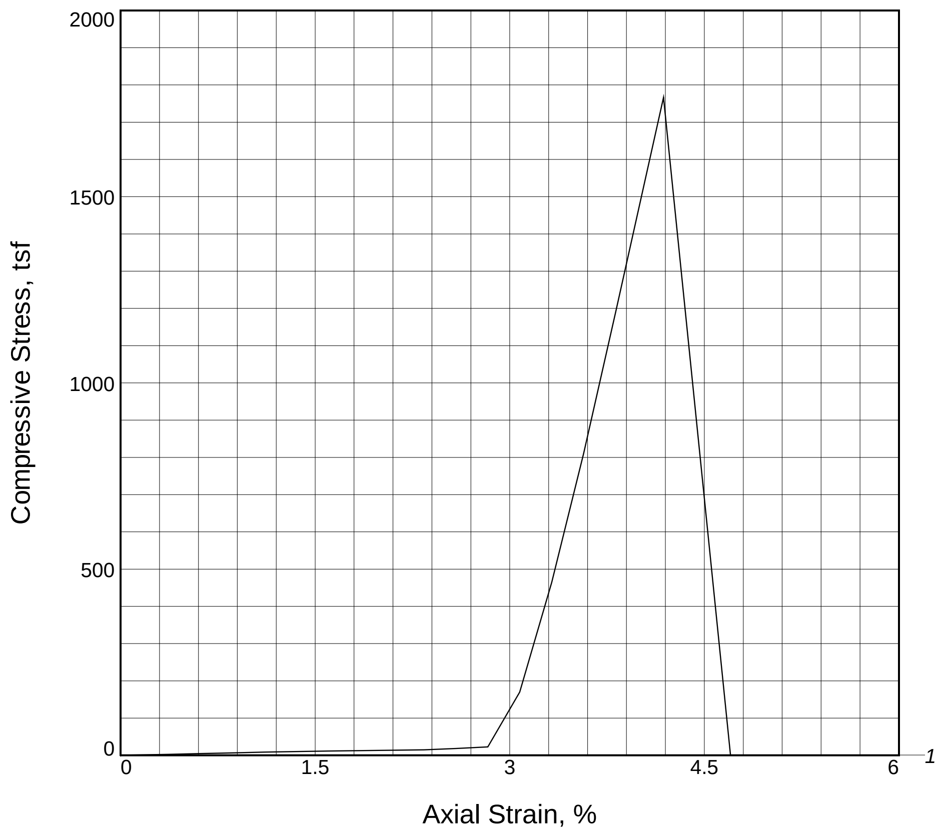
BOWSER MORNER

BOWSER MORNER, INC
DETERMINING SULFATE CONTENT IN SOILS
ODOT SUPPLEMENT 1122

Client: Terracon
Project No.: 177157
Project: Hancock County Flood Diversion PH1/ODOT, W.O. No. N165419
Report Date: 10/26/2016

Lab Number	Boring Number	Sample Depth	Soaking Time (hr)	Dilution Ratio	Replicate Sample Readings			Average Reading	Sulfate Content (ppm)
					1	2	3		
7283	B-1	0.0'-1.5'	20.0	20	4	3.9	4.3	4.1	81
7358	B-11	4.0'-5.5'	20.0	20	5.1	4.6	4.3	4.7	93

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	1766.5639			
Undrained shear strength, tsf	883.2820			
Failure strain, %	4.2			
Strain rate, in./min.	0.040			
Water content, %	0.9			
Wet density, pcf	164.1			
Dry density, pcf	162.6			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.995			
Specimen height, in.	4.062			
Height/diameter ratio	2.04			

Description: LIMESTONE

LL =	PL =	PI =	Assumed GS=	Type: Limestone

Project No.: N1165419
Date Sampled: 10-24-16
Remarks:

Figure 7366

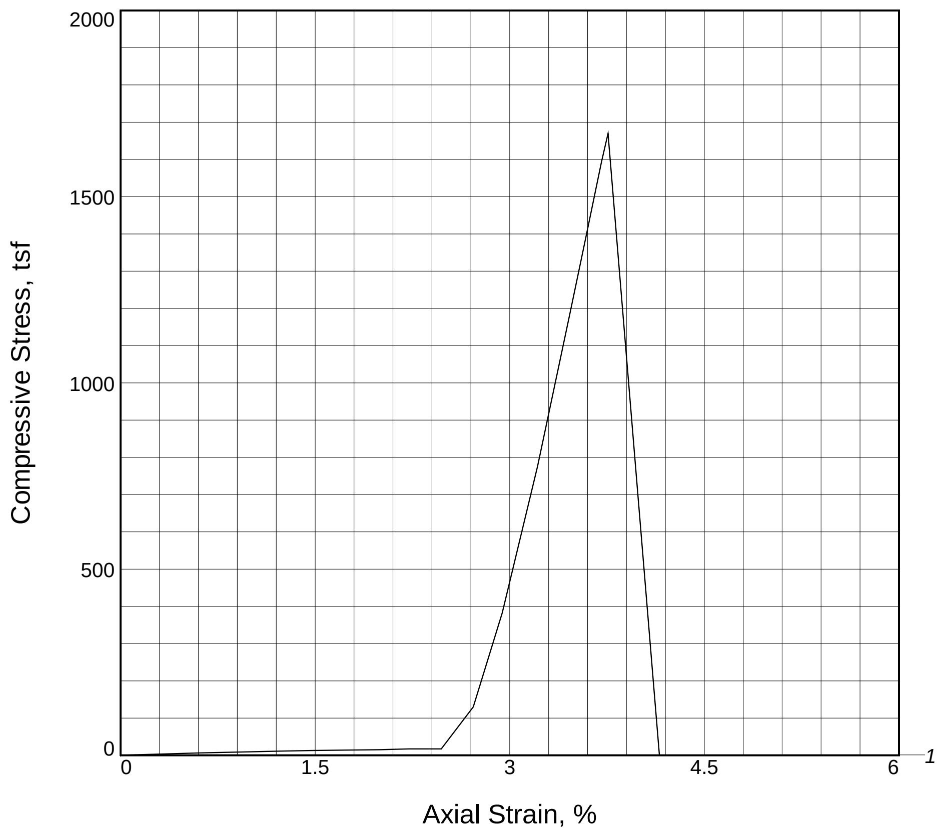
Client: STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Source of Sample: B-2 **Depth:** 31-31.8'
Sample Number: RC

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	1669.4971			
Undrained shear strength, tsf	834.7486			
Failure strain, %	3.8			
Strain rate, in./min.	0.040			
Water content, %	0.4			
Wet density, pcf	170.2			
Dry density, pcf	169.6			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.987			
Specimen height, in.	4.045			
Height/diameter ratio	2.04			

Description: LIMESTONE

LL =	PL =	PI =	Assumed GS=	Type: Limestone

Project No.: N1165419
Date Sampled: 10-24-16
Remarks:

Figure 7367

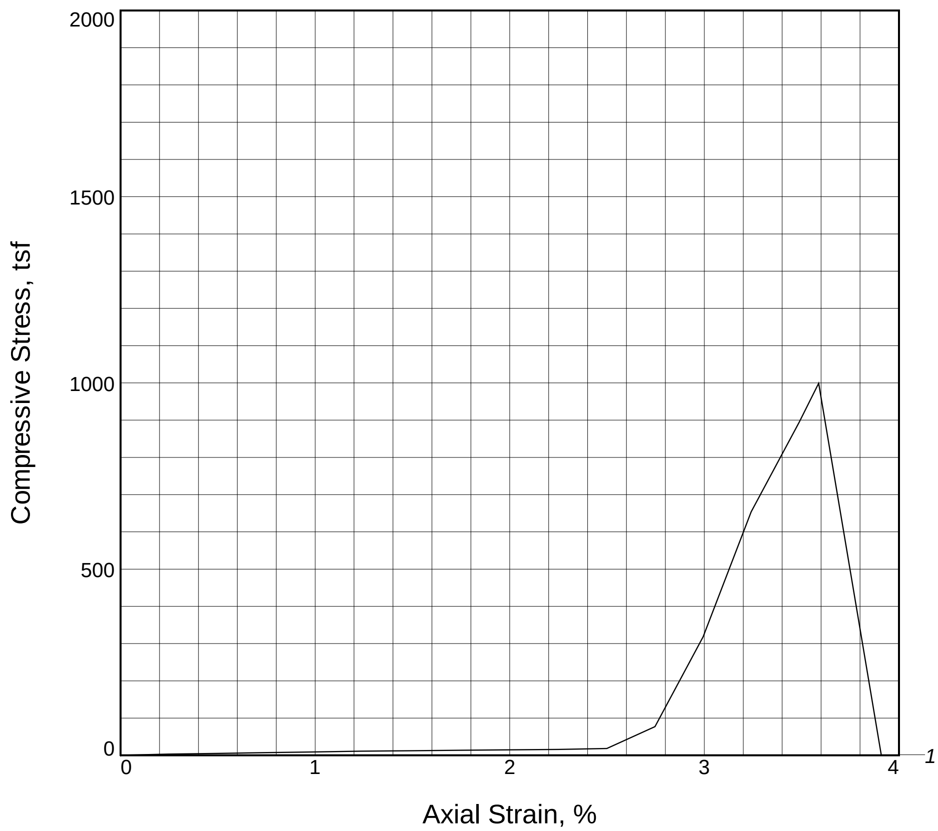
Client: STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Source of Sample: B-3 **Depth:** 17.3-18.1'
Sample Number: RC

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	998.8772			
Undrained shear strength, tsf	499.4386			
Failure strain, %	3.6			
Strain rate, in./min.	0.040			
Water content, %	1.2			
Wet density, pcf	167.6			
Dry density, pcf	165.5			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.990			
Specimen height, in.	4.042			
Height/diameter ratio	2.03			

Description: LIMESTONE

LL =	PL =	PI =	Assumed GS=	Type: Limestone

Project No.: N1165419
Date Sampled: 10-24-16
Remarks:

Figure 7368

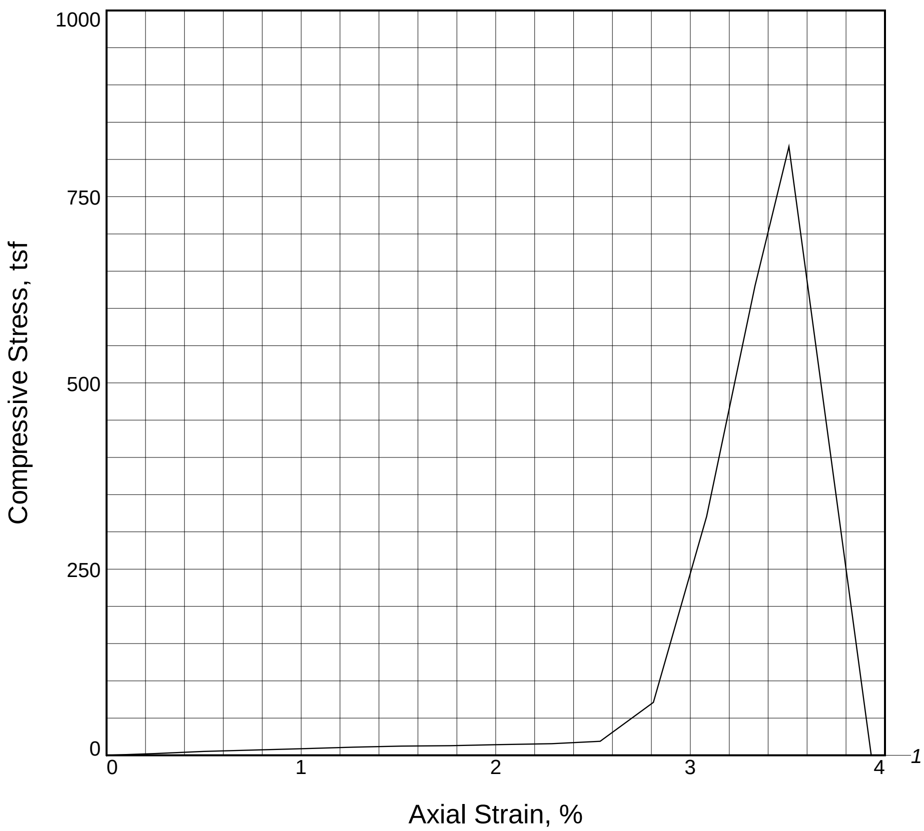
Client: STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Source of Sample: B-4 **Depth:** 40-40.7'
Sample Number: RC

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	817.1546			
Undrained shear strength, tsf	408.5773			
Failure strain, %	3.5			
Strain rate, in./min.	0.040			
Water content, %	0.1			
Wet density, pcf	173.4			
Dry density, pcf	173.2			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.991			
Specimen height, in.	4.021			
Height/diameter ratio	2.02			

Description: LIMESTONE

LL =	**PL =**	**PI =**	**Assumed GS=**	**Type:** Limestone

Project No.: N1165419
Date Sampled: 10-24-16
Remarks:

Figure 7369

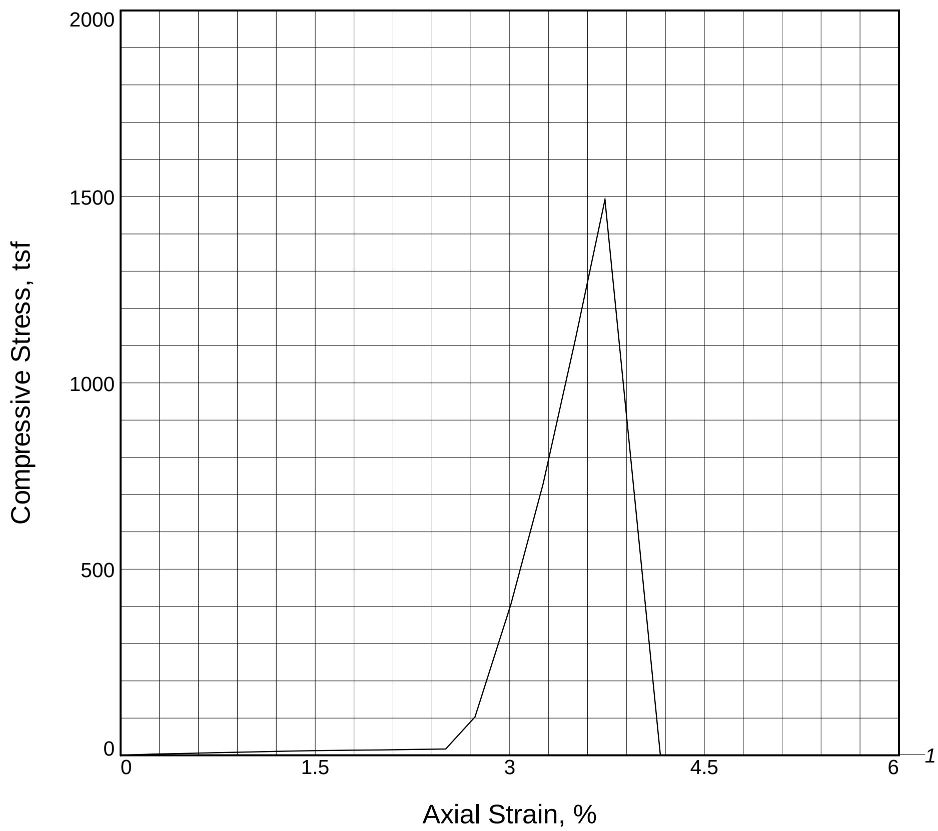
Client: STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Source of Sample: B-5 **Depth:** 25-25.7'
Sample Number: RC

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	1491.7879			
Undrained shear strength, tsf	745.8940			
Failure strain, %	3.7			
Strain rate, in./min.	0.039			
Water content, %	0.3			
Wet density, pcf	158.6			
Dry density, pcf	158.2			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.989			
Specimen height, in.	3.990			
Height/diameter ratio	2.01			

Description: LIMESTONE

LL =	**PL =**	**PI =**	**Assumed GS=**	**Type:** Limestone

Project No.: N1165419
Date Sampled: 10-24-16
Remarks:

Figure 7370

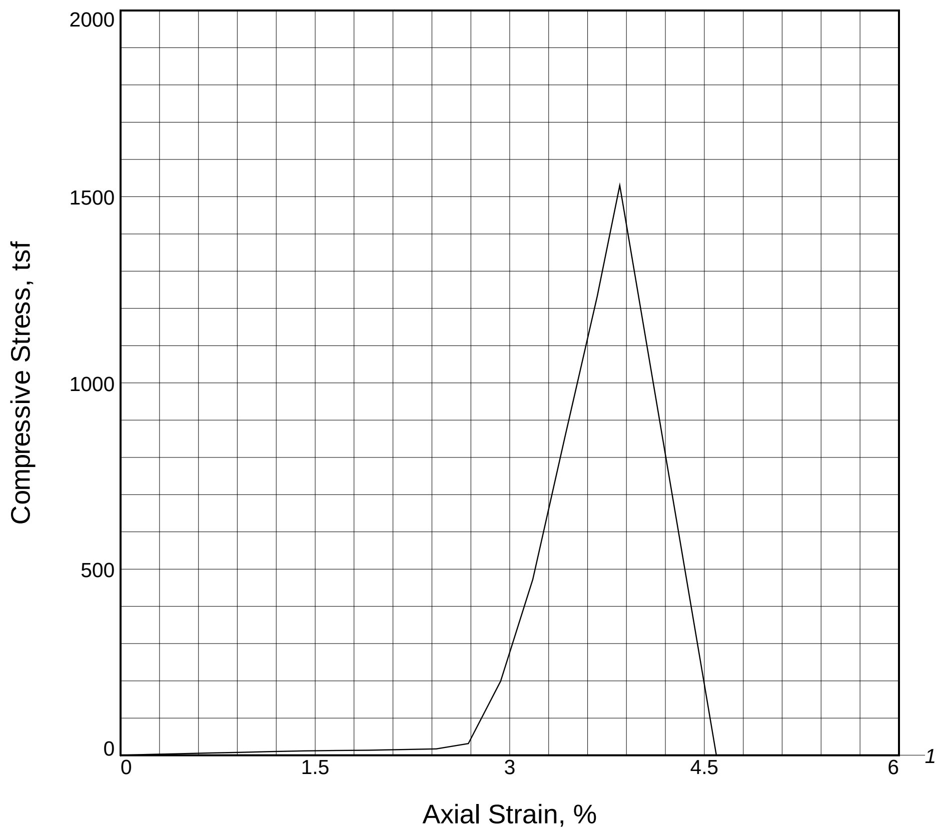
Client: STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Source of Sample: B-7 **Depth:** 23.8-24.3'
Sample Number: RC

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	1530.3534			
Undrained shear strength, tsf	765.1767			
Failure strain, %	3.8			
Strain rate, in./min.	0.040			
Water content, %	2.1			
Wet density, pcf	166.9			
Dry density, pcf	163.4			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.991			
Specimen height, in.	4.028			
Height/diameter ratio	2.02			

Description: LIMESTONE

LL =	PL =	PI =	Assumed GS=	Type: Limestone

Project No.: N1165419
Date Sampled: 10-24-16
Remarks:

Client: STANTEC CONSULTING SERVICES, INC

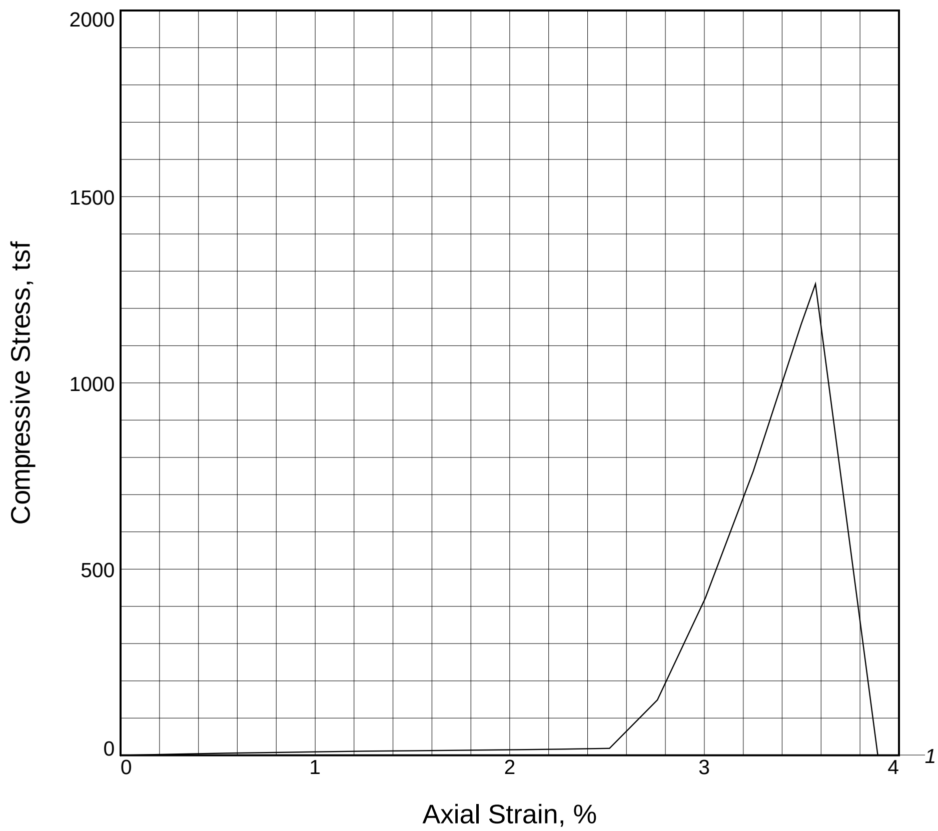
Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Source of Sample: B-8 **Depth:** 31.8-32.4

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Figure 7371

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	1265.5500			
Undrained shear strength, tsf	632.7750			
Failure strain, %	3.6			
Strain rate, in./min.	0.040			
Water content, %	3.0			
Wet density, pcf	165.5			
Dry density, pcf	160.7			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.990			
Specimen height, in.	4.060			
Height/diameter ratio	2.04			

Description: LIMESTONE

LL =	PL =	PI =	Assumed GS=	Type: Limestone

Project No.: N1165419
Date Sampled: 10-24-16
Remarks:

Figure 7372

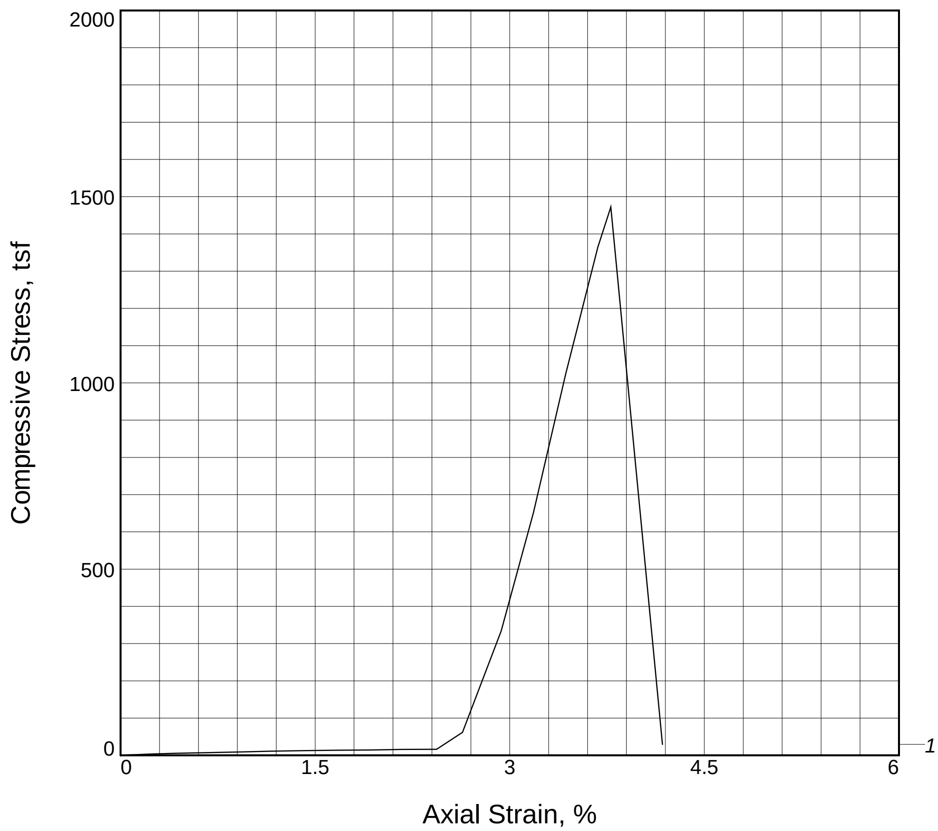
Client: STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Source of Sample: B-9 **Depth:** 28.3-28.9'
Sample Number: RC

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	1472.3356			
Undrained shear strength, tsf	736.1678			
Failure strain, %	3.8			
Strain rate, in./min.	0.040			
Water content, %	0.9			
Wet density, pcf	167.1			
Dry density, pcf	165.7			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.990			
Specimen height, in.	4.022			
Height/diameter ratio	2.02			

Description: LIMESTONE

LL =	PL =	PI =	Assumed GS=	Type: Limestone

Project No.: N1165419
Date Sampled: 10-24-15
Remarks:

Figure 7373

Client: STANTEC CONSULTING SERVICES, INC

Project: HANCOCK COUNTY FLOOD DIVERSION Ph. 1
PROJECT NO. 174316204
Source of Sample: B-10 **Depth:** 40.7-41.4'
Sample Number: RC

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

APPENDIX C
BEDROCK CORE PHOTOGRAPHS

Photo 1 B-2, Run 1 and Run 2 (18.0’-24.0’), Box 1 of 1
B-2 (Alt), Run 1 and Run 2 (18.0’-28.0’), Box 1 of 2

Photo 2 B-2 (Alt), Run 3 and Run 4 (28.0’-38.0’), Box 2 of 2
B-3, Run 1 (17.3’-22.3’), Box 1 of 2

Photo 3 B-3, Run 2 through Run 4 (22.3'-37.3'), Box 2 of 2

Photo 4 B-4, Run 1 through Run 3 (31.0'-46.0'), Box 1 of 2

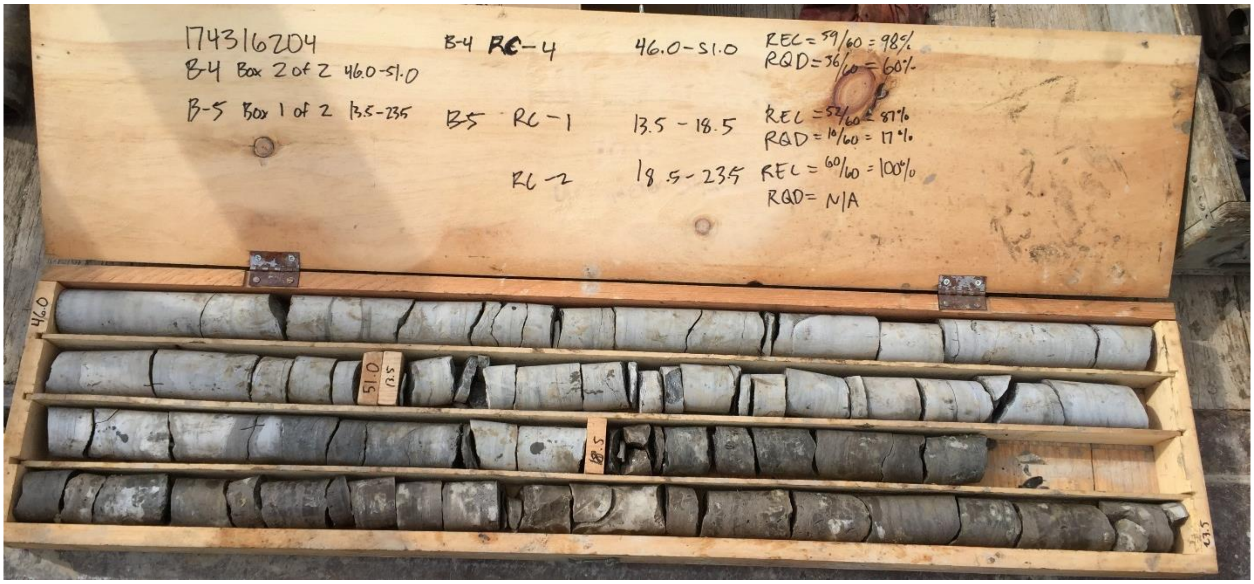


Photo 5 B-4, Run 4 (46.0'-51.0'), Box 2 of 2
B-5, Run 1 and Run 2 (13.5'-23.5'), Box 1 of 2

Photo 6 B-5, Run 1 and Run 2 (23.5'-33.5'), Box 2 of 2
B-6, Run 1 (18.0'-23.0'), Box 1 of 1

Photo 7 B-10, Run 1 through Run 3 (25.0'-40.0'), Box 1 of 2

Photo 8 B-10, Run 4 (40.0'-45.0'), Box 2 of 2
B-8, Run 1 and Run 2 (12.8'-22.8'), Box 1 of 2

Photo 9 B-8, Run 3 through Run 5 (22.8'-33.0'), Box 2 of 2
B-7, Run 1 (8.5'-13.5'), Box 1 of 2

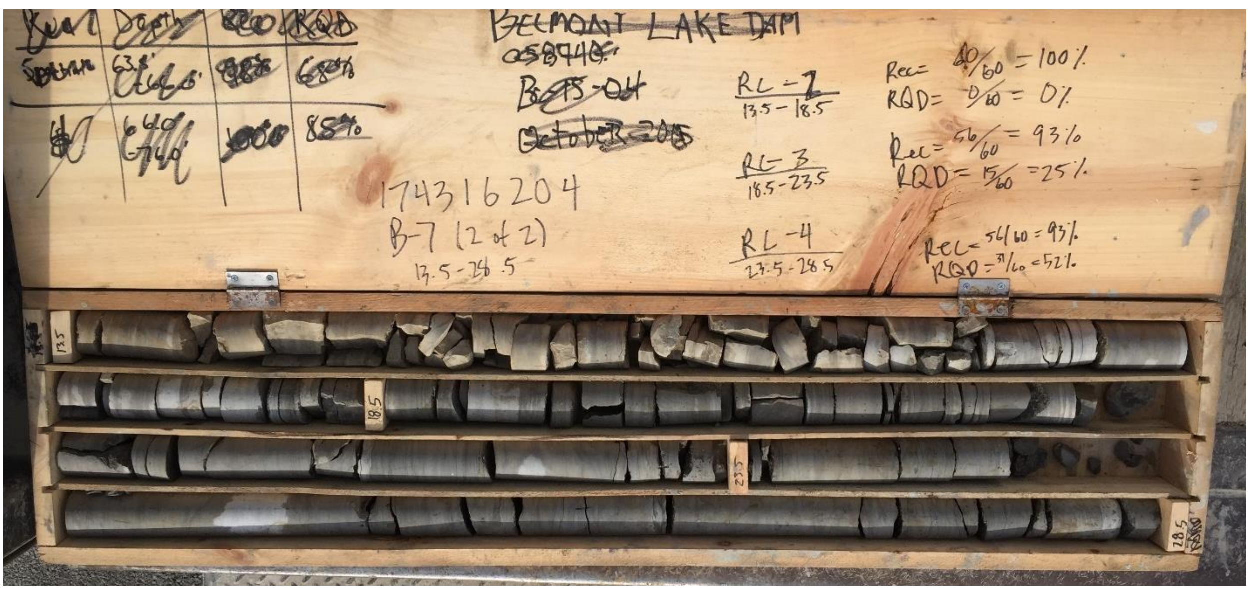


Photo 10 B-7, Run 2 through Run 4 (13.5'-28.5'), Box 2 of 2

Photo 11 B-9, Run 1 through Run 3 (13.0'-28.0'), Box 1 of 2

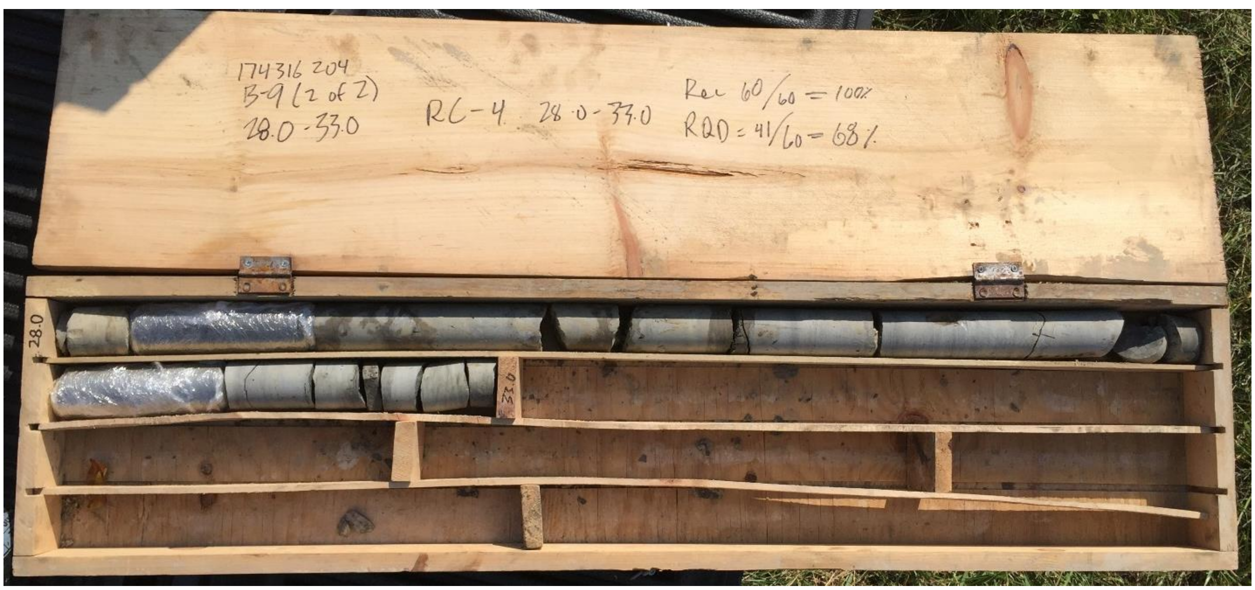
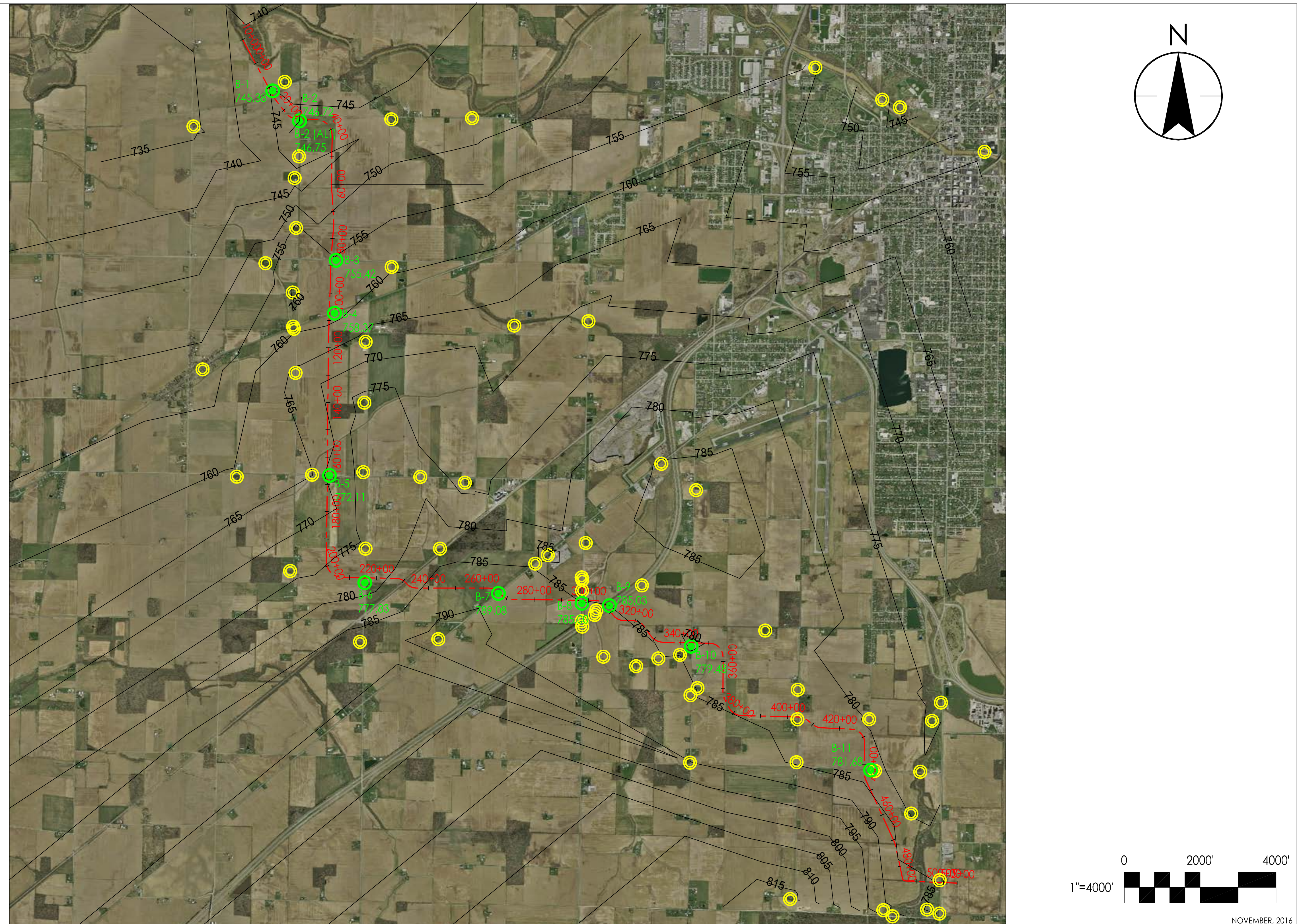


Photo 12 B-9, Run 4 (28.0'-33.0'), Box 2 of 2

APPENDIX D
INTERPRETED TOP OF BEDROCK SURFACE



NOVEMBER, 2016
174316204

Legend

STANTEC BORING LOCATION
B-1 BORING NO.
745.38 TOP OF ROCK ELEVATION

HISTORIC BORING LOCATION

240+00 PROPOSED CHANNEL ALIGNMENT

Note

THE BEDROCK SURFACE WAS INTERPOLATED FROM SURVEYED COORDINATES AND ELEVATIONS OF HISTORIC GEOTECHNICAL BORINGS AND SUPPLEMENTED WITH BORINGS PERFORMED BY STANTEC IN OCTOBER 2016. HISTORIC BORING LOCATIONS AND ELEVATIONS ARE PRESENTED IN THE BLANCHARD RIVER FLOOD RISK MANAGEMENT FEASIBILITY STUDY, GEOTECHNICAL ENGINEERING APPENDIX-DRAFT (USACE, AUGUST 31, 2015) AND BLANCHARD RIVER WATERSHED STUDY GEOTECHNICAL REPORT (URS/BAIRD, MARCH 2013). SURVEYED LOCATIONS AND ELEVATIONS OF THE 2016 BORINGS WERE PROVIDED BY BOCKRATH & ASSOCIATES ENGINEERING AND SURVEYING ON OCTOBER 19, 2016. BORING LOCATIONS (HISTORICAL AND STANTEC) ARE SHOWN IN THE STATE PLANE COORDINATE SYSTEM (NAD 83 HORIZONTAL DATUM). ELEVATIONS ARE SHOWN IN THE NAVD 88 VERTICAL DATUM.

Stantec

11687 Lebanon Road
Cincinnati, Ohio 45241-2012
www.stantec.com

Client/Project
MAUMEE WATERSHED CONSERVANCY DISTRICT
HANCOCK CO. FLOOD DIVERSION PROJECT
PHASE I

Figure No.
01

Title
INTERPRETED BEDROCK SURFACE

APPENDIX E
CALCULATIONS

Hancock County Flood Diversion Project
174316204
Geotechnical Report
Appendix E
Embankment Fill Suitability and Shear Strength (Page 1 of 2)

Boring No.	Layer Thickness (ft)	Layer Class	PI	Short Term C (psf)	Short Term Phi (deg)	Long Term C' (psf)	Long Term Phi' (deg)		Weighted C (psf)	Weighted Phi (deg)	Weighted C' (psf)	Weighted Phi' (deg)
B-1	3	A-7-6	32	1500	0	400	26.7		262	0	70	4.7
	14.2	A-6a	12	2000	0	400	31.9		1651	0	330	26.3
								Weighted Average:	**1913**	**0**	**400**	**31.0**
B-2	6.8	A-6b	20	1700	0	400	28.5		649	0	153	10.9
	11	A-6a	15	2000	0	400	30.2		1236	0	247	18.7
								Weighted Average:	**1885**	**0**	**400**	**29.6**
B-3	7.3	A-6b	21	1700	0	400	28.3		705	0	166	11.7
	2.6	A-6a	11	2000	0	400	32.0		295	0	59	4.7
	7.7	A-4a	10	2000	0	550	33.0		875	0	241	14.4
								Weighted Average:	**1876**	**0**	**466**	**30.9**
B-4	17	A-6a	13	2000	0	400	31.2		1511	0	302	23.6
	5.5	A-4a	3	2000	0	550	33.0		489	0	134	8.1
								Weighted Average:	**2000**	**0**	**437**	**31.7**
B-5	6.1	A-6b	19	1700	0	400	28.8		988	0	232	16.7
	1.5	A-6b	18	1700	0	400	29.1		243	0	57	4.2
	1.8	A-4a	N/A	2000	0	550	33.0		343	0	94	5.7
	1.1	A-6a	13	2000	0	400	31.2		210	0	42	3.3
								Weighted Average:	**1783**	**0**	**426**	**29.8**
B-6	7.5	A-6b	21	1700	0	400	28.3		892	0	210	14.8
	4.3	A-6a	13	2000	0	400	31.2		601	0	120	9.4
	2.5	A-6b	20	1700	0	400	28.5		297	0	70	5.0
								Weighted Average:	**1790**	**0**	**400**	**29.2**
B-7	6.5	A-6b	21	1700	0	400	28.3		1700	0	400	28.3
								Weighted Average:	**1700**	**0**	**400**	**28.3**
B-8	9.4	A-6a	14	2000	0	400	30.7		1649	0	330	25.3
	2	A-4a	9	2000	0	550	33.0		351	0	96	5.8
								Weighted Average:	**2000**	**0**	**426**	**31.1**
B-9	12.5	A-6b	19	1700	0	400	28.8		1700	0	400	28.8
								Weighted Average:	**1700**	**0**	**400**	**28.8**
B-10	9.3	A-6a	15	2000	0	400	30.2		1301	0	260	19.6
	5	A-6b	16	1700	0	400	29.8		594	0	140	10.4
								Weighted Average:	**1895**	**0**	**400**	**30.1**
B-11	3.1	A-6b	19	1700	0	400	28.8		388	0	91	6.6
	8	A-6a	13	2000	0	400	31.2		1176	0	235	18.4
	2.5	A-6a	11	2000	0	400	32.0		368	0	74	5.9
								Weighted Average:	**1932**	**0**	**400**	**30.8**

OVERALL CALCULATIONS

Layer Thickness (ft)	Layer Class	PI	Short Term C (psf)	Short Term Phi (deg)	Long Term C' (psf)	Long Term Phi' (deg)	Weighted C (psf)	Weighted Phi (deg)	Weighted C' (psf)	Weighted Phi' (deg)
3	A-7-6	32	1500	0	400	26.7	4500	0	1200	80.0
14.2	A-6a	12	2000	0	400	31.9	28400	0	5680	452.7
6.8	A-6b	20	1700	0	400	28.5	11560	0	2720	194.1
11	A-6a	15	2000	0	400	30.2	22000	0	4400	332.3
7.3	A-6b	21	1700	0	400	28.3	12410	0	2920	206.6
2.6	A-6a	11	2000	0	400	32.0	5200	0	1040	83.2
7.7	A-4a	10	2000	0	550	33.0	15400	0	4235	254.1
17	A-6a	13	2000	0	400	31.2	34000	0	6800	531.0
5.5	A-4a	3	2000	0	550	33.0	11000	0	3025	181.5
6.1	A-6b	19	1700	0	400	28.8	10370	0	2440	175.7
1.5	A-6b	18	1700	0	400	29.1	2550	0	600	43.6
1.8	A-4a	N/A	2000	0	550	33.0	3600	0	990	59.4
1.1	A-6a	13	2000	0	400	31.2	2200	0	440	34.4
7.5	A-6b	21	1700	0	400	28.3	12750	0	3000	212.3
4.3	A-6a	13	2000	0	400	31.2	8600	0	1720	134.3
2.5	A-6b	20	1700	0	400	28.5	4250	0	1000	71.4
6.5	A-6b	21	1700	0	400	28.3	11050	0	2600	184.0
9.4	A-6a	14	2000	0	400	30.7	18800	0	3760	288.5
2	A-4a	9	2000	0	550	33.0	4000	0	1100	66.0
12.5	A-6b	19	1700	0	400	28.8	21250	0	5000	360.1
9.3	A-6a	15	2000	0	400	30.2	18600	0	3720	280.9
5	A-6b	16	1700	0	400	29.8	8500	0	2000	149.0
3.1	A-6b	19	1700	0	400	28.8	5270	0	1240	89.3
8	A-6a	13	2000	0	400	31.2	16000	0	3200	249.9
2.5	A-6a	11	2000	0	400	32.0	5000	0	1000	80.0
						Weighted Average:	**1879**	**0**	**416**	**30.3**

REFERENCE FROM ODOT GB 6

Soil Type	Short Term C (psf)	Short Term Phi (deg)	Long Term C' (psf)	Long Term Phi' (deg)
A-4a	2000	0	550	33
A-6a	2000	0	400	32
A-6b	1700	0	400	30
A-7-6	1500	0	400	28

Boring No.	Overburden length (ft)
B-1	18.7
B-2	18
B-3	17.3
B-4	30
B-5	12.9
B-6	17.2
B-7	8.5
B-8	12.5
B-9	13
B-10	25
B-11	18

158.2	Total length of silts and clays (ft)
191.1	Total length of overburden (ft)
83%	Percentage silts and clays

Boring B-1		Surface Elevation (ft)	764.1
		Channel Bottom Elevation (ft)	754.0
Depth	**Elevation**	**D_{50} (mm)**	**Weighted D_{50} (mm)**
10	754.1	0.0089	0.0134
11.5	752.6	0.0090	0.0135
13	751.1	<0.0040	0.0060
14.5	749.6	0.0781	0.1172
		Sum (mm)	0.1500
		Total Depth (ft)	6
		Weighted D_{50} Average	**0.0250**

Boring B-2		Surface Elevation (ft)	764.7
		Channel Bottom Elevation (ft)	755.5
Depth	**Elevation**	**D_{50} (mm)**	**Weighted D_{50} (mm)**
10	754.7	0.0078	0.0117
11.5	753.2	0.0071	0.0107
13	751.7	0.0103	0.0155
		Sum (mm)	0.0378
		Total Depth (ft)	4.5
		Weighted D_{50} Average	**0.0084**

Boring B-3		Surface Elevation (ft)	772.7
		Channel Bottom Elevation (ft)	766.0
Depth	**Elevation**	**D_{50} (mm)**	**Weighted D_{50} (mm)**
7.5	765.2	<0.0040	0.0060
9	763.7	<0.0040	0.0024
9.6	763.1	0.0221	0.0199
10.5	762.2	0.0238	0.0357
12	760.7	0.0151	0.0227
		Sum (mm)	0.0866
		Total Depth (ft)	6
		Weighted D_{50} Average	**0.0144**

Boring B-4		Surface Elevation (ft)	788.4
		Channel Bottom Elevation (ft)	770.0
Depth	**Elevation**	**D_{50} (mm)**	**Weighted D_{50} (mm)**
17.5	770.9	0.0085	0.0128
19	769.4	0.0065	0.0098
20.5	767.9	0.0065	0.0065
21.5	766.9	0.5533	0.2767
22	766.4	0.5533	0.8300
		Sum (mm)	1.1356
		Total Depth (ft)	6
		Weighted D_{50} Average	**0.1893**

Boring B-5		Surface Elevation (ft)	785.0
		Channel Bottom Elevation (ft)	775.0
Depth	**Elevation**	**D_{50} (mm)**	**Weighted D_{50} (mm)**
10	775.0	0.0070	0.0077
11.5	773.5	0.224	0.3360
12.9	772.1	ROCK	n/a
		Sum (mm)	0.3437
		Total Depth (ft)	2.6
		Weighted D_{50} Average	**0.1322**

Boring B-6		Surface Elevation (ft)	795.0
		Channel Bottom Elevation (ft)	779.0
Depth	**Elevation**	**D_{50} (mm)**	**Weighted D_{50} (mm)**
16	779.0	2.0116	2.4139
17.2	777.8	ROCK	n/a
		Sum (mm)	2.4139
		Total Depth (ft)	1.2
		Weighted D_{50} Average	**2.0116**

Boring B-7		Surface Elevation (ft)	797.6
		Channel Bottom Elevation (ft)	782.0
Depth	**Elevation**	**D_{50} (mm)**	
8.5	789.1	ROCK	

Boring B-8	Surface Elevation (ft)		797.5
	Channel Bottom Elevation (ft)		784.0
Depth	**Elevation**	**D_{50} (mm)**	
12.5	785.0	ROCK	

Boring B-9	Surface Elevation (ft)		798.0
	Channel Bottom Elevation (ft)		785.0
Depth	**Elevation**	**D_{50} (mm)**	
13	785.0	ROCK	

Boring B-10	Surface Elevation (ft)		804.5
	Channel Bottom Elevation (ft)		787.0
Depth	**Elevation**	**D_{50} (mm)**	**Weighted D_{50} (mm)**
17.5	787.0	3.1978	4.7967
19	785.5	3.1978	11.1923
23.5	781.0	1.0404	1.0404
		Sum (mm)	17.0294
		Total Depth (ft)	6
		Weighted D_{50} Average	**2.8382**

Boring B-11	Surface Elevation (ft)		799.7
	Channel Bottom Elevation (ft)		794.0
Depth	**Elevation**	**D_{50} (mm)**	**Weighted D_{50} (mm)**
5.5	794.2	0.0119	0.0179
7	792.7	0.0119	0.0179
8.5	791.2	n/a	n/a
10	789.7	n/a	n/a
		Sum (mm)	0.0357
		Total Depth (ft)	3
		Weighted D_{50} Average	**0.0119**

Appendix E – HANCOCK COUNTY FLOOD RISK REDUCTION PROGRAM: BENEFIT COST ANALYSIS

Hancock County Flood Risk Reduction Program: Benefit Cost Analysis

(STANTEC Project # 174316204)

Prepared for:

Stantec

Submitted by:

Economics
Public Policy
Planning

Jack Faucett Associates

Since 1963

Point of Contact:

Michael F. Lawrence, JFA President

4915 Saint Elmo Avenue, Suite 205

Bethesda, Maryland 20814

Phone: (301) 961-8835 Fax: (301) 469-3001

lawrence@jfaucett.com

March 2017

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Table of Contents

List of Exhibits

List of Appendices

Executive Summary

The project team, including the Hancock County Commissioners, City of Findlay, and the Maumee Watershed Conservancy District (MWCD), engaged the services of Stantec to analyze the feasibility of alternative structural and non-structural flood control approaches in their community. The U.S. Army Corps of Engineers (USACE), Buffalo District, previously published a report in November 2015 entitled, "The Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT)." Jack Faucett Associates (JFA) supported Stantec by updating that report. In Phase 1 of the support, JFA conducted a review of the USACE economics report (*Phase 1 Memorandum: Review and Assessment of the "Blanchard River Management Feasibility Study Appendix B – Economics (Draft)"* – December 2016). In Phase 2 of the support, JFA conducted an updated benefit-cost analysis (BCA) of the Full Program and the Hydraulic Improvements component of the Hancock County Flood Risk Reduction Program. This BCA effort is further described in detail in this report.

The summary of costs and benefits are provided in Exhibit ES 1.1. The net present value of costs, including maintenance, equal **$20.2 million** for the Hydraulic Improvements component, while costs of the Full Program with maintenance equals **$159.9 million**. The anticipated annual Program costs and benefits are included in Appendix A.

Exhibit ES 1.1: Net Present Value of Benefits and Costs of the Hancock County Flood Risk Reduction Program, Thousands of 2017 Dollars

	Benefits	Costs
Hydraulic Improvements	$93,966	$20,233
Full Program	$255,208	$159,876

To summarize the individual benefits described in the report and Exhibit ES 1.1 provide the present values of each of the individual benefits, over the expected 50-year program analysis period.

Exhibit ES 1.2 provides the benefits from the scenario that considers only the Hydraulic Improvements component. Summing all of the present values of these benefits, the total benefits attributable to the Hydraulic Improvements component are approximately **$94 million**, achieving a Benefit-Cost Ratio of **4.64**.

Exhibit ES 1.3 provides the benefits from the Full Program. Summing all of the present values of these benefits, the total benefits attributable to the Full Program are approximately **$255 million**, achieving a Benefit-Cost Ratio of 1.6.

Exhibit ES 1.2: Present Value Benefits from the Hydraulic Improvements Component, Thousands of 2017 Dollars

Hydraulic Improvments			
From Report Chapter Number	Costs (Net Present Value)	Benefits (Net Present Value)	Benefit/ Cost Ratio
3. Program Costs	$ 20,233		
4. Structural (Residential)		$ 33,896	
4. Structural (Business)		$ 24,901	
5. Motor Vehicles		$ 2,523	
6. Transportation		$ 5,969	
7. Emergency Response		$ 4,050	
8. NFIP Administrative Cost		$ 5,698	
9. Business Losses (Income)		$ 2,067	
9. Business Losses (Cleanup)		$ 2,673	
9. Business Losses (E-Plan)		$ 797	
10. Agricultural		$ 163	
11. Environment		$ 11,229	
Total	$ 20,233	$ 93,966	4.64

Exhibit ES.1.3: Present Value Benefits from the Full Program, Thousands of 2017 Dollars

Full Program			
Category	Costs (Net Present Value)	Benefits (Net Present Value)	Benefit/ Cost Ratio
3. Program Costs	$ 159,876		
4. Structural (Residential)		$ 107,450	
4. Structural (Business)		$ 42,867	
5. Motor Vehicles		$ 5,388	
6. Transportation		$ 8,992	
7. Emergency Response		$ 6,419	
8. NFIP Administrative Cost		$ 18,311	
9. Business Losses (Income)		$ 3,276	
9. Business Losses (Cleanup)		$ 3,153	
9. Business Losses (E-Plan)		$ 1,277	
10. Agricultural		$ 368	
11. Environment		$ 57,707	
Total	$ 159,876	$ 255,208	1.60

Respectfully Submitted,

Michael F. Lawrence, President

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Chapter 1 Introduction

The project team, including the Hancock County Commissioners, City of Findlay, and the Maumee Watershed Conservancy District (MWCD), engaged the services of Stantec to analyze the feasibility of alternative structural and non-structural flood control approaches in their community. The U.S. Army Corps of Engineers (USACE), Buffalo District, previously published a report in November 2015 entitled, “The Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT).” Jack Faucett Associates (JFA) supported Stantec by updating that report. In Phase 1 of the support, JFA conducted a review of the USACE economics report (*Phase 1 Memorandum: Review and Assessment of the “Blanchard River Management Feasibility Study Appendix B – Economics (Draft)”* – December 2016). In Phase 2 of the support, JFA conducted an updated benefit-cost analysis (BCA) of the Full Program and the Hydraulic Improvements component of the Hancock County Flood Risk Reduction Program. This BCA effort is further described in detail in this report.

1.1 Organization of the Report

This report contains 12 chapters. Chapter 1, the introductory chapter, describes the project background along with a brief history of the areas typically impacted by flooding, impacts of the 2007 flood event and progress on flood mitigation efforts to date. It also provides an overview of the study effort, report organization and project rationale. Chapter 2, Methodology, enumerates the tasks included in Phase 2 of the project and the literature reviewed by JFA. It also provides an overview of benefit-cost analysis (BCA) and describes the types of benefits included. Chapter 3 describes the program costs of the flood mitigation efforts. Chapter 4 reviews the benefit of reduced structural damages to residences and businesses as a result of the proposed program alternatives. Chapter 5 covers reduced damages to motor vehicles. Chapter 6 reports the benefits of reduced road closures. Chapter 7 provides the benefits of reduced costs related to emergency responses and debris removal. Chapter 8 looks at the benefit of avoiding administrative costs for the National Flood Insurance Program. Chapter 9 reviews the estimated values of reduced business sales and wage losses. Chapter 10 reports agricultural losses that may be mitigated by the program. Chapter 11 outlines increased land values and economic activity from protecting properties. Chapter 12 reports and summarizes the key results of the BCA.

1.2 Background and Flood History

The Blanchard River Watershed, a portion of the Maumee River Watershed, is located within the counties of Allen, Hancock, Hardin, Putnam, Seneca, and Wyandot in northwest Ohio. The Blanchard River has a history of flooding with records dating back to January 1846, causing significant damages in the City of Findlay and Villages of Ottawa and Glandorf during the 2007 and 2008 floods. According to the stream gage located at Findlay[1] maintained by the U.S. Geological Survey (USGS), the Blanchard River has reached flood stage at least once in 15 of the past 20 years. Between December 2006 and March 2008, Findlay flooded four times with events considered larger than the 10-percent annual chance exceedance (ACE) event flood. Two of the four flooding events were within the top five floods ever recorded in the City.[2]

Three types of flooding occur most often in the Blanchard River Basin – river flooding, flash flooding and urban flooding. Flooding takes place in the urban areas of Findlay and throughout the agricultural land adjacent to the major streams, particularly in the spring when the snows melt and rainfall increases.[3] In the City of Findlay and the Villages of Ottawa and Glandorf, tens of millions of dollars in damage result from flooding in 2007 and 2008. Based upon available information, the estimated value of the properties in the potential floodplain within the areas influenced by the recommended Flood Risk Reduction Program exceeds $1 trillion. Both businesses and residences experience substantial damage during flood events. Flooding often persists for days during major events, resulting in significant cleanup and restoration expenses to the local, state and federal governments.[4]

In addition to the flood damage to residences and small businesses, flooding damages disrupt the local road and rail systems, as well as regional manufacturing businesses that rely on those facilities. During the periods of major flooding, extensive road closures and delays are typical.

1.3 Benefit-Cost Analysis

The application of a benefit-cost analysis (BCA) has a long-standing history in the region to augment community information and inform local decision-making. Historically, the Ohio Conservancy Law (ORC Chapter 6101), passed in 1914, gave the state authority to establish watershed districts to raise funds for improvements through various funding mechanisms.[5] In the early 20th century, the Miami Conservancy District project brought this approach to fruition with its use of complex simulation and optimization modeling, a detailed cost–benefit analysis, and its linking of economics, engineering, science, and law into a far-reaching solution to a complex water resources problem.[6] The Miami Conservancy District is a river management agency operating in Southwest Ohio to control flooding of the Great Miami River and its tributaries. Similarly, the Maumee Watershed Conservancy District, or MWCD, established in

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[1] USGS stream gage located in Blanchard River near Findlay, Ohio (04189000)

[2] National Weather Service. http://www.weather.gov/

[3] USACE, Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT), November 2015

[4] Ibid.

[5] http://www.ohiohistorycentral.org/w/Ohio_Conservancy_Law

[6] Holmes, K. & Wolman, M. Early Development of Systems Analysis in Natural Resources Management from *Man and Nature* to the Miami Conservancy District. Environmental Management (2001) 27: 177

June of 1950, was established to provide similar solutions to 15 counties tributary to the Maumee River and western basin of Lake Erie. The upper reaches of the Blanchard River examined within this report are included within the Maumee River watershed.

The benefit-cost ratio (BCR) is determined by dividing the present value of total estimated economic benefits by the present value of estimated costs of the recommended improvements. The BCR indicates which project alternatives produce the most benefits for each dollar of cost. Projects with high BCRs produce the most efficiency per dollar invested. The ratio of benefits to costs must exceed 1.0 to be considered for advancement under Ohio Conservancy Law.

In this BCA study, the research team identified the estimated costs that could be avoided if flooding was reduced in and around the City of Findlay. Stantec developed the Hancock County Flood Risk Reduction Program to mitigate the risk of flooding and to increase protection for the community and their assets from periodic flooding events. Stantec provided JFA with Water Surface Profiles (WSP) for the Blanchard River, Eagle Creek, and Lye Creek for eight different return frequencies. By combining the WSP and the floodplain structure inventory the team determined the expected flood damages avoided over the life of the program.

1.4 Project Description and Rationale

In September 2016, the Hancock County Commissioners ceded control of the project to the Maumee Watershed Conservancy District (MWCD) through a memorandum of agreement (MOA). Representing 15 counties in northwest Ohio and the second largest conservancy district in the state, MWCD is a political subdivision of the State of Ohio that oversees water management, including flood risk reduction, as established under Ohio Revised Code Chapter 6101. The District has the experience assessing these issues and the authority to deal with drainage in the watershed. However, existing finances for the project are currently under County control through the MOA noted above.

In mid-2016, Hancock County's commissioners engaged Stantec to provide a second opinion of the plan proposed by the USACE. Stantec discovered inconsistencies within the USACE's hydraulic model, reducing the flood reduction estimate of the selected project alternative from 4.5 feet to less than 2 feet in downtown Findlay at Main Street. Stantec received direction from the client that the planning level project objective was to reduce the stage of the 1-percent annual chance event flood in downtown Findlay by about 4.5 feet. As a result, Stantec reviewed the recommended USACE plan for technically feasible optimizations and took a step back to see if there were other feasible and cost-effective alternatives to the USACE plan.

After project refinement, Stantec added additional alternatives to the base project including dry storage basins on Eagle Creek, the Blanchard River, and Potato Run, removing inline structures on the Blanchard River and widening the floodplain bench as the Blanchard River flows through the City. The Final Program recommended by Stantec increases the level of flood reduction and is currently estimated to reduce the flooding stage for the 1-percent annual change event by about 3.6 feet below the existing flood elevation at Main Street.

Stantec hired JFA to evaluate the existing USACE benefit-cost analysis report and produce a new benefit-cost analysis for the revised Final Program, as well as the initial Hydraulic Improvements along the Blanchard River in downtown Findlay. This BCA produced a revised BCR that demonstrates to the community that the program benefits outweigh the costs and warrant additional support for moving forward. However, as some of the flood improvements may involve the use of land currently supporting agriculture, the recommended alternative may encounter some community resistance. The project team of the County Commissioners, the City of Findlay and MWCD hope the BCA will demonstrate to the community that despite these concerns, the project is highly beneficial to the Hancock County community and its residents.

This Phase 2 report describes the methodology used in the BCA, program costs and anticipated benefits of the Full Program and the Hydraulic Improvements component of the Hancock County Flood Risk Reduction Program compared to the existing conditions.

Chapter 2 Methodology

Chapter 2 describes the methodology used to evaluate the economic efficiency of the proposed *Hancock County Flood Risk Reduction Program* . It provides background on conducting a benefit-cost analysis (BCA), explains the "base case", or "no action", condition in a BCA, expands on the types of benefits measured and explains the net present value and concept of discounting in this type of the project.

2.1 Fundamentals of Benefit Cost Analysis

This section provides a brief overview of the essentials of benefit-cost analysis (BCA). Benefit-cost analysis is an economic technique to evaluate what is achieved (benefits) compared to what is invested (costs).[7] BCA analyzes whether the value of benefits exceeds the value of the costs. This allows decision makers to allocate resources in an efficient manner.

BCA can assist decision makers select the best alternative by monetizing both benefits and costs. The first comparison in BCA is to calculate the net benefits by subtracting economic costs from total economic benefits. This allows the analysis to scale a range of alternatives for comparison. The second comparison is to calculate the benefit-cost ratio (BCR) by dividing the present value of total economic benefits by present value of total economic costs. The ratio allows for ranking or comparing different projects by informing which alternative produces the most benefits for every dollar of cost (total benefits/total costs). A (BCR) of one (1) indicates the total benefits equal the total costs. For each dollar of cost, a dollar of benefit accrues. If the ratio is less than one (1), the total costs exceed the total benefits. This indicates a poor investment of resources.

For projects such as flood risk management, decision makers can compare and prioritize projects from across the nation and regionally. Projects with higher BCRs are preferred and the BCR becomes a factor by which projects are authorized to move from conceptual planning to detailed design and implementation. In this project, the prior USACE plan used BCA to compare a range of flood mitigation alternatives from a national perspective. Under the current program, with the efforts being led by the Maumee Watershed Conservancy District (MWCD), the Program Team is utilizing the BCA to examine the costs and benefits of the recommended Flood Risk Reduction Program from a regional perspective. Exhibit 2-1 provides some useful applications of BCA.

[7] USACE & Institute for Water Resources. Economics Primer. IWR Report 09-R-3, June 2009.

Exhibit 2.1: Useful Applications of Benefit Cost Analyses

Useful Applications of Benefit Cost Analyses

A BCA considers the changes in benefits and costs that a project would cause by a potential improvement to the status quo protection. In flood mitigation, decision makers may use BCA to help determine the following:

- ***Whether or not a project should be undertaken at all*** - (i.e., whether the project's life-cycle benefits will exceed its costs)
- ***When a project should be undertaken -*** A BCA may reveal that the project does not pass economic muster now, but would be worth pursuing 10 years from now due to projected regional growth. If so, it may be prudent to take steps now to preserve the future project's footprint.
- ***Which among many competing alternatives and projects should be funded* given a limited budget -** A BCA can be used to select from among design alternatives that yield different benefits
- ***After project implementation -*** *BCA can evaluate current project performance or* evaluate implemented projects to verify BCA ratios for future project performance measurement

Comparison of benefits to costs over the life of a project is not a simple issue of adding up the benefits. The value of a dollar changes with time. A dollar an entity spends or earns in the future is usually worth less than it is today. To compare multiyear projects, one must account for the changing value of the dollar. Two factors account for the diminishing value of the dollar with time. These two factors are inflation and the time value of resources. BCA compares projects in real or base year dollars, with the effects of inflation removed. The process measures the time value of resources by the annual percentage factor known as the discount rate. Through discounting, decision makers can objectively compare different investment alternatives based on their respective current values.

The USACE developed a series of manuals describing how to evaluate urban benefits of water resources implementation projects. The general guidance within these manuals are applicable for both national and regional analyses. JFA followed the guidance of these manuals in reviewing the current BCA and, as described below, used these USACE-derived procedures to

estimate Regional Economic Development (RED) benefits and costs of the recommended water resource projects.[8] [9] Exhibit 2-2 provides the major steps in the BCA process.
The objective of the following sections is to discuss in greater detail several methodological issues and procedures applied in this review. These areas include defining the base case condition, project alternatives, Regional Economic Development (RED) measures, and analysis methodology.

2.2 Base Case Condition ("Without Project Alternative")

An important aspect of benefit-cost analysis is the selection of a base case (i.e. a "without-project condition" or "no action condition") and its comparison with the recommended Flood Risk Reduction Program. According to the USACE's Planning Guidance Notebook, the without-project condition is defined as, *"… the most likely condition expected to exist in the future in the absence of a proposed water resources project. Proper definition and forecast of the future without-project condition are critical to the success of the planning process. The future without-project condition constitutes the benchmark against which plans are evaluated."*[10]

Exhibit 2.2: Major Steps in the Benefit Cost Analysis Process

1. Establish objectives
2. Identify constraints and specify assumptions
3. Define the base case and identify alternatives
4. Set the analysis period
5. Define the level of effort for screening alternatives
6. Develop base case damage estimate
7. Estimate benefits and costs relative to base case
8. Evaluate risks
9. Compare net benefits and rank alternatives
10. Make recommendations

2.3 Definition of NED and RED Benefits

The USACE defines National Economic Development (NED) benefits as benefits that accrue to the nation as a whole: *"Beneficial effects in the NED account are increases in the economic value of the national output of goods and services from a plan."*[11] The methodology employed by the USACE recognizes NED benefits as only those impacts that would be lost to the nation in the absence of the project. In addition, USACE recognizes improvements in efficiency, such as reductions in the nation's overall flood protection bill as NED benefits.

[8] USACE, Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, 1983

[9] Planning Guidance Notebook" (Engineering Record No. 1105-2-100).

[10] USACE. 2000. "Planning Guidance Notebook." (Engineering Record No. 1105-2-100, Section 2-4.b.(1)). http://www.usace.army.mil/publications/eng-regs/er1105-2-100/

[11] USACE. 1983. "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." p.8, Section 1.7.1.(b).

The USACE defines Regional Economic Development (RED) benefits as benefits that accrue at the regional level. According to the USACE Principles and Guidelines, *"The RED account registers changes in the distribution of regional economic activity that result from each alternative plan."* [12]

2.4 Definition of the RED Area

According to the USACE Principles and Guidelines, *"The regions used for RED analysis are those regions with in which the plan will have particularly significant income and employment effects."* [13] For this study, Hancock County is the core of the RED area.

2.5 Benefit-Cost and Net Present Value Analysis

To determine whether an investment is justifiable, the project sponsor performs a Benefit-Cost Analysis (BCA) that quantifies the benefits and costs. The analysis can analyze benefit and cost quantities in many ways, such as total benefits minus total costs (i.e. net present value analysis) or benefits divided by costs (i.e. benefit-cost ratio). In this case, the net present value of the costs is based upon estimated costs provided by Stantec for the proposed Hydraulic Improvements components and the Full Program within the Blanchard River, Eagle Creek and Lye Creek floodplain in and near Findlay, Ohio. However, in order to be meaningful, a BCA must not only express all benefits and costs in monetary terms, it must also account for the change in the value of the dollar over time.

The value of a dollar changes not only with inflation, but also because today's dollar is worth more than a dollar available years from now. For example, a single dollar available today would be worth more than one single dollar in five years because it could be invested and earn interest for five years. An economic concept called "net present value," accounts for the impact of time on the value of money and discounts the future value of a dollar. An appropriate discount rate can be used to calculate the "present value" of any sum of resources or money to be spent or received in the future. The discount rate for costs and benefits applied here is from the annual US Office of Management and Budget (OMB) publication, ***Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses*** which applies to long lived infrastructure investments. The application of the discount rate to future sums to calculate their present value is known as "discounting." Through discounting, different investment alternatives can be objectively compared based on their respective present values, even though each has a different stream of future benefits and costs. This concept of net present value is important because the timing of costs and benefits of a flood risk reduction program are often different.

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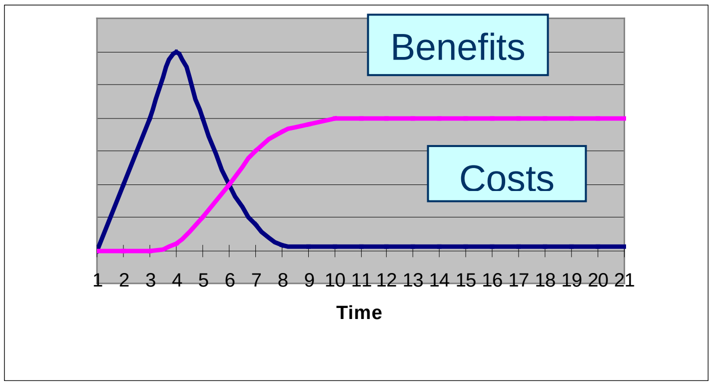
[12] Ibid., p. 11, Section 1.7.4.(a)(1).

[13] USACE. 1983. "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." p. 11, 1.7.4.(a)(2).

A frequent observation in public infrastructure projects is that costs accrue both immediately and over time, while benefits accrue over time after the majority of costs accrue. Exhibit 2-3 provides a sample of typical project benefit and cost flows. Costs, as considered by an engineer for example, inflate over time to reflect generally accepted increases in the costs for goods and services. This provides an estimate of the cash that is going to be necessary to complete a project. However, benefits, as considered in economics, are discounted as they move into the future. Net present value provides the common ground against which the analysis considers costs and benefits.

Exhibit 2.3: Sample Project Costs and Benefit Streams



Most major infrastructure projects use a period of analysis of 50 to 100 years.[14] However there is no specific criterion for selecting a period of analysis. For the purposes of developing this BCA, a period of 50 years has been utilized.

A Benefit-Cost Ratio (BCR) greater than one indicates the anticipated net present value of benefits derived because of the proposed improvements will exceed the estimated net present value of costs and that the investment is anticipated to provide positive value to the community. A ratio of less than one indicates that the anticipated benefits are less than the estimated costs and would require further study or innovative strategies to justify the project.

2.6 Economic Analysis Methodology

There are several steps undertaken to develop a flood risk reduction program BCA. Estimating the program costs and benefits is the initial step in the economic analysis methodology. Once the engineers have analyzed the causes of flooding and developed alternative mitigation strategies, a cost to implement the strategy or strategies will be developed. This will include both construction cost and the on-going maintenance of the program.

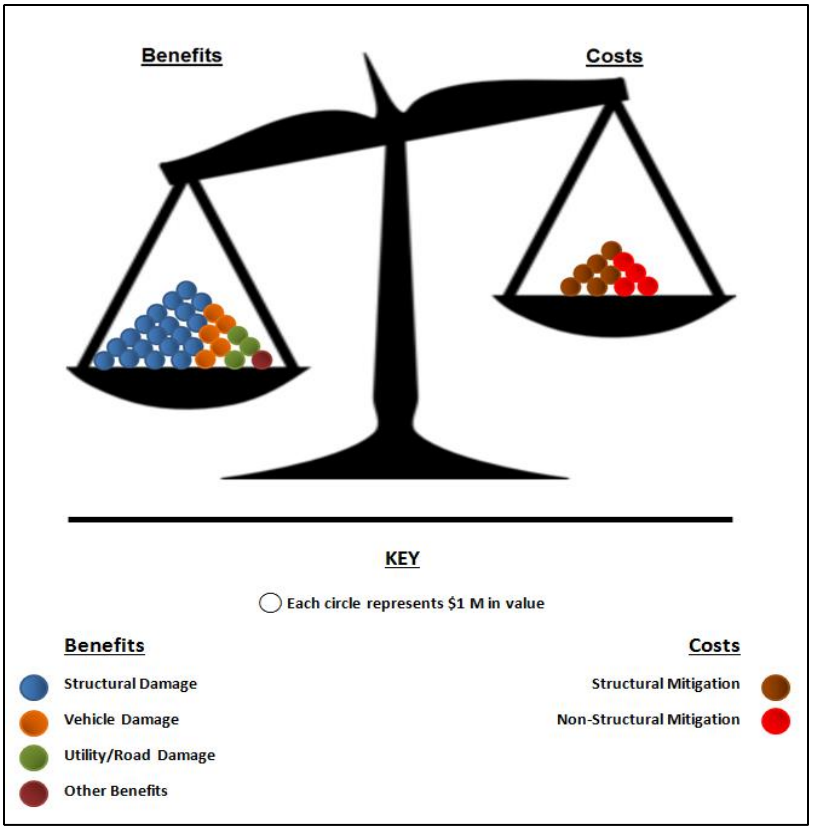
Program benefits are changes in value to the output of goods and services expressed in monetary units. Economic benefits are those that accrue in the planning area and the rest of

[14] USACE, National Economic Development Procedures Manual, Urban Flood Damage. IWR Report 88-R-2. March 1988

the nation from the selected program. Benefits typically include flood damage reduction avoided in commercial and residential buildings, vehicles, transportation, utilities, equipment, roads, bridges, crops and others. Exhibit 2-4 provides an example of how the BCA weighs benefits and costs against each other.

Flood damages to property, injury and the loss of human life has identified flood risk as the largest single category of loss from natural disasters. Many of these losses can be reduced or prevented with proper planning and engineered solutions. A flood damage reduction plan includes one or more of the measures identified by the engineers. Each one of these measures has some effect on one or more of the three input relationships to the hydro-economic model used to estimate expected annual damages (EAD). The effects of damage reduction measures on the various EAD relationships are what provide the monetized benefits of flood risk reduction.

Exhibit 2.4: Example of Benefits Versus Costs in Flood Mitigation BCA



A stage-damage function (i.e., depth-damage or damage function) shows the relationship between the depth of water and the amount of damages sustained at that depth. Damages may be separated by contents, structure, business loss, transportation losses and other categories of physical and economic damage. The effectiveness of any plan in reducing these various categories of damages will vary from measure-to-measure and plan-to-plan. It is generally the economist's job to estimate a damage function without and with a plan in place and then to estimate a new damage function for every plan that may alter the damage function.

A stage-discharge function (i.e., the rating curve) shows the relationship between the amount of water (discharge or flow) and the stage or depth it reaches in the floodplain reach. Some flood damage reduction measures will alter the stage-discharge relationship. A levee or floodwall for example may actually cause a given amount of water to attain a greater depth, causing the rating curve or a part of it to shift upward.

The discharge-exceedance frequency function (i.e., the flow-frequency or frequency curve) shows the relationship between a flow of water (discharge) and the frequency with which a flow of that amount or a greater amount will occur in any given year. Some flood damage measures alter this relationship. Ordinarily, a given flow or discharge will become less frequent, thereby reducing damages. It is generally the engineer's job to estimate discharge-exceedance frequency relationships without a plan in place and then to estimate new functions for every plan that may alter the discharge-exceedance frequency function.

Channel modifications can affect the discharge-exceedance frequency function as well as the rating curve. In many cases, the modifications will increase velocity in the improved section but downstream, where no improvements have been made, there may be a greater discharge and an increase in its frequency. For more detailed discussion of these relationships, refer to Stantec's Hancock County Flood Risk Reduction Program Final Report.

The analysis proceeds with an inventory of all structures and land use within the identified floodplain. Structural damage costs for the without program and with the program were estimated using the USACE Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Economic model. The analysis follows the framework and methodology as directed by the *HEC-FDA Flood Damage Reduction Analysis User's Manual (April 2016).* The content damage including motor vehicles are also estimated by applying the HEC-FDA model to the structure inventory and the water surface profiles without the program, with the Hydraulic Improvements component and with the Full Program. The difference between the without and with program damages are the damages avoided for the major categories of benefits. Other benefit categories included in this report include:

- Transportation
- Emergency Response
- NFIP Administrative Cost
- Business Losses (Income)
- Business Losses (Cleanup)
- Business Losses (Emergency-Plan)
- Agricultural
- Environmental

For each of these benefit categories the study team utilized existing data and tools or developed new data and tools to estimate the EAD as was done with the HEC-FDA model. The team conducted surveys and interviews with key leaders of the local business, agricultural, and educational communities. Information was collected on how their organizations were impacted by the 2007 flood or other flooding events to determine how a reduction in the flood water depths would reduce flooding damages and disruptions. Each chapter of this report discusses these loss reductions and how they were estimated.

The team employed data and tools from Federal Emergency Management Agency (FEMA), USACE, the IMPLAN Group, Inc. and the Office of Management and Budget (OMB). From FEMA we utilized the portion of the HAZUS-Flood model dealing with motor vehicle damages. FEMA databases also provided estimates of the one-time environmental benefits from the conversion of land use to low flood damage risk. Data acquired by the USACE in the original efforts related to Hancock County and Blanchard River provided a detailed crop damage model that was calibrated to Hancock County and OMB provided the discount rate for long lived infrastructure projects. IMPLAN is a supplier of detailed economic models designed to measure how the Hancock County economy would be impacted due to the loss of business activity during and after the flood event.

Chapter 3 Project Costs and Schedule

This chapter presents the estimates for both one-time capital and ongoing maintenance costs associated with the Hancock County Flood Risk Reduction Program. The first section describes what are project costs used in a Benefit Cost Analysis. The next section provides the details on 1) one-time construction, planning, engineering and design costs 2) maintenance and associated costs 3) program timeline of costs and benefits. The third and final section of this chapter presents the discounted value of the costs.

3.1 Definition of Project Costs

All of the expenditures required for implementation of the project define the costs of the program. The benefit-cost analysis (BCA) weighs the costs of the project against the project benefits. In this program, the cost includes preparatory work, engineering, construction and other elements described below, plus operations and maintenance (O&M) costs to maintain performance of the proposed improvements program. Costs are based on professional judgement based upon past experience, prior bid prices received from previous analogous projects, estimated material costs and other anecdotal information provided by the local communities. Contingencies and administrative expenses factor into project cost estimates. For this program, costs are based on local costs to the City of Findlay and Hancock County, rather than national estimates.

3.2 Hancock County Flood Risk Reduction Program Cost Estimates

This BCA estimates the anticipated costs and benefits of both the proposed Full Flood Risk Reduction Program and the initial Hydraulic Improvements component against a baseline (also called the “base case” or “no build” case). The baseline represents an assessment of the way the world would look if this project is not undertaken. This section covers the estimated Construction Costs, Maintenance Cost and the timeline for the initiation of these costs and their associated benefits.

Construction Costs

Stantec developed estimates for the opinion of probable costs for the Program reported in the Final Proof of Concept report (*Hancock County Flood Risk Reduction Program – Final Report: Data Review, Gap Analysis, USACE Plan and Alternatives Review, and Program Recommendation*). Exhibit 3-1 to Exhibit 3-5 summarize the opinion of probable costs for various phases and elements of the Full Program. Each exhibit lists the description of each of ten areas of work tasks. These elements include:

- Mobilization, Demobilization and Preparatory Work
- Lands and Damages
- Relocations

- Fish and Wildlife
- Road, Railroads & Bridges
- Channels and Canals
- Floodway Control & Diversion
- Cultural Resources
- Engineering & Design
- Construction Management

The remaining four columns of the exhibits detail the work cost, contingency percent (30.0% in each case), contingency amount and the total cost. The work phases shown in the five exhibits are:

- Exhibit 3-1: Riffle/Inline Structures Removal
- Exhibit 3-2: Floodplain Bench Widening and Railroad Bridge Modifications
- Exhibit 3-3: Eagle Creek Dry Storage Basin
- Exhibit 3-4: Blanchard River Dry Storage Basin
- Exhibit 3-5: Potato Run Dry Storage Basin

Exhibit 3-1 and Exhibit 3-2 together represent the opinion of probable costs of the Hydraulic Improvements component of the Program. The Full Program includes the costs of the Hydraulic Improvements, plus the costs of the recommended dry storage basins shown in Exhibits 3-3, 3-4 and 3-5.

Exhibit 3.1: Riffle/Inline Structures Removal: Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$40,000	30.0%	$12,000	$52,000
01 - Lands and Damages	$10,000	30.0%	$3,000	$13,000
02 - Relocations	$0	30.0%	$0	$0
06 - Fish and Wildlife	$20,000	30.0%	$6,000	$26,000
08 - Road, Railroads & Bridges	$70,000	30.0%	$21,000	$91,000
09 - Channels and Canals	$380,000	30.0%	$114,000	$494,000
15 - Floodway Control & Diversion	$50,000	30.0%	$15,000	$65,000
18 - Cultural Resources	$10,000	30.0%	$3,000	$13,000
30 - Engineering & Design	$110,000	30.0%	$33,000	$143,000
31 - Construction Management	$90,000	30.0%	$27,000	$117,000
Total	**$780,000**		**$234,000**	**$1,014,000**

Exhibit 3.2: Floodplain Bench Widening and Railroad Bridge Modifications: Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$400,000	30.0%	$120,000	$520,000
01 - Lands and Damages	$100,000	30.0%	$30,000	$130,000
02 - Relocations	$200,000	30.0%	$60,000	$260,000
06 - Fish and Wildlife	$100,000	30.0%	$30,000	$130,000
08 - Road, Railroads & Bridges	$2,500,000	30.0%	$750,000	$3,250,000
09 - Channels and Canals	$8,200,000	30.0%	$2,460,000	$10,660,000
15 - Floodway Control & Diversion	$100,000	30.0%	$30,000	$130,000
18 - Cultural Resources	$100,000	30.0%	$30,000	$130,000
30 - Engineering & Design	$1,800,000	30.0%	$540,000	$2,340,000
31 - Construction Management	$1,000,000	30.0%	$300,000	$1,300,000
Total	**$14,500,000**		**$4,350,000**	**$18,850,000**

Exhibit 3.3: Eagle Creek Dry Storage Basin: Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$1,200,000	30.0%	$360,000	$1,560,000
01 - Lands and Damages	$18,900,000	30.0%	$5,670,000	$24,570,000
02 - Relocations	$100,000	30.0%	$30,000	$130,000
06 - Fish and Wildlife	$500,000	30.0%	$150,000	$650,000
08 - Road, Railroads & Bridges	$1,600,000	30.0%	$480,000	$2,080,000
09 - Channels and Canals	$10,300,000	30.0%	$3,090,000	$13,390,000
15 - Floodway Control & Diversion	$10,900,000	30.0%	$3,270,000	$14,170,000
18 - Cultural Resources	$300,000	30.0%	$90,000	$390,000
30 - Engineering & Design	$6,600,000	30.0%	$1,980,000	$8,580,000
31 - Construction Management	$3,100,000	30.0%	$930,000	$4,030,000
Total	**$53,500,000**		**$16,050,000**	**$69,550,000**

Exhibit 3.4: Blanchard River Dry Storage Basin: Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$600,000	30.0%	$180,000	$780,000
01 - Lands and Damages	$13,600,000	30.0%	$4,080,000	$17,680,000
02 - Relocations	$100,000	30.0%	$30,000	$130,000
06 - Fish and Wildlife	$2,500,000	30.0%	$750,000	$3,250,000
08 - Road, Railroads & Bridges	$800,000	30.0%	$240,000	$1,040,000
09 - Channels and Canals	$2,600,000	30.0%	$780,000	$3,380,000
15 - Floodway Control & Diversion	$7,800,000	30.0%	$2,340,000	$10,140,000
18 - Cultural Resources	$200,000	30.0%	$60,000	$260,000
30 - Engineering & Design	$4,200,000	30.0%	$1,260,000	$5,460,000
31 - Construction Management	$2,000,000	30.0%	$600,000	$2,600,000
Total	**$34,400,000**		**$10,320,000**	**$44,720,000**

Exhibit 3.5: Potato Run Dry Storage Basin: Opinion of Probable Cost

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$400,000	30.0%	$120,000	$520,000
01 - Lands and Damages	$8,400,000	30.0%	$2,520,000	$10,920,000
02 - Relocations	$0	30.0%	$0	$0
06 - Fish and Wildlife	$200,000	30.0%	$60,000	$260,000
08 - Road, Railroads & Bridges	$1,400,000	30.0%	$420,000	$1,820,000
09 - Channels and Canals	$1,100,000	30.0%	$330,000	$1,430,000
15 - Floodway Control & Diversion	$4,500,000	30.0%	$1,350,000	$5,850,000
18 - Cultural Resources	$100,000	30.0%	$30,000	$130,000
30 - Engineering & Design	$2,400,000	30.0%	$720,000	$3,120,000
31 - Construction Management	$1,200,000	30.0%	$360,000	$1,560,000
Total	**$19,700,000**		**$5,910,000**	**$25,610,000**

The costs for the Hydraulic Improvements include the riffle/inline structures removal (Exhibit 3-1) plus the floodplain bench widening and railroad bridge modifications (Exhibit 3-2). The total for the Hydraulic Improvements is $19,864,000. The Full Program costs include the Hydraulic Improvements plus the costs of the remaining three phases including the Eagle Creek Dry Storage Basin, Blanchard River Dry Storage Basin and the Potato Run Dry Storage Basin. Total program costs are estimated to be $159,744,000.

Maintenance Costs

This section outlines the maintenance costs of the program. Stantec provided estimated values of the Operations, Maintenance and Replacement (OM&R) costs for the project.

Operations and maintenance for the benching area in the Hydraulic Improvements component are estimated at $17,700 annually for mowing and occasional debris removal following flooding events. No additional OM&R costs are applied. The following calculations inform the costs:

- Mowing: 8 hours/mowing x ($25/hour (fully loaded labor rate) + $25/hour mower cost) x 1 mowing/week x 36 weeks/year = $14,400.00

- Debris Removal: 2 staff x $25/hour x 8 hours x 2 times/year + $1,000 per day for equipment x 2 days + $500 disposal = $3,300.00
- Mowing plus Debris Removal = $14,400 + $3,300 = $17,700.00

The Norfolk Southern railroad bridge OM&R costs assume annual inspections and replacement in approximately 75 years. However, the bridge is owned and maintained by the railroad with yearly inspections and minor upkeep in the range of $10,000 - $12,000 annually. The cost analysis assumes inspections and replacement would occur regardless of this program and thus are not factored into these calculations.

The total annual OM&R costs are $172,700 for the Full Program, based upon the $17,700 for Hydraulic Improvements component above, plus the estimated O&M for the recommended dry storage basins as follows:

- $75,000 for Eagle Creek Storage Basin
- $40,000 for Blanchard River Basin
- $40,000 for Potato Run

Timeline of Costs and Benefits

This section provides the timeline of costs and benefits for the phases of the program. The analysis assumes costs divide equally over the span of the timeline for each project. Benefits occur incrementally after the early stages of the Program are completed. The benefits of the Full Program occur at terminus of construction. Exhibit 3-6 provides the starting and ending years for costs incurred at each phase of the Full Program. Though the following exhibit assumes a starting year of 2017, Stantec doubts construction will begin before 2018 and the initial benefits derived from the completion of the Hydraulic Improvements will not begin to be realized until early in 2019.

Exhibit 3.6: Program Schedule by Phase of Project

Category	Phase 1 – Hydraulic Improvements	Phase 2 – Eagle Creek Dry Storage Basin	Phase 3A – Blanchard River Dry Storage Basin	Phase 3B – Potato Run Dry Storage Basin
Timeline (year)	2017 - 2021	2019-2025	2020-2027	2020-2029

Exhibit 3-7 shows the timeline when the percentage of annual program benefits start to accrue as the program implementation progresses. The left two columns show when benefits for the Hydraulic Improvements component will commence. The right two columns show when benefits begin to accrue for the Full Program.

Exhibit 3.7: Program Benefits Schedule

Hydraulic Improvements		Full Program	
Year	Benefits	Year	Benefits
2018		2018	
2019	One-Third	2019	
2020	Two-Thirds	2020	
2021	Total	2021	One-Third
		2022	
		2023	
		2024	
		2025	Two-Thirds
		2026	
		2027	
		2028	
		2029	Total
		2030	

Present Value of Program Construction and OM&R Cost

This section provides the total construction costs, including OM&R and present value of total costs by year for the Hydraulic Improvements and Full Program. Cost for the Hydraulic Improvements component span the first four construction years, from 2017 to 2021. Subsequent construction costs represent maintenance costs shown in the second column of the exhibit. The third column shows the discounted present value costs for each year.

Total costs for the Hydraulic Improvements component are $20.7 million in 2017 dollars. The total net present value of the probable costs associated with the Hydraulic Improvements component in 2017 dollars is $20.2 million, based upon a present-worth calculation utilizing an assumed 0.7% over 50 years. Similarly, the total probable costs associated with the Full Program in 2017 dollars are $146,615 million. Based upon a present-worth calculation utilizing an assumed 0.7% over 50 years, the net present value of the Full program in 2017 dollars is $159,876.   These totals serve as the denominator in the subsequent BCR calculations presented within this report for the Hydraulic Improvements and Full Program.

Exhibit 3.8: Construction and Discounted Construction Project Costs by Year

	Hydraulic Improvements			Full Program				
Year	Construct: Hydraulic Improvements	Maint.	Net Present Value	Construct: Eagle Creek	Construct: Blanchard River	Construct: Potato Run	Maint.	Net Present Value
2017			-					-
2018	4,966.0		4,931.5					4,931.5
2019	4,966.0		4,897.2	9,935.7				14,695.3
2020	4,966.0		4,863.2	9,935.7	5,590.0	2,561.0		22,575.3
2021	4,966.0		4,829.4	9,935.7	5,590.0	2,561.0		22,418.4
2022		17.7	17.1	9,935.7	5,590.0	2,561.0		17,483.9
2023		17.7	17.0	9,935.7	5,590.0	2,561.0		17,362.3
2024		17.7	16.9	9,935.7	5,590.0	2,561.0		17,241.6
2025		17.7	16.7	9,935.7	5,590.0	2,561.0		17,121.8
2026		17.7	16.6		5,590.0	2,561.0	75.0	7,742.1
2027		17.7	16.5		5,590.0	2,561.0	75.0	7,688.2
2028		17.7	16.4			2,561.0	115.0	2,494.7
2029		17.7	16.3			2,561.0	115.0	2,477.4
2030		17.7	16.2				155.0	157.7
2031		17.7	16.1				155.0	156.6
2032		17.7	15.9				155.0	155.5
2033		17.7	15.8				155.0	154.5
2034		17.7	15.7				155.0	153.4
2035		17.7	15.6				155.0	152.3
2036		17.7	15.5				155.0	151.3
2037		17.7	15.4				155.0	150.2
2038		17.7	15.3				155.0	149.2
2039		17.7	15.2				155.0	148.1
2040		17.7	15.1				155.0	147.1
2041		17.7	15.0				155.0	146.1
2042		17.7	14.9				155.0	145.1
2043		17.7	14.8				155.0	144.1
2044		17.7	14.7				155.0	143.1
2045		17.7	14.6				155.0	142.1
2046		17.7	14.5				155.0	141.1
2047		17.7	14.4				155.0	140.1
2048		17.7	14.3				155.0	139.1
2049		17.7	14.2				155.0	138.1
2050		17.7	14.1				155.0	137.2
2051		17.7	14.0				155.0	136.2
2052		17.7	13.9				155.0	135.3
2053		17.7	13.8				155.0	134.3
2054		17.7	13.7				155.0	133.4
2055		17.7	13.6				155.0	132.5
2056		17.7	13.5				155.0	131.6
2057		17.7	13.4				155.0	130.7
2058		17.7	13.3				155.0	129.7
2059		17.7	13.2				155.0	128.8
2060		17.7	13.1				155.0	127.9
2061		17.7	13.0				155.0	127.1
2062		17.7	12.9				155.0	126.2
2063		17.7	12.8				155.0	125.3
2064		17.7	12.8				155.0	124.4
2065		17.7	12.7				155.0	123.6
2066		17.7	12.6				155.0	122.7
2067		17.7	12.5				155.0	121.8
2068		17.7	12.4				155.0	121.0
2069		17.7	12.3				155.0	120.2
2070		17.7	12.2				155.0	119.3
Total	**19,864.0**	**867.3**	**20,233.1**	**69,550.0**	**44,720.0**	**25,610.0**	**6,735.0**	**159,876.4**

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Chapter 4 Structure Inventory

Damages to structure, contents, and automobiles account for the majority of damages that result from a flood event. These categories provide the foundation for the economic evaluation of the alternatives. Flood risk reduction projects are developed with these damages in mind; the goal of plan formulation is to minimize these flood impacts in a way that is consistent with protecting the environment and quality of life in our communities. The USACE Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software was used in this BCA to estimate damages to structures, contents, and automobiles for without-project and with-project alternatives of the Hancock County Flood Risk Reduction Program including the Full Program and the Hydraulic Improvements component.

The structure inventory developed for the HEC-FDA analysis comprises all residential and nonresidential structures within the planning model's 0.21% Annual Chance Exceedance (ACE) (500-year) event floodplain and additional structures located in areas that could potentially experience induced flooding identified by project engineers. The structure inventory used for the March 2017 analysis was updated based on the 2015 inventory with modifications as described in the following sections.

4.1 Structure Inventory Overview

The structure inventory developed and refined for the analysis contains 4,489 structures: 3,893 residential (86.7%), 456 commercial (10.2%), 130 public (2.9%) and 10 industrial (0.2%). This structure breakdown is depicted in Exhibit 4.1.

Exhibit 4.1: Findlay Structure Inventory

Structure Type	Damage Category	Structure Count	Percent of Total
Residential	RES	3,893	86.7
Commercial	COM	456	10.2
Public/Other	P&O	130	2.9
Industrial	IND	10	0.2
	TOTAL:	**4,489**	**100.0**

Residential structures comprise a majority of the structures in the inventory. A summary of the type of residential structures which exist in the study area is provided in Exhibit 4.2. Of the 3,893 residential structures included in the analysis: 1,801 are one-story without basements (46.3%), 886 are one-story with basements (22.8%), 794 are two-plus stories with basements (20.4%), 310 are two-plus stories without basements (8.0%), 56 are split levels without basements (1.4%), and 46 are split levels (1.2%) with basements.

Exhibit 4.2: Residential Structures by Type

Residence Type	Number	Percent of Total
1ST-NB	1,801	46.3
1ST-B	886	22.8
2ST-B	794	20.4
2ST-NB	310	8.0
SL-NB	56	1.4
SL-B	46	1.2
TOTAL:	**3,893**	**100.0**

The structure inventory includes specific building attributes for each structure, including a unique structure name, parcel ID, latitude/longitude, structure type, structure/content value, stream and bank side on which the structure is located, approximate stream station location, depth damage function (DDF), first floor elevation (FFE), ground elevation and begin damage elevation.

Following the 2007 flood event, Hancock County purchased multiple structures for flood mitigation via grants funded by the City of Findlay, Hancock County, and Northwest Ohio Flood Mitigation Partnership. Hancock County provided a list of 166 structures that the County purchased inside the 1% ACE floodplain. These structures were removed from the inventory used in the analysis since they no longer exist in the floodplain.

4.2 Structure Location

Project engineers determined structure locations using a Geographic Information System (GIS) address shapefile. Each structure with an address was represented by a point file generally near the mailbox of the structure. This location was assumed to be generally representative of the location of the structure. Structures within the planning model's 0.2% ACE floodplain were selected for analysis. The address point files were joined to their respective parcel shapefile obtained from Hancock County tax assessor. This file contained parcel boundaries and parcel numbers that could be cross referenced with the Hancock County tax assessor information.

Project engineers assigned structures to a stream based on their location in the study area. The stream that was adjacent to the structure was typically assigned. In cases where it was not clear which stream to assign (e.g., structure located at the confluence of two streams), professional judgment was used to assign the stream based on which stream was most representative of the flood characteristics for that structure. The structures in Hancock County were assigned to one of three streams: Blanchard River, Eagle Creek, and Lye Creek.

Stream stations which correspond to those used in hydraulic modeling were imported into ArcGIS software and used to match each structure to a stream station. The assigned station was the closest point where the structure was perpendicular to the stream.

4.3 Structure Elevation

Project engineers determined the First Floor Elevation (FFE) for each structure by using a 2.5-foot Digital Elevation Model (DEM) created by the Ohio Geographically Referenced Information Program (OGRIP). The DEM was derived from Light Detection and Ranging (LiDAR) collected in 2007 by OGRIP.

Based on the structure locations (denoted as points), the DEM was used to extract an elevation of the adjacent grade to the structure point file (ground elevation). Since the study area is very flat, the analysis assumes the ground elevation surrounding a structure was a consistent height. Therefore, grade at each structure was used to represent the adjacent ground elevation. The ground elevation was then adjusted and increased by 1.5 feet to estimate the height of the first floor relative to the ground (FFE).

Since most structures in the study area are damaged by overland flooding, the begin damage point for each structure was assumed to be the elevation of the adjacent grade. HEC-FDA uses the begin damage point to estimate the water elevation that could start to impact a structure. If the begin damage point is not entered, HEC-FDA would begin to estimate damages beginning from the bottom of the depth-damage function assigned to a structure. For overland flooding, flood water would not be anticipated to impact a structure until water reached the structure. For structures with basements, it would be anticipated that floodwater would enter the structure and fill the basement through a window or other low-level opening. Therefore, the begin damage point was set at the adjacent grade to avoid overestimating damages, especially to structures with basements.

4.4 Depreciated Replacement Value

Hancock and Putnam County tax assessors provided value data for residential and non-residential structures in the study area. The tax assessor data listed multiple valuation components (e.g., land, improvement) for each parcel that could be used to represent the value of structures in the study area. To ensure compliance with USACE guidance requiring the use of depreciated replacement values for structures, a random sample of the structures were valued using RSMeans[15], a commercially available valuation method for comparison to the tax assessor valuations.

[15] Replacement costs were estimated using the model approach provided in the RSMeans Square Foot Costs book (2012). The replacement values were adjusted for depreciation using ratios developed for the USACE Institute for Water Resources.

A field inventory of 10% of the structures in the study area was conducted to collect characteristics of the structures, such as size, condition, quality, roofing material, etc. The characteristics are input variables used to estimate the replacement value using RSMeans. The replacement values were adjusted for depreciation using ratios developed by the Institute for Water Resources (IWR). The depreciated replacement values calculated for the sample of inventoried structures were compared to tax assessor values to determine if a relationship between the data sets could be identified. However, there was great variance between the data sets and a relationship could not be identified. Because of the impact that nonresidential structures can have on the results of a flood risk management study and because there were relatively few nonresidential structures in the study area, a second field inventory was conducted to inventory the remaining nonresidential structures. The remaining nonresidential structures were also valued using RSMeans and depreciated. These values were used for the economic analysis of nonresidential structures.

The 2015 USACE inventory further refined structure value using a random sample of records in the inventory. From the random sample, an average dollar per square foot value was estimated based on the structure type (e.g., one-story, two-story). The average dollar per square foot value was then applied to each residential structure in the study area based on the size and characteristics from the tax assessor database. While individual structures may not be as accurate using this method, USACE determined it should provide a reasonable overall estimate of the study area.

The 2015 USACE inventory developed depreciated replacement values from October 2012 prices. These values were updated to November 2014 prices for the current analysis using the Civil Works Construction Cost Index System (CWCCIS – EM 111-2-1304) composite index. The 2015 USACE inventory yielded a 4% increase in structure inventory values. These values were indexed using a 1.0267 percent to account for property value increases to the base year of 2018.

Besides the structures identified by the USACE in 2015, project engineers identified an additional 992 structures located in the 0.2 ACE (500-year) floodplain for the March 2017 analysis. The values used for these structures were based on the Hancock County tax assessor records. The remaining 3,497 records kept the beginning damage depths, structure values and structure types developed by the USACE in 2015.

4.5 Depth-Damage Functions

Each structure was assigned a Depth Damage Function (DDF) that estimates an economic loss as a percentage of the value of the structure or contents based on the depth of flooding. The DDFs used in the March 2017 analysis were based on the USACE analysis completed in 2015. The 2015 analysis used four sources: Economic Guidance Memorandum (EGM) 04-01 Generic Depth-Damage Relationships for Residential Structures, EGM 09-04 Generic Depth-Damage Relationships for Vehicles, building specific commercial damage surveys and generic curves obtained from USACE Galveston District.

4.5.1 Residential Structures

All structure and content DDFs assigned to residential structures were developed by IWR as referenced in EGM 04-01. These DDFs are considered generic and are appropriate for use throughout the United States. The DDFs are divided into multiple categories based on the type of structure (e.g., one-story, two-story, foundation type), with separate DDFs to represent damages to the structure and the contents. The DDFs were assigned to each structure based on information contained in the tax assessor databases (e.g., number of floors, presence of basement). A content-to-structural value (CSVR) of 55 percent was used for residential structures.

4.5.2 Non-Residential Structures

All structure DDFs assigned to non-residential structures were obtained from the 2015 USACE analysis (based on the USACE Galveston District values). These DDFs were selected for use because structures in both locations are built using similar techniques and materials, and they represent fresh water flood damages. The appropriate DDFs were selected from available USACE Galveston District based on the type and the use of the structure. A portion of the DDFs assigned to nonresidential structures were developed based on personal interviews with business owners and operators.

4.5.3 Residential and Non-Residential Structure

In cases where multiple structures were located on a single parcel, the data on the individual structures from the interviews (completed by the USACE in 2015) were combined to form a single DDF. Therefore, each entry in the structural inventory is representative of the damages that would occur for that parcel - not necessarily each structure on the parcel. The content-to-structure-value ratios (CSVRs) for all of the structures were incorporated into the analysis based on the assigned DDF and interview data.

4.6 HEC-FDA Methodology

Structural damage costs were estimated using the USACE Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Economic model. The analysis follows the framework and methodology as directed by the *HEC-FDA Flood Damage Reduction Analysis User's Manual (April 2016).* Project analysts used Revision 1.4.1 of the HEC-FDA model to assess floodplain damage and develop Equivalent Annual Damage (EAD) estimates for the base case ("without") and two alternative build scenarios:

- Without Scenario (Base Case). The Without scenario evaluated damage to structures in the base case and none of the proposed improvements were constructed.
- Hydraulic Improvements Scenario. The Hydraulic Improvements scenario estimated the costs of structural damage if the Hydraulic Improvements component of the Full Program is constructed. This scenario a combination of modifications including: floodplain bench widening on the right bank of the Blanchard between Broad Avenue and the Norfolk Southern Railroad bridge, adding a 50-foot span to the Norfolk

Southern Railroad bridge, and the removal of four dam/riffle structures located along the Findlay corridor of the Blanchard River.

- Full Program Scenario. The Full Program scenario estimated structural damage if all the proposed improvements are constructed. The Full Program scenario includes the Hydraulic Improvements mentioned above and dry storage basins on Eagle Creek, the Blanchard River, and Potato Run.

The time value of resources is measured by an annual percentage factor known as the discount rate. An appropriate discount rate can be used to calculate the "present value" of any sum of resources or money to be spent or received in the future. The analysis used a discount rate of 0.7 percent for the present value calculation. This discount rate was obtained from the annual Office of Management and Budget publication, *Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses*[16] which applies to long lived infrastructure investments. The application of the discount rate to future sums to calculate their present value is known as "discounting." Through discounting, different investment alternatives can be objectively compared based on their respective present values, even though each has a different stream of future benefits and costs.

Costs and benefits are expressed in March 2017 prices and a 50-year planning period is assumed between 2018 and 2068. No uncertainty factors were used to develop the analysis nor were Monte Carlo simulations employed to evaluate risk and uncertainty in the analysis.

The analyses of without-project and with-project damages include damages or costs incurred from a range of categories. Categories considered in the economic analysis are: damages to structures and contents, damages to automobiles, increased emergency response expenditures, evacuation and subsistence expenditures, reoccupation costs, and costs for commercial cleanup and restoration. These categories are intended to capture a substantial portion of the financial burden incurred by a flood event; however, they are not comprehensive enough to capture every cost or damage that could result from flooding in the area.

Generally, flood damages increase as flood frequency decreases; they are typically higher for the 0.01% Annual Chance Exceedance (ACE) flood compared to the 50% ACE flood. Damages by flood frequency are paramount from the economic perspective since flood damages are reduced to annualized averages based upon the annual chance probability of flood occurrence.

To estimate expected annual damages (EADs) from flooding, eight flooding event frequencies were modeled, representing a range of recurrence probabilities from a 50% ACE (2-year) flood event to 0.2% ACE (500-year) flood event.

Hydrologic and Hydraulic Modeling

Refer to Stantec's Hancock County Flood Risk Reduction Program Final Report for additional details.

[16] https://obamawhitehouse.archives.gov/omb/circulars_a094/a94_appx-c

4.6.1 Damage Reaches

The streams in the study area were divided into reaches based on existing features (e.g., bridges) and the extent of proposed alternatives. Dividing the streams into reaches provided the ability to more accurately assess the impacts of proposed alternatives and to focus the analysis on specific areas.

Project engineers assigned reaches index locations as a point of reference development of the stream profiles. The project engineers assigned index locations to locations that were considered to be most closely representative of the actual field conditions when compared to the model results. Exhibit 4.3 summarizes the streams, reaches, and index locations for this HEC-FDA study.

Using HEC-RAS, project engineers developed water surface profiles for each stream and damage reach in the Without, Hydraulic Improvements and Full Program scenarios. These water surface profiles are read into the HEC-FDA model in order to estimate damage for the eight return frequencies.

Exhibit 4.3: Findlay Streams, Reaches, and Index Locations

Stream Name	Reach Name	Beginning Station	Ending Station	Index Station
Blanchard				
	Above_Potato	394284.7	439732.5	394284.7
	Above_Findlay	299534	393578.9	299534
	Eagle-Lye	298205	298802	298205
	Findlay	291423	297726	291423
	Below_Findlay	268028	290955	268028
	Gilboa	118486.4	265870	118486.4
Eagle Creek				
	Full_Length	207	49960	207
Lye Creek				
	Full_Length	21515.59	63760	21515.59
	y	72	15758.7	72

4.6.2 Flood Stage Damage Estimation

HEC-FDA uses modeled flooding events to estimate damages to affected structures based on data associated with each structure. HEC-FDA was used to estimate the damages for structures, contents, and automobiles. The HEC-FDA program compiles data generated from the hydraulic analyses, as well as the structure inventory and associated data described above. The hydraulic components used in this analysis included the water surface profiles for every stream for each of the eight analyzed exceedance probability flood events: 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), 0.5% (200-year) and 0.2% (500-year) ACE flood events.

These compiled data are a series of probabilistic curves defining relationships between flood stage and frequency of occurrence, and flood stage and damages. These relationships are used to generate a curve relating probability of occurrence and total damages; the integration of which provides the EAD.

With-project and without-project damages are estimated for both the initial baseline conditions and future conditions, which account for any growth in development and runoff in the study area. As the hydrologic condition of the study area is not anticipated to increase over the period of analysis, the HEC-FDA model was run only for the initial baseline condition, with the resulting annual damages expected to prevail over the 50-year period of analysis.

4.6.3 Damage Categories

Project analysts assigned each structure or vehicle record to one of five damage categories defined for the analysis consistent with USACE guidance:

- **RES.** Residential structure damage category which includes one story, two story homes with and without basements
- **COM.** Commercial structure damage category which includes activities such as offices and restaurants.
- **IND.** Industrial structures damage category which includes activities such as warehouses.
- **P&O.** Public and other structure damage category which includes municipal buildings, public schools, colleges/universities and hospitals.
- **AUTO.** Vehicle damage category including private automobiles, light trucks and heavy trucks.

These damage categories were used to calculate the stage-damage functions and to calculate the Equivalent Annual Damage (EAD) described in the next section.

4.7 Equivalent Annual Damage (EAD)

The results of the HEC-FDA analysis are expressed as an Equivalent Annual Damage (EAD) for each scenario. The USACE defines EAD as the damage value associated with the without- or with-project condition over the analysis period (project life) considering changes in hydrology, hydraulics, and flood damage conditions over the life. HEC-FDA calculates expected annual damage for each analysis year and discounts the value to present worth, then annualizes it to obtain the EAD. Rather than compute the expected annual damage for each year, HEC-FDA computes EAD for the base year and most likely future years and interpolates it for subsequent years. The expected annual damage for years beyond the most likely future conditions year is assumed equal to that year.

Expected annual damage represents the mean amount of damage that would occur in **any given year**, if **that year** were repeated infinitely many times over. The mean value is based on the frequency of recurrence for each flood event, as well as the uncertainties in stage-damage, stage flow, and flow-frequency relationships.

EAD can vary by year, depending on changes in hydraulic, hydrologic, and economic conditions. Throughout the period of analysis, EAD can vary if there are changes in hydraulic, hydrologic, or economic conditions. If each year is taken in sequence from the beginning of the period of analysis to the end, the result is a series or "stream" of EAD values.

Calculated EAD for each scenario, stream and damage category is presented in Exhibit 4.4 and Exhibit 4.5. These values are reported in 2017 dollars.

Exhibit 4.4: Equivalent Annual Damage by Damage Category ($1,000s)

	Without (Base Case)	Hydraulic Improvements	Full Program
AUTO	152.20	92.37	15.72
RES	3,000.66	2,196.97	229.18
COM	769.90	398.60	48.68
IND	3.44	1.85	0.09
P&O	240.97	150.43	21.47
TOTAL	**4,167.17**	**2,840.22**	**315.14**

Exhibit 4.5: Equivalent Annual Damage by Stream, Scenario and Damage Category ($1,000s)

	Without (Base Case)	Hydraulic Improvements	Full Program
Blanchard			
AUTO	118.52	70.66	13.46
RES	1377.52	836.10	168.99
COM	622.48	321.27	40.53
IND	3.28	1.78	0.09
P&O	234.68	146.74	19.95
SUBTOTAL	**2356.48**	**1376.55**	**243.02**
Lye			
AUTO	4.05	2.88	1.03
RES	261.76	189.31	41.71
COM	6.00	4.75	0.96
IND	0.00	0.00	0.00
P&O	0.36	0.26	0.00
SUBTOTAL	**272.17**	**197.21**	**43.70**
Eagle			
AUTO	29.63	18.83	1.23
RES	1361.38	1171.56	18.48
COM	141.42	72.58	7.19
IND	0.16	0.07	0.00
P&O	5.93	3.43	1.52
SUBTOTAL	**1538.52**	**1266.47**	**28.42**
TOTAL	**4167.17**	**2840.23**	**315.14**

Chapter 5 Motor Vehicles

5.1 Vehicle Inventory Overview

Project analysts used the structure inventory and Hancock County tax assessor records to determine the location and value of vehicles in the study area. An estimate of the value of private automobiles and light trucks was developed at the location of each residential structure recorded in the inventory. For commercial, industrial and public/exempt structures, project analysts developed an estimate of the value of private automobiles, light trucks and heavy trucks at the location of each structure. For non-residential structures, the vehicle estimates are based on the size (square footage) of the structure.

The vehicle inventory contains 9,764 records: 7,976 residential automobiles and light trucks (81.7%), 596 non-residential automobiles (6.1%), 596 non-residential light truck records (6.1%) and 596 heavy truck records (6.1%) as summarized in Exhibit 5.1.

Exhibit 5.1: Vehicle Inventory

Vehicle Records	Count	Percent of Total
Residential Autos	3,988	40.9
Residential Light Trucks	3,988	40.8
Non-Residential Autos	596	6.1
Non-Residential Light Trucks	596	6.1
Non-Residential Heavy Trucks	596	6.1
TOTAL	**9,764**	**100.0**

Each vehicle inventory record includes specific attributes for each vehicle, including a unique record ID, parcel ID (associated with the vehicle), latitude/longitude of parcel, AUTO structure type (i.e. auto, light truck or heavy truck), vehicle value, stream and bank side on which the vehicle is located (based on structure), approximate stream station location, depth damage function (DDF), first floor elevation (FFE), ground elevation and begin damage elevation.

One light truck and one auto record was generated for each structure record. Project analysts determined that average value for each residential auto record based on data from the US Department of Commerce, Bureau of Economic Analysis was $1,944.52 and $3,144.52 for each residential auto and light truck record. This is the average value of vehicles left at the residence including all the residences where the vehicles were removed and had a zero vehicle value. For non-residential structures, a complete estimation procedure was conducted and described in further detail in Section 5.2.

5.2 Estimation Procedures

In order to estimate flood damage of motor vehicles for non-residential structures, project analysts conducted an estimation procedures using the following steps:

1. Identification of square footage for commercial, industrial, public/other structural records in database.
2. Identification of square footage conversion factors in order to estimate the number of vehicles by building type and size. Calculate number of vehicles for each structure based on conversion factors.
3. Determine average vehicle value of by vehicle type. Calculate total vehicle value for each record.
4. Estimate average parking demand utilization rates for daytime and nighttime.

5.2.1 Square Footage by Building Type

Project analysts obtained the square footage for each structure record using Hancock County tax assessment data.

5.2.2 Square Footage Conversion Factors

Square footage conversion factors were used to estimate the total number of private automobiles, light trucks and heavy trucks at each non-residential structure. These conversion factors were supplied by the Federal Emergency Management Agency (FEMA) and are shown in Exhibit 5.2.

Exhibit 5.2: HAZUS Conversion Factors

HAZUS ID	HAZUS Building Code	HAZUS Building Category	Automobiles per 1,000 Sq. Feet	Light Trucks per 1,000 Sq. Feet	Heavy Trucks per 1,000 Sq. Feet
1	RES1	Single Family Dwelling	0.433963581	0.318221882	0.012114262
2	RES2	Mobile Home	0.995114383	0.729712148	0.012114262
3	RES3A	Multi Family Dwelling (2)	0.371494481	0.272413472	0.012114262
4	RES3B	Multi Family Dwelling (3-4)	0.63776341	0.467667709	0.012114262
5	RES3C	Multi Family Dwelling (5-9)	0.864554076	0.633972651	0.012114262
6	RES3D	Multi Family Dwelling (10-19)	0.864554076	0.633972651	0.012114262
7	RES3E	Multi Family Dwelling (20-49)	0.864554076	0.633972651	0.012114262
8	RES3F	Multi Family Dwelling (50+)	0.988022505	0.724511694	0.012114262
9	RES4	Temporary Lodging	1.705562886	1.25120129	0.012114262
10	RES5	Institutional Dormitory	0.376217121	0.276167215	0.012114262

HAZUS ID	HAZUS Building Code	HAZUS Building Category	Automobiles per 1,000 Sq. Feet	Light Trucks per 1,000 Sq. Feet	Heavy Trucks per 1,000 Sq. Feet
11	RES6	Nursing Home	0.376217121	0.276167215	0.012114262
12	COM1	Retail Trade	1.261496553	0.926023763	0.308363031
13	COM2	Wholesale Trade	0.099306308	0.072925726	0.148675033
14	COM3	Personal and Repair Services	1.275829259	0.936660392	0.022025931
15	COM4	Professional/Technical Services	0.808172817	0.5936239	0.022025931
16	COM5	Banks	0.963020482	0.707189087	0.022025931
17	COM6	Hospital	1.152703116	0.846410007	0.022025931
18	COM7	Medical Office/Clinic	1.360449937	0.999090593	0.022025931
19	COM8	Entertainment & Recreation	3.588709699	2.634551062	0.022025931
20	COM9	Theaters	1.075357971	0.789343319	0.022025931
21	COM10	Parking			
22	IND1	Heavy	0.318307367	0.233768977	0.249994314
23	IND2	Light	0.195878311	0.143885211	0.249994314
24	IND3	Food/Drugs/Chemicals	0.318307367	0.233768977	0.249994314
25	IND4	Metals/Minerals Processing	0.318307367	0.233768977	0.249994314
26	IND5	High Technology	0.431667604	0.316994686	0.249994314
27	IND6	Construction	0.431667604	0.316994686	0.249994314
28	AGR	Agriculture	0.431667604	0.316994686	0.249994314
29	REL	Church/Non Profit	0.578117035	0.424301047	0.022025931
30	GOV1	General Services	1.182910329	0.868840761	0.022025931
31	GOV2	Emergency Services	1.476090593	1.083956859	0.022025931
32	EDU1	Schools/Libraries	0.600851617	0.441152292	0.022025931
33	EDU2	Colleges/Universities	0.390941783	0.287079052	0.022025931
Dollar Value			**$6,932.22**	**$9,841.89**	**$16,625.21**

5.2.3 Average Value of Vehicles By Vehicle Type

An estimate of the average vehicle value by vehicle type was calculated using data on the value of all consumer and business vehicles developed by the Bureau of Economic Analysis (BEA). The BEA dataset was taken from the "Fixed Asset Table of Current-Cost Net Stock of Consumer Durable Goods" (2006). The data are shown in the first part of Exhibit 5.3.

Separate data were available for business and consumer automobiles, light truck, and heavy trucks. The value of consumer owned heavy trucks was estimated at 50 percent of the BEA estimate of the values of Recreational Vehicles (RVs) and parts. The BEA did not have data on the value of the vehicles stocks held by governments. Total vehicle values were converted to a per vehicle average based on two tables from the Federal Highway Administration's (FHWA) "Highway Statistics 2006". Those two tables are Annual Vehicle Distance Travel in Miles and Related Data (Table VM-1) and Publicly Owned Vehicles (Table MV-7). Using these sources, the average automobile was valued at $5,320; the average light truck was valued at $10,013; and average heavy truck was valued at $23,411.

Exhibit 5.3: Average Value of Vehicles by Vehicle Type

	Value (Billions)			Number of Vehicles			Value per Vehicle
	Consumers	Business	Private	Public	Private	All	
Automobiles	574.3	138.7	713.0	1,387,576	134,012,369	135,399,945	5,320
Light Trucks	738.8	231.4	970.2	2,235,485	96,889,290	99,124,775	10,013
Heavy Trucks	33.8	161.4	195.2	483,161	8,335,846	8,819,007	23,411
Data Source	BEA	BEA	Sum of Consumer and Business values	FHWA, MV-7	FHWA (VM-1 [All] minus MV-7 [Public])	FHWA, VM-1	

Sources: Bureau of Economic Analysis (BEA), "Fixed Asset Table of Current-Cost Net Stock of Consumer Durable Goods" 2006

http://www.bea.gov/scb/pdf/2006/09September/0906_Fixed_Assets.pdf

FHWA Highway Statistics 2006, "Annual Vehicle Distance Travel in Miles and Related Data" (Table VM-1)

http://www.fhwa.dot.gov/policy/ohim/hs05/htm/vm1.htm

FHWA Highway Statistics 2006, "Publicly Owned Vehicles" (Table MV-7)

http://www.fhwa.dot.gov/policy/ohim/hs06/htm/mv1.htm

5.2.4 Parking Demand Utilization Rates for Daytime and Nighttime

Parking rates change considerably at a given location based on the time of day and week. Large differences in parking demand can be observed during the day and night and also on weekdays and weekends. Residences generally display higher parking generation rates at night than during the day. In contrast, most types of businesses, with the exception of theaters, display higher daytime generation rates than at night. In order to more accurately assess the number of cars parked at specific HAZUS building classes during a flood event it is useful to estimate daytime and nighttime parking demand. The daytime is assumed to be the 12 hours between 6 a.m. to 5 p.m. Nighttime comprises the rest of the day.

Information on hourly parking occupancy rates as a percent of peak period parking demand for various Land Use Descriptions are provided by the Institute of Traffic Engineers (ITE). However, many of the observations in the ITE report do not cover all the hours in a day. Where information was missing on hourly occupancy rates, project staff sought secondary information to develop estimates or extrapolated from trends observed in the available ITE data. In addition, the data on hourly parking demand in the ITE report are not available for all of the ITE Land Use Descriptions. Therefore, the concordance between the HAZUS building categories and the ITE Land Use Descriptions varies slightly from that used for peak parking generation rates.

In order to calculate the specific value of the vehicles in each census block, the ratio of square feet in each HAZUS building category to the number of each vehicle type for each vehicle class was developed. The daytime and nighttime ratios of vehicle type to HAZUS building category are provided in Exhibits 5.6 and 5.7.

The product of the value per vehicle and the daytime and nighttime number of parked vehicles are provided in Exhibits 5.4 and 5.5, respectively.

Exhibit 5.4: Total Value of Daytime Parked Vehicles

HAZUS ID	HAZUS Building Code	HAZUS Building Category	Daytime Number of Parked Autos Scaled Up	Daytime Number of Parked Light Trucks Scaled Up	Daytime Parked Heavy Trucks	Value of Daytime Parked Autos (Billions)	Value of Daytime Parked Light Trucks (Billions)	Value of Daytime Parked Heavy Trucks (Billions)
1	RES1	Single Family Dwelling	32,397,346	23,799,563	1,435,908	$172.37	$238.32	$33.62
2	RES2	Mobile Home	5,725,343	4,205,920	110,085	$30.46	$42.12	$2.58
3	RES3A	Multi Family Dwelling (2)	1,714,322	1,259,366	88,898	$9.12	$12.61	$2.08
4	RES3B	Multi Family Dwelling (3-4)	1,624,791	1,193,595	48,856	$8.64	$11.95	$1.14
5	RES3C	Multi Family Dwelling (5-9)	2,319,360	1,703,836	51,362	$12.34	$17.06	$1.20
6	RES3D	Multi Family Dwelling (10-19)	1,860,569	1,366,801	41,202	$9.90	$13.69	$0.96
7	RES3E	Multi Family Dwelling (20-49)	1,447,089	1,063,053	32,045	$7.70	$10.64	$0.75
8	RES3F	Multi Family Dwelling (50+)	2,628,485	1,930,923	50,904	$13.98	$19.34	$1.19
9	RES4	Temporary Lodging	1,932,331	1,419,518	14,266	$10.28	$14.21	$0.33
10	RES5	Institutional Dormitory	1,978,368	1,453,338	43,608	$10.53	$14.55	$1.02
11	RES6	Nursing Home	275,295	202,236	6,068	$1.46	$2.03	$0.14
12	COM1	Retail Trade	12,958,238	9,519,310	2,161,590	$68.94	$95.32	$50.60
13	COM2	Wholesale Trade	1,024,057	752,287	865,717	$5.45	$7.53	$20.27
14	COM3	Personal and Repair Services	7,594,323	5,578,901	83,892	$40.40	$55.86	$1.96
15	COM4	Professional/Technical Services	14,168,438	10,408,341	197,123	$75.38	$104.22	$4.61
16	COM5	Banks	810,401	595,332	10,508	$4.31	$5.96	$0.25
17	COM6	Hospital	1,821,900	1,338,394	20,514	$9.69	$13.40	$0.48
18	COM7	Medical Office/Clinic	3,723,727	2,735,504	33,411	$19.81	$27.39	$0.78
19	COM8	Entertainment & Recreation	14,856,815	10,914,033	59,831	$79.04	$109.29	$1.40
20	COM9	Theaters	155,591	114,300	2,239	$0.83	$1.14	$0.05
21	COM10	Parking	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
22	IND1	Heavy	2,215,573	1,627,592	947,248	$11.79	$16.30	$22.18
23	IND2	Light	1,107,387	813,503	706,594	$5.89	$8.15	$16.54
24	IND3	Food/Drugs/Chemicals	648,885	476,680	277,425	$3.45	$4.77	$6.49
25	IND4	Metals/Minerals Processing	289,311	212,532	123,692	$1.54	$2.13	$2.90
26	IND5	High Technology	108,202	79,486	35,435	$0.58	$0.80	$0.83
27	IND6	Construction	2,038,485	1,497,501	667,583	$10.85	$15.00	$15.63
28	AGR	Agriculture	1,099,365	807,610	360,031	$5.85	$8.09	$8.43
29	REL	Church/Non Profit	2,112,839	1,552,122	60,803	$11.24	$15.54	$1.42
30	GOV1	General Services	2,560,185	1,880,749	24,768	$13.62	$18.83	$0.58
31	GOV2	Emergency Services	513,169	376,981	4,346	$2.73	$3.77	$0.10
32	EDU1	Schools/Libraries	1,797,395	1,320,392	40,658	$9.56	$13.22	$0.95
33	EDU2	Colleges/Universities	420,102	308,613	13,567	$2.24	$3.09	$0.32
		TOTAL	**125,927,686**	**92,508,313**	**8,620,178**	**$669.99**	**$926.33**	**$201.81**

Exhibit 5.5: Total Value of Nighttime Parked Vehicles

HAZUS ID	HAZUS Building Code	HAZUS Building Category	Nighttime Number of Parked Autos Scaled Up	Nighttime Number of Parked Light Trucks Scaled Up	Nighttime Parked Heavy Trucks	Value of Nighttime Parked Autos (Billions)	Value of Nighttime Parked Light Trucks (Billions)	Value of Nighttime Parked Heavy Trucks (Billions)
1	RES1	Single Family Dwelling	73,274,142	53,688,460	1,513,953	$389.85	$537.61	$35.44
2	RES2	Mobile Home	12,851,777	9,416,584	116,068	$68.38	$94.29	$2.72
3	RES3A	Multi Family Dwelling (2)	3,886,097	2,847,370	93,729	$20.68	$28.51	$2.19
4	RES3B	Multi Family Dwelling (3-4)	3,659,141	2,681,077	51,512	$19.47	$26.85	$1.21
5	RES3C	Multi Family Dwelling (5-9)	5,210,896	3,818,059	54,153	$27.72	$38.23	$1.27
6	RES3D	Multi Family Dwelling (10-19)	4,180,131	3,062,810	43,441	$22.24	$30.67	$1.02
7	RES3E	Multi Family Dwelling (20-49)	3,251,169	2,382,153	33,787	$17.30	$23.85	$0.79
8	RES3F	Multi Family Dwelling (50+)	5,900,453	4,323,302	53,671	$31.39	$43.29	$1.26
9	RES4	Temporary Lodging	2,193,877	1,607,468	15,041	$11.67	$16.10	$0.35
10	RES5	Institutional Dormitory	803,794	588,945	45,978	$4.28	$5.90	$1.08
11	RES6	Nursing Home	111,850	81,953	6,398	$0.60	$0.82	$0.15
12	COM1	Retail Trade	5,208,292	3,816,151	2,279,077	$27.71	$38.21	$53.36
13	COM2	Wholesale Trade	163,870	120,068	912,770	$0.87	$1.20	$21.37
14	COM3	Personal and Repair Services	2,388,537	1,750,097	88,452	$12.71	$17.52	$2.07
15	COM4	Professional/Technical Services	690,286	505,777	207,837	$3.67	$5.06	$4.87
16	COM5	Banks	133,466	97,791	11,079	$0.71	$0.98	$0.26
17	COM6	Hospital	383,610	281,074	21,629	$2.04	$2.81	$0.51
18	COM7	Medical Office/Clinic	515,763	377,903	35,227	$2.74	$3.78	$0.82
19	COM8	Entertainment & Recreation	5,169,682	3,787,861	63,083	$27.50	$37.93	$1.48
20	COM9	Theaters	69,004	50,560	2,361	$0.37	$0.51	$0.06
21	COM10	Parking	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
22	IND1	Heavy	262,164	192,090	998,733	$1.39	$1.92	$23.38
23	IND2	Light	29,980	21,967	744,999	$0.16	$0.22	$17.44
24	IND3	Food/Drugs/Chemicals	76,781	56,258	292,504	$0.41	$0.56	$6.85
25	IND4	Metals/Minerals Processing	34,234	25,083	130,415	$0.18	$0.25	$3.05
26	IND5	High Technology	17,496	12,819	37,361	$0.09	$0.13	$0.87
27	IND6	Construction	329,613	241,510	703,868	$1.75	$2.42	$16.48
28	AGR	Agriculture	177,762	130,247	379,599	$0.95	$1.30	$8.89
29	REL	Church/Non Profit	1,165,698	854,115	64,108	$6.20	$8.55	$1.50
30	GOV1	General Services	172,432	126,342	26,114	$0.92	$1.27	$0.61
31	GOV2	Emergency Services	85,157	62,395	4,582	$0.45	$0.62	$0.11
32	EDU1	Schools/Libraries	481,155	352,545	42,868	$2.56	$3.53	$1.00
33	EDU2	Colleges/Universities	74,607	54,665	14,305	$0.40	$0.55	$0.33
		TOTAL	**132,952,915**	**97,415,501**	**9,088,703**	**$707.36**	**$975.47**	**$212.78**

Exhibit 5.6: Daytime Ratio of Vehicle Type to HAZUS Building Category

HAZUS ID	HAZUS Building Code	HAZUS Building Category	Automobiles per 1,000 Sq. Feet	Light Trucks per 1,000 Sq. Feet	Heavy Trucks per 1,000 Sq. Feet
1	RES1	Single Family Dwelling	0.2661	0.1955	0.0118
2	RES2	Mobile Home	0.6134	0.4506	0.0118
3	RES3A	Multi Family Dwelling (2)	0.2274	0.1671	0.0118
4	RES3B	Multi Family Dwelling (3-4)	0.3922	0.2881	0.0118
5	RES3C	Multi Family Dwelling (5-9)	0.5326	0.3912	0.0118
6	RES3D	Multi Family Dwelling (10-19)	0.5326	0.3912	0.0118
7	RES3E	Multi Family Dwelling (20-49)	0.5326	0.3912	0.0118
8	RES3F	Multi Family Dwelling (50+)	0.6090	0.4474	0.0118
9	RES4	Temporary Lodging	1.5975	1.1735	0.0118
10	RES5	Institutional Dormitory	0.5350	0.3931	0.0118
11	RES6	Nursing Home	0.5350	0.3931	0.0118
12	COM1	Retail Trade	1.7997	1.3221	0.3002
13	COM2	Wholesale Trade	0.1712	0.1258	0.1447
14	COM3	Personal and Repair Services	1.9411	1.4260	0.0214
15	COM4	Professional/Technical Services	1.5413	1.1322	0.0214
16	COM5	Banks	1.6537	1.2148	0.0214
17	COM6	Hospital	1.9044	1.3990	0.0214
18	COM7	Medical Office/Clinic	2.3899	1.7556	0.0214
19	COM8	Entertainment & Recreation	5.3246	3.9115	0.0214
20	COM9	Theaters	1.4899	1.0945	0.0214
21	COM10	Parking	n.a.	n.a.	n.a.
22	IND1	Heavy	0.5693	0.4182	0.2434
23	IND2	Light	0.3814	0.2802	0.2434
24	IND3	Food/Drugs/Chemicals	0.5693	0.4182	0.2434
25	IND4	Metals/Minerals Processing	0.5693	0.4182	0.2434
26	IND5	High Technology	0.7432	0.5459	0.2434
27	IND6	Construction	0.7432	0.5459	0.2434
28	AGR	Agriculture	0.7432	0.5459	0.2434
29	REL	Church/Non Profit	0.7451	0.5474	0.0214
30	GOV1	General Services	2.2165	1.6283	0.0214
31	GOV2	Emergency Services	2.5320	1.8601	0.0214
32	EDU1	Schools/Libraries	0.9479	0.6964	0.0214
33	EDU2	Colleges/Universities	0.6640	0.4878	0.0214

Exhibit 5.7: Nighttime Ratio of Vehicle Type to HAZUS Building Category

HAZUS ID	HAZUS Building Code	HAZUS Building Category	Automobiles per 1,000 Sq. Feet	Light Trucks per 1,000 Sq. Feet	Heavy Trucks per 1,000 Sq. Feet
1	RES1	Single Family Dwelling	0.6018	0.4410	0.0124
2	RES2	Mobile Home	1.3769	1.0088	0.0124
3	RES3A	Multi Family Dwelling (2)	0.5156	0.3778	0.0124
4	RES3B	Multi Family Dwelling (3-4)	0.8833	0.6472	0.0124
5	RES3C	Multi Family Dwelling (5-9)	1.1965	0.8767	0.0124
6	RES3D	Multi Family Dwelling (10-19)	1.1965	0.8767	0.0124
7	RES3E	Multi Family Dwelling (20-49)	1.1965	0.8767	0.0124
8	RES3F	Multi Family Dwelling (50+)	1.3671	1.0017	0.0124
9	RES4	Temporary Lodging	1.8137	1.3289	0.0124
10	RES5	Institutional Dormitory	0.2174	0.1593	0.0124
11	RES6	Nursing Home	0.2174	0.1593	0.0124
12	COM1	Retail Trade	0.7233	0.5300	0.3165
13	COM2	Wholesale Trade	0.0274	0.0201	0.1526
14	COM3	Personal and Repair Services	0.6105	0.4473	0.0226
15	COM4	Professional/Technical Services	0.0751	0.0550	0.0226
16	COM5	Banks	0.2723	0.1996	0.0226
17	COM6	Hospital	0.4010	0.2938	0.0226
18	COM7	Medical Office/Clinic	0.3310	0.2425	0.0226
19	COM8	Entertainment & Recreation	1.8528	1.3576	0.0226
20	COM9	Theaters	0.6608	0.4842	0.0226
21	COM10	Parking	n.a.	n.a.	n.a.
22	IND1	Heavy	0.0674	0.0494	0.2566
23	IND2	Light	0.0103	0.0076	0.2566
24	IND3	Food/Drugs/Chemicals	0.0674	0.0494	0.2566
25	IND4	Metals/Minerals Processing	0.0674	0.0494	0.2566
26	IND5	High Technology	0.1202	0.0880	0.2566
27	IND6	Construction	0.1202	0.0880	0.2566
28	AGR	Agriculture	0.1202	0.0880	0.2566
29	REL	Church/Non Profit	0.4111	0.3012	0.0226
30	GOV1	General Services	0.1493	0.1094	0.0226
31	GOV2	Emergency Services	0.4202	0.3079	0.0226
32	EDU1	Schools/Libraries	0.2538	0.1859	0.0226
33	EDU2	Colleges/Universities	0.1179	0.0864	0.0226

5.3 Vehicle Location

Project analysts derived vehicle location from the location of the associated structure and its assignment to the stream; stream bank and damage reach used for the analysis. Project engineers determined structure locations using a Geographic Information System (GIS) address shapefile. Each structure with an address was represented by a point file generally near the mailbox of the structure. This location was assumed to be generally representative of the location of the structure. Structures within the planning model's 0.2% ACE floodplain were selected for analysis. The address point files were joined to their respective parcel shapefile obtained from Hancock County tax assessor. This file contained parcel boundaries and parcel numbers that could be cross referenced with the Hancock County tax assessor information.

Project engineers assigned structures to a stream based on their location in the study area. The stream that was adjacent to the structure was typically assigned. In cases where it was not clear which stream to assign (e.g., structure located at the confluence of two streams), professional judgment was used to assign the stream based on which stream was most representative of the flood characteristics for that structure. The structures in Hancock County were assigned to one of three streams: Blanchard River, Eagle Creek, and Lye Creek.

Stream stations which correspond to those used in hydraulic modeling were imported into ArcGIS software and used to match each structure to a stream station. The assigned station was the closest point where the structure was perpendicular to the stream.

5.4 Depth-Damage Functions

Project analysts developed estimates of the value of flood damage to vehicles using data from an unpublished U.S. Army Corps of Engineers (USACE) document entitled, "Estimating Flood Damage to Vehicles" by Stuart A. Davis, Institute for Water Resources. The data used in the USACE document was based on a survey of 640 vehicles. The results were used in a statistical regression analysis to estimate the percent of damage sustained by various vehicles types relative to the depth of flooding. The USACE vehicle types included: sedans, pickups, SUVs, sports cars, and minivans. Project staff assigned sedans and sport cars as proxies for automobiles; pickups, SUVs and minivans as proxies for light trucks. It was assumed that the cabin floor in heavy trucks is two feet higher than light trucks. Using this assumption it was estimated that heavy trucks would sustain the same degree of damage as light trucks but at higher levels of flooding. The percent damage to vehicles by flood water depth is provided in Exhibit 5.8.

These USACE estimates represent a significant improvement in data quality compared to previous estimates. Data in the earlier version of the HAZUS provided data for only three general levels of waters and were based on rough estimates of damages collected from industry experts. These estimates can be applied to the estimates of vehicle value for any census block to estimate the impacts of flood damage for a given water depth.

Exhibit 5.8: Percent Damage to Vehicles by Water Depth and Vehicle Type

Depth Above Ground	Survey Data*					Calculated Data**		
	Sedans	Pickups	SUVs	Sports	Mini Vans	Autos	Light Trucks	Heavy Trucks
0.5	7.6%	5.2%	0.0%	1.4%	0.0%	7.0%	1.9%	0.0%
1	28.0%	20.3%	13.8%	29.2%	17.8%	28.1%	16.7%	0.0%
2	46.2%	34.4%	30.6%	52.8%	38.3%	46.9%	33.0%	1.9%
3	62.2%	47.5%	45.8%	72.2%	56.8%	63.2%	47.9%	16.7%
4	76.0%	59.6%	59.4%	87.4%	73.3%	77.1%	61.3%	33.0%
5	87.6%	70.7%	71.4%	98.4%	87.8%	88.7%	73.3%	47.9%
6	97.0%	80.8%	81.8%	100.0%	100.0%	97.3%	83.8%	61.3%
7	100.0%	89.9%	90.6%	100.0%	100.0%	100.0%	91.6%	73.3%
8	100.0%	98.0%	97.8%	100.0%	100.0%	100.0%	98.2%	83.8%
9	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	91.6%
10	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	98.2%
11	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

**Auto damage percentages were estimated by weighting sedans at 90 percent and sports cars at 10 percent. These weights were derived from the relative numbers of these vehicles surveyed in the Institute for Water Resources draft, where there were 37 sports cars and 369 sedans surveyed. Light truck damage percentages were estimated by weighting by the relative number of these vehicles in 2015 as reported in Table MV-9 from the Federal Highway Administration's Highway Statistics. The table reports 46,844,188 pickups, 64,703,676 sport utilities and 16,917,823 vans. Heavy truck damage percentages were estimated assuming that these vehicles have an additional two feet of clearance relative to light trucks based on data from the previous HAZUS model.

5.5 Results

The complete methodology of the analysis is described in Chapter 2 and as above within this Chapter. The results of the HEC-FDA analysis are expressed as an Equivalent Annual Damage (EAD) for each scenario. The US Army Corps of Engineers defines EAD as the damage value associated with the without-or-with project condition over the analysis period (project life) considering changes in hydrology, hydraulics, and flood damage conditions that may occur over the useful life of the program. HEC-FDA calculates expected annual damage for each analysis year and discounts the value to present worth, then annualizes it to obtain the EAD. Rather than compute the expected annual damage for each year, HEC-FDA computes EAD for the base year and most likely future years and interpolates it for subsequent years. The expected annual damage for years beyond the most likely future conditions year is assumed equal to that year.

The EAD represents the mean amount of damage that may occur in **any given year**, if **that year** were repeated infinitely many times over. The mean value is based on the frequency of recurrence for each flood event, as well as the uncertainties in stage-damage, stage-flow, and flow-frequency relationships.

EAD can vary by year, depending on changes in hydraulic, hydrologic, and economic conditions. Throughout the period of analysis, EAD can vary if there are changes in hydraulic, hydrologic, or economic conditions. If each year is taken in sequence from the beginning of the period of analysis to the end, the result is a series or "stream" of EAD values.

Calculated EAD for each scenario, stream and damage category is presented in Exhibit 5.9. These values are reported in 2017 dollars.

Exhibit 5.9: Equivalent Annual Damage for the AUTO Damage Category ($1,000s)

	Without (Base Case)	Hydraulic Improvements	Full Program
Blanchard	118.52	70.66	13.46
Lye	4.05	2.88	1.03
Eagle	29.63	18.83	1.23
TOTAL	**152.20**	**92.37**	**15.72**

Chapter 6 Transportation Benefits

A flood event can have significant impacts on a regional transportation network. These impacts include road closures, and impediment to traffic flow between the origin and destination both resulting in increased travel times due to detours. This chapter presents the benefits provided by reducing the risk of potential impacts related to flood events. It includes the rationale and justification for including these benefits and the methodology the study team used to calculate the benefits.

6.1 Rationale and Justification for Inclusion

This section provides the rationale and justification for inclusion of transportation benefits in the BCA. The analysis of the benefits of flood mitigation projects commonly assess the benefits of reduced flooding on the transportation network. For example, the USACE National Economic Development Procedures Manual for Urban Flood Damage (NED Manual) states:

> *"Flooding can temporarily impede traffic by covering roads and bridges. Even the threat of flooding and concern for public safety may make it necessary to close roads and detour traffic. Bridge and road damage may cause detours for several months until repairs can be made. The costs of traffic disruption include 1) the additional operating cost for each vehicle, including depreciation, maintenance, and gasoline per mile of detour; and, 2) the traffic delay costs per passenger."*[17]

In the November 2015 USACE Economics Report (Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT), the authors acknowledge the consequence of road flooding noting that:

> *"The Blanchard River Watershed is located in the center of an extensive transportation network of road and rail systems. The level of accessibility afforded by this network has contributed significantly to both local and regional economic growth. Although Hancock County is largely rural, it is also home to many businesses, (including Cooper Tire, Hearthside Foods, Marathon Petroleum, and Whirlpool Corporation) that are able to quickly and easily export manufactured goods using the area's many convenient State routes and interstates.*
>
> *During flood events, transportation infrastructure in the study area (including, but not limited to, I-75) is significantly impacted. Closure times range from short to relatively long to account for inundation, debris clearance, and safety assessments which vary by storm and particular*

[17] U.S. Army Corps of Engineers, National Economic Development Procedures Manual - Urban Flood Damage. IWR Report 88-R-2, March 1988. pp. VII-6 – VII-11.

transportation route. During major flood events, a majority of the Blanchard River crossings are closed. Major flooding has also resulted in the closure of several Blanchard River rail crossings."[18]

6.2 Estimation Methodology

This section describes the methodology used to estimate the transportation related benefits. The USACE describes in its NED Manual the recommended method for estimating the costs of rerouting traffic. The costs of traffic disruption include:

- The additional operating cost for each vehicle, including depreciation, maintenance, and gasoline per mile of detour
- The traffic delay costs per passenger

The USACE NED Manual notes "To determine traffic operating cost, it is first necessary to determine the frequency, depth, and duration of flooding along major stretches of road that are subject to flooding. In order to concentrate on areas where the most significant benefits might occur, it is necessary to focus on portions of roads where there would be considerable traffic rerouting for long periods of time."

The manual notes that beyond the inundation mapping, there are several tasks necessary to determine the operating costs of traffic rerouting:[19]

Step 1: Determine the amount of time that particular stretches of road would be impassable.

Step 2: Determine the number of miles for the original route.

Step 3: Determine the number of miles for the best alternative route.

Step 4: Determine the additional miles per vehicle.

Step 5: Determine the total additional mileage by multiplying the additional miles per vehicle by the average daily travel and period that the roads are impassable.

Step 6: Estimate the average vehicle operating expense.

Step 7: Multiply average operating cost by total mileage to obtain additional operating cost.

[18] Ibid, Section 1.3, p. 2.

[19] The steps described roughly parallel those that USACE provides in the National Economic Development Procedures Manual for Urban Flood Damage. However, the discussion both edited the steps to simplify the descriptions and enhanced them to include steps that the manual did not specifically discuss.

The second portion of traffic rerouting is traffic delay costs. This cost accounts for the additional time spent by individuals forced to take the detours due to road closures. Since time is usually more valuable than the average vehicle operating costs in the same period, traffic delay costs are often higher than traffic operating costs. The procedures for calculating traffic delay costs are as follows:

Step 1: Determine the amount of time that particular stretches of road would be impassable.

Step 2: Determine the number of miles for the original route.

Step 3: Determine the number of miles for the best alternative route.

Step 4: Determine the additional miles per vehicle.

Step 5: Determine the amount of time required on the original route.

Step 6: Determine the amount of time required on the alternative route.

Step 7: Subtract the original from the rerouted travel time to compute additional travel time.

Step 8: Determine the approximate average number of passengers per vehicle.

Step 9: Determine the total additional time by multiplying the additional time per vehicle by the number of passengers per vehicle and the average daily travel and the period that the roads are impassable.

Step 10: Determine the value-of-time for passengers using area wage rates.

Step 11: Multiply the additional travel time by the value-of-time.

During the 2007 floods, numerous routes become impassable. Based upon that anecdotal information from local records and interviews, the methodology calculates the results for each route separately and sums the results. In addition, the number of route closures has a significant impact on travel delays. According to local officials, traffic during the 2007 flood caused significant traffic delays on the alternative routes. As a result, the analysis assumes that the travel times on the alternate routes would be double the travel times with no delay.

The following sections detail the calculations that the analysis study team undertook to calculate the transportation benefits of reduced flooding that the proposed program alternatives would provide.

Inundated Routes

Steve Wilson, the former Hancock County Engineer and current Project manager for the MWCD, provided a list of road closures and the estimated duration of those closures during the 2007 flood event. Exhibit 6.1 lists those road closures, along with the Average Daily Travel (ADT) traffic volume on sample segments for each of the roads. The exhibit also provides the estimates of closure durations during the 2007 event and an approximated detour, or in one case, detours. The Ohio Department of Transportation (ODOT) was the source of ADT traffic volumes.

Exhibit 6.1: Inundated Travel Routes, Average Daily Travel and Detours

Name	Average Daily Travel	Duration of Closure During 2007 Event	Approximated Detour
US 224 - CR 140 to I-75	11,000	24	Local Traffic Westbound on 224 -- (West on Trenton Ave. (US 224), Turn right on Northridge Rd., Turn left on TR 94, Turn Left CR140)
			Non-Local Traffic Wanting to travel West -- (North on I-75, West on State Route 613, South on Local Road and destination)
Main St - Center St to Sandusky St	18,000	72	Southbound Main Street at Center Street -- Travel North to Trenton Ave. (224), turn left to I-75, travel south to SR 12 (exit 157), turn left to head east on Main Cross St. to Western Ave., to Hardin Street.)
Main St - Olive Street to SR 15	8,000	48	Southbound Main Street -- Turn right at Orchard Lane, Right on Western Avenue to Lima Avenue, Left on Lima Avenue to CR 9, Left (south on CR 9 to CR 37) to US 68
Main Cross St - Western Ave To Bright Rd 5 (West St)	12,000	72	Eastbound on SR 12 (Main Cross St.) -- Get onto northbound I-75, Take exit 159 to East 224, Travel east onto 224 back to the City.
Main Cross St - Western Ave To Bright Rd 4 (East St)	12,000	72	
Main Cross St - Western Ave To Bright Rd 3 (Blanchard St)	12,000	72	
Main Cross St - Western Ave To Bright Rd 2 (Warrington)	12,000	72	
Main Cross St - Western Ave To Bright Rd 1 (West of Bright)	12,000	72	
SR 37 - Main St to TR 205	5,000	72	Eastbound on SR 37 at Main St and Lincoln --Travel South on Main Street to Lima Avenue to CR 9, travel South on CR 9 to CR 37, continue on CR 37 to SR 37 south of SR 15.
SR 37 - CR 8 to TR 234	4,000	48	Southeast bound on SR 37 -- South on TR 180 to SR 15 to SR 37
Sandusky St (SR568) - Main St to TR 237 (TR 236)	12,000	72	Regionally closed to TR 245 - West on 568 from Main Street, Backtrack to I-75, go north to 224, follow 224 east to CR 330 (4 miles east of Findlay) follow CR 330 south to 568.
Sandusky St (SR568) - Main St to TR 237 (Lye Creek Bridge)	12,000	72	
Sandusky St (SR568) - Main St to TR 237 (Blanchard St)	12,000	72	
Sandusky St (SR568) - Main St to TR 237 (RR)	12,000	72	
SR 568 - TR 237 to TR 245 (twp hwy 241)	6,000	48	
SR 568 - TR 237 to TR 245 (TR 245)	6,000	48	
US 68 / SR 15 @ Eagle Creek (SR 15)	20,000	48	Westbound on SR 15, go south to Village of Vanlue SR 330. Get off at interchange, turn left through village, changes into CR 330. Follow north to US 224, West to I-75. Southbound on SR 15 from I-75, backtrack toward I-75 to Lima Avenue. Lima Ave west to CR 9, south on CR 9 to CR 37, east on CR 37 to SR 37, back north to SR 15.
US 68 / SR 15 @ Eagle Creek (US 68)	20,000	48	From South to North, (to west side of Findlay) get off of US 68 at CR 37 to CR 9 to Lima Ave into Findlay. From South to North, (to east side of Findlay) TWP 168 to Twp Rd 180. turn left on 180 to SR 15. East on SR 15 to Village of Vanlue and SR 330.

Time and Distance Values

The research team selected ten road segments and their expected detour routes for analysis. Exhibit 6.2 lists each of the road segments, the ADT, the change in distance in miles due to detour, the change in time in minutes due to detour, the mileage rate the analysis used, and the value of time in dollars per minute that the analysis used. The analysis calculated distances and times using standard travel route mapping software. The Internal Revenue Service was the source for the mileage rate for 2017 of $0.535. The value of time per vehicle per minute of $0.314 is a weighted average of personal and commercial wage rates multiplied by average vehicle occupancy. The weighting, 95.4 percent for personal purposes and 4.6 percent for business, is from the US DOT. The US Bureau of Labor Statistics, State Occupational Employment and Wage Estimates, was the source of the 2015 mean hourly wage rate for Ohio of $21.52. The assumption was that the personal value of time was half the wage rate. The source of the vehicle occupancy rate of 1.67 was the 2009 National Household Travel Survey, which is the latest version of that survey.

Exhibit 6.2: Time, Distance, and Rate Variables

Name	ADT	Change in Distance (miles)	Change in Time (minutes)	Mileage Rate ($)	Value of Time ($/minute)
US 224 - CR 140 to I-75	11,000	1.1	9	0.535	$ 0.314
Main St - Center St to Sandusky St	18,000	4.2	23	0.535	$ 0.314
Main St - Olive Street to SR 15	8,000	7.8	28	0.535	$ 0.314
Main Cross St - Western Ave To Bright Rd 3 (Blanchard St)	12,000	3.1	26	0.535	$ 0.314
SR 37 - Main St to TR 205	5,000	5.5	34	0.535	$ 0.314
SR 37 - CR 8 to TR 234	4,000	1.9	11	0.535	$ 0.314
Sandusky St (SR568) - Main St to TR 237 (Lye Creek Bridge)	12,000	15.8	58	0.535	$ 0.314
SR 568 - TR 237 to TR 245 (TR 245)	6,000	15.8	58	0.535	$ 0.314
US 68 / SR 15 @ Eagle Creek (SR 15)	20,000	8.2	38	0.535	$ 0.314
US 68 / SR 15 @ Eagle Creek (US 68)	20,000	2.7	20	0.535	$ 0.314

:

Road Closure Durations

The research team estimated durations of road closures using water surface profiles and time-varied inundation mapping from the planning level hydraulic modeling. Stantec calculated the closure durations using HEC-RAS for each scenario and eight flood frequencies. Stantec assumed that for roads with inundation depths less than 0.5 feet the segment did not close. If the inundation depth was between 0.5 and 0.9 feet, Stantec assumed the closure was a minimum of 12 hours, or longer in 2-hour increments if the inundation was greater than 12 hours. If the inundation depth was greater than 1.0 foot, Stantec assumed the closure was a minimum of 24 hours, or longer in 2-hour increments if the inundation was greater than 24 hours. The ADT from Exhibit 6-2 were used for this analysis. Exhibit 6-3 provides road closure durations for the without project conditions, the Hydraulic Improvements component, and the difference between the two scenarios. Exhibit 6-4 provides road closure durations for the without project conditions, the Full Program, and the difference between the two scenarios.

Change in Distance Traveled

Exhibit 6.5 estimates the number of vehicles impacted and changes in distance traveled due to detour. The exhibit calculates the number of vehicles impacted by multiplying the ADT by the duration of flooding in hours and dividing the result by 24. Exhibit 6.5 shows the calculated changes in distance traveled. These values were developed by multiplying the number of vehicles impacted by the change in distance caused by the detour. Exhibit 6.5 provides results by flood frequency and road segment. The exhibit also provides the results for the Hydraulic Improvements scenario in the top of the table and the results for the Full Program in the bottom of the table.

Exhibit 6.3: Road Closure Durations for the Hydraulic Improvement

	Existing Conditions - Road Closed (Flooding > 6 inches (Hours))								Hydraulic Improvemnets - Road Closed (Flooding > 6 inches (Hours)								Difference in Duration of Road Closure (Hours)							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	0	0	0	28	36	44	48	54	0	0	0	28	36	44	48	54	0	0	0	0	0	0	0	0
Main St - Center St to Sandusky St	0	0	24	40	46	50	54	60	0	0	0	24	34	41	46	52	0	0	24	16	12	9	8	8
Main St - Olive Street to SR 15	0	0	0	12	16	24	24	28	0	0	0	12	16	24	24	28	0	0	0	0	0	0	0	0
Main Cross St - Western Ave To Bright Rd 3	48	56	62	70	74	78	82	88	28	46	54	60	64	68	72	76	20	10	8	10	10	10	10	12
SR 37 - Main St to TR 205	0	0	24	30	38	44	48	54	0	0	0	24	30	36	42	48	0	0	24	6	8	8	6	6
SR 37 - CR 8 to TR 234	0	0	0	0	12	12	12	24	0	0	0	0	12	12	12	24	0	0	0	0	0	0	0	0
Sandusky St (SR568) - Main St to TR 237	0	20	34	46	50	54	58	64	0	0	14	34	42	48	54	56	0	20	20	12	8	6	4	8
SR 568 - TR 237 to TR 245 (TR 245)	0	0	0	0	12	18	28	36	0	0	0	0	12	18	28	36	0	0	0	0	0	0	0	0
US 68 / SR 15 @ Eagle Creek (SR 15)	0	0	0	0	0	12	24	24	0	0	0	0	0	12	24	24	0	0	0	0	0	0	0	0
US 68 / SR 15 @ Eagle Creek (US 68)	0	0	0	24	24	24	24	28	0	0	0	24	24	24	24	28	0	0	0	0	0	0	0	0

Exhibit 6.4: Road Closure Durations for the Full Program

	Existing Conditions - Road Closed (Flooding > 6 inches (Hours))								Full Program Road Closed (Flooding > 6 inches (Hours))								Difference in Duration of Road Closure (Hours)							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	0	0	0	28	36	44	48	54	0	0	0	0	12	24	32	44	0	0	0	28	24	20	16	10
Main St - Center St to Sandusky St	0	0	24	40	46	50	54	60	0	0	0	0	0	24	30	42	0	0	24	40	46	26	24	18
Main St - Olive Street to SR 15	0	0	0	12	16	24	24	28	0	0	0	0	0	0	0	0	0	0	0	12	16	24	24	28
Main Cross St - Western Ave To Bright Rd 3	48	56	62	70	74	78	82	88	24	44	54	64	72	80	88	98	24	12	8	6	2	-2	-6	-10
SR 37 - Main St to TR 205	0	0	24	30	38	44	48	54	0	0	0	0	0	12	24	32	0	0	24	30	38	32	24	22
SR 37 - CR 8 to TR 234	0	0	0	0	12	12	12	24	0	0	0	0	12	12	12	24	0	0	0	0	0	0	0	0
Sandusky St (SR568) - Main St to TR 237	0	20	34	46	50	54	58	64	0	0	0	0	24	36	44	56	0	20	34	46	26	18	14	8
SR 568 - TR 237 to TR 245 (TR 245)	0	0	0	0	12	18	28	36	0	0	0	0	0	0	16	26	0	0	0	0	12	18	12	10
US 68 / SR 15 @ Eagle Creek (SR 15)	0	0	0	0	0	12	24	24	0	0	0	0	0	0	0	0	0	0	0	0	0	12	24	24
US 68 / SR 15 @ Eagle Creek (US 68)	0	0	0	24	24	24	24	28	0	0	0	0	0	0	0	0	0	0	0	24	24	24	24	28

Exhibit 6.5: Number of Vehicles Impacted and Change in Distance Traveled

Name	Number of Vehicles Impacted - Hydraulic Improvements								Change in Distance Traveled (miles) - Hydraulic Improvements							
	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main St - Center St to Sandusky St	-	-	18,000	12,000	9,000	6,750	6,000	6,000	-	-	75,600	50,400	37,800	28,350	25,200	25,200
Main St - Olive Street to SR 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main Cross St - Western Ave To Bright Rd 3	10,000	5,000	4,000	5,000	5,000	5,000	5,000	6,000	31,000	15,500	12,400	15,500	15,500	15,500	15,500	18,600
SR 37 - Main St to TR 205	-	-	5,000	1,250	1,667	1,667	1,250	1,250	-	-	27,500	6,875	9,167	9,167	6,875	6,875
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandusky St (SR568) - Main St to TR 237	-	10,000	10,000	6,000	4,000	3,000	2,000	4,000	-	158,000	158,000	94,800	63,200	47,400	31,600	63,200
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	Number of Vehicles Impacted - Full Program								Change in Distance Traveled (miles) - Full Program							
	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	12,833	11,000	9,167	7,333	4,583	-	-	-	14,117	12,100	10,083	8,067	5,042
Main St - Center St to Sandusky St	-	-	18,000	30,000	34,500	19,500	18,000	13,500	-	-	75,600	126,000	144,900	81,900	75,600	56,700
Main St - Olive Street to SR 15	-	-	-	4,000	5,333	8,000	8,000	9,333	-	-	-	31,200	41,600	62,400	62,400	72,800
Main Cross St - Western Ave To Bright Rd 3	12,000	6,000	4,000	3,000	1,000	(1,000)	(3,000)	(5,000)	37,200	18,600	12,400	9,300	3,100	(3,100)	(9,300)	(15,500)
SR 37 - Main St to TR 205	-	-	5,000	6,250	7,917	6,667	5,000	4,583	-	-	27,500	34,375	43,542	36,667	27,500	25,208
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandusky St (SR568) - Main St to TR 237	-	10,000	17,000	23,000	13,000	9,000	7,000	4,000	-	158,000	268,600	363,400	205,400	142,200	110,600	63,200
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	-	3,000	4,500	3,000	2,500	-	-	-	-	47,400	71,100	47,400	39,500
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	10,000	20,000	20,000	-	-	-	-	-	82,000	164,000	164,000
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	20,000	20,000	20,000	20,000	23,333	-	-	-	54,000	54,000	54,000	54,000	63,000

Change in Vehicle Operating Cost

Exhibit 6.6 estimates the change in vehicle operating cost. The exhibit calculates change in vehicle operating cost by multiplying the changes in distance traveled by the IRS mileage rate. The exhibit provides results by flood frequency and road segment. The exhibit provides the results for the hydraulic improvements in the top of the exhibit and the results for the full program in the bottom of the exhibit.

Exhibit 6.6: Change in Vehicle Operating Cost

	Change in Vehicle Operating Cost ($) - Hydraulic Improvements							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	-	-	-	-	-
Main St - Center St to Sandusky St	-	-	40,446	26,964	20,223	15,167	13,482	13,482
Main St - Olive Street to SR 15	-	-	-	-	-	-	-	-
Main Cross St - Western Ave To Bright Rd 3	16,585	8,293	6,634	8,293	8,293	8,293	8,293	9,951
SR 37 - Main St to TR 205	-	-	14,713	3,678	4,904	4,904	3,678	3,678
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	-
Sandusky St (SR568) - Main St to TR 237	-	84,530	84,530	50,718	33,812	25,359	16,906	33,812
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	-	-	-	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	-	-	-
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	-	-	-	-	-
	Change in Vehicle Operating Cost ($) - Full Program							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	7,552	6,474	5,395	4,316	2,697
Main St - Center St to Sandusky St	-	-	40,446	67,410	77,522	43,817	40,446	30,335
Main St - Olive Street to SR 15	-	-	-	16,692	22,256	33,384	33,384	38,948
Main Cross St - Western Ave To Bright Rd 3	19,902	9,951	6,634	4,976	1,659	(1,659)	(4,976)	(8,293)
SR 37 - Main St to TR 205	-	-	14,713	18,391	23,295	19,617	14,713	13,486
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	-
Sandusky St (SR568) - Main St to TR 237	-	84,530	143,701	194,419	109,889	76,077	59,171	33,812
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	-	25,359	38,039	25,359	21,133
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	43,870	87,740	87,740
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	28,890	28,890	28,890	28,890	33,705

Change in Time Traveled and Value of Time

Exhibit 6.7 estimates the change in time traveled due to detour and change in value of time. The exhibit shows the calculated change in time traveled. These values were developed by multiplying the number of vehicles impacted by the change in time the detour causes. The exhibit also shows the changes in value of time calculated by multiplying the change in time traveled by the value of time per hour. The exhibit provides results by flood frequency and road segment. Exhibit 6.7 provides the results for the Hydraulic Improvements scenario in the top of the table and the results for the Full Program in the bottom of the table.

Exhibit 6.7: Change in Time Traveled and Value of Time

:

	Change in Time Traveled (minutes) - Hydraulic Improvements								Change in Value of Time ($) - Hydraulic Improvements							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main St - Center St to Sandusky St	-	-	414,000	276,000	207,000	155,250	138,000	138,000	-	-	129,821	86,547	64,910	48,683	43,274	43,274
Main St - Olive Street to SR 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main Cross St - Western Ave To Bright Rd 3	260,000	130,000	104,000	130,000	130,000	130,000	130,000	156,000	81,530	40,765	32,612	40,765	40,765	40,765	40,765	48,918
SR 37 - Main St to TR 205	-	-	170,000	42,500	56,667	56,667	42,500	42,500	-	-	53,308	13,327	17,769	17,769	13,327	13,327
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandusky St (SR568) - Main St to TR 237	-	580,000	580,000	348,000	232,000	174,000	116,000	232,000	-	181,875	181,875	109,125	72,750	54,562	36,375	72,750
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Change in Time Traveled (minutes) - Full Program								Change in Value of Time ($) - Full Program							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	115,500	99,000	82,500	66,000	41,250	-	-	-	36,218	31,044	25,870	20,696	12,935
Main St - Center St to Sandusky St	-	-	414,000	690,000	793,500	448,500	414,000	310,500	-	-	129,821	216,368	248,823	140,639	129,821	97,366
Main St - Olive Street to SR 15	-	-	-	112,000	149,333	224,000	224,000	261,333	-	-	-	35,121	46,828	70,241	70,241	81,948
Main Cross St - Western Ave To Bright Rd 3	312,000	156,000	104,000	78,000	26,000	(26,000)	(78,000)	(130,000)	97,836	48,918	32,612	24,459	8,153	(8,153)	(24,459)	(40,765)
SR 37 - Main St to TR 205	-	-	170,000	212,500	269,167	226,667	170,000	155,833	-	-	53,308	66,635	84,405	71,077	53,308	48,866
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandusky St (SR568) - Main St to TR 237	-	580,000	986,000	1,334,000	754,000	522,000	406,000	232,000	-	181,875	309,187	418,312	236,437	163,687	127,312	72,750
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	-	174,000	261,000	174,000	145,000	-	-	-	-	54,562	81,844	54,562	45,469
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	380,000	760,000	760,000	-	-	-	-	-	119,159	238,319	238,319
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	400,000	400,000	400,000	400,000	466,667	-	-	-	125,431	125,431	125,431	125,431	146,336

Change in Transportation Cost

Exhibit 6.8 estimates the change in transportation cost. The exhibit shows the change in transportation cost calculated by summing the change in vehicle operating cost and the change in value of time. The exhibit provides results by flood frequency and road segment. The exhibit provides the results for the Hydraulic Improvements scenario in the top of the exhibit and the results for the Full Program in the bottom of the exhibit.

Exhibit 6.8: Change in Transportation Cost

	Change in Transportation Cost ($) - Hydraulic Improvements							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	-	-	-	-	-
Main St - Center St to Sandusky St	-	-	170,267	113,511	85,133	63,850	56,756	56,756
Main St - Olive Street to SR 15	-	-	-	-	-	-	-	-
Main Cross St - Western Ave To Bright Rd 3	98,115	49,058	39,246	49,058	49,058	49,058	49,058	58,869
SR 37 - Main St to TR 205	-	-	68,021	17,005	22,674	22,674	17,005	17,005
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	-
Sandusky St (SR568) - Main St to TR 237	-	266,405	266,405	159,843	106,562	79,921	53,281	106,562
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	-	-	-	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	-	-	-
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	-	-	-	-	-
	Change in Transportation Cost ($) - Full Program							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	43,771	37,518	31,265	25,012	15,632
Main St - Center St to Sandusky St	-	-	170,267	283,778	326,345	184,456	170,267	127,700
Main St - Olive Street to SR 15	-	-	-	51,813	69,084	103,625	103,625	120,896
Main Cross St - Western Ave To Bright Rd 3	117,738	58,869	39,246	29,435	9,812	(9,812)	(29,435)	(49,058)
SR 37 - Main St to TR 205	-	-	68,021	85,026	107,699	90,694	68,021	62,352
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	-
Sandusky St (SR568) - Main St to TR 237	-	266,405	452,888	612,731	346,326	239,764	186,483	106,562
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	-	79,921	119,882	79,921	66,601
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	163,029	326,059	326,059
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	154,321	154,321	154,321	154,321	180,041

6.3 Results

Exhibit 6.9 estimates the average annual benefit (the change in transportation cost). The first column of the exhibit lists the flood frequencies. The second column lists the sum of the change in transportation costs from Exhibit 6.8. The final stage of the analysis (columns three through six) involves constructing a frequency-damage curve from the results of the change in transportation cost for each frequency. This involves the calculation of the average change in transportation cost, the probability of occurrence, the incremental occurrence and the average annual change in transportation cost. The sum of the average annual change over the eight frequencies provides the incremental average annual change in transportation cost, which is the estimate of the benefit. The exhibit provides the results for the Hydraulic Improvements scenario in the top of the exhibit and the results for the Full Program in the bottom of the exhibit. The annual average benefit of reducing flood related transportation detours is $141,532 for the Hydraulic Improvements component and $222,401 for the Full Program.

Exhibit 6.9: Average Annual Transportation Benefits

Hydraulic Improvements					
Flood Event	**Change in Transportation Cost**	**Average Change**	**Probability of Occurrence**	**Incremental Occurrence**	**Average Annual Change**
500	$ 239,192		0.002		
		$ 207,645		0.003	$ 623
200	$ 176,099		0.005		
		$ 195,801		0.005	$ 979
100	$ 215,503		0.01		
		$ 239,464		0.01	$ 2,395
50	$ 263,426		0.02		
		$ 301,422		0.02	$ 6,028
25	$ 339,417		0.04		
		$ 441,678		0.06	$ 26,501
10	$ 543,938		0.1		
		$ 429,700		0.1	$ 42,970
5	$ 315,462		0.2		
		$ 206,789		0.3	$ 62,037
2	$ 98,115		0.5		
Incremental average annual change in transportation cost:					**$ 141,532**

Final Plan					
Flood Event	**Change in Transportation Cost**	**Average Change**	**Probability of Occurrence**	**Incremental Occurrence**	**Average Annual Change**
500	$ 956,786		0.002		
		$ 1,020,530		0.003	$ 3,062
200	$ 1,084,274		0.005		
		$ 1,080,750		0.005	$ 5,404
100	$ 1,077,225		0.01		
		$ 1,104,125		0.01	$ 11,041
50	$ 1,131,025		0.02		
		$ 1,195,949		0.02	$ 23,919
25	$ 1,260,873		0.04		
		$ 995,647		0.06	$ 59,739
10	$ 730,422		0.1		
		$ 527,848		0.1	$ 52,785
5	$ 325,274		0.2		
		$ 221,506		0.3	$ 66,452
2	$ 117,738		0.5		
Incremental average annual change in transportation cost:					**$ 222,401**

Chapter 7 Debris Removal, Relocations & Emergency Response

This chapter presents the rationale, methodology and results of the economic benefit resulting from reduction of Emergency Response expenses. These reductions occur when emergency responders from Hancock County, various Townships and the City of Findlay are able to avoid the expenses brought about by responses and rescues related to significant flood events. The flood damage expenses avoided may include water and flood-related rescues, utility damages, debris removal, costs associated with emergency shelters and temporary relocations for residents, government agencies and businesses, and other disaster related costs. The savings in emergency response expenditures constitutes a benefit of the Hancock County Flood Risk Reduction Program.

7.1 Rationale and Justification for Inclusion

The US Army Corps of Engineers (USACE) classifies emergency costs as nonphysical flood losses.[20] Emergency response costs are incurred by Federal, State, and local government agencies that provide emergency services and debris removal during a flood. Benefits accrue when the community avoids expenses for emergency services brought on by flooding. These may include, for example, costs of rescue, flood fighting and cleanup along with the costs of debris removal, resident evacuation and temporary housing, and first responders including police and fire. As noted by the USACE,

> *"Emergency costs include those expenses resulting from a flood that would not otherwise be incurred. For example, the costs of evacuation and reoccupation, flood fighting, and administrative costs of disaster relief; increased costs of normal operations during the flood; and increased costs of police, fire, or military patrol. Emergency costs should be determined by specific survey or research and should not be estimated by applying arbitrary percentages to the physical damage estimates."*[21]

The agency's Flood Risk Management report elaborates:

> *"Clean up and recovery costs include the cost of all labor and materials associated with cleaning up flood debris and damage, repairing damages, replacing evacuated and moved*

[20] Flood Risk Management. Institute for Water Resources Report 2013-R-05, Department of the Army, U.S. Army Corps of Engineers, Washington, DC, June 2013.

[21] Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, Planning Guidance Notebook, ER 1105-2-100, Department of the Army, U.S. Army Corps of Engineers, Washington, DC, 22 April 2000.

property, providing emergency food, water, shelter and medical expenses, policing and securing damaged areas, clearing roads, disposing of debris and other similar expenses."[22]

7.2 Estimation Methodology

This section describes the methodology used to estimate the economic benefit from reduced emergency expenses. The research team received a summary of Disaster Assistance funds distributed by FEMA for the 2007 flood in Findlay (not including Flood Insurance payments to businesses) from the Maumee Watershed Conservancy District Project Manager. The Ohio Emergency Management Agency (EMA) provided the information. [23] There are two sets of data, one covering loans and one covering public assistance.

Loans

Exhibit 7.1 provides the Hancock County loan funding that came from two sources, the Individuals and Households Program (IHP) and the Small Business Administration (SBA). The IHP provides financial help or direct services to those who have necessary expenses and serious needs if they are unable to meet the needs through other means. [24] The SBA provides federal disaster loan assistance to businesses, homeowners, nonprofits and renters.[25] The total loans issued in response to 2007 flooding event summed to just under $20 million. The IHP funding represented 2,743 registrations of which 1,748 were approved for $7,234,175.67. The SBA funds covered 211 Home/Personal Property Loans totaling $6,798,400 and 69 Business Loans totaling $5,768,700.

Exhibit 7.1: Hancock County Loan Funding

				Small Business Administration (SBA)			
	Individuals and Households Program (IHP)			Home/Personal Property Loans		Business Loans	
County	Registrations	Approved	Amount				
Hancock	2,743	1,748	$7,234,175.67	211	$6,798,400	69	$5,768,700

Because these were loans, according to Steve C. Wilson, Project Manager for the MWCD, and funds used primarily for structure and content damage, these funds are not included in this part of the analysis. The runs of the HEC model produce values for individual and household losses.

[22] Flood Risk Management. Institute for Water Resources Report 2013-R-05, Department of the Army, U.S. Army Corps of Engineers, Washington, DC, June 2013.

[23] http://www.ema.ohio.gov/

[24] https://www.fema.gov/media-library/assets/documents/24945

[25] https://disasterloan.sba.gov/ela/Declarations

Public Assistance

The second funding source, representing $7,652,947.58 in public assistance, provided detail for Hancock County grant awards in response to the 2007 flood event. The data included the fund recipients, such as Blanchard Valley Health System and Findlay City Schools, and the breakdown by funding source, such as Federal, Administrative (federal) State or Local share.

The first column in Exhibit 7.2 provides the total public assistance for each entity. First, the research team assigned these expenses to one of four expense categories. The categories were debris removal and roadway and bridge impacts, emergency services, structure or content damage, and outside of the Flood Risk Reduction Program zone of influence.

Exhibit 7.2: Hancock County Grant Recipients by Jurisdiction and Damage Category

Jurisdiction	Total Grant Award	Debris Removal and Roadway and Bridge Impacts	Emergency Services	Structure and Content Damage	Outside of Program Influence
Amanda Township	$45,051	$45,051	$0	$0	$0
Blanchard Township	$5,471	$5,471	$0	$0	$0
Blanchard Valley Health System	$50,416	$0	$50,416	$0	$0
City of Findlay	$1,592,447	$1,592,447	$0	$0	$0
Delaware Township	$7,342	$7,342	$0	$0	$0
Findlay City Schools	$2,457,104	$0	$0	$2,457,104	$0
Findlay-Hancock Co. Public Library	$2,220,342	$0	$0	$2,220,342	$0
Hancock County Agency on Aging	$6,496	$0	$6,496	$0	$0
Hancock County Board of Elections	$130,431	$0	$0	$130,431	$0
Hancock County Board of MR/DD	$3,566	$0	$0	$3,566	$0
Hancock County Commissioners	$656,513	$0	$0	$656,513	$0
Hancock County Engineer	$195,774	$195,774	$0	$0	$0
Hancock County Fairgrounds	$19,787	$4,947	$0	$14,840	$0
Hancock County Health Dept.	$19,118	$0	$0	$19,118	$0
Hancock County Sheriff	$28,385	$0	$0	$28,385	$0
Hancock Park District	$14,995	$0	$0	$14,995	$0
Liberty Township	$13,590	$13,590	$0	$0	$0
Madison Township	$4,047	$0	$0	$0	$4,047
Marion Township	$18,375	$18,375	$0	$0	$0
Pioneer Club	$7,279	$0	$0	$7,279	$0
The Arts Partnership of Greater Hancock	$26,697	$0	$0	$26,697	$0
Village of Arlington	$78,236	$0	$0	$0	$78,236
Village of Jenera	$3,813	$0	$0	$0	$3,813
Village of Mt. Blanchard	$47,671	$0	$0	$0	$47,671
HANCOCK COUNTY TOTALS	**$7,652,948**	**$1,882,997**	**$56,912**	**$5,579,270**	**$133,768**

Second, the research team determined which of the entities were outside the area of influence of the of Flood Risk Reduction Program based on geographic location. As shown in the rightmost column of Exhibit 4.2, expenses expended to jurisdictions outside of the Program influence totaled $133,768.

Third, to assign the remaining funds to the remaining three categories of Debris Removal and Bridge Impacts, Emergency Services and Structure and Content Damage, the research team collected FEMA damage applications as available from the Hancock County Historical Society and reviewed them to determine what the actual funding request was for.

7.3 Results

This section provides the results of the BCA. In order to estimate the benefits the research team made several assumptions. First, the research team removed funding for structure and contents damage to avoid double counting. Second, the research team assumed that the estimates included within the funding applications submitted in response to the 2007 flood event approximated these costs during a 100-year event. Third, a method was required to scale these estimates to other flood frequencies. Duration of road closures provides a reasonable proxy for debris removal and the research team chose to use road closures as the proxy. Thus, the impacts were scaled to the other flood frequencies using the number of hours of road closures. Exhibit 7.3 provides the results of emergency response avoidance benefits under the existing, Hydraulic Improvements and Full Program scenarios.

The water surface elevation (WSE) reductions related to the recommended Hydraulic Improvements along the Blanchard River and full Flood Risk Reduction Program scenarios are compared to the existing 100-year flood event. The Hydraulic Improvements scenario would save $96,028 ($288,497 - $192,469) in incremental annual damage. The Full Program improvements scenario saves $159,401 ($288,497 - $129,096) in incremental annual damage.

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Exhibit 7.3: Benefits of Avoidance of Emergency Responses under Three Scenarios

Flood Event	Duration of Road Closures (hours)	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Damage	Incremental Annual Damage
			Existing Conditions				
500	460	$ 2,478,774		0.002			
			$ 2,322,503		0.003	$ 6,968	
200	402	$ 2,166,233		0.005			
			$ 2,053,071		0.005	$ 10,265	
100	360	$ 1,939,910		0.01			
			$ 1,799,805		0.01	$ 17,998	
50	308	$ 1,659,701		0.02			
			$ 1,503,430		0.02	$ 30,069	
25	250	$ 1,347,160		0.04			
			$ 1,061,562		0.06	$ 63,694	
10	144	$ 775,964		0.1			
			$ 592,750		0.1	$ 59,275	
5	76	$ 409,537		0.2			
			$ 334,096		0.3	$ 100,229	
2	48	$ 258,655		0.5			
Total average annual damage:						$ 288,497	
			Hydraulic Improvments				
500	426	$ 2,295,560		0.002			
			$ 2,155,455		0.003	$ 6,466	
200	374	$ 2,015,351		0.005			
			$ 1,888,718		0.005	$ 9,444	
100	327	$ 1,762,085		0.01			
			$ 1,608,509		0.01	$ 16,085	
50	270	$ 1,454,932		0.02			
			$ 1,282,496		0.02	$ 25,650	
25	206	$ 1,110,060		0.04			
			$ 738,244		0.06	$ 44,295	
10	68	$ 366,427		0.1			
			$ 307,152		0.1	$ 30,715	
5	46	$ 247,877		0.2			
			$ 199,380		0.3	$ 59,814	
2	28	$ 150,882		0.5			
						$ 192,469	**$ 96,028**
			Final Program				
500	322	$ 1,735,142		0.002			
			$ 1,530,373		0.003	$ 4,591	
200	246	$ 1,325,605		0.005			
			$ 1,169,335		0.005	$ 5,847	
100	188	$ 1,013,064		0.01			
			$ 829,850		0.01	$ 8,299	
50	120	$ 646,637		0.02			
			$ 495,755		0.02	$ 9,915	
25	64	$ 344,873		0.04			
			$ 317,930		0.06	$ 19,076	
10	54	$ 290,986		0.1			
			$ 264,043		0.1	$ 26,404	
5	44	$ 237,100		0.2			
			$ 183,214		0.3	$ 54,964	
2	24	$ 129,327		0.5			
						$ 129,096	**$ 159,401**

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Chapter 8 Reduced NFIP Administrative Costs

This chapter presents the rationale, methodology and results of the economic benefit resulting from reduction of National Flood Insurance Program (NFIP) administrative costs. These reductions occur when structure owners are no longer required to purchase flood insurance or experience fewer flood events. The savings in administrative costs is a benefit of the flood mitigation program.

8.1 Rationale and Justification for Inclusion

The NFIP is a Federal program created by Congress in 1968 to mitigate future flood losses nationwide through sound, community-enforced building and zoning ordinances and to provide access to affordable, federally backed primary flood insurance protection for property owners. The NFIP provides an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.[26] One purpose is to reduce flood risk through the adoption of floodplain management standards.[27]

This section provides the rationale and justification for inclusion of savings in administrative costs for policies in the national flood insurance program. Owners of structures within the 1% Annual Chance Exceedance (ACE) (100-year) floodplain are required to purchase NFIP flood insurance. As with any insurance, the owners pay yearly premiums for the insurance policies regardless of whether they file claims. The NFIP program returns the majority of these premiums to the owners in the form of payments for claims. However, the program includes administrative costs that owners never recover. In essence, these administrative costs are "lost" each year.

The proposed Flood Risk Reduction Program will result in the removal of some of the structures from the 1% ACE (100-year) floodplain. The owners of these parcels will no longer be required to purchase NFIP insurance and therefore would not pay for certain administrative costs such as insurance agent's commissions and general overhead costs. The proposed Flood Risk Mitigation Program also reduces the frequency that individual structures are flooded. This reduces other administrative costs such as the cost of claim adjustment. Flood mitigation projects that eliminate the requirement to carry a flood insurance policy or reduce the claim administration burden provide benefits in the form of reduced NFIP administrative costs.

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[26] U.S. Department of Homeland Security. FEMA. National Flood Insurance Program. Answers to Questions about the NFIP. FEMA F-084. March 2011.

[27] Congressional Research Service. Introduction to FEMA's National Flood Insurance Program (NFIP). August 16, 2016.

8.2 Estimation Methodology

This section describes the methodology used to estimate the benefit from reduced NFIP administrative costs. This methodology uses data on NFIP administrative costs and data on flooding of structures.

NFIP Administrative Costs

The USACE publishes guidance on NFIP administrative costs for flood projects.[28] The current updated operating cost per policy is $192. However, USACE has not updated the guidance memorandum since 2006. The research team was able to identify newer data from an actuarial rate review that the Federal Insurance and Mitigation Administration (FIMA) conducted.[29] In addition, recently an analyst at the National Water Management Center (NWMC) calculated the average administrative cost per policy in second quarter 2015 dollar terms.[30] This included the calculation of the 2005-2009 arithmetic mean, of price updated administrative costs, for each year. The NWMC price updated the FEMA data using Implicit Price Deflators for Gross Domestic Product published by the US Bureau of Economic Analysis. Using the same source, the research team further updated the table to fourth quarter 2016 dollar terms. [31]

Exhibit 8.1 provides the estimated cost of national flood insurance based on 2011 actuarial analysis. The top part of the exhibit provides the data that the NWMC extracted from the FEMA Actuarial report, the middle part of the exhibit provides the data the authors used to calculate the average administrative cost per policy, and the lower part of the exhibit provides the conversion to current dollars. Average administrative cost per policy in 2017 dollar terms is $315.66.

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[28] USACE, National Flood Insurance Program Operating Costs, Fiscal Year 2006, Memorandum For Planning Community Of Practice, Economic Guidance Memorandum 06-04, CECW-CP April 6, 2006.

[29] Actuarial Rate Review In Support of the Recommended October 1, 2011, Rate and Rule Changes; Thomas L. Hayes, ACAS, MAAA Actuary and D. Andrew Neal, FSA Actuary Federal Insurance and Mitigation Administration (FIMA).

[30] George Townsley, National Water Management Center, April 19, 2016.

[31] Table 1.1.9. Implicit Price Deflators for Gross Domestic Product. 2016 Q4. Last revised on February 28, 2017. https://www.bea.gov/iTable/print.cfm?fid=8EC8715DF4FB000DB2A357143D957BBB4913E39063BAEC803B3577F1834F944D34489B04E477C8CE18763E70CCBD82FECB2735F11ABC8412BC67CCD385C0F4AC

Exhibit 8.1: Estimated Cost of National Flood Insurance based on 2011 Actuarial Analysis

Item	2005	2006	2007	2008	2009	Arithmetic Mean 2005-2009
Actuarial Data						
1) Average Amount of Insurance per Policy	$170,683	$185,090	$196,009	$205,768	$213,659	$194,242
2) Earned Premium (A)	$1,967,567,898	$2,246,009,756	$2,538,508,566	$2,781,296,850	$2,975,306,740	$2,501,737,962
3) Losses Cost Incurred (B)	$17,574,729,866	$632,729,059	$605,120,360	$3,362,868,736	$727,585,902	$4,580,606,785
4A) Allocated Loss Adjustment Expense (ALAE)	$456,472,905	$28,755,619	$27,540,260	$129,548,476	$38,051,385	$136,073,729
4B) Special All. Loss Adjustment Expense (SALAE)	$41,507,953	$3,189,318	$2,935,928	$10,201,394	$1,948,928	$11,956,704
4C) Unallocated Loss Adjustment Expense (ULAE)	$558,464,178	$17,804,122	$16,757,316	$104,041,398	$19,172,477	$143,247,898
5) Loss Cost & LAE per Policy	$18,631,174,902	$682,478,119	$652,353,863	$3,606,660,004	$786,758,692	$4,871,885,116
6) Loss & LAE Ratio	9.469	0.304	0.257	1.297	0.264	$2
7A) Direct Agent Commission	$13,358,493	$13,404,745	$13,949,376	$14,608,696	$14,850,458	$14,034,354
7B) WYO Agent Commission Allowance	$281,776,692	$323,496,719	$366,826,909	$402,585,831	$431,445,553	$361,226,341
8A) Direct & Bureau General Expense	$54,800,000	$58,320,000	$68,753,000	$72,501,000	$81,315,000	$67,137,800
8B) Interest on 2005 Borrowing	$5,232,217	$523,535,548	$730,185,164	$811,515,698	$214,368,255	$456,967,376
8C) WYO Operating Allowance (w/o ULAE)	$326,860,963	$378,491,161	$406,566,491	$407,953,642	$437,198,160	$391,414,083
9) Earned Exposure (C)	4,657,365	5,132,786	5,463,375	5,587,482	5,616,311	$5,291,464
10) Average Premium	$422.46	$437.58	$464.64	$497.77	$529.76	$470
11) Average Operating Expense Other than Agent Commission & Loss Adjustment Expense	$83.07	$187.10	$220.65	$231.23	$130.49	$171
12) Average Agent Commission	$63.37	$65.64	$69.70	$74.67	$79.46	$71
13) Average Loss Cost & LAE per Policy	$4,000.37	$132.96	$119.40	$645.49	$140.08	$1,008
14) Underwriting Profit/(Deficit) per Policy	($3,724.34)	$51.88	$54.89	($453.61)	$179.72	$778
Calculation of Average Administrative Cost Per Policy						
Million Exposures	4.66	5.13	5.46	5.59	5.62	5.29
4) Allocated Loss Adjustment Expenses (ALAE)	$497,980,858	$31,944,937	$30,476,188	$139,749,870	$40,000,313	$148,030,433
4) Allocated Loss Adjustment Expenses (ALAE)/Exposures	$106.92	$6.22	$5.58	$25.01	$7.12	$30.17
10) Average Operating Other than Agent Commission & Loss Adjustsment Expense	$83.07	$187.10	$220.65	$231.23	$130.49	$170.51
11) Average Insurance Agents' Commission	$63.37	$65.64	$69.70	$74.67	$79.46	$70.57
Average Administrative Cost Per Policy	$253.36	$258.96	$295.93	$330.91	$217.07	$271.25
Conversion to Current Dollars						
GDP-IPD	91.543	94.587	97.194	98.995	99.895	112.208
Average Administrative Cost Per Policy (2016 QIV Dollar Terms)	$310.56	$307.21	$341.64	$375.08	$243.83	$315.66

For the period 2005 to 2009, the administrative cost consists of three major expenses:

- Loss Adjustment Expenses (ALAE)/Exposures ($30.17)
- Operating Expense ($170.51)
- Insurance Agents' Commission

Note that only the smallest category depends on whether a structure is flooded, while the bulk of administrative costs depends on whether there is a policy in place. If the structure is out of the 1% ACE (100-year) floodplain, the owner saves the administrative costs of the insurance policy. Therefore, the methodology derives the estimate of benefits by multiplying the number of structures removed from the 1% ACE (100-year) floodplain in each alternative by the NFIP administrative cost.

Number of Structures

The research team determined the number of structures currently within the 1% ACE (100-year) floodplain "Without Project" base case and the number protected from flooding in the two "With Project" cases of the Hydraulic Improvements and the Full Program. Exhibit 8.2 provides the number of structures with total damage greater than zero for the 1% ACE (100-year) flood. The earlier chapter on structures provides a detailed description of the development of these estimates.

Exhibit 8.2: Number of Structures with Total Damage Greater Than Zero for the 100-Year Flood

Area	Base Case	Hydraulic Improvements	Full Program
Eagle Creek	482	415	15
Lye Creek	112	66	8
Blanchard River	1038	723	112
TOTAL	**1632**	**1204**	**135**

8.3 Results

Exhibit 8.3 provides the calculation of the annual benefit for each alternative. The methodology multiples tallies of residential structures no longer flooded in the 1% ACE (100-year) flood event by the average NFIP administrative cost. The average annual benefit is $135,104 for the Hydraulic Improvements and $472,547 for the Full Program.

Exhibit 8.3: Benefits of Reduced NFIP Administrative Costs

Alternative	Structures Flooded in 100-Year Event	Reduced Number of Structures	NFIP Administrative Cost per Structure	Yearly Savings (Benefit)
Without project	1,632			
Hydraulic improvements	1,204	428	$315.66	$135,104
Full program	135	1,497	$315.66	$472,547

The reduction in average annual damages this chapter describes will occur as the community implements the Flood Risk Reduction Program. The reduction in average annual damages will then continue throughout the 50-year analysis period of the program. The Results chapter at the end of this report describes and provides the calculation of the net present value of this stream of benefits.

Chapter 9 Business Losses

This chapter presents the rationale, methodology and results of the economic benefit resulting from reduction of business losses due to the implementation of flood protection measures contained in the *Hancock County Flood Risk Reduction Program*. These reductions occur when business structure owners are no longer impaired by recurring flooding events and do not have to close their businesses for an extended or temporary period of time. The reduction in business losses generated from flood protection measures is a benefit of the flood mitigation program.

9.1 Rationale and Justification for Inclusion

The USACE report quotes its own guidance informing how lost wages should be included over and above physical flood damages. The guidance goes on to explain the method to derive those estimates. However, lost income or lost wages do not appear to be included in the Blanchard Economic Report results. The National Economic Development (NED) Manual classifies income loss under non-physical damage.[32] The manual defines it as:

> *"the loss of wages or net profits to businesses over and above physical flood damages. It results from a disruption of normal activities that cannot be recouped from other businesses or from the same business at another time. Prevention of income loss can be counted as a national benefit only to the extent that such loss cannot be offset by postponement of an activity or transfer of the activity to other establishments."*[33]

Under some conditions, income loss is an NED benefit. The NED Manual states

> *"Income losses are reductions in the national income when flooding or the threat of flooding halts production or delivery of goods and services. National losses occur 1) when the production or delivery of these goods and services are not recuperated by postponing the activity or transferring it to another location, or, 2) when there are additional costs caused by delay or transfer of the activity. Income losses are incurred by businesses and labor as a result of flood induced shut-down in the production and delivery of goods and services. These losses can occur at any time during three periods: 1) flood warning, when business operations shut down and effort concentrates on damage prevention and evacuation; 2) flood inundation, when flood fighting and evacuation continues; and, 3) cleanup and restoration, when there may be a phasing in of normal activity. Even the threat of flooding can cause shut down of business operations for extended periods along large river basins. Inundation can vary from*

[32] USACE. National Economic Development Procedures Manual – Urban Flood Damage. 1988 Section VII-2.

[33] Ibid.

several hours to over a week, depending on the sources of flooding. Income losses may occur directly to the business or institution being flooded. Losses may occur indirectly when roads are closed and public utilities are cut off. Business losses can also occur from the spoilage of perishable commodities and when their processing or distribution are [sic] interrupted by flooding. Income losses also include any additional transportation or production costs that occur from transferring production from one area to another."[34]

9.2 Estimation Methodology

This section describes the methodology used to estimate the benefit from reduced business losses in Hancock County generated by the Hancock County Flood Risk Reduction Program. It is structured in three main parts: Business Loss Categories, Business Loss Recovery Rate and Final Methodology.

9.2.1 Business Loss Categories

The U.S. Army Corps of Engineers (USACE), Buffalo District, previously published a report in November 2015 entitled "The Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT)." The business loss benefit category and methodology uses data on business losses and flooding of business structures captured in a survey called "Commercial and Industrial Flood Damage Survey Findlay, OH" (Survey) which was part of the aforementioned report.[35] The Survey included 431 businesses responses, which JFA used to estimate the business losses for this BCA. In order to generate the business loss results, the research team extracted the following three response categories from the Survey:

1. Loss of Net Income
2. Cost of Cleanup
3. Cost of Emergency Plan

Please note that all the above categories and the respective values represent estimates made by the business owners who responded to the Survey. Furthermore, the research team made several assumptions in order to provide for a conservative estimate of business losses. First, the team considered losses of net income as losses in sales, which is a more conservative approach, since it includes all taxes and fees. Second, JFA assumed that the responses the Survey collected represent the entirety of all business activities in Hancock County. Since the Survey included 431 responses and there are over 1,500 businesses in Hancock County, this approach neglects possible additional business losses that may occur in the case of a flooding event or have occurred during flooding events in the past. Therefore, this approach is more conservative than an extrapolation of business losses to the total of 1,500 businesses. Exhibit 9.1 shows an extract

[34] Ibid.

[35] Office of Budget and Management (OMB), Commercial and Industrial Flood Damage Survey Findlay, OH, OMB Control Number 0710-0001

of the responses from the Survey. It includes the following columns: *Has the facility flooded in the past? (Y/N)*, *Loss of Net Income*, *Cost of Cleanup* and *Estimated Cost of Emergency Plan*.

Exhibit 9.1: Extract of Business Loss Categories

Has the Facility flooded in the past (Y/N)	Loss of Net Income	Cost of Cleanup	Estimated cost of emergency plan
Y	?	?	$ 1,000
Y	?	?	$ 200
Y	?	?	$ 1,000
Y	$ -	$ 7,000	$ -
Y	$ 300,000	$ 30,000	$ -
Y	$ -	$ 1,000	$ 5,000
Y	$ -	$ 5,000	$ 75
Y	$ -	$ -	$ 200
Y	$ 3,000	$ 4,000	$ 6,000
Y	$ 7,000	$ 4,000	$ 1,000
Y	$ -	$ -	$ 200
Y	$ 200,000	$ 300,000	$ 3,000
Y	$ -	$ 200	$ 500
Y	$ -	$ -	$ 7,000
Y	$ -	$ 500,000	$ -
Y	$ -	$ 2,500	$ -
Y	$ 400	$ 300	$ 30
Y	$ -	$ -	$ -
Y	$ -	$ 22,000	$ 400
Y	$ 35,000	$ 500	$ 500
Y	$ 25,000	$ 15,000	$ 1,010
Y	?	$ 500	$ 50

9.2.2 Business Loss Recovery Rate

It is common that businesses are able to recover temporary business losses caused by flooding later on. Therefore, the research team generated an average business loss recovery rate and applied it to the estimated business losses in order to provide for meaningful benefit results in this category.

For this purpose, the team used most recent data from a new on-line business survey that the Program Team conducted in cooperation with the Findlay-Hancock County Chamber of Commerce and Economic Development offices to estimate the business loss recovery rate for this benefit category. Based on the current business survey, the JFA team created the following formula to estimate the average business loss recovery rate:

$$Business\ Loss\ Recovery\ Rate = \frac{\left(\left(\frac{100+91}{2}\right)*21\right)+\left(\left(\frac{90+75}{2}\right)*5\right)+\left(\left(\frac{0+74}{2}\right)*16\right)}{42}$$

The numbers used as multiplication factors within the numerator of the above equation represent the number of businesses that estimated their business loss recovery rate in one of the following three brackets:

1. 91-100% (21 responses)
2. 75-90% (5 responses)
3. 0-74% (16 responses)

The denominator within the equation represents the total count of responses for business loss recovery rates included in the recent business survey. JFA used these responses because they represent the most recent data on business loss recovery in Hancock County.

This formula results in an average business loss recovery rate of 71.67%. The JFA team used this average in the *Final Methodology* section to generate the final benefit results for this benefit category.

9.2.3 Final Methodology

This section brings together the Business Loss Categories and Business Loss Recovery Rate sections to provide a concise overview of the final methodology the research team utilized to generate the benefits for this category. In order to generate the business loss results, the research team extracted the following three business loss categories from the Survey:

1. Loss of Net Income
2. Cost of Cleanup
3. Cost of Emergency Plan

This section is structured based on these three business loss categories. The *Cost of Cleanup* and *Cost of Emergency Plan* are direct expenses that the respective businesses would not have to incur if there was no flooding event. Therefore, they can be summed up as direct benefits, since they represent a reduction of business expenses. This section describes the methodology for business loss category 2 (Cost of Cleanup) and 3 (Cost of Emergency Plan) first. Exhibit 9.2 shows the totals for both of these business loss categories. Please note that these figures were extracted directly from the Survey and reflect 2007 dollar values. This approach provides a conservative estimate, since the figures would be higher in 2017 dollars.

Exhibit 9.2: Total Costs of Cleanup and Emergency Plan in 2007 Dollars

Data Point	Total
Total Cost of Cleanup	$ 7,316,873
Estimated Cost of Emergency Plan	$ 1,386,061

The team did not apply the *Business Loss Recovery Rate* to these *Costs of Cleanup and Emergency Plan* since the businesses that incurred expenses for these two categories cannot recoup these expenses through regular business activities.

Second, the *Loss of Net Income* needs to be calculated. Since this research effort is only interested in the economic value that was lost due to the flooding event in 2007, the total amount of *Loss of Net Income* needs an adjustment. For this purpose, the research team assigned each *Loss of Net Income* response collected in the survey to an IMPLAN code. IMPLAN is an economic model that estimates the final amount of *Value Added* for the Business Losses Category *Loss of Net Income.* Exhibit 9.3 shows an extract of the single survey responses with the according IMPLAN code, business description and *Loss of Net Income* dollar amount.

Exhibit 9.3: Loss of Net Income Responses with IMPLAN Codes

All Assigned IMPLAN Codes	IMPLAN Description	Loss of Net Income
399	Retail - Building material and garden equipment and supplies stores	$ 60,000
400	Retail - Food and beverage stores	$ 10,000
509	Personal care services	$ 20,000
509	Personal care services	$ 1,500
509	Personal care services	$ 2,000
499	Hotels and motels, including casino hotels	$ 50,000
406	Retail - Miscellaneous store retailers	$ 400

Exhibit 9.4 shows the total dollar amount for *Loss of Net Income* based on the Survey mentioned above.

Exhibit 9.4: Total Loss of Net Income

Data Point	Total
Total Loss of Net Income	$ 6,393,892

Finally, the team summed up the dollar amount for each IMPLAN sector and ran it through the IMPLAN Model. An extract of the final IMPLAN concordance is shown in Exhibit 9.5.

Exhibit 9.5: Extract of Final IMPLAN Concordance

All Assigned IMPLAN Codes	Loss of Net Income By IMPLAN Sector
56	$ 10,000
58	$ 20,000
59	$ 10,000
166	$ 60,000
394	$ 3,300
395	$ 4,000
396	$ 76,000
398	$ 10,000
399	$ 138,750
400	$ 185,600
401	$ 47,000
403	$ 14,000
404	$ 10,000
406	$ 164,900
416	$ 55,750

As a last step, the research team applied the business loss recovery rate of 100%-76.67%=28.33% to the *Value Added* result of IMPLAN.

9.3 Results

This section provides the results of the BCA. In order to estimate the benefits the research team made several assumptions. First, the research team assumed that the 2007 estimates approximated these costs during a 1% (100-year) annual chance event (ACE). Second, a method was required to scale these estimates to other flood return frequencies. Duration of road closures provides a reasonable proxy for *Loss of Net Income*. For the other two categories, *Costs of Cleanup* and *Costs of Emergency Plan*, the research team utilized the total count of industrial and commercial buildings that reported damage in the former, original USACE Survey. This count also includes public and tax exempt buildings, such as schools, hospitals and fire stations. Thus, the impacts were scaled to the other flood frequencies using the number of hours of road closures for *Business Loss Category* 1 (Loss of Net Income) and using the number of flooded commercial and industrial buildings for *Business Loss Categories* 2 (Cost of Cleanup) and 3 (Cost of Emergency Plan). Exhibit 9.6 provides the results of avoided business loss benefits (Average Annual Damages – AAD) under the Hydraulic Improvements component and Full Program scenarios for Business Loss Category 1, *Loss of Net Income*.

In each case, the AAD avoided is the basis for the Net Present Value of damages or costs avoided over the 50 year analysis period of the Hancock County Flood Risk Reduction Program. In Chapter 11, Benefit-Cost Results, the average annual damages avoided for each benefit component is used to calculate the 2017 Net Present Value of the sum of the benefits which are compared to the Net Present Value of program costs to determine the efficiency of the investment to the community, the benefit-to-cost ratio (BCR).

Exhibit 9.6: Results for Business Loss Category 1, *Loss of Net Income*

Flood Event	Duration of Road Closures (hours)	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Damage	Incremental Annual Damage
Existing Conditions							
500	460	$ 1,265,066		0.002			
			$ 1,185,312		0.003	$ 3,556	
200	402	$ 1,105,558		0.005			
			$ 1,047,805		0.005	$ 5,239	
100	360	$ 990,052		0.01			
			$ 918,548		0.01	$ 9,185	
50	308	$ 847,044		0.02			
			$ 767,290		0.02	$ 15,346	
25	250	$ 687,536		0.04			
			$ 541,778		0.06	$ 32,507	
10	144	$ 396,021		0.1			
			$ 302,516		0.1	$ 30,252	
5	76	$ 209,011		0.2			
			$ 170,509		0.3	$ 51,153	
2	48	$ 132,007		0.5			
Total average annual damage:						$ 147,237	
Hydraulic Improvments							
500	426	$ 1,171,561		0.002			
			$ 1,100,058		0.003	$ 3,300	
200	374	$ 1,028,554		0.005			
			$ 963,926		0.005	$ 4,820	
100	327	$ 899,297		0.01			
			$ 820,918		0.01	$ 8,209	
50	270	$ 742,539		0.02			
			$ 654,534		0.02	$ 13,091	
25	206	$ 566,530		0.04			
			$ 376,770		0.06	$ 22,606	
10	68	$ 187,010		0.1			
			$ 156,758		0.1	$ 15,676	
5	46	$ 126,507		0.2			
			$ 101,755		0.3	$ 30,527	
2	28	$ 77,004		0.5			
						$ 98,228	**$ 49,009**
Final Program							
500	322	$ 885,546		0.002			
			$ 781,041		0.003	$ 2,343	
200	246	$ 676,535		0.005			
			$ 596,781		0.005	$ 2,984	
100	188	$ 517,027		0.01			
			$ 423,522		0.01	$ 4,235	
50	120	$ 330,017		0.02			
			$ 253,013		0.02	$ 5,060	
25	64	$ 176,009		0.04			
			$ 162,259		0.06	$ 9,736	
10	54	$ 148,508		0.1			
			$ 134,757		0.1	$ 13,476	
5	44	$ 121,006		0.2			
			$ 93,505		0.3	$ 28,051	
2	24	$ 66,003		0.5			
						$ 65,885	**$ 81,352**

Exhibit 9.7 provides the results of avoided business loss benefits under the Hydraulic Improvements component and Full Program scenarios for Business Loss Category 2, *Costs of Cleanup*.

Exhibit 9.7: Results for Business Loss Category 2, Costs of Cleanup

Flood Event	Total Number of Commercial and Industrial Buildings	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Damage	Incremental Annual Damage
Existing Conditions							
500	366	$ 1,006,553		0.002			
			$ 848,420		0.003	$ 2,545	
200	251	$ 690,286		0.005			
			$ 4,003,580		0.005	$ 20,018	
100	174	$ 7,316,873		0.01			
			$ 3,802,819		0.01	$ 38,028	
50	105	$ 288,765		0.02			
			$ 222,762		0.02	$ 4,455	
25	57	$ 156,758		0.04			
			$ 107,256		0.06	$ 6,435	
10	21	$ 57,753		0.1			
			$ 38,502		0.1	$ 3,850	
5	7	$ 19,251		0.2			
			$ 11,001		0.3	$ 3,300	
2	1	$ 2,750		0.5			
Total average annual damage:						$ 78,632	
Hydraulic Improvments							
500	324	$ 891,047		0.002			
			$ 720,538		0.003	$ 2,162	
200	200	$ 550,029		0.005			
			$ 430,398		0.005	$ 2,152	
100	113	$ 310,766		0.01			
			$ 244,763		0.01	$ 2,448	
50	65	$ 178,759		0.02			
			$ 134,757		0.02	$ 2,695	
25	33	$ 90,755		0.04			
			$ 57,753		0.06	$ 3,465	
10	9	$ 24,751		0.1			
			$ 15,126		0.1	$ 1,513	
5	2	$ 5,500		0.2			
			$ 2,750		0.3	$ 825	
2	0	$ -		0.5			
						$ 15,259	**$ 63,373**
Final Program							
500	90	$ 247,513		0.002			
			$ 191,135		0.003	$ 573	
200	49	$ 134,757		0.005			
			$ 100,380		0.005	$ 502	
100	24	$ 66,003		0.01			
			$ 52,253		0.01	$ 523	
50	14	$ 38,502		0.02			
			$ 22,001		0.02	$ 440	
25	2	$ 5,500		0.04			
			$ 4,125		0.06	$ 248	
10	1	$ 2,750		0.1			
			$ 1,375		0.1	$ 138	
5	0	$ -		0.2			
			$ -		0.3	$ -	
2	0	$ -		0.5			
						$ 2,423	**$ 76,209**

Exhibit 9.8 provides the results of avoided business loss benefits under the Hydraulic Improvements component and Full Program scenarios for Business Loss Category 3, *Costs of Emergency Plan*.

Exhibit 9.8: Results for Business Loss Category 3, Costs of Emergency Plan

Flood Event	Total Number of Commercial and Industrial Buildings	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Damage	Incremental Annual Damage
Existing Conditions							
500	366	$ 1,006,553		0.002			
			$ 848,420		0.003	$ 2,545	
200	251	$ 690,286		0.005			
			$ 1,038,174		0.005	$ 5,191	
100	174	$ 1,386,061		0.01			
			$ 837,413		0.01	$ 8,374	
50	105	$ 288,765		0.02			
			$ 222,762		0.02	$ 4,455	
25	57	$ 156,758		0.04			
			$ 107,256		0.06	$ 6,435	
10	21	$ 57,753		0.1			
			$ 38,502		0.1	$ 3,850	
5	7	$ 19,251		0.2			
			$ 11,001		0.3	$ 3,300	
2	1	$ 2,750		0.5			
Total average annual damage:						$ 34,151	
Hydraulic Improvments							
500	324	$ 891,047		0.002			
			$ 720,538		0.003	$ 2,162	
200	200	$ 550,029		0.005			
			$ 430,398		0.005	$ 2,152	
100	113	$ 310,766		0.01			
			$ 244,763		0.01	$ 2,448	
50	65	$ 178,759		0.02			
			$ 134,757		0.02	$ 2,695	
25	33	$ 90,755		0.04			
			$ 57,753		0.06	$ 3,465	
10	9	$ 24,751		0.1			
			$ 15,126		0.1	$ 1,513	
5	2	$ 5,500		0.2			
			$ 2,750		0.3	$ 825	
2	0	$ -		0.5			
						$ 15,259	**$ 18,892**
Final Program							
500	90	$ 247,513		0.002			
			$ 191,135		0.003	$ 573	
200	49	$ 134,757		0.005			
			$ 100,380		0.005	$ 502	
100	24	$ 66,003		0.01			
			$ 52,253		0.01	$ 523	
50	14	$ 38,502		0.02			
			$ 22,001		0.02	$ 440	
25	2	$ 5,500		0.04			
			$ 4,125		0.06	$ 248	
10	1	$ 2,750		0.1			
			$ 1,375		0.1	$ 138	
5	0	$ -		0.2			
			$ -		0.3	$ -	
2	0	$ -		0.5			
						$ 2,423	**$ 31,728**

Finally, Exhibits 9.9 and 9.10 summarize the AAD and incremental AAD avoided which represent the benefits of the three *Business Loss Categories*. Please note that the table contains standard dollar values, as opposed to other tables in this report. The Hydraulic Improvements scenario would save $131,274 in incremental annual damages. The Full Program improvements scenario saves $189,290 in incremental annual damage.

Exhibit 9.9: Business Losses Final Results 1 (AAD Avoided)

Average Annual Damages			
Category and Scenario	**Existing Conditions**	**Hydraulic Improvements**	**Final Program**
Loss of Net Income	$ 147,237	$ 98,228	$ 65,885
Cost of Cleanup	$ 78,632	$ 15,259	$ 2,423
Cost of Emergency Plan	$ 34,151	$ 15,259	$ 2,423
Total	**$ 260,021**	**$ 128,746**	**$ 70,731**

Exhibit 9.10: Business Losses Final Results 2 (Incremental AAD Avoided)

Incremental Average Annual Damages Avoided			
Category and Scenario	**Existing Conditions**	**Hydraulic Improvements**	**Final Program**
Loss of Net Income	-	$ 49,009	$ 81,352
Cost of Cleanup	-	$ 63,373	$ 76,209
Cost of Emergency Plan	-	$ 18,892	$ 31,728
Total	**-**	**$ 131,274**	**$ 189,290**

Chapter 10 Agricultural Damages Avoided

This chapter presents the agricultural damages avoided by the Hancock County Flood Risk Reduction Program, including individual review of the Hydraulic Improvements component and the Full Program. The first section describes the rationale and justification for inclusion of agricultural damages in a benefit cost analysis. The second section explains the methodology used to calculate the costs and benefits.[36] The third section presents the results of the benefit cost analysis.

10.1 Rationale and Justification for Inclusion

Ponding and flooding can damage crops, but the extent of the damage depends on the type of plant, growth stage, air temperature, and the duration of the flooding.[37] In general:

- Plants with some growth above the water level are more likely to survive.
- A warmer mid-summer flood increases the rate of damage and death to submerged plants, whereas plants can survive longer under water during a colder spring flood.
- Plants that encounter flash-flooding, where the water rises and recedes quickly, are more likely to survive than longer-duration flooding.

The agricultural analysis focuses on Hancock County, where the primary crops grown are soybeans, corn, and wheat.

Soybeans can generally survive for 2 to 4 days when completely submersed. The actual time frame depends on air temperature, cloud cover, soil moisture conditions prior to flooding, and rate of soil drainage. Cool air temperatures and cloudy days increase the survival of a flooded soybean crop; whereas in temperatures of 80 degrees Fahrenheit or above, soybean plants may only survive a few days. Increased soil moisture conditions prior to flooding and a decreased rate of soil drainage contribute to the buildup of toxins and carbon dioxide, which is more damaging to plants than lack of oxygen.

The extent to which ponding and flooding damages corn crops is determined by the plant stage of development when ponding occurs, the duration of ponding, and the air temperature. Prior to the 6-leaf collar stage or when the growing plant is at or below the soil surface, corn can usually survive only 2 to 4 days of flooded conditions. If the air temperature is greater than 77 degrees Fahrenheit during ponding, corn plants may not survive 24 hours, but cooler air

[36] The research team received detailed spreadsheets, modeling program and a draft write-up of this chapter from the USACE. The research team relied extensively on these materials.

[37] Exhibit 10-2 and the discussion of that exhibit provide the sources this study used to estimate potential reduction in yield from flooding by crop.

temperatures (mid-60s or cooler) can prolong survival up to about 4 days. Also, once the growing point is above the water level, the likelihood for survival improves greatly.

The most significant factor affecting wheat during a flooding event is air temperature. During summer conditions, plant growth can be impacted after 2 to 3 days of flooding. If the air temperature is above 65 degrees Fahrenheit and the plants are submerged for more than 5 to 7 days, the wheat crops will not survive. There is limited information on the effect of flooding on wheat when temperatures are below 40 degrees Fahrenheit. Under cooler temperatures, the negative effects of flooding take longer to impact plant tissues, so winter wheat can tolerate flooding beyond the limits described above for summer conditions.

10.2 Methodology

The methodology applied to evaluate flood damages to crops is described in the resources published by the USDA National Water Management Center. The resources may be found online.[38] The following basic data were used in the agricultural damages estimation:

- The land use, average crop production (bushels per acre), and crop progress and condition by month in Hancock and Putnam Counties was obtained from the U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS).
- Costs of farm operation per acre (crop production costs) USDA using Agricultural Resource Management Survey data and other sources. The Agricultural Resource Management Survey (ARMS) is sponsored jointly by USDA's Economic Research Service (ERS) and National Agricultural Statistics Service (NASS).
- The USDA Economic Research Service provided the 2012 normalized value of production per acre by county and crop (based on 5-year lagged averages of actual market prices).
- Air temperature ranges and probabilities by month were obtained from Weather Spark.
- rop floodwater damage percentages indicate the average loss of yield by month compared to flood-free conditions. The percentages vary according to the depth and the duration of the flood event and were vetted by the Hancock County Soil and Water Conservation District.
- The number of acres flooded for the with- and without-project conditions were estimated by month for varying magnitudes of flooding for the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent-annual chance event (ACE) floods.

The method for calculating agricultural benefits began with the identification of land use and cropping patterns. The study focused on the three primary crops grown in the study area: soybeans, corn, and wheat. The crop distribution was assumed to remain consistent over the period of analysis for each alternative that is being considered. The analysis used the following crop distribution for Hancock County:

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[38] USDA, Natural Resources Conservation Service, National Water Management Center. Flood Damage Assessment Tools. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/nwmc/partners/?&cid=nrcs143_009725

- 54 percent soybeans
- 36 percent corn
- 8 percent wheat

Stantec provided data sourced from hydraulic modeling in conjunction with GIS to provide the number of acres flooded. The research team distributed the damage by duration (less than one day, 1 to 2 days, 2 to 3 days, and more than 3 days) for each flood recurrence interval using data from the previous USACE study. The research team calculated the areas flooded under exiting conditions, with the hydraulic improvements and under the final program. Exhibit 10.1 shows the area flooded under the three conditions and areas removed from flooding under the two program scenarios for the various flood stages.

Exhibit 10.1: Acres Flooded and Protected under Three Scenarios by Flood Stage

Flood Stage (yr)	Ag Area Flooding (Acres)			Ag Area Removed From Flooding (Ac.)	
	Existing Condtions	Hydraulic Improvements	Full Program	Hydraulic Improvements	Full Program
2	3,736	3,739	3,137	-3	599
5	4,736	4,744	3,855	-9	881
10	5,638	5,644	4,389	-6	1,249
25	6,939	6,958	5,106	-20	1,832
50	7,917	7,905	5,793	12	2,124
100	9,063	9,031	6,497	32	2,566
200	10,300	10,285	7,195	15	3,105
500	11,701	11,695	8,288	6	3,414

Then the acres were identified as soybean, corn or wheat crops according the crop distribution. The damages were valued by analyzing the production function of farm land under the with- and without-project alternatives. Assuming the cropping pattern did not change; the benefit was determined by using the applicable farm budget and the likelihood of a yield loss and/or need for replanting according to each month of the year.

The reduction in crop yield as a result of flooding was estimated from publications and work on other studies (Butzen, 2010; Elmore and Abendroth, 2008; Nielsen, 2011; Pedersen, 2008; Ransom, 2009; Thomison, 2012), but primarily from the USDA Natural Resources Conservation Service study, *Final Supplementation Watershed Plan No. 1 and Environmental Assessment for Big Slough Watershed.* Exhibit 10.2 presents the anticipated reduction in yield, which accounts for the impacts of air temperature, crop progress by month, and whether there is an opportunity to replant the crop. Flooding durations less than the amount described above would have minimal impacts on the yield.

Exhibit 10.2 Potential Reduction in Yield from Flooding

	Soybeans	Winter Wheat	Corn
January	No loss	100% yield loss	No loss
February	No loss	100% yield loss	No loss
March	No loss	100% yield loss	No loss
April	Replanting	100% yield loss	Replanting
May	Replanting	100% yield loss	Replanting & 25% yield loss
June	Replanting & 25% yield loss	10–65% yield loss	50–75% yield loss
July	50–100% yield loss	0% loss	100% yield loss
August	100% yield loss	0% loss	100% yield loss
September	65–100% yield loss	Replanting	60–85% yield loss
October	10–65% yield loss	Replanting	25–50% yield loss
November	0–5% yield loss	25% yield loss	10–30% yield loss
December	No loss	40–100% yield loss	No loss

Replanting costs, based on the Ohio State University Farm Management Enterprise Budgets, were estimated to be:

- $320 per acre for corn
- $138 per acre for soybeans
- $162 per acre for wheat

Exhibit 10-3 provides production values, operating costs, replanting costs and overhead for corn, soybean and wheat production for planted acre in the program area for the 2104. Soybeans were the most profitable crop followed by corn and wheat, as valued by calculating production less operating costs.

Exhibit 10.3: Production Values and Returns in the Program Area

Item	Corn	Soybeans	Wheat
Gross value of production			
Primary product	628.29	554.37	341.62
Secondary product	0.29		6.56
Total, gross value of production	**628.58**	**554.37**	**348.18**
Operating costs:			
Seed	**108.41**	**57.83**	**31.15**
Fertilizer 2/	**156.78**	**36.28**	**101.73**
Chemicals	**29.94**	**26.54**	**9.80**
Custom operations 3/	16.93	9.24	11.67
Fuel, lube, and electricity	28.20	16.73	14.00
Repairs	23.79	19.46	15.44
Purchased irrigation water	0.00	0.00	0.50
Interest on operating capital	0.12	0.05	0.06
Total, operating costs	364.17	166.13	184.35
Replanting Cost	**320.16**	**138.43**	**162.07**
Allocated overhead:			
Hired labor	**2.86**	**1.77**	**1.67**
Opportunity cost of unpaid labor	**22.17**	**16.01**	**17.72**
Capital recovery of machinery and equipment	95.64	79.10	69.34
Opportunity cost of land (rental rate)	208.03	192.03	141.91
Taxes and insurance	8.58	10.36	6.98
General farm overhead	18.98	18.34	13.99
Total, allocated overhead	356.26	317.61	251.61
Total, costs listed	720.43	483.74	435.96
Value of production less total costs listed	-91.85	70.63	-87.78
Value of production less operating costs	264.41	388.24	163.83
Supporting information:			
Yield (bushels per planted acre)	179	51	62.0
Price (dollars per bushel at harvest)	3.51	10.87	5.51
Enterprise size (planted acres) 1/	313	268	101

Using the value of production per acre and the average yield for each crop, the normalized value of production per bushel was calculated. Exhibit 10.4 shows the normalized value of production per crop for Hancock County, as well as Putnam County downstream. For each crop, the table reports the yield, value per acre and value per bushel for each county. The bottom row of the exhibit shows the average value for the two counties.

Exhibit 10.4: Normalized Value of Production

	Wheat Yield	Wheat Value per Acre	Wheat Value per Bushel	Corn Yield	Corn Value per Acre	Corn Value per Bushel	Soybean Yield	Soybean Value per Acre	Soybean Value per Bushel
Hancock County	64.8	$287.62	$4.44	150.9	$519.16	$3.44	44.6	$376.70	$8.45
Putnam County	61.5	$273.15	$4.44	149.9	$515.79	$3.44	43.2	$365.04	$8.45
Average	**63.2**	**$280.39**	**$4.44**	**150.4**	**$517.48**	**$3.44**	**43.9**	**$370.87**	**$8.45**

The full damages (complete loss of crop) for each month were calculated by multiplying the average value of the crop per acre and adding the replanting cost (Exhibit 10-3) if necessary by the percentage yield loss. It is assumed that damages would occur under two scenarios, if there was 2 to 3 days of flooding or more than 3 days of flooding. To estimate the damages for each of these scenarios and each flood event, the full damages for each month were multiplied by the corresponding probability that each flood event would occur in that particular month. The probability that a flood event would occur in a particular month was obtained by observing the maximum peak yearly stream flow data for the USGS gage nearest Findlay for the period of 1923 to 2011.There were 85 events, with the majority occurring during the winter and spring (nearly 79 percent). The damages for each scenario were multiplied by the corresponding number of acres damaged for each crop and for each flood event. The NED benefit is the net increase in yield attributable to a with-project alternative.

10.3 Results

This section presents the results of the benefit cost analysis in the base case (no action alternative), as well as the Hydraulic Improvements component and Full Program cases. Exhibit 10.5 shows the average annual damage in the base case and Hydraulic Improvement scenarios for each modeled ACE flooding event. The average annual damage in the no project or base case was $56,171. With the Hydraulic Improvements in place, the average annual damage fell to $52,308. The incremental average annual damage avoided would then be $3,864, representing the difference between the two averages.

Exhibit 10.5: Flood Damage by Event in Base Case and Hydraulic Improvement Scenarios

Without Project					
Flood Event	**Total Damage**	**Average Damage**	**Probability of Occurrence**	**Incremental Occurrence**	**Average Annual Damage**
500	$ 1,245,303		0.002		
		$ 1,048,883		0.003	$ 3,147
200	$ 852,463		0.005		
		$ 724,606		0.005	$ 3,623
100	$ 596,750		0.01		
		$ 533,780		0.01	$ 5,338
50	$ 470,809		0.02		
		$ 437,914		0.02	$ 8,758
25	$ 405,019		0.04		
		$ 321,571		0.06	$ 19,294
10	$ 238,122		0.1		
		$ 126,902		0.1	$ 12,690
5	$ 15,682		0.2		
		$ 11,071		0.3	$ 3,321
2	$ 6,460		0.5		
Total Average Annual Damage:					**$ 56,171**
Hydraulic Improvement Component					
500	$ 1,242,159		0.002		
		$ 1,043,100		0.003	$ 3,129
200	$ 844,041		0.005		
		$ 715,957		0.005	$ 3,580
100	$ 587,872		0.01		
		$ 526,150		0.01	$ 5,261
50	$ 464,427		0.02		
		$ 431,504		0.02	$ 8,630
25	$ 398,581		0.04		
		$ 312,946		0.06	$ 18,777
10	$ 227,312		0.1		
		$ 115,143		0.1	$ 11,514
5	$ 2,975		0.2		
		$ 4,720		0.3	$ 1,416
2	$ 6,466		0.5		
Total Average Annual Damage:					**$ 52,308**
Incremental Average Annual Damage Avoided:					**$ 3,864**

Exhibit 10.6 presents the same information as the previous exhibit for the Full Program case. Once again, in the base case, the average annual damage was $56,171. With the implementation of the Full Program, the average annual damage falls to $46,811 making the incremental average annual damage avoided $9,360.

Exhibit 10.6: Flood Damage by Event in Base Case and Full Program Scenarios

Without Project					
Flood Event	**Total Damage**	**Average Damage**	**Probability of Occurrence**	**Incremental Occurrence**	**Average Annual Damage**
500	$ 1,245,303		0.002		
		$ 1,048,883		0.003	$ 3,147
200	$ 852,463		0.005		
		$ 724,606		0.005	$ 3,623
100	$ 596,750		0.01		
		$ 533,780		0.01	$ 5,338
50	$ 470,809		0.02		
		$ 437,914		0.02	$ 8,758
25	$ 405,019		0.04		
		$ 321,571		0.06	$ 19,294
10	$ 238,122		0.1		
		$ 126,902		0.1	$ 12,690
5	$ 15,682		0.2		
		$ 11,071		0.3	$ 3,321
2	$ 6,460		0.5		
Total Average Annual Damage:					**$ 56,171**
Final Plan					
500	$ 890,130		0.002		
		$ 746,967		0.003	$ 2,241
200	$ 603,805		0.005		
		$ 539,984		0.005	$ 2,700
100	$ 476,163		0.01		
		$ 432,966		0.01	$ 4,330
50	$ 389,770		0.02		
		$ 358,241		0.02	$ 7,165
25	$ 326,712		0.04		
		$ 265,954		0.06	$ 15,957
10	$ 205,195		0.1		
		$ 110,252		0.1	$ 11,025
5	$ 15,309		0.2		
		$ 11,312		0.3	$ 3,393
2	$ 7,314		0.5		
Total Average Annual Damage:					**$ 46,811**
Incremental Average Annual Damage Avoided:					**$ 9,360**

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Chapter 11 Environmental and Land Use Benefits

This chapter presents the benefits of environmental land use from the purchase and conversion of land and properties that may be purchased to facilitate the implementation of the Flood Risk Reduction Program. It includes the rationale and justification for including these benefits and the methodology used to calculate the economic benefits resulting from the purchases.

11.1 Rationale and Justification for Inclusion

This section provides the rationale and justification for inclusion of environmental land use benefits in the BCA. Environmental benefits are an important component of flood protection benefits. FEMA guidance contends specified types of environmental benefits may be realized when land is returned to open space uses. The purchase of land is a significant cost attributed to the Hancock County Flood Risk Reduction Program. However, new uses of the purchased properties provide economic benefits.

FEMA allows consideration of Environmental Benefits in the Evaluation of Acquisition Projects under its Hazard Mitigation Assistance (HMA) Programs.[39] Therefore, this project, in accordance with the FEMA guidance, includes environmental benefits in the benefit cost analysis (BCA). The objective is to determine the benefits and costs under the recommended Full Program and the initial Hydraulic Improvements component.

11.2 Estimation Methodology

This section describes the methodology used to estimate the environmental land use benefits from the flood mitigation project. The City of Findlay and Hancock County purchased approximately 150 properties damaged in prior flooding. In addition, the proposed project will include the purchase, use, and conversion of lands among various land use types. Each of these land acquisitions and conversions may provide environmental benefit beyond the avoidance of structure damage. Changes in land value are benefits of newly protected lands from the base case and the two project alternatives.

Land Definitions

Stantec provided the research team with the acreage of the converted lands for three types of land use classifications. The three post-flood mitigation classifications are:

[39] U.S. Department of Homeland Security. FEMA Mitigation Policy – FP-108-024-01

Green Open Space defined as land allowed to revert to a natural state or be converted into park-like settings.

Riparian Areas are similar to Green Open Space but the lot is located along a water feature such as the stream, creek, or river. These areas serve as a buffer to improve water quality entering the stream, as well as reducing erosion potential.

Agricultural Land - The third type of post-mitigation land use assumes a portion of the acquired land remains agricultural and is either leased or sold back for agricultural purposes.

Land Values

Land values were required for the three types of land affected by this project. The research team evaluated three sources of land values.

One source of land values was FEMA. FEMA guidance provides values for two of the types of land analyzed in the project.[40] The FEMA values are:

- Green/Open Space valued @ $2.57 per square foot
- Riparian Areas valued @ $12.29 per square foot

Riparian Areas generate significantly more benefits than Green Open Space because of the number and value of ecosystem service benefits these areas provide. Note for Woods and Shrubs the research team assigned the same value as Green Open Space for purposes of this analysis. FEMA estimates these dollars per square foot values with a set of assumptions about discounting and the list of environmental benefits that are different from the design of the Hancock County Flood Risk Reduction Program. Therefore, the study team assumed that in this case, only about thirty percent of the Full Program FEMA estimated Environmental benefits would be realized. This value can be refined at later stages of project design.

Due to the anticipated use of significant portions of the recommended dry storage basins for crop production, this analysis of environmental benefits also required values for a third type of land use, Agricultural Lands. The 2012 USDA Census of Agriculture provided one potential source of agricultural land values. Conducted every five years in years ending in two and seven, the 2012 Census data are the latest currently available. Results of the 2017 Census will not be available until at least 2018. However, the 2012 Census does detail results at the county level, in this case for Hancock County, Ohio.[41] The reported agricultural land value was $4,731 per acre, equal to roughly $0.10 per square foot.

Another source was a report from Ohio State University of agricultural land values and rental rates in Ohio. According to the Ohio State University's Department of Agricultural, Environmental, and Development Economics annual survey, the value of "average" quality

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[40] FEMA, Hazard Mitigation Assistance Guidance, Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program. February 27, 2015

[41] USDA, NASS. 2012 Census of Agriculture. Quick Stats.

This link is to state value: https://www.nass.usda.gov/Charts_and_Maps/Land_Values/crop_value_map.php cropland in northwest Ohio, which includes Hancock County, was $6,868 per acre in 2015.[42] The projected value in 2016 reflected a decrease of 9.4 percent to $6,224 per acre. Annual rental rates for cropland deemed "average" in quality was $178 per acre in 2015, projected to decline to $167 per acre in 2016.

The research team selected the more recent Ohio State 2016 value of $6,224 for this analysis. Because the FEMA values are reported in terms of a one-time land use values, the research team chose to use the purchase price, rather than the lease price, for agricultural lands. Note that the lease price ($178/acre) reported in the Ohio State data is approximately one thirty-fifth of the purchase price ($6,224/acre, or $0.14/SF) indicating that the sum of a stream of annual lease prices, over the life of the project, would provide a similar value to a one-time purchase price.

Agricultural Land Acreages

Stantec provided the aerial photos containing the approximate acreage for each type of land use area. Exhibit 11.1 displays the approximate locations of land use areas before the flood mitigation project (shown in the left column) and after the flood mitigation project (shown in the right column) for three Hancock County locations:

Set A - Blanchard River Hydraulic Improvements

Set B - Eagle Creek Dry Storage

Set C - Potato Run & Blanchard River Dry Storage

The research team calculated the changes in land use area for each location using the acreage values indicated in the six photos. Exhibit 11.2 tabulates the detailed acreage data.

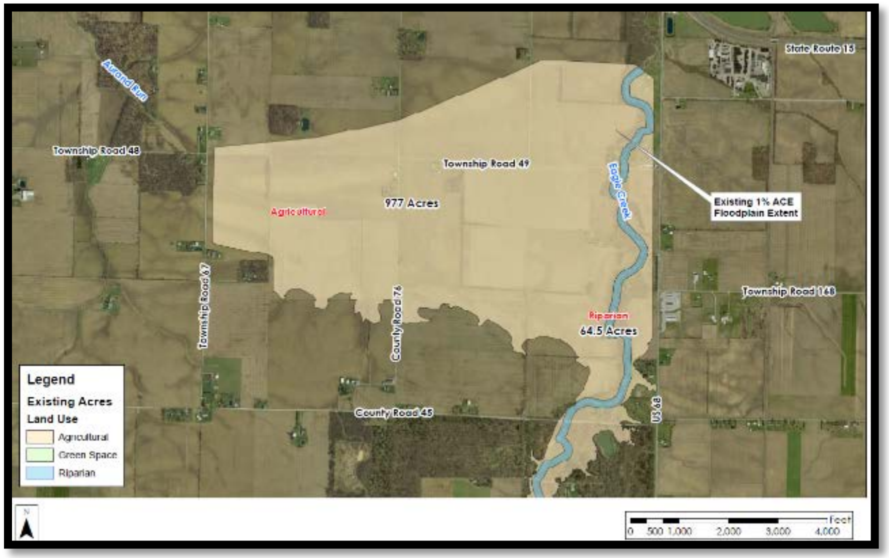
[42] Ohio State University, Department of Agricultural, Environmental, and Development Economics. Western Ohio Cropland Values and Cash Rents 2015-16.

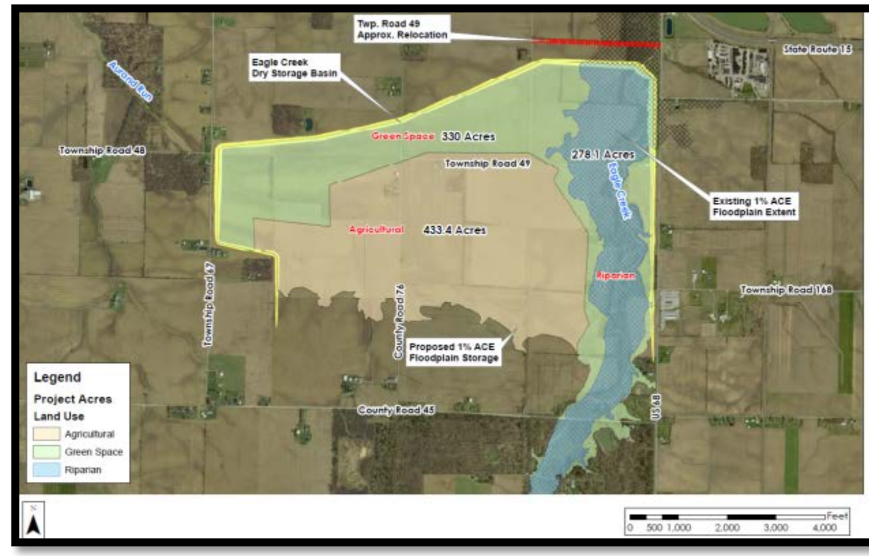
Exhibit 11.1: Locations of Pre- and Post-Project Land Uses and Acreages

Pre-Project	Post-Project

Set A. Blanchard River Hydraulic Improvements

Set B. Eagle Creek Dry Storage





Set C. Potato Run and Blanchard River Storage

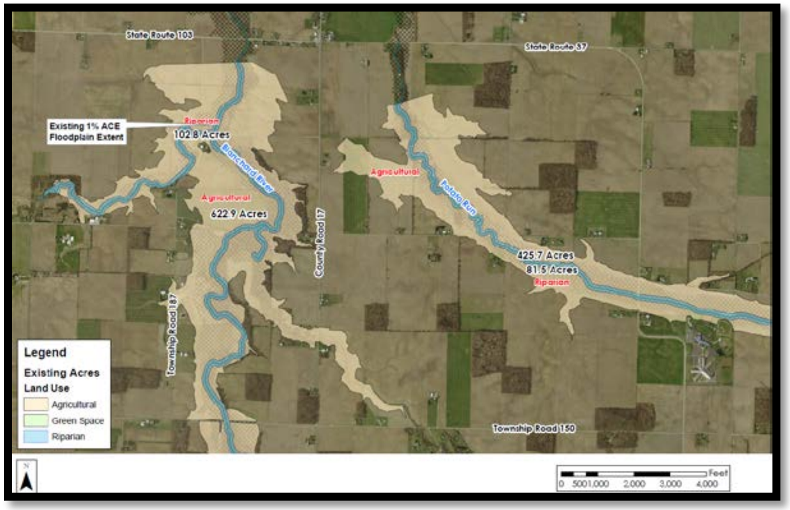


Exhibit 11.2: Change in Land Use Acreage by Location

	Woods & Shrubs	Agricultural	Green Space	Riparian	Total
Set A. Blanchard River					
Before	24.43	0.00	5.53	0.00	29.96
After	0.00	0.00	3.44	26.52	29.96
Set B. Eagle Creek					
Before	0.00	977.00	0.00	64.50	1041.50
After	0.00	433.40	330.00	278.10	1041.50
Set C. Potato Run					
Before	0.00	622.90	0.00	102.80	725.70
After	0.00	441.10	182.20	102.80	726.10
Set C. Blanchard River					
Before	0.00	425.70	0.00	81.50	507.20
After	0.00	245.00	180.70	81.50	507.20
Total					
Before	24.43	2025.60	5.53	248.80	2304.36
After	0.00	1119.50	696.34	488.92	2304.76
Difference	**-24.43**	**-906.10**	**690.81**	**240.12**	**0.40**

Using the acreage data provided in Exhibit 11-2, the research team tabulated the four types of land use to calculate the changes before and after the project. Exhibit 11.3 summarizes the acreage changes in the hydraulic improvements component of the program. The wood and shrubs acreage was valued equal to green open space.

Exhibit 11.3: Land Use Before and After the Hydraulic Improvements Project (in acres)

Land Use	Wood & Shrubs	Agricultural	Green Space	Riparian
Before	24.43	0.00	5.53	0.00
After	0.00	0.00	3.44	26.52
Difference	-24.43	0.00	-2.09	26.52

Exhibit 11.4 summarizes the acreage changes in the Full Program. As above, the wood and shrubs acreage was valued equal to green open space.

Exhibit 11.4: Land Use Before and After the Full Flood Risk Reduction Program (in acres)

Land Use	Wood & Shrubs	Agricultural	Green Space	Riparian
Before	24.43	2025.60	5.53	248.80
After	0.00	1119.50	696.34	488.92
Difference	-24.43	-906.10	690.81	240.12

11.3 Results

This section provides the benefit value for environmental land use. The research team used the property acreages and classifications above. The analysis converted the acres to square feet by multiplying the number of acres by 43,560, the number of square feet in an acre. The benefit value is the product of multiplying the square footage for riparian, agricultural, and green open space and the appropriate FEMA and Census of Agriculture derived land values. The two exhibits provide the benefit values for the Hydraulic Improvements component and the Full Program.

Exhibit 11.5 and 11.6 calculate the benefit values for each type of land use in the Hydraulic Improvements component and the Full Program. Additional data from FEMA was used to reduce the values of riparian and green space lands to in the full program to eliminate erosion control and recreational/tourism values. This is because these do not apply to the lands used as dry storage basins. The first column shows the type of land use. The second column displays the change in acreage from Exhibit 11.3. The third column converts the acreage to square feet. Column four contains the land values for each type of land use. The square foot area is multiplied by each land value and the results are shown in column five. The estimated economic benefits for the initial stages of construction for the hydraulic improvements along the Blanchard River east of Main Street in Findlay would be $11.2 million. The estimated economic benefits for the full program of recommended improvements would be $57.7 million.

Exhibit 11.5: Land Use Benefit Value for the Hydraulic Improvements

Land Use	Change in Acreage	Square Footage	Value/Sq. Ft.	Benefit Value
Riparian	26.52	1,155,211	$12.29	$14,197,546
Green Space	-2.09	-91,040	$2.57	-$233,974
Wood & Shrubs	-24.43	-1,064,171	$2.57	-$2,734,919
Agriculture	0.00	0	$0.14	$0
Total	**0.00**	**0**		**$11,228,653**

Exhibit 11.6: Land Use Benefit Value for the Full Program

Land Use	Change in Acreage	Square Footage	Value/Sq. Ft.	Benefit Value
Riparian	240.12	10,459,627	$4.03	$42,171,884
Green Space	690.81	30,091,684	$0.79	$23,795,577
Agriculture	-906.10	-39,469,716	$0.14	($5,525,760)
Wood & Shrubs	-24.43	-1,064,171	$2.57	($2,734,919)
Total				**$57,706,783**

Chapter 12 Benefit Cost Analysis Results

The data on benefits and costs developed in the previous sections of this report are summarized and compared in this section. The section begins with an overview of Conservancy Court Law, summarizes costs, summarizes benefits, compares costs to benefits, and then concludes with the presentation of benefit-cost ratios.

For the Conservancy Court to approve a reappraisal of benefits, it must determine that the benefits exceed the cost. In Muskingum Watershed Conservancy District vs. Clow, 57 Ohio App. 132 (Fifth District 1937) the syllabus of the court discussed section 6828-33 of the General Code (now R.C. §6101.34) and stated that it was essential “that it be determined as a matter of fact that the estimated cost of the improvement is less than the benefit appraised.” The Court also noted that the term “cost,” as used in this section means the cost of the district and does not include contribution by the Federal Government, or by the State of Ohio.

The primary purpose of this report is to evaluate the benefits and costs of the Hancock County Flood Risk Reduction Program, including the proposed activities in the Program Plan. From a legal perspective it is important to consider the benefits and costs of the entire program from its inception. For this study the analysis of the Hancock County Flood Risk Reduction Program included separate evaluations for the Hydraulic Improvements component and for the Full Program. The timing of the construction activities and costs, maintenance, and the period where partial and full benefits begin to accrue for the community determine the present value of benefits and costs.

The summary of costs and benefits are provided in Exhibit 12.1. The net present value of costs, including maintenance, equal **$20.2 million** for the Hydraulic Improvements component, while costs of the Full program with maintenance equals **$159.9 million**. The anticipated annual Program costs and benefits are included in Appendix A.

Exhibit 12.1: Net Present Value of Benefits and Costs of the Hancock County Flood Risk Reduction Program, Thousands of 2017 Dollars

	Benefits	Costs
Hydraulic Improvements	$93,966	$20,233
Full Program	$255,208	$159,876

To summarize the individual benefits described in the previous chapters, and 12.1 provide the present values of each of the individual benefits, over the expected 50-year program analysis period. Exhibit 12.2 provides the benefits from the scenario that considers only the Hydraulic Improvements component. Summing all of the present values of these benefits, the total benefits attributable to the Hydraulic Improvements component are approximately **$94 million**, achieving a Benefit-Cost Ratio of **4.64**.

Exhibit 12.2: Present Value Benefits from the Hydraulic Improvements Component, Thousands of 2017 Dollars

Hydraulic Improvments			
From Report Chapter Number	Costs (Net Present Value)	Benefits (Net Present Value)	Benefit/ Cost Ratio
3. Program Costs	$ 20,233		
4. Structural (Residential)		$ 33,896	
4. Structural (Business)		$ 24,901	
5. Motor Vehicles		$ 2,523	
6. Transportation		$ 5,969	
7. Emergency Response		$ 4,050	
8. NFIP Administrative Cost		$ 5,698	
9. Business Losses (Income)		$ 2,067	
9. Business Losses (Cleanup)		$ 2,673	
9. Business Losses (E-Plan)		$ 797	
10. Agricultural		$ 163	
11. Environment		$ 11,229	
Total	$ 20,233	$ 93,966	4.64

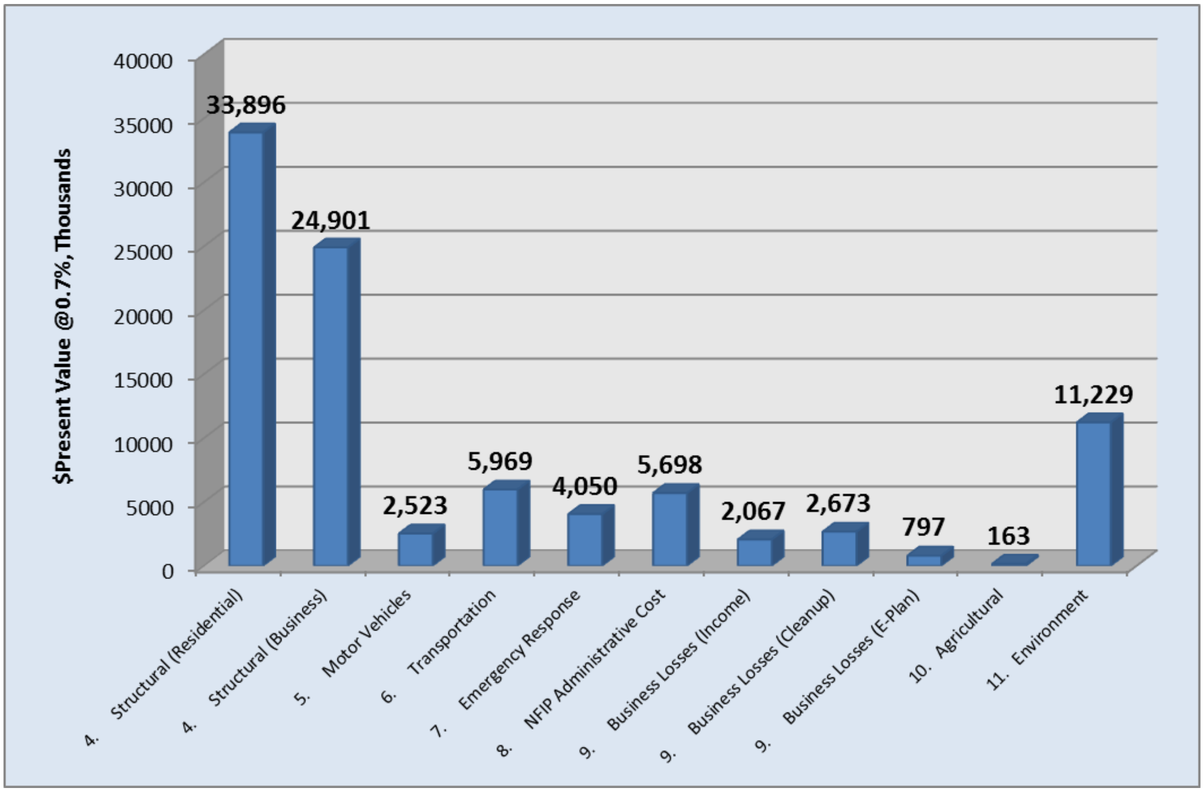
Exhibit 12.3 provides the benefits from the Full Program. Summing all of the present values of these benefits, the total benefits attributable to the Full Program are approximately **$255 million**, achieving a Benefit-Cost Ratio of 1.6.

Exhibit 12.3: Present Value Benefits from the Full Program, Thousands of 2017 Dollars

Full Program			
Category	Costs (Net Present Value)	Benefits (Net Present Value)	Benefit/ Cost Ratio
3. Program Costs	$ 159,876		
4. Structural (Residential)		$ 107,450	
4. Structural (Business)		$ 42,867	
5. Motor Vehicles		$ 5,388	
6. Transportation		$ 8,992	
7. Emergency Response		$ 6,419	
8. NFIP Administrative Cost		$ 18,311	
9. Business Losses (Income)		$ 3,276	
9. Business Losses (Cleanup)		$ 3,153	
9. Business Losses (E-Plan)		$ 1,277	
10. Agricultural		$ 368	
11. Environment		$ 57,707	
Total	$ 159,876	$ 255,208	1.60

Exhibit 12.4 and Exhibit 12.5 present the benefits for both scenarios graphically for a side-by-side comparison. In the first scenario, where only the Hydraulic Improvements benefits are included, benefits from the reduced flooding of structures constitute the largest share of benefits, followed by environmental benefits.

Exhibit-12.4: Benefits from the Hydraulic Improvements component, Thousands in 2017 Dollars



In the second Full Program scenario the largest share of benefits are once again attributable to the reduced flooding of structures in the floodplain. Environmental benefits become a greater proportion of total benefits in the Full Program evaluation, 11% to 22% of total, due to the larger amount of land involved.

Exhibit 12.5: Benefits from the Full Program in Thousands (2017 Dollars)

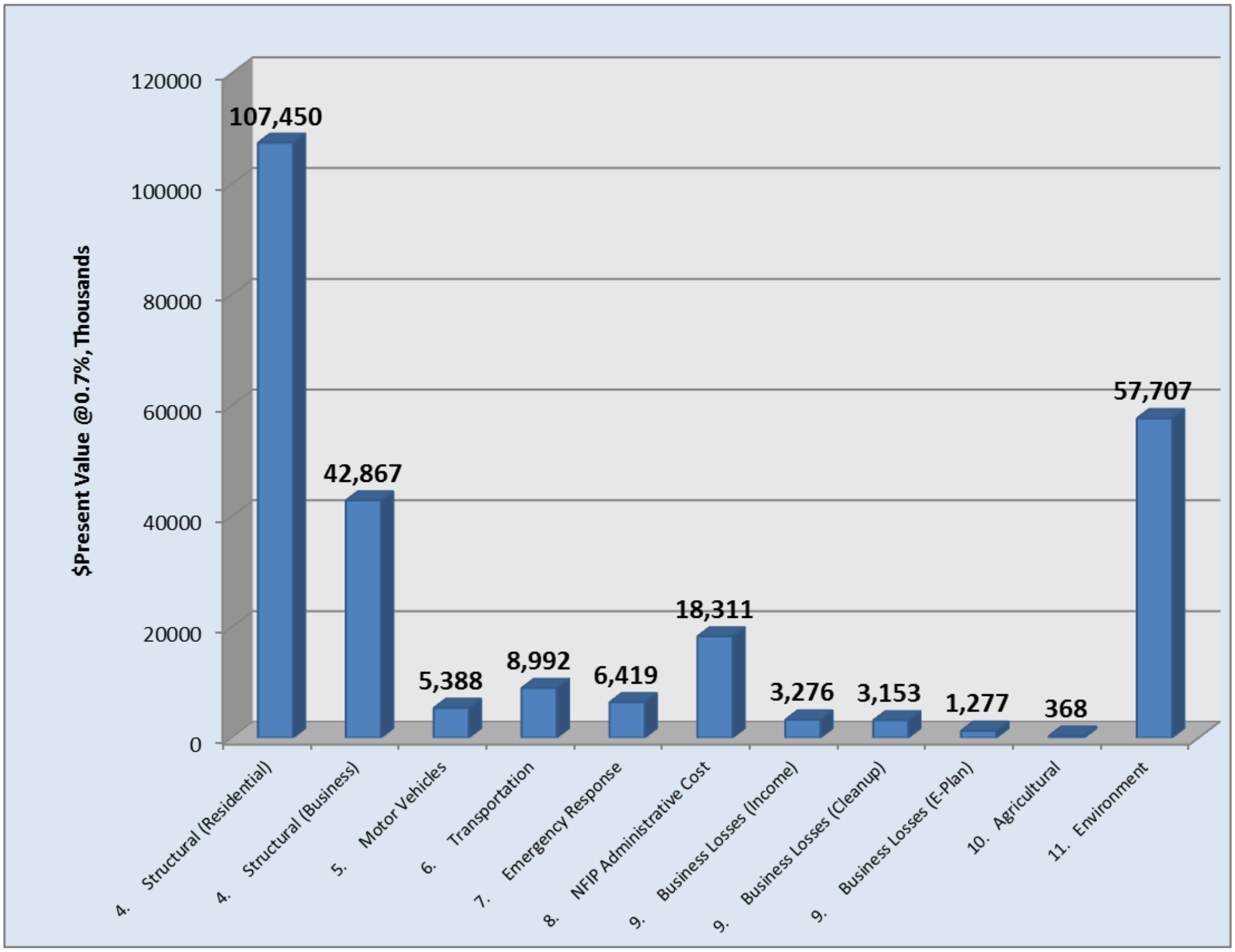
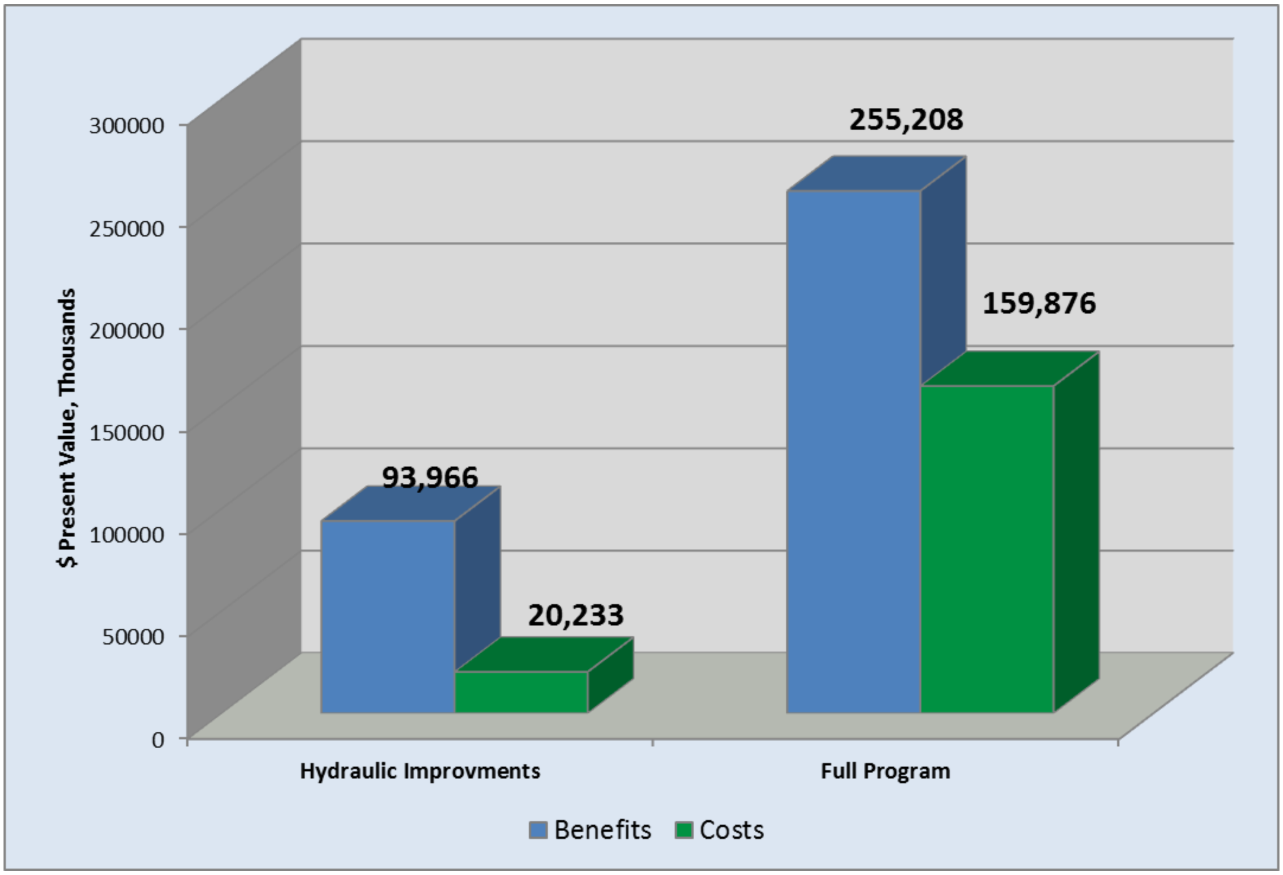


Exhibit 12.6 compares the two benefits scenarios with the two costs graphically for a side-by-side comparison. The exhibit shows that the estimated benefits of the Hancock County Flood Risk Reduction Program are larger than the preliminary opinion of probable cost estimates for both the Hydraulic Improvements component and the Full Program.

Exhibit 12.6: Summary of Hancock County Flood Risk Reduction Program in Thousands (2017 Dollars)



The present values of benefits and costs are compared in two ways. One is to calculate the difference between the benefits and the costs. This value is referred to as the net present value (NPV). If this value is larger than zero, benefits exceed costs and the project is economically justified. The second method is to calculate the ratio of benefits to costs. In this case, if the benefit-cost ratio (B/C Ratio) exceeds one, the project is economically justified.[43]

Exhibit 12.7 presents the results of the benefit cost analysis, in terms of both net present value and benefit-cost ratio, for both scenarios.

[43] These two methods are mathematically equivalent. Consider the following illustration:

A > B is equivalent to A – B > 0 (subtract B from both sides) and A/B > 1 (divide B from both sides).

Exhibit 12.7: Summary of Results of the Benefit Cost Analysis, NPV and B/C Ratio

Net Costs and Benefits in Thousands (2017 Dollars):

	Benefits	Costs	Net Benefits
Hydraulic Improvements	$ 93,966	$ 20,233	$ 73,732
Full Program	$ 255,208	$ 159,876	$ 95,332

Benefit Cost Ratio:

Hydraulic Improvements	4.64
Full Program	1.60

This Benefit Cost Analysis of the Hancock County Flood Risk Reduction Program, including the Hydraulic Improvements component and the Full Program, demonstrates that the recommended Flood Risk Reduction Program is cost effective. The Net Present Value of the two scenarios substantially exceeds the cost, indicating that it is an efficient infrastructure investment. In addition, the Benefit Cost Ratios of 4.64 for the Hydraulic Improvements component and 1.60 for the Full Program reveals a substantial benefit margin over costs. This indicates that for each dollar of investment in the Program, the communities will receive $4.64 and $1.60, respectively, in estimated benefits.

Appendix A:

50 Year Calculation of the Benefits and Costs of the Hancock County Flood Risk Reduction Program

A-1: Hancock County Flood Risk Reduction Program Costs, Present Value in Thousands (2007 Dollars)

		Hydraulic Improvements			Full Program				
Yr.	Year	Construct: Hydraulic Improvements	Maint.	Net Present Value	Construct: Eagle Creek	Construct: Blanchard River	Construct: Potato Run	Maint.	Net Present Value
1	2017			-					-
2	2018	4,966.0		4,931.5					4,931.5
3	2019	4,966.0		4,897.2	9,935.7				14,695.3
4	2020	4,966.0		4,863.2	9,935.7	5,590.0	2,561.0		22,575.3
5	2021	4,966.0		4,829.4	9,935.7	5,590.0	2,561.0		22,418.4
6	2022		17.7	17.1	9,935.7	5,590.0	2,561.0		17,483.9
7	2023		17.7	17.0	9,935.7	5,590.0	2,561.0		17,362.3
8	2024		17.7	16.9	9,935.7	5,590.0	2,561.0		17,241.6
9	2025		17.7	16.7	9,935.7	5,590.0	2,561.0		17,121.8
10	2026		17.7	16.6		5,590.0	2,561.0	75.0	7,742.1
11	2027		17.7	16.5		5,590.0	2,561.0	75.0	7,688.2
12	2028		17.7	16.4			2,561.0	115.0	2,494.7
13	2029		17.7	16.3			2,561.0	115.0	2,477.4
14	2030		17.7	16.2				155.0	157.7
15	2031		17.7	16.1				155.0	156.6
16	2032		17.7	15.9				155.0	155.5
17	2033		17.7	15.8				155.0	154.5
18	2034		17.7	15.7				155.0	153.4
19	2035		17.7	15.6				155.0	152.3
20	2036		17.7	15.5				155.0	151.3
21	2037		17.7	15.4				155.0	150.2
22	2038		17.7	15.3				155.0	149.2
23	2039		17.7	15.2				155.0	148.1
24	2040		17.7	15.1				155.0	147.1
25	2041		17.7	15.0				155.0	146.1
26	2042		17.7	14.9				155.0	145.1
27	2043		17.7	14.8				155.0	144.1
28	2044		17.7	14.7				155.0	143.1
29	2045		17.7	14.6				155.0	142.1
30	2046		17.7	14.5				155.0	141.1
31	2047		17.7	14.4				155.0	140.1
32	2048		17.7	14.3				155.0	139.1
33	2049		17.7	14.2				155.0	138.1
34	2050		17.7	14.1				155.0	137.2
35	2051		17.7	14.0				155.0	136.2
36	2052		17.7	13.9				155.0	135.3
37	2053		17.7	13.8				155.0	134.3
38	2054		17.7	13.7				155.0	133.4
39	2055		17.7	13.6				155.0	132.5
40	2056		17.7	13.5				155.0	131.6
41	2057		17.7	13.4				155.0	130.7
42	2058		17.7	13.3				155.0	129.7
43	2059		17.7	13.2				155.0	128.8
44	2060		17.7	13.1				155.0	127.9
45	2061		17.7	13.0				155.0	127.1
46	2062		17.7	12.9				155.0	126.2
47	2063		17.7	12.8				155.0	125.3
48	2064		17.7	12.8				155.0	124.4
49	2065		17.7	12.7				155.0	123.6
50	2066		17.7	12.6				155.0	122.7
51	2067		17.7	12.5				155.0	121.8
52	2068		17.7	12.4				155.0	121.0
53	2069		17.7	12.3				155.0	120.2
54	2070		17.7	12.2				155.0	119.3
	Total	**19,864.0**	**867.3**	**20,233.1**	**69,550.0**	**44,720.0**	**25,610.0**	**6,735.0**	**159,876.4**

A-2: Hancock County Flood Risk Reduction Program - Anticipated Annual Benefits, in Thousands (2007 Dollars)												
Hydraulic Improvements Component												
Year	Residential Structures	Business Structures	Vehicles	Transport	Emergency Response	NFIP Admin.	Business Loss	Business Cleanup	Business Emergency Prep	Agriculture	Environ-mental	Total
2017												-
2018												-
2019	267.9	196.8	19.9	47.2	32.0	45.0	16.3	21.1	6.3	1.3		653.9
2020	535.8	393.6	39.9	94.4	64.0	90.1	32.7	42.2	12.6	2.6		1,307.8
2021	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2022	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2023	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2024	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2025	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2026	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2027	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2028	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2029	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2030	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2031	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2032	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2033	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2034	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2035	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2036	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2037	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2038	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2039	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2040	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2041	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2042	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2043	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2044	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2045	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2046	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2047	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2048	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2049	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2050	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2051	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2052	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2053	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2054	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2055	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2056	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2057	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2058	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2059	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2060	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2061	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2062	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2063	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2064	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2065	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2066	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2067	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2068	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2069	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
2070	803.7	590.4	59.8	141.5	96.0	135.1	49.0	63.4	18.9	3.9		1,961.8
Total	**40,988.2**	**30,111.9**	**3,051.3**	**7,218.1**	**4,897.4**	**6,890.3**	**2,499.5**	**3,232.0**	**963.5**	**197.0**	**11,228.7**	**111,278.0**

A-3: Hancock County Flood Risk Reduction Program - Anticipated Annual Benefits, in Thousands (2017 Dollars)												
Full Program												
Year	Residential Structures	Business Structures	Vehicles	Transport	Emergency Response	NFIP Admin.	Business Loss	Business Cleanup	Business Emergency Prep	Agriculture	Environ-mental	Total
2017												-
2018												-
2019	267.9	196.8	19.9	47.2	32.0	45.0	16.3	21.1	6.3	1.3		653.9
2020	535.8	393.6	39.9	94.4	64.0	90.1	32.7	42.2	12.6	2.6		1,307.8
2021	1,459.6	750.6	85.4	168.5	117.2	247.6	59.8	67.7	23.2	5.7		2,985.2
2022	1,459.6	750.6	85.4	168.5	117.2	247.6	59.8	67.7	23.2	5.7		2,985.2
2023	1,459.6	750.6	85.4	168.5	117.2	247.6	59.8	67.7	23.2	5.7		2,985.2
2024	1,459.6	750.6	85.4	168.5	117.2	247.6	59.8	67.7	23.2	5.7		2,985.2
2025	2,115.6	910.9	110.9	195.4	138.3	360.1	70.6	71.9	27.4	7.5		4,008.6
2026	2,115.6	910.9	110.9	195.4	138.3	360.1	70.6	71.9	27.4	7.5		4,008.6
2027	2,115.6	910.9	110.9	195.4	138.3	360.1	70.6	71.9	27.4	7.5		4,008.6
2028	2,115.6	910.9	110.9	195.4	138.3	360.1	70.6	71.9	27.4	7.5		4,008.6
2029	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2030	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2031	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2032	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2033	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2034	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2035	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2036	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2037	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2038	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2039	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2040	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2041	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2042	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2043	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2044	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2045	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2046	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2047	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2048	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2049	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2050	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2051	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2052	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2053	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2054	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2055	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2056	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2057	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2058	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2059	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2060	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2061	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2062	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2063	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2064	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2065	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2066	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2067	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2068	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2069	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
2070	2,771.5	1,071.1	136.5	222.4	159.4	472.5	81.4	76.2	31.7	9.4		5,032.0
Total	**131,506.5**	**52,221.4**	**6,577.2**	**10,938.1**	**7,812.6**	**22,412.7**	**3,987.2**	**3,822.5**	**1,553.9**	**449.9**	**57,706.8**	**298,988.8**

A-4: Hancock County Flood Risk Reduction Program - Anticipated Annual Benefits, Present Value in Thousands (2017 Dollars)

Hydraulic Improvements Component

Year	Residential Structures	Business Structures	Vehicles	Transport	Emergency Response	NFIP Admin.	Business Loss	Business Cleanup	Business Emergency Prep	Agriculture	Environ-mental	Total
2017	-	-	-	-	-	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-	-	-	-	-
2019	264.2	194.1	19.7	46.5	31.6	44.4	16.1	20.8	6.2	1.3	-	644.9
2020	524.7	385.5	39.1	92.4	62.7	88.2	32.0	41.4	12.3	2.5	-	1,280.7
2021	781.6	574.2	58.2	137.6	93.4	131.4	47.7	61.6	18.4	3.8	-	1,907.8
2022	776.1	570.2	57.8	136.7	92.7	130.5	47.3	61.2	18.2	3.7	-	1,894.5
2023	770.7	566.2	57.4	135.7	92.1	129.6	47.0	60.8	18.1	3.7	-	1,881.3
2024	765.4	562.3	57.0	134.8	91.5	128.7	46.7	60.4	18.0	3.7	-	1,868.3
2025	760.1	558.4	56.6	133.9	90.8	127.8	46.3	59.9	17.9	3.7	-	1,855.3
2026	754.8	554.5	56.2	132.9	90.2	126.9	46.0	59.5	17.7	3.6	-	1,842.4
2027	749.5	550.6	55.8	132.0	89.6	126.0	45.7	59.1	17.6	3.6	-	1,829.6
2028	744.3	546.8	55.4	131.1	88.9	125.1	45.4	58.7	17.5	3.6	-	1,816.9
2029	739.2	543.0	55.0	130.2	88.3	124.3	45.1	58.3	17.4	3.6	-	1,804.2
2030	734.0	539.2	54.6	129.3	87.7	123.4	44.8	57.9	17.3	3.5	-	1,791.7
2031	728.9	535.5	54.3	128.4	87.1	122.5	44.4	57.5	17.1	3.5	-	1,779.2
2032	723.8	531.8	53.9	127.5	86.5	121.7	44.1	57.1	17.0	3.5	-	1,766.9
2033	718.8	528.1	53.5	126.6	85.9	120.8	43.8	56.7	16.9	3.5	-	1,754.6
2034	713.8	524.4	53.1	125.7	85.3	120.0	43.5	56.3	16.8	3.4	-	1,742.4
2035	708.9	520.8	52.8	124.8	84.7	119.2	43.2	55.9	16.7	3.4	-	1,730.3
2036	703.9	517.1	52.4	124.0	84.1	118.3	42.9	55.5	16.5	3.4	-	1,718.2
2037	699.0	513.5	52.0	123.1	83.5	117.5	42.6	55.1	16.4	3.4	-	1,706.3
2038	694.2	510.0	51.7	122.2	82.9	116.7	42.3	54.7	16.3	3.3	-	1,694.4
2039	689.4	506.4	51.3	121.4	82.4	115.9	42.0	54.4	16.2	3.3	-	1,682.7
2040	684.6	502.9	51.0	120.6	81.8	115.1	41.7	54.0	16.1	3.3	-	1,671.0
2041	679.8	499.4	50.6	119.7	81.2	114.3	41.5	53.6	16.0	3.3	-	1,659.3
2042	675.1	495.9	50.3	118.9	80.7	113.5	41.2	53.2	15.9	3.2	-	1,647.8
2043	670.4	492.5	49.9	118.1	80.1	112.7	40.9	52.9	15.8	3.2	-	1,636.4
2044	665.7	489.1	49.6	117.2	79.5	111.9	40.6	52.5	15.6	3.2	-	1,625.0
2045	661.1	485.7	49.2	116.4	79.0	111.1	40.3	52.1	15.5	3.2	-	1,613.7
2046	656.5	482.3	48.9	115.6	78.4	110.4	40.0	51.8	15.4	3.2	-	1,602.5
2047	651.9	478.9	48.5	114.8	77.9	109.6	39.8	51.4	15.3	3.1	-	1,591.3
2048	647.4	475.6	48.2	114.0	77.4	108.8	39.5	51.0	15.2	3.1	-	1,580.3
2049	642.9	472.3	47.9	113.2	76.8	108.1	39.2	50.7	15.1	3.1	-	1,569.3
2050	638.4	469.0	47.5	112.4	76.3	107.3	38.9	50.3	15.0	3.1	-	1,558.4
2051	634.0	465.8	47.2	111.6	75.8	106.6	38.7	50.0	14.9	3.0	-	1,547.5
2052	629.6	462.5	46.9	110.9	75.2	105.8	38.4	49.6	14.8	3.0	-	1,536.8
2053	625.2	459.3	46.5	110.1	74.7	105.1	38.1	49.3	14.7	3.0	-	1,526.1
2054	620.9	456.1	46.2	109.3	74.2	104.4	37.9	49.0	14.6	3.0	-	1,515.5
2055	616.6	452.9	45.9	108.6	73.7	103.6	37.6	48.6	14.5	3.0	-	1,505.0
2056	612.3	449.8	45.6	107.8	73.2	102.9	37.3	48.3	14.4	2.9	-	1,494.5
2057	608.0	446.7	45.3	107.1	72.6	102.2	37.1	47.9	14.3	2.9	-	1,484.1
2058	603.8	443.6	44.9	106.3	72.1	101.5	36.8	47.6	14.2	2.9	-	1,473.8
2059	599.6	440.5	44.6	105.6	71.6	100.8	36.6	47.3	14.1	2.9	-	1,463.5
2060	595.4	437.4	44.3	104.9	71.1	100.1	36.3	47.0	14.0	2.9	-	1,453.4
2061	591.3	434.4	44.0	104.1	70.6	99.4	36.1	46.6	13.9	2.8	-	1,443.3
2062	587.2	431.4	43.7	103.4	70.2	98.7	35.8	46.3	13.8	2.8	-	1,433.2
2063	583.1	428.4	43.4	102.7	69.7	98.0	35.6	46.0	13.7	2.8	-	1,423.3
2064	579.0	425.4	43.1	102.0	69.2	97.3	35.3	45.7	13.6	2.8	-	1,413.4
2065	575.0	422.4	42.8	101.3	68.7	96.7	35.1	45.3	13.5	2.8	-	1,403.6
2066	571.0	419.5	42.5	100.6	68.2	96.0	34.8	45.0	13.4	2.7	-	1,393.8
2067	567.0	416.6	42.2	99.9	67.8	95.3	34.6	44.7	13.3	2.7	-	1,384.1
2068	563.1	413.7	41.9	99.2	67.3	94.7	34.3	44.4	13.2	2.7	-	1,374.5
2069	559.2	410.8	41.6	98.5	66.8	94.0	34.1	44.1	13.1	2.7	-	1,364.9
2070	555.3	407.9	41.3	97.8	66.3	93.3	33.9	43.8	13.1	2.7	-	1,355.4
Total	**33,895.7**	**24,901.4**	**2,523.3**	**5,969.1**	**4,050.0**	**5,698.0**	**2,067.0**	**2,672.8**	**796.8**	**162.9**	**11,228.7**	**93,965.6**

A-5: Hancock County Flood Risk Reduction Program - Anticipated Annual Benefits, Present Value in Thousands (2017 Dollars)												
Full Program												
Year	Residential Structures	Business Structures	Vehicles	Transport	Emergency Response	NFIP Admin.	Business Loss	Business Cleanup	Business Emergency Prep	Agriculture	Environ-mental	Total
2017	-	-	-	-	-	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-	-	-	-	-
2019	264.2	194.1	19.7	46.5	31.6	44.4	16.1	20.8	6.2	1.3	-	644.9
2020	524.7	385.5	39.1	92.4	62.7	88.2	32.0	41.4	12.3	2.5	-	1,280.7
2021	1,419.5	730.0	83.0	163.9	113.9	240.8	58.1	65.8	22.5	5.5	-	2,903.0
2022	1,409.6	724.9	82.5	162.7	113.1	239.1	57.7	65.3	22.4	5.5	-	2,882.9
2023	1,399.8	719.9	81.9	161.6	112.4	237.4	57.3	64.9	22.2	5.5	-	2,862.8
2024	1,390.1	714.9	81.3	160.5	111.6	235.8	56.9	64.4	22.1	5.4	-	2,842.9
2025	2,000.7	861.4	104.9	184.8	130.8	340.5	66.7	68.0	26.0	7.1	-	3,791.0
2026	1,986.8	855.4	104.2	183.6	129.9	338.2	66.3	67.6	25.8	7.1	-	3,764.7
2027	1,973.0	849.5	103.5	182.3	129.0	335.8	65.8	67.1	25.6	7.0	-	3,738.5
2028	1,959.3	843.6	102.7	181.0	128.1	333.5	65.4	66.6	25.4	7.0	-	3,712.5
2029	2,548.9	985.1	125.5	204.5	146.6	434.6	74.8	70.1	29.2	8.6	-	4,628.0
2030	2,531.2	978.2	124.6	203.1	145.6	431.6	74.3	69.6	29.0	8.5	-	4,595.8
2031	2,513.6	971.4	123.8	201.7	144.6	428.6	73.8	69.1	28.8	8.5	-	4,563.8
2032	2,496.1	964.7	122.9	200.3	143.6	425.6	73.3	68.6	28.6	8.4	-	4,532.1
2033	2,478.8	958.0	122.1	198.9	142.6	422.6	72.8	68.2	28.4	8.4	-	4,500.6
2034	2,461.6	951.3	121.2	197.5	141.6	419.7	72.3	67.7	28.2	8.3	-	4,469.3
2035	2,444.5	944.7	120.4	196.2	140.6	416.8	71.8	67.2	28.0	8.3	-	4,438.3
2036	2,427.5	938.1	119.5	194.8	139.6	413.9	71.3	66.7	27.8	8.2	-	4,407.4
2037	2,410.6	931.6	118.7	193.4	138.6	411.0	70.8	66.3	27.6	8.1	-	4,376.8
2038	2,393.8	925.1	117.9	192.1	137.7	408.2	70.3	65.8	27.4	8.1	-	4,346.3
2039	2,377.2	918.7	117.1	190.8	136.7	405.3	69.8	65.4	27.2	8.0	-	4,316.1
2040	2,360.7	912.3	116.2	189.4	135.8	402.5	69.3	64.9	27.0	8.0	-	4,286.1
2041	2,344.3	906.0	115.4	188.1	134.8	399.7	68.8	64.5	26.8	7.9	-	4,256.3
2042	2,328.0	899.7	114.6	186.8	133.9	396.9	68.3	64.0	26.7	7.9	-	4,226.7
2043	2,311.8	893.4	113.8	185.5	133.0	394.2	67.9	63.6	26.5	7.8	-	4,197.4
2044	2,295.7	887.2	113.1	184.2	132.0	391.4	67.4	63.1	26.3	7.8	-	4,168.2
2045	2,279.7	881.0	112.3	182.9	131.1	388.7	66.9	62.7	26.1	7.7	-	4,139.2
2046	2,263.9	874.9	111.5	181.7	130.2	386.0	66.5	62.3	25.9	7.6	-	4,110.4
2047	2,248.2	868.8	110.7	180.4	129.3	383.3	66.0	61.8	25.7	7.6	-	4,081.9
2048	2,232.5	862.8	109.9	179.2	128.4	380.7	65.5	61.4	25.6	7.5	-	4,053.5
2049	2,217.0	856.8	109.2	177.9	127.5	378.0	65.1	61.0	25.4	7.5	-	4,025.3
2050	2,201.6	850.8	108.4	176.7	126.6	375.4	64.6	60.5	25.2	7.4	-	3,997.3
2051	2,186.3	844.9	107.7	175.4	125.7	372.8	64.2	60.1	25.0	7.4	-	3,969.5
2052	2,171.1	839.0	106.9	174.2	124.9	370.2	63.7	59.7	24.9	7.3	-	3,942.0
2053	2,156.0	833.2	106.2	173.0	124.0	367.6	63.3	59.3	24.7	7.3	-	3,914.6
2054	2,141.0	827.4	105.4	171.8	123.1	365.1	62.8	58.9	24.5	7.2	-	3,887.3
2055	2,126.1	821.7	104.7	170.6	122.3	362.5	62.4	58.5	24.3	7.2	-	3,860.3
2056	2,111.4	816.0	104.0	169.4	121.4	360.0	62.0	58.1	24.2	7.1	-	3,833.5
2057	2,096.7	810.3	103.3	168.3	120.6	357.5	61.5	57.7	24.0	7.1	-	3,806.8
2058	2,082.1	804.7	102.5	167.1	119.8	355.0	61.1	57.3	23.8	7.0	-	3,780.4
2059	2,067.6	799.1	101.8	165.9	118.9	352.5	60.7	56.9	23.7	7.0	-	3,754.1
2060	2,053.3	793.5	101.1	164.8	118.1	350.1	60.3	56.5	23.5	6.9	-	3,728.0
2061	2,039.0	788.0	100.4	163.6	117.3	347.7	59.9	56.1	23.3	6.9	-	3,702.1
2062	2,024.8	782.5	99.7	162.5	116.5	345.2	59.4	55.7	23.2	6.8	-	3,676.4
2063	2,010.7	777.1	99.0	161.4	115.6	342.8	59.0	55.3	23.0	6.8	-	3,650.8
2064	1,996.8	771.7	98.3	160.2	114.8	340.5	58.6	54.9	22.9	6.7	-	3,625.4
2065	1,982.9	766.3	97.6	159.1	114.0	338.1	58.2	54.5	22.7	6.7	-	3,600.2
2066	1,969.1	761.0	97.0	158.0	113.3	335.7	57.8	54.1	22.5	6.7	-	3,575.2
2067	1,955.4	755.7	96.3	156.9	112.5	333.4	57.4	53.8	22.4	6.6	-	3,550.3
2068	1,941.8	750.4	95.6	155.8	111.7	331.1	57.0	53.4	22.2	6.6	-	3,525.7
2069	1,928.3	745.2	95.0	154.7	110.9	328.8	56.6	53.0	22.1	6.5	-	3,501.1
2070	1,914.9	740.0	94.3	153.7	110.1	326.5	56.2	52.7	21.9	6.5	-	3,476.8
Total	**107,450.1**	**42,867.4**	**5,388.4**	**8,991.9**	**6,418.8**	**18,311.4**	**3,275.9**	**3,152.6**	**1,276.6**	**368.4**	**57,706.8**	**255,208.2**

Appendix F – HANCOCK COUNTY FLOOD RISK REDUCTION PLAN CONCEPTUAL DRAWINGS

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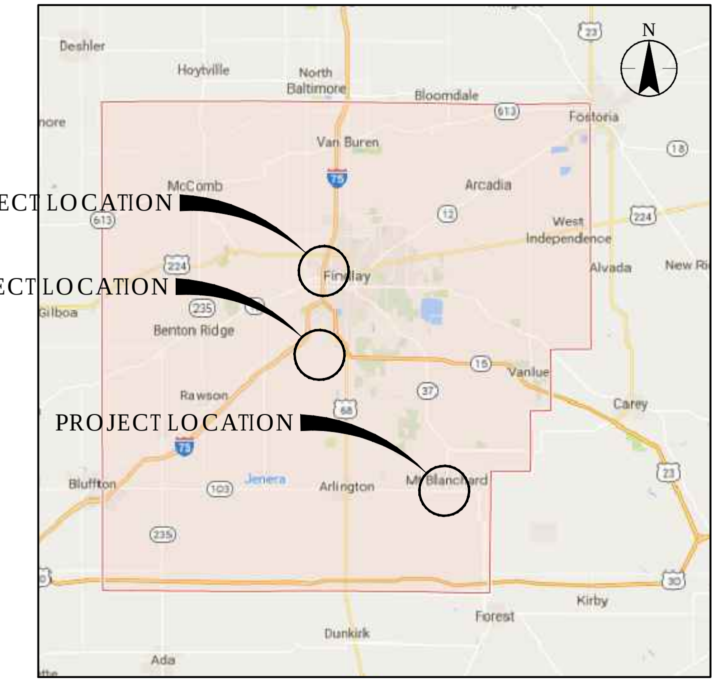

VICINITY MAP
NOT TO SCALE

PREPARED FOR:
MAUMEE WATERSHED CONSERVANCY DISTRICT

HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

FEBRUARY 2017

Project Number: 174316204

INDEX OF SHEETS

SHEET NO.	TITLE
1	COVER SHEET
2	BR EXHIBIT 1 - PLAN OVERVIEW
3	BR EXHIBIT 2 - PLAN AND CROSS SECTIONS
4	BR EXHIBIT 3 - RIFFLE / INLINE STRUCTURE REMOVAL
5	BR EXHIBIT 4 - RIFFLE / INLINE STRUCTURE REMOVAL
6	EC EXHIBIT 1 - PLAN OVERVIEW
7	EC EXHIBIT 2 - PLAN AND PROFILE
8	EC EXHIBIT 3 - PLAN AND PROFILE
9	EC EXHIBIT 4 - PLAN AND PROFILE
10	EC EXHIBIT 5 - PLAN AND PROFILE
11	EC EXHIBIT 6 - PLAN AND PROFILE
12	MB EXHIBIT 1 - PLAN OVERVIEW
13	MB EXHIBIT 2 - BLANCHARD PLAN AND PROFILE
14	MB EXHIBIT 3 - BLANCHARD PLAN AND PROFILE
15	MB EXHIBIT 4 - POTATO RUN PLAN AND PROFILE

BR - BLANCHARD RIVER HYDRAULIC IMPROVEMENTS
EC - EAGLE CREEK DRY STORAGE BASIN
MB - MT BLANCHARD DRY STORAGE BASIN

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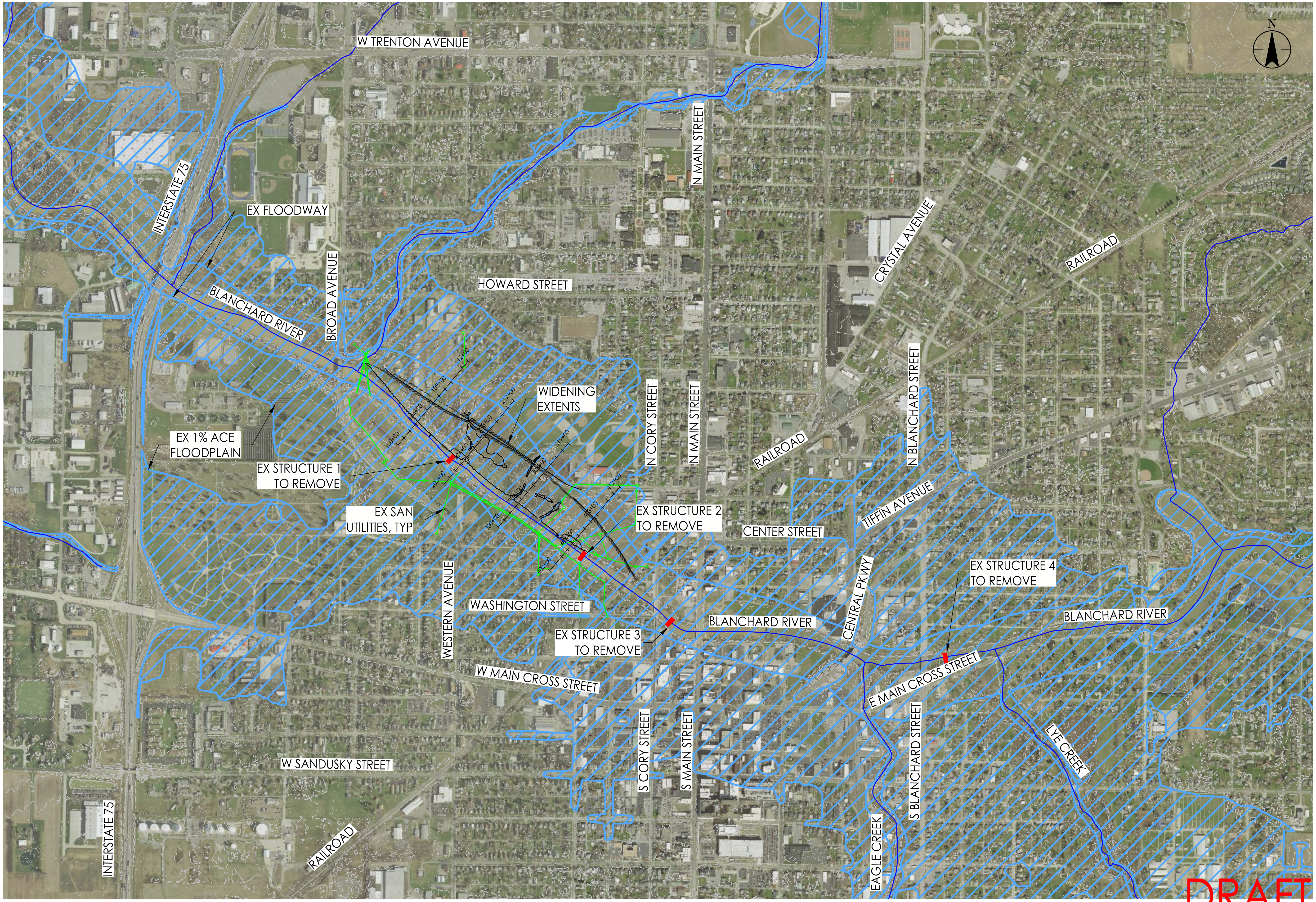

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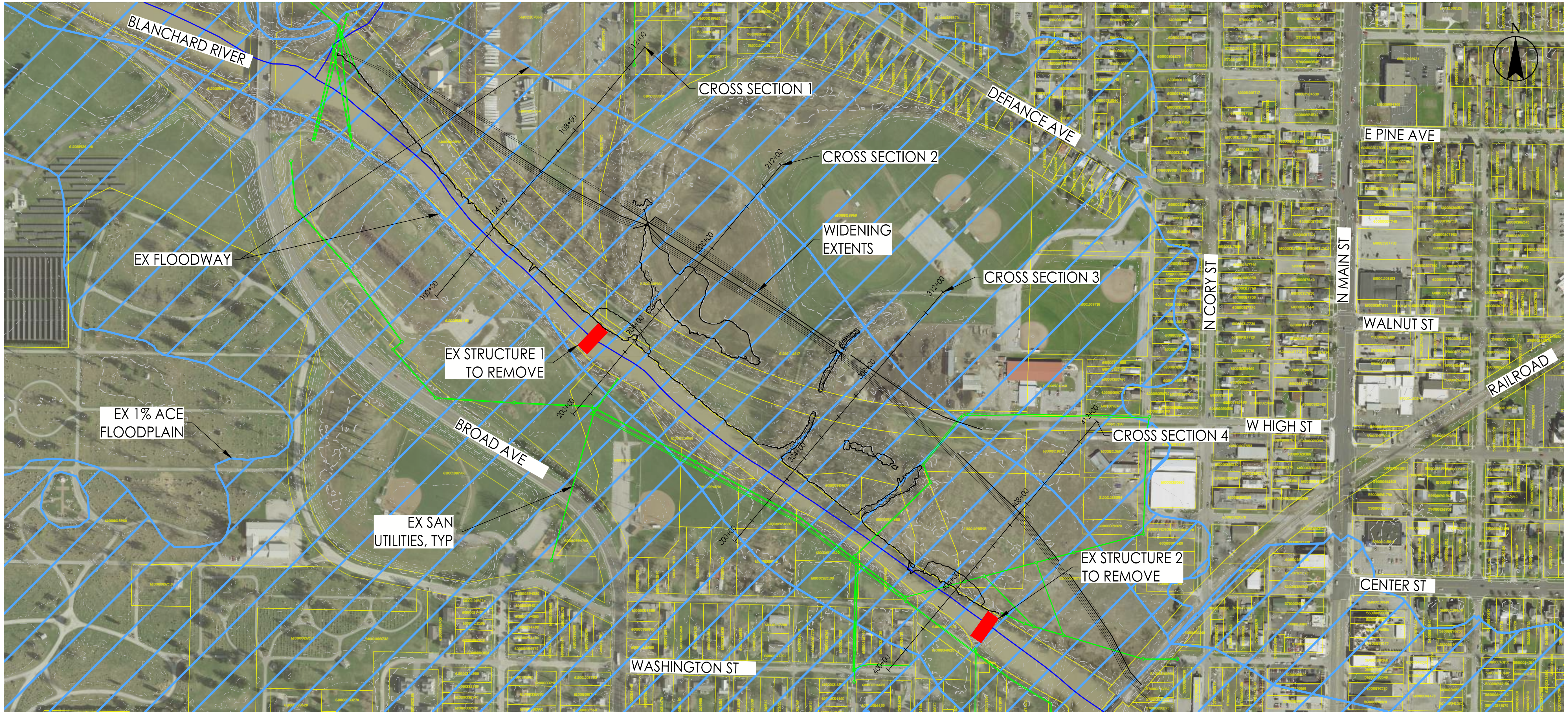
MAUMEE WATERSHED CONSERVANCY DISTRICT
HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

Title
BLANCHARD RIVER HYDRAULIC IMPROVEMENTS
EXHIBIT 1 - PLAN OVERVIEW

Project Number: 174316204
File Name: 174316204_widening_plan_prof.dwg

Dwn.	Chkd.	Dsgn.	YY.MM.DD

Drawing No. #
Revision 0
Sheet 2 of 15



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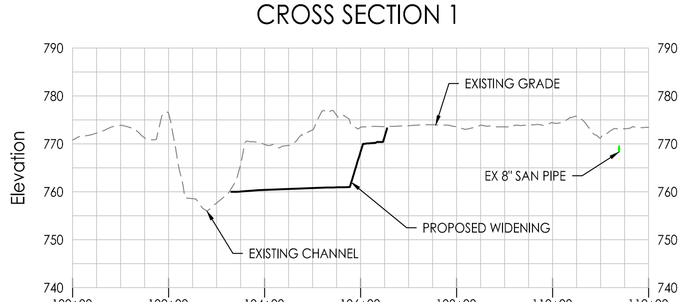

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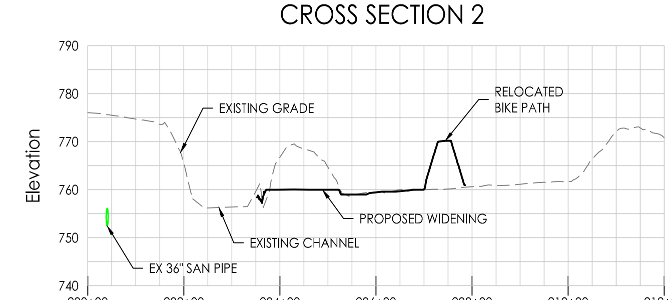

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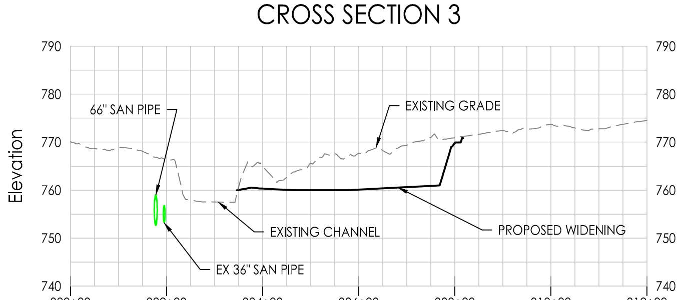

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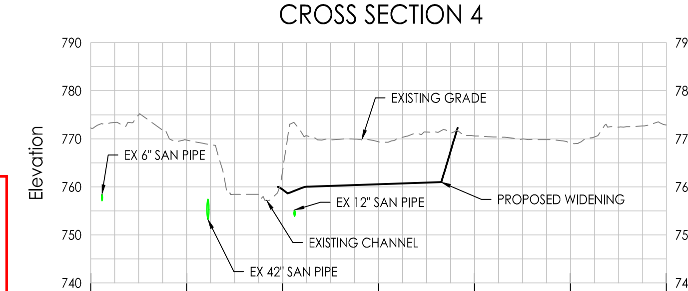
CROSS SECTION 4



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1"=20'V 0 10' 20' 40'

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HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

Title
BLANCHARD RIVER HYDRAULIC IMPROVEMENTS
EXHIBIT 2 - PLAN AND CROSS SECTIONS

Permit-Seal

Project Number: 174316204

File Name: 174316204_widening_plan_prof.dwg

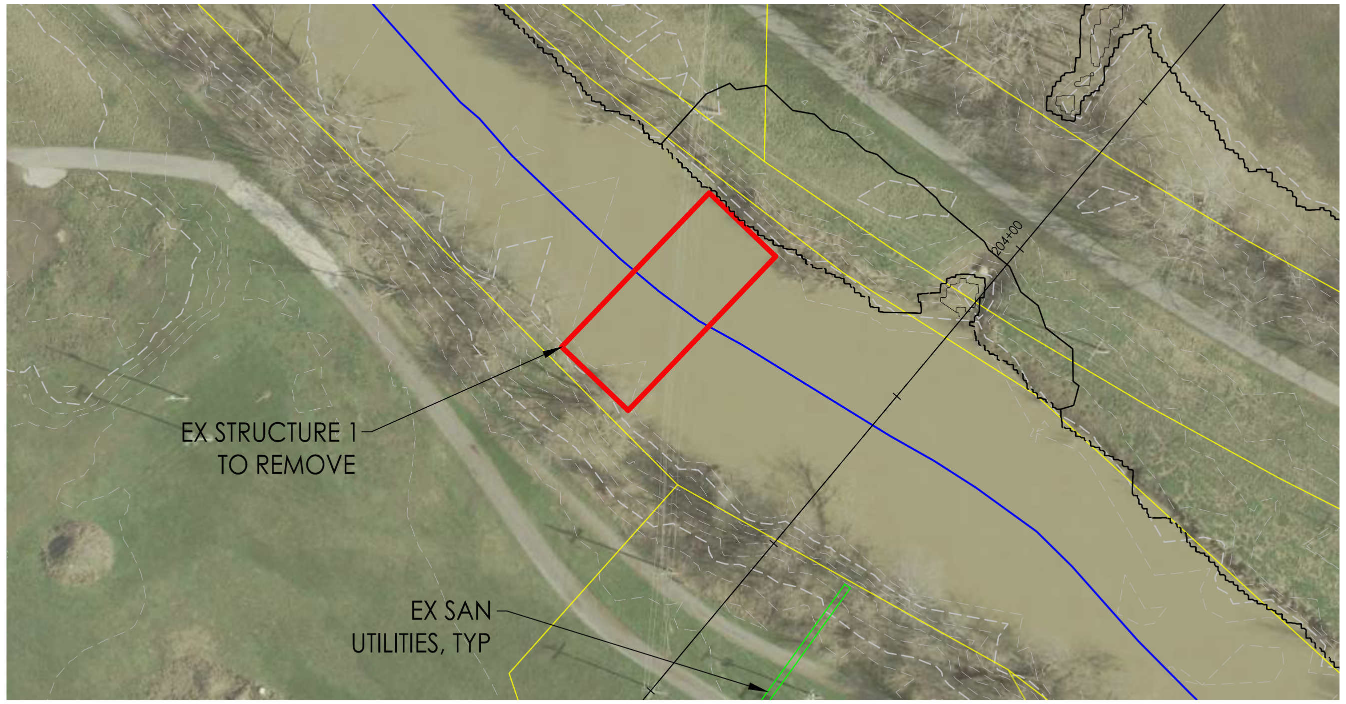
Dwn.	Chkd.	Dsgn.	YY.MM.DD

Drawing No. #

Revision 0

Sheet 3 of 15

RIFFLE / INLINE STRUCTURE REMOVAL 1



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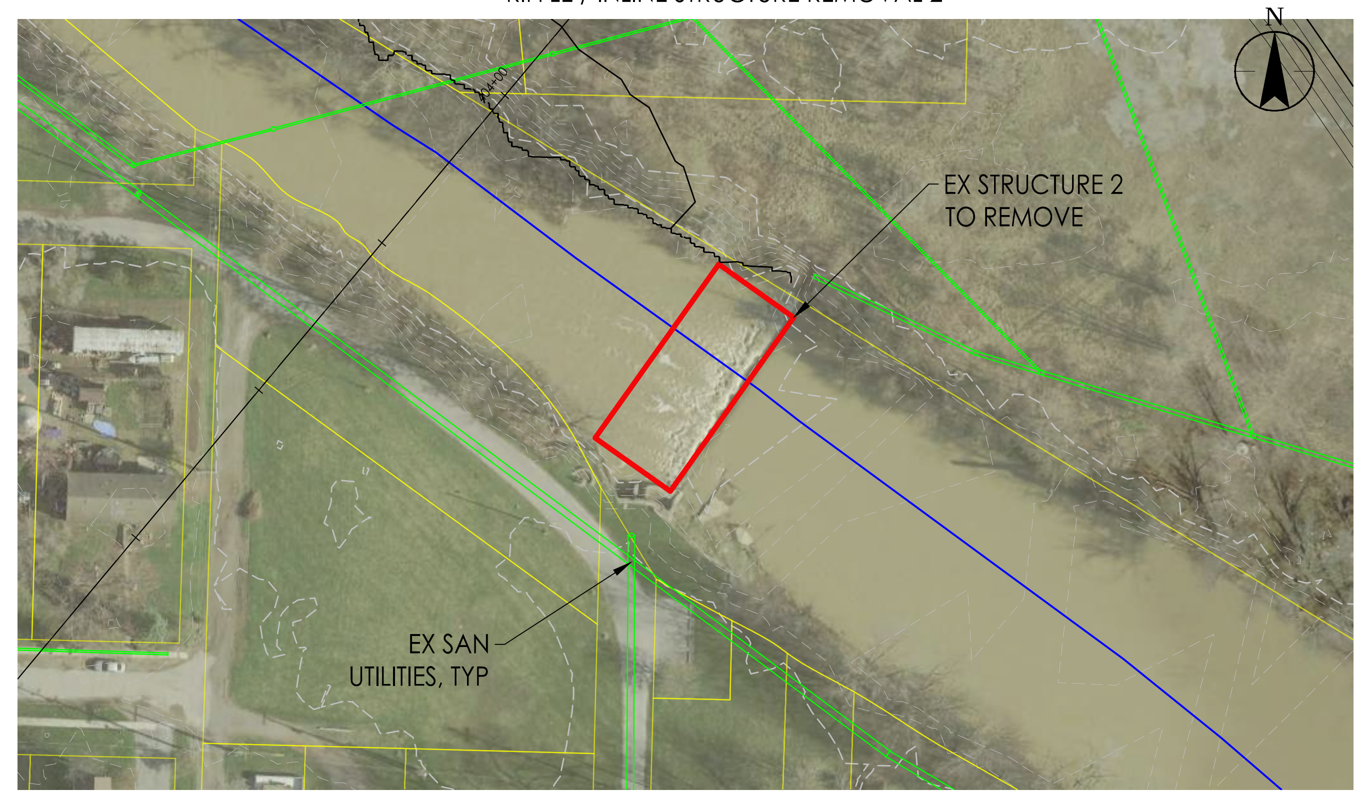

UPSTREAM OF BROAD AVENUE

DOWNSTREAM OF RAILROAD BRIDGE

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0 25' 50' 100'
1"=50'

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Client/Project
MAUMEE WATERSHED CONSERVANCY DISTRICT
HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

Title
BLANCHARD RIVER HYDRAULIC IMPROVEMENTS
EXHIBIT 3 - RIFFLE / INLINE STRUCTURE REMOVAL

Project Number: 174316204
File Name: 174316204_widening_plan_prof.dwg

Dwn.	Chkd.	Dsgn.	YY.MM.DD

Drawing No. #

Revision 0
Sheet 4 of 15

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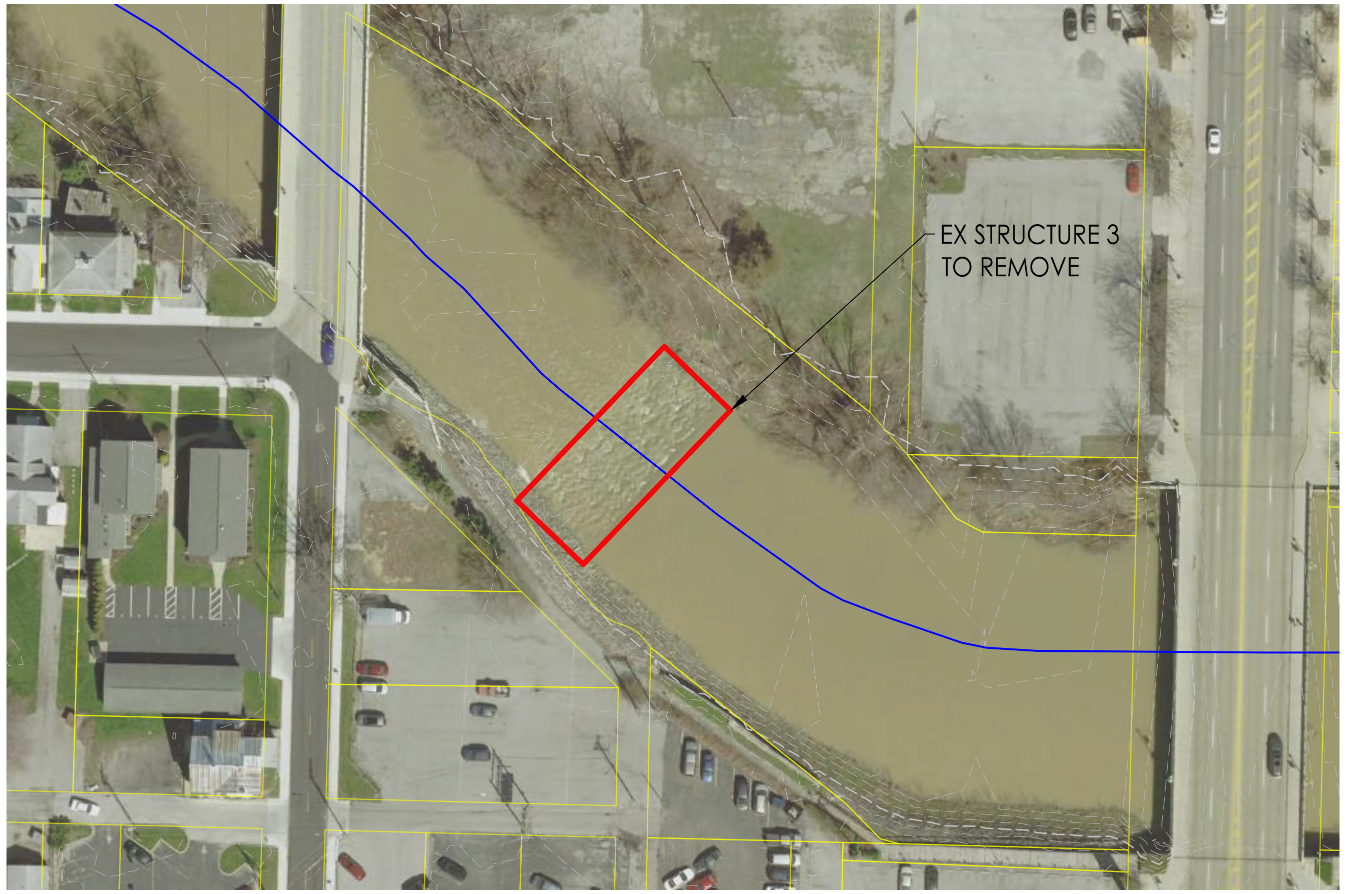
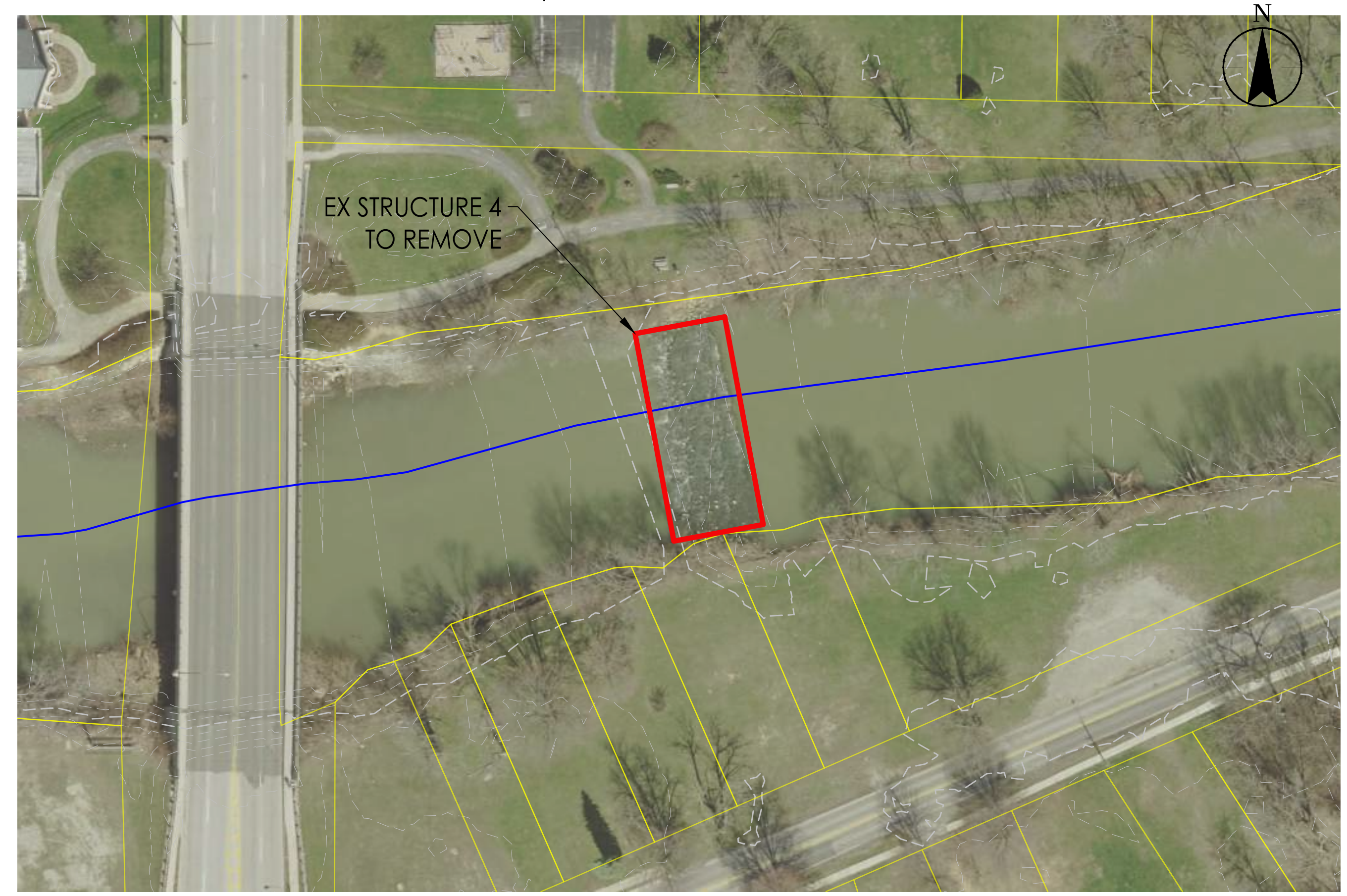
RIFFLE / INLINE STRUCTURE REMOVAL 3



RIFFLE / INLINE STRUCTURE REMOVAL 4



DOWNSTREAM OF MAIN STREET BRIDGE

UPSTREAM OF BLANCHARD STREET

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1"=50' 0 25' 50' 100'

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MAUMEE WATERSHED CONSERVANCY DISTRICT

HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT

Hancock County, Ohio

Title
BLANCHARD RIVER HYDRAULIC IMPROVEMENTS
EXHIBIT 4 - RIFFLE / INLINE STRUCTURE REMOVAL

Project Number: 174316204

File Name: 174316204_widening_plan_prof.dwg

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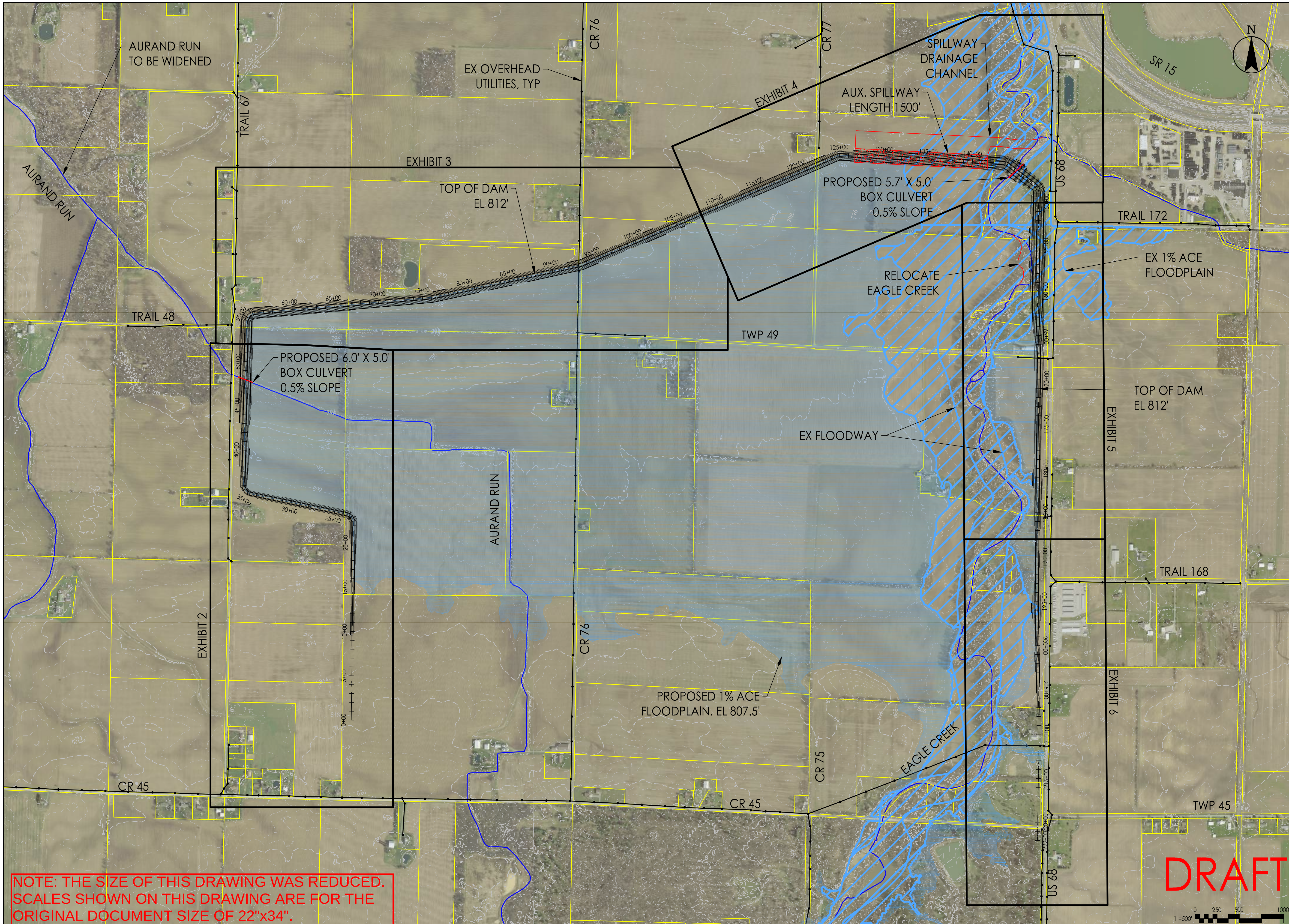
Revision 0

Sheet 5 of 15



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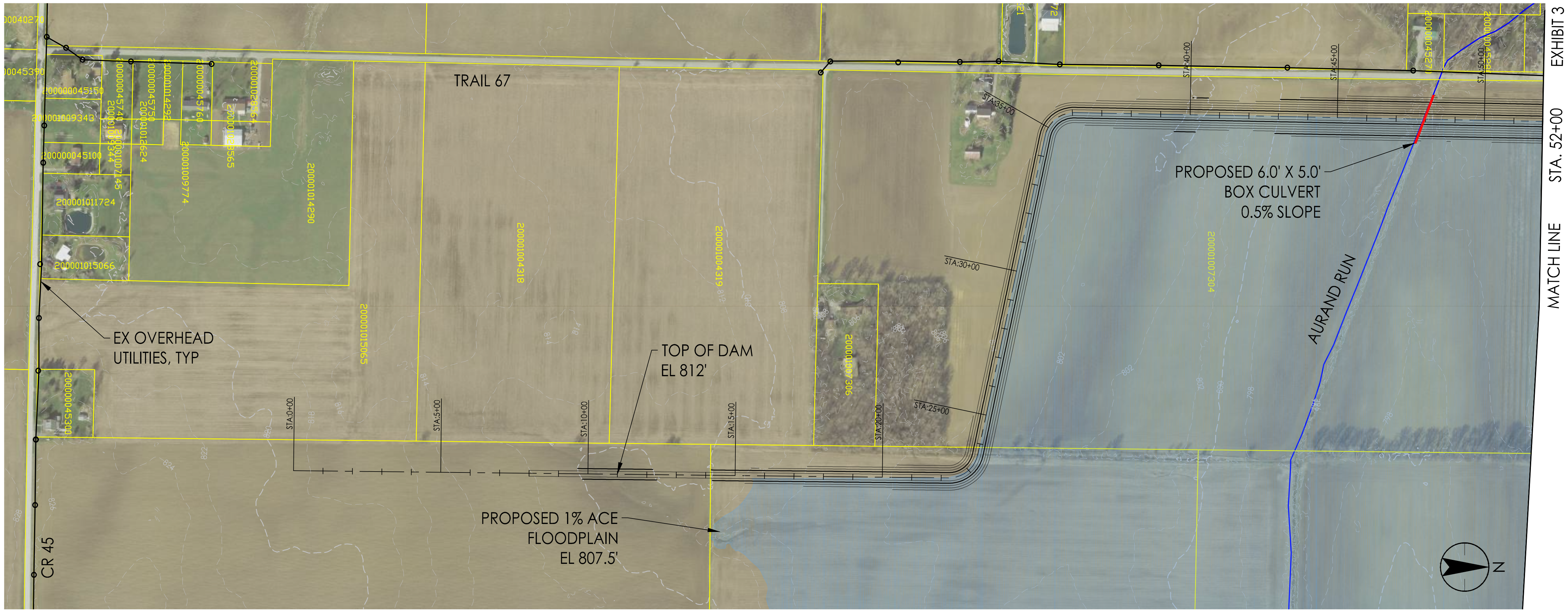
Client/Project
MAUMEE WATERSHED CONSERVANCY DISTRICT
HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

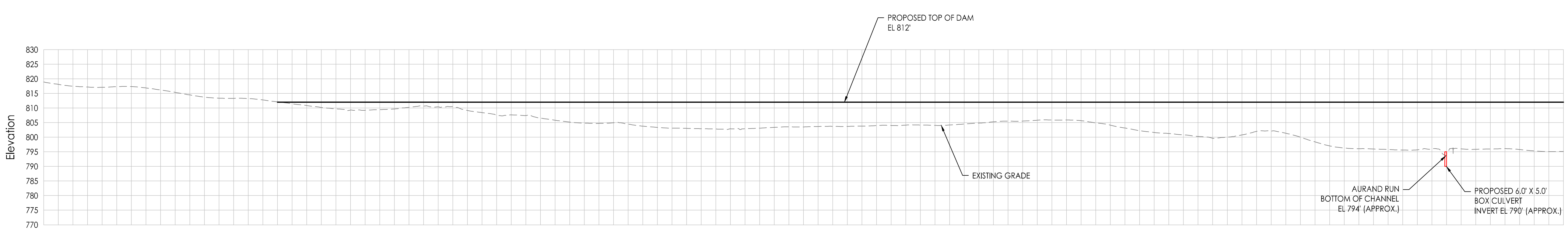
Title
EAGLE CREEK DRY STORAGE BASIN
EXHIBIT 1 - PLAN OVERVIEW

Project Number: 174316204
File Name: 174316204_EC_storage_plan_prof.dwg

Dwn.	Chkd.	Dsgn.	YY.MM.DD

Drawing No. #
Revision 0
Sheet 6 of 15





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1"=200'H 0 100' 200' 400'
1"=20'V 0 10' 20' 40'

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MAUMEE WATERSHED CONSERVANCY DISTRICT
HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

Title
EAGLE CREEK DRY STORAGE BASIN
EXHIBIT 2 - PLAN AND PROFILE

Project Number: 174316204
File Name: 174316204_EC_storage_plan_prof.dwg
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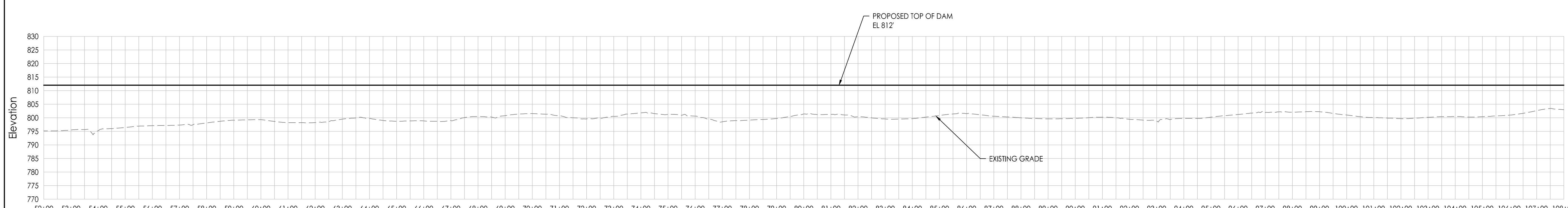
Drawing No. #
Revision 0
Sheet 7 of 15



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MAUMEE WATERSHED CONSERVANCY DISTRICT
HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

Title
EAGLE CREEK DRY STORAGE BASIN
EXHIBIT 3 - PLAN AND PROFILE

Project Number: 174316204
File Name: 174316204_EC_storage_plan_prof.dwg

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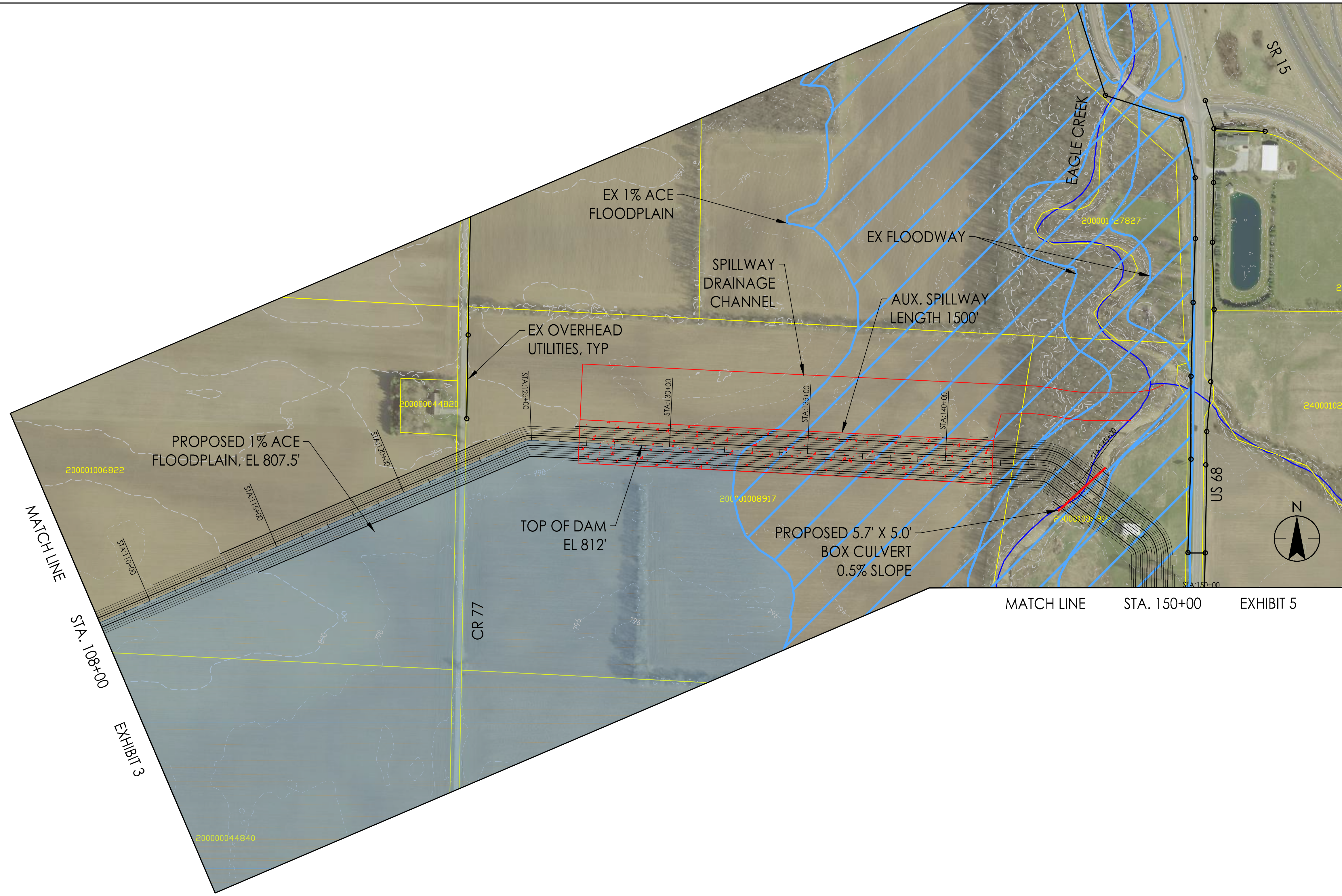
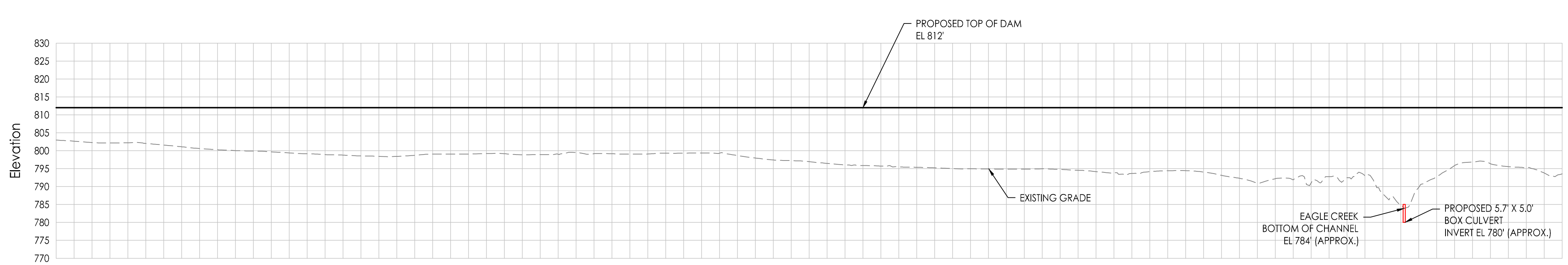
Drawing No. #
Revision 0
Sheet 8 of 15





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1"=20'V

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HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

Title
EAGLE CREEK DRY STORAGE BASIN
EXHIBIT 4 - PLAN AND PROFILE

Permit-Seal

Project Number: 174316204
File Name: 174316204_EC_storage_plan_prof.dwg

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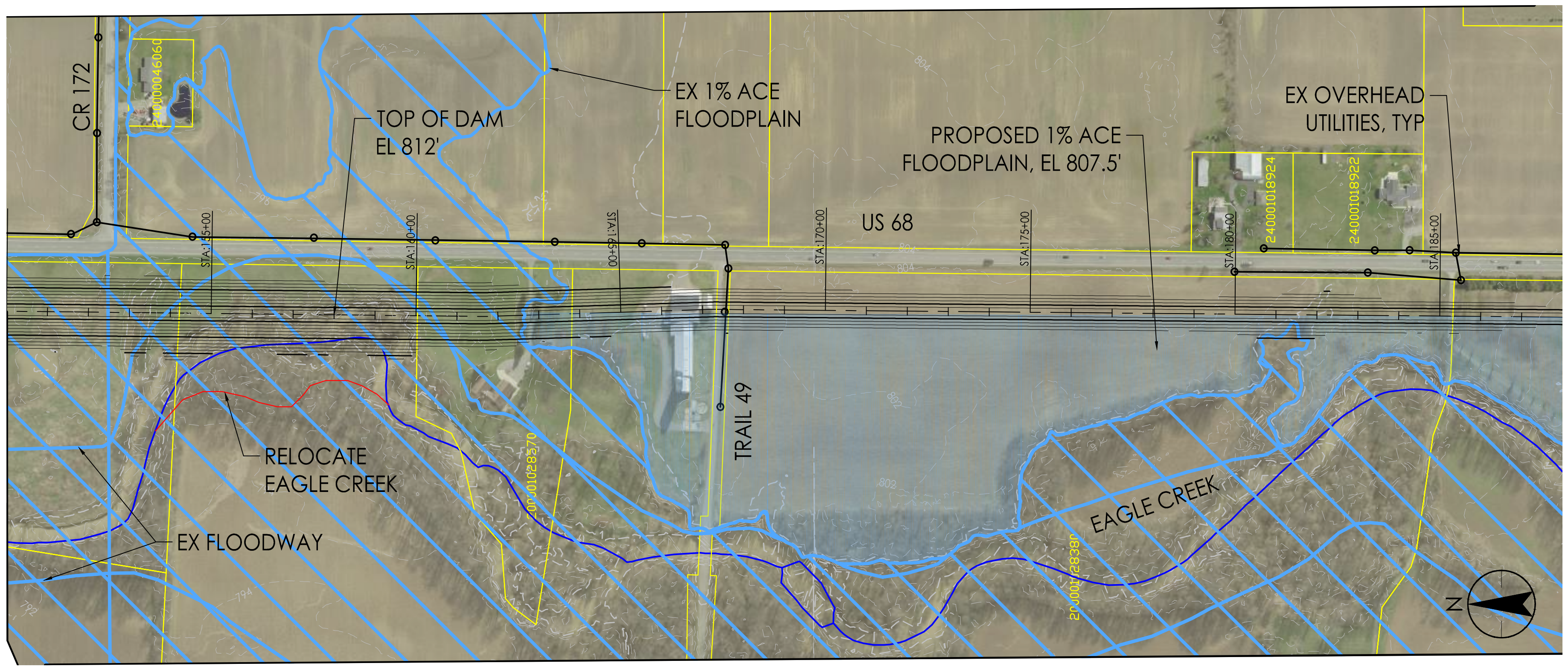
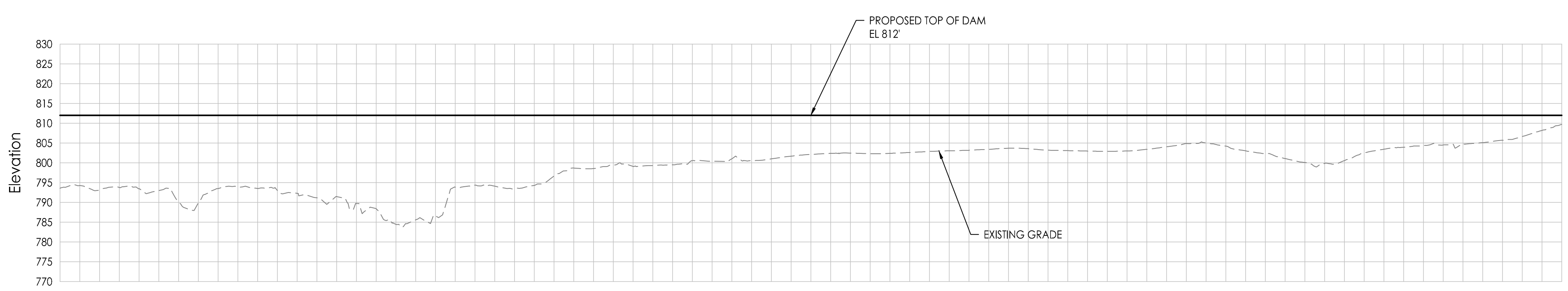
Drawing No. #

Revision 0

Sheet 9 of 15





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HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

Title
EAGLE CREEK DRY STORAGE BASIN
EXHIBIT 5 - PLAN AND PROFILE

Permit-Seal

Project Number: 174316204
File Name: 174316204_EC_storage_plan_prof.dwg
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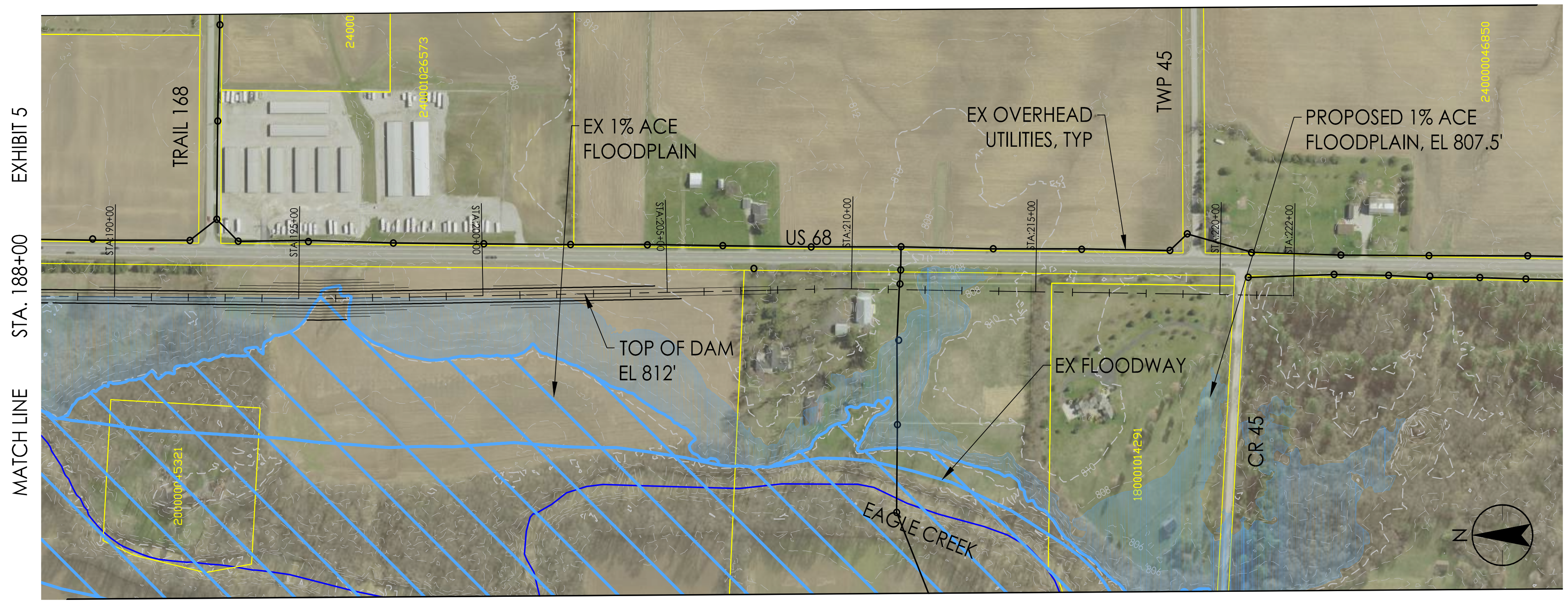
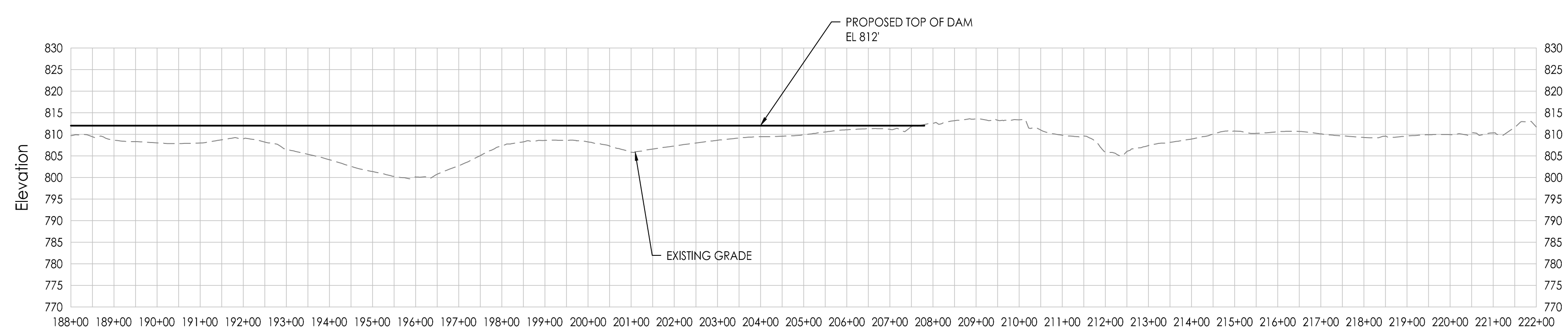
Drawing No. #
Revision 0
Sheet 10 of 15





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HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

Title
EAGLE CREEK DRY STORAGE BASIN
EXHIBIT 6 - PLAN AND PROFILE

Project Number: 174316204
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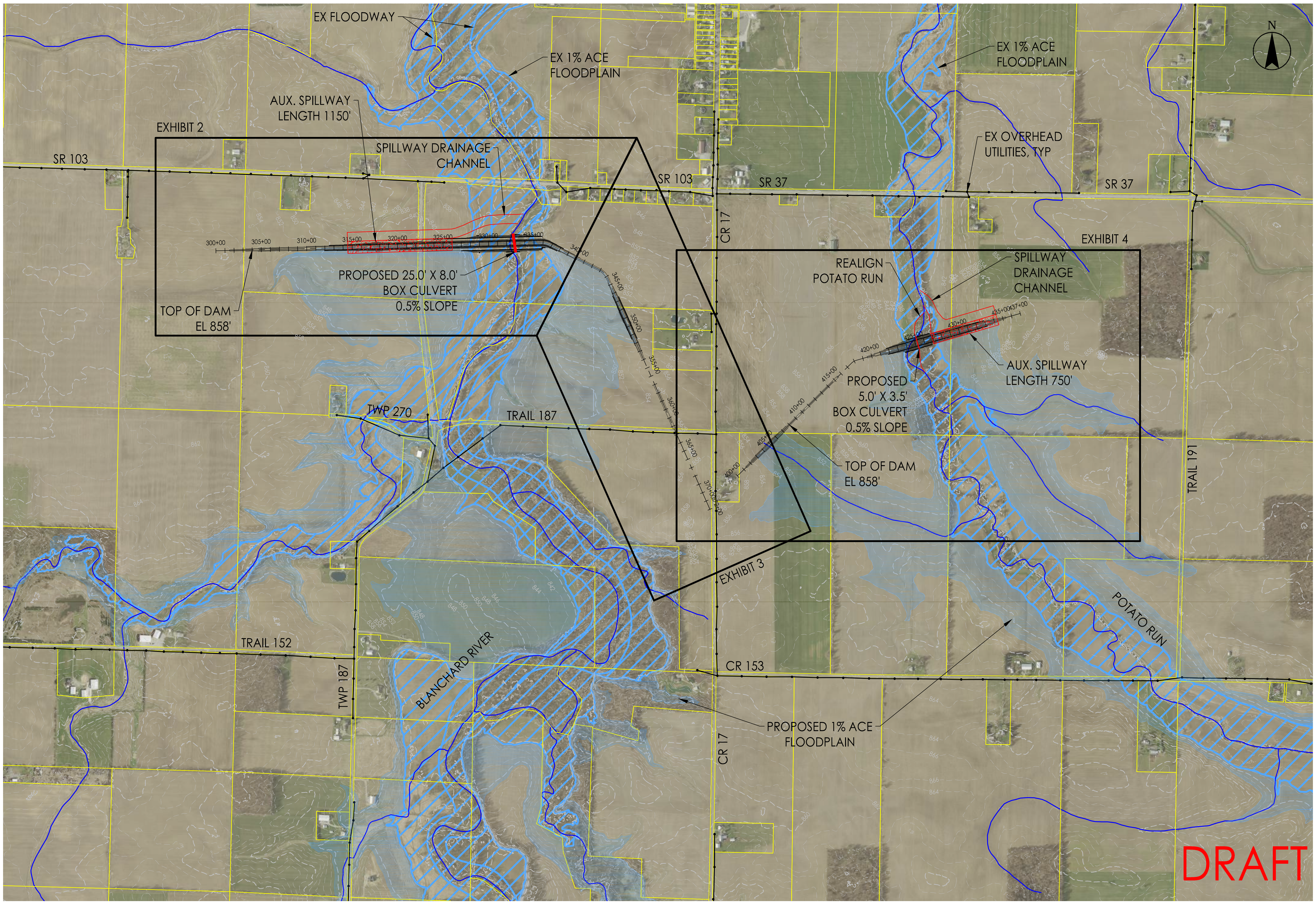
Drawing No. #
Revision 0
Sheet 11 of 15



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Revision	By	Appd.	YY.MM.DD

Issued	By	Appd.	YY.MM.DD

Client/Project
MAUMEE WATERSHED CONSERVANCY DISTRICT

HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT

Hancock County, Ohio

Title
MT. BLANCHARD DRY STORAGE BASIN
EXHIBIT 1 - PLAN OVERVIEW

Permit-Seal

Project Number: 174316204

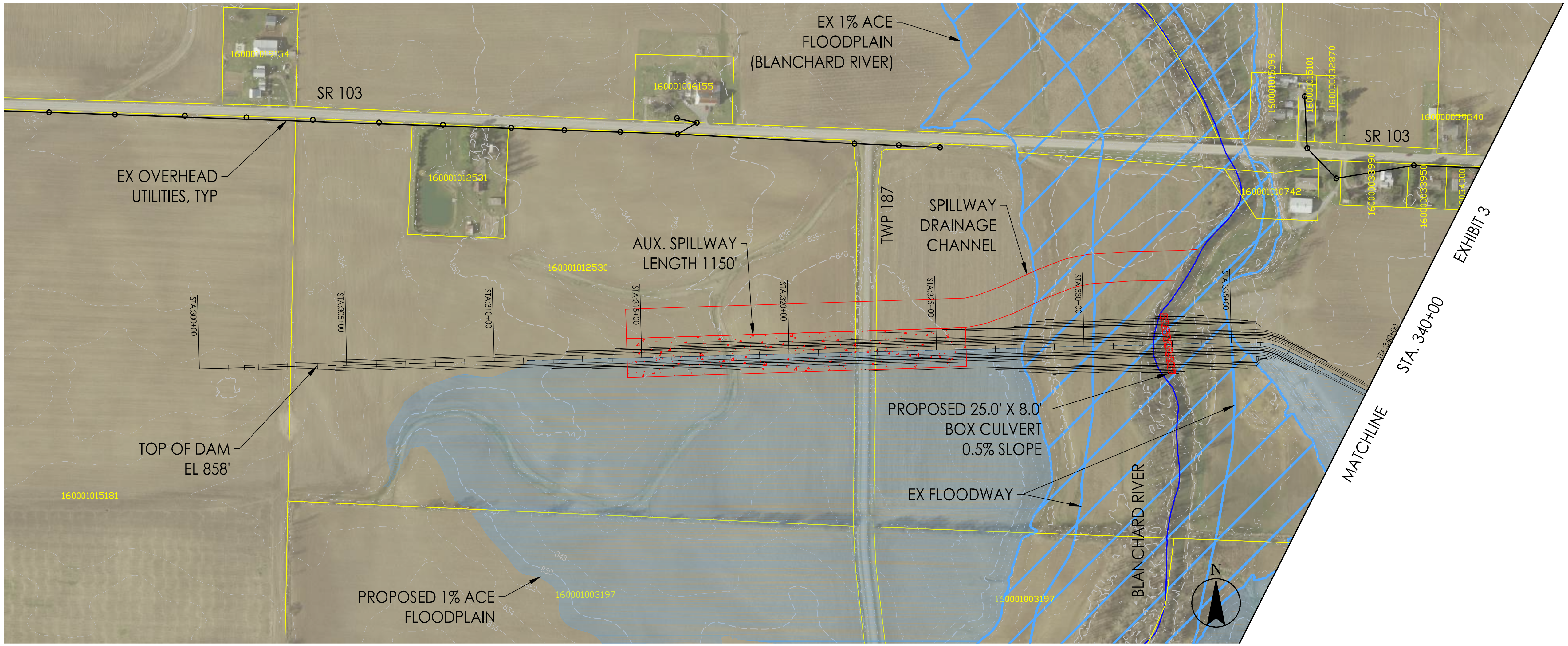
File Name: 174316204_MB_storage_plan_prof.dwg

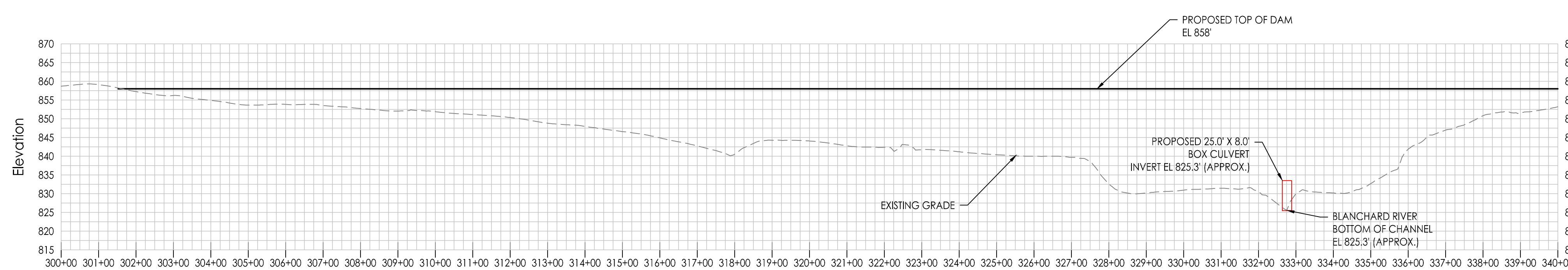
Dwn.	Chkd.	Dsgn.	YY.MM.DD

Drawing No. #

Revision 0

Sheet 12 of 15





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1"=20'V 0 10' 20' 40'

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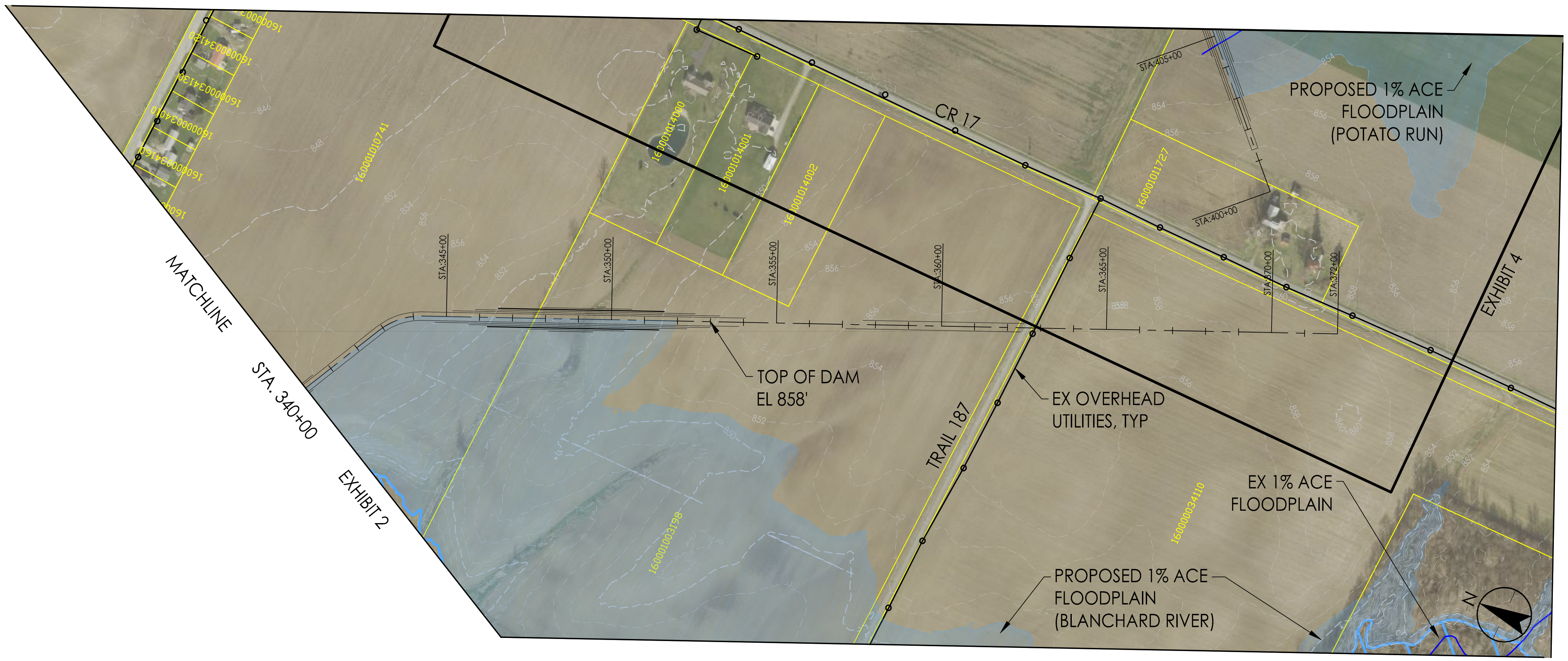
Client/Project
MAUMEE WATERSHED CONSERVANCY DISTRICT
HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

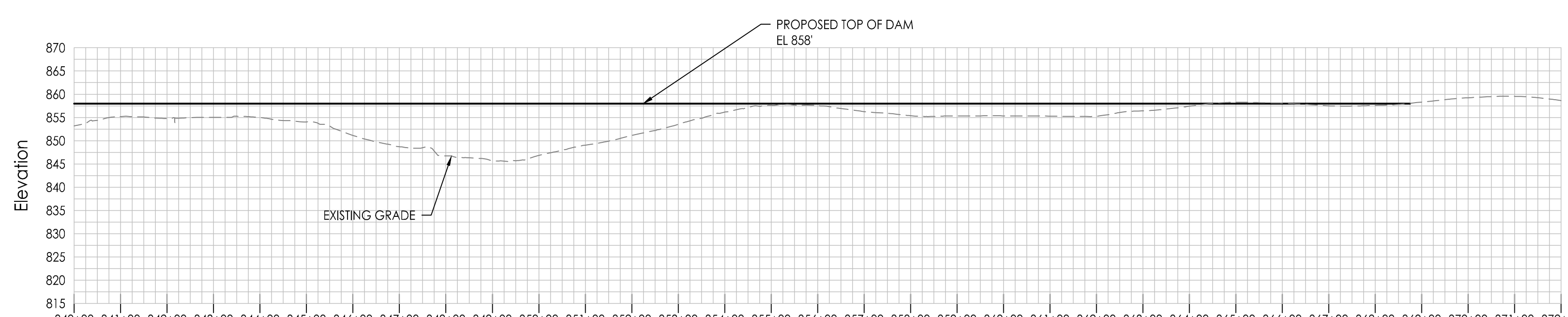
Title
MT. BLANCHARD DRY STORAGE BASIN
EXHIBIT 2 - BLANCHARD PLAN AND PROFILE

Permit-Seal

Project Number: 174316204
File Name: 174316204_MB_storage_plan_prof.dwg
Dwn. Chkd. Dsgn. YY.MM.DD

Drawing No. #
Revision 0
Sheet 13 of 15





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Client/Project
MAUMEE WATERSHED CONSERVANCY DISTRICT

HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT

Hancock County, Ohio

Title
MT. BLANCHARD DRY STORAGE BASIN
EXHIBIT 3 - BLANCHARD PLAN AND PROFILE

Permit-Seal

Project Number: 174316204

File Name: 174316204_MB_storage_plan_prof.dwg

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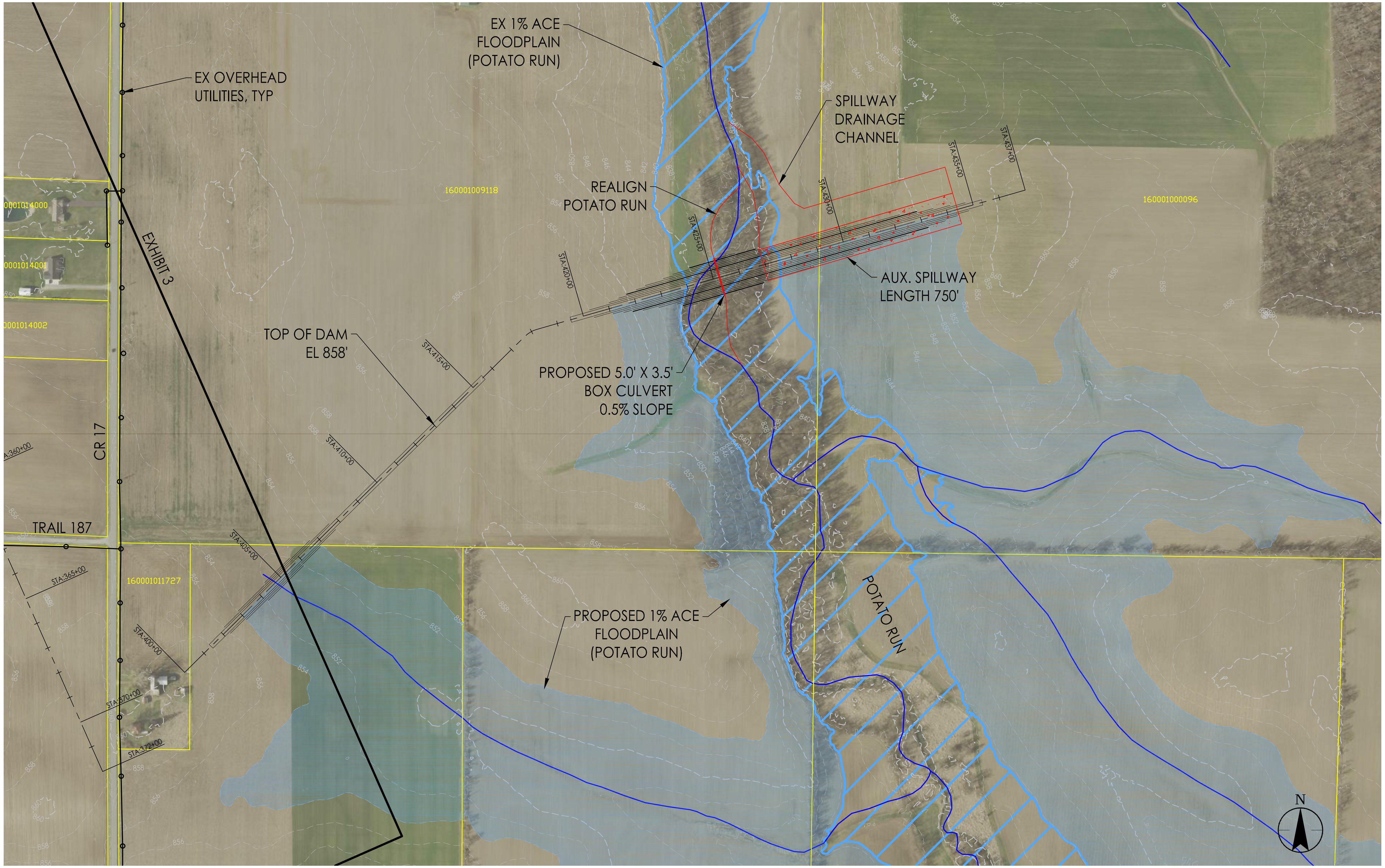
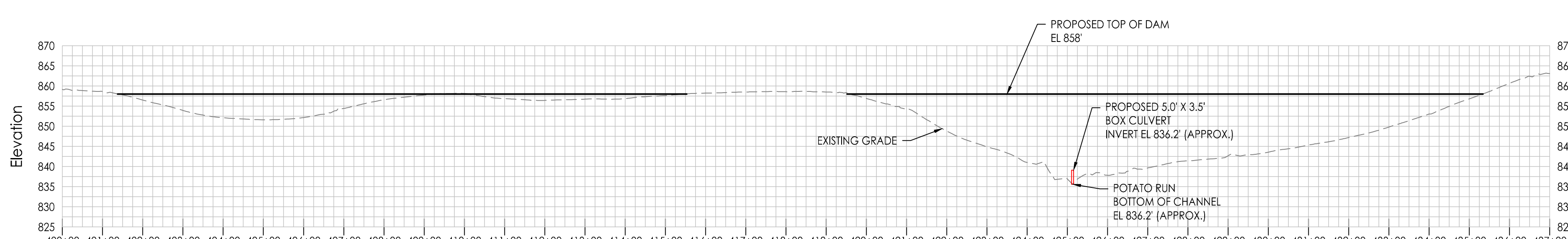
Drawing No. #

Revision 0 Sheet 14 of 15





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HANCOCK COUNTY FLOOD RISK REDUCTION PROJECT
Hancock County, Ohio

Title
MT. BLANCHARD DRY STORAGE BASIN
EXHIBIT 4 - POTATO RUN PLAN AND PROFILE

Permit-Seal

Project Number: 174316204

File Name: 174316204_MB_storage_plan_prof.dwg

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Drawing No. #

Revision 0

Sheet 15 of 15