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HYDRAULIC STUDY

Elwood Wilson Drain, Sam Craig and John Holleran Arms

Prepared for: Hamilton County Drainage Board

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1.0 INTRODUCTION

1.1 Project Background and Purpose

Clark Dietz was retained by the Hamilton County Drainage Board to prepare a hydraulic study for the Sam Craig and John Holleran Arms of the Elwood Wilson Drain. The drain was originally constructed in 1887. The watershed is located east of SR 37, on both sides of 186th Street. The watershed drains approximately 1.33 square miles and discharges into the Elwood Wilson Drain, which flows downstream into Stony Creek. The Sam Craig and John Holleran Arms are shown in Figure 1-1 with a light blue line. Neighboring regulated drains are shown with a dark blue line. The watershed is outlined in red.

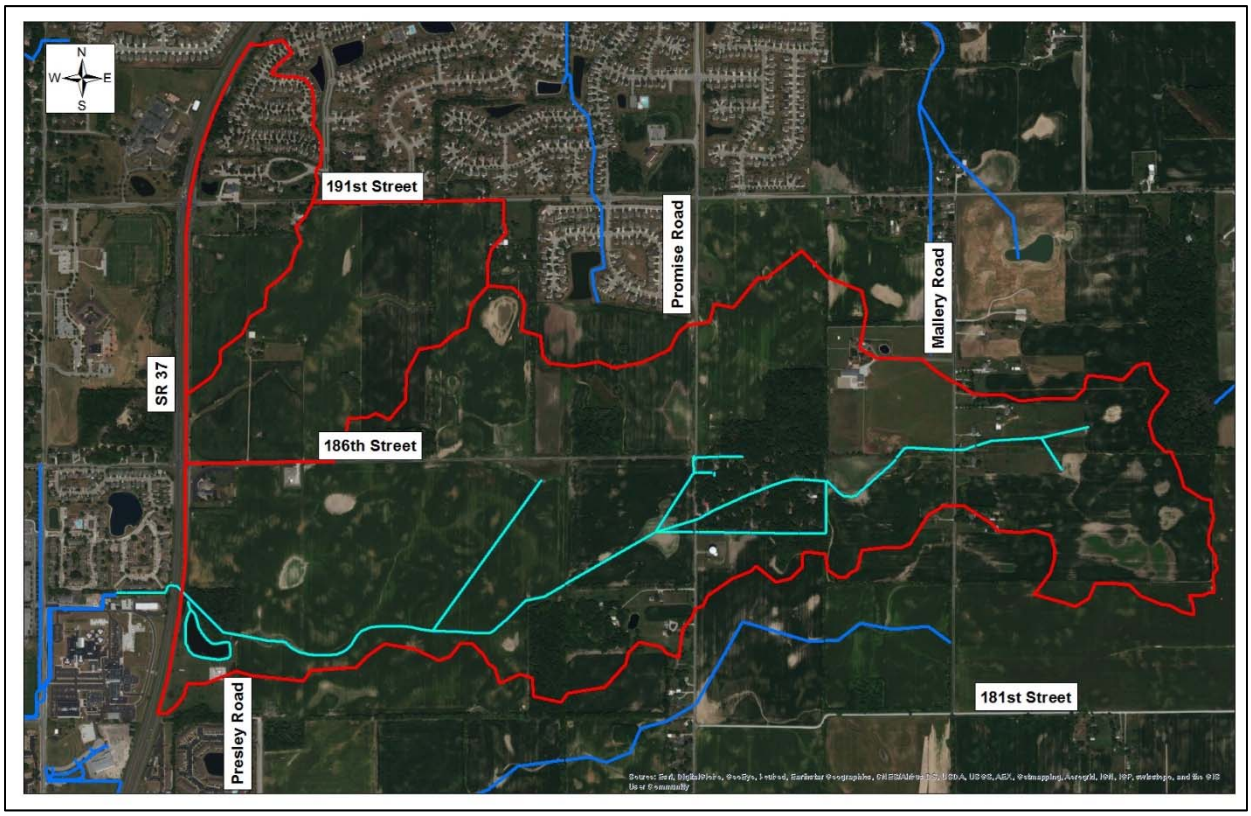


Figure 1-1 – Project Area Map

The watershed is a mix of about 90% agricultural land and 10% single family residences. The drain flows from east to west and is composed entirely of closed field tiles ranging in size from 10 inches to 18 inches in diameter. The drain crosses SR 37 half way between 181st Street and 186th Street. A detention pond is located south of the drain crossing on the east side of SR 37. This pond was constructed by Hamilton County as part of the Jail Complex project located west of SR 37.

North of 186th Street, three culverts cross under SR 37 and drain to the west. These culverts drain to a designated wetland area on the west side of the highway that is used by the Noblesville school system as an outdoor educational venue known as the Chinquapin Outdoor Education Center and Mallery Woods area.

There are plans to extend Presley Drive north to 186th Street. The road extension will cross the existing drain. This future project will be taken into consideration with the recommendation for the drain at this location.

The majority of the watershed is currently agricultural but is expected to develop, especially in light of the planned roadway and future sanitary sewer service extensions planned by the City of Noblesville. It will be critical to have an improved outlet for upstream development, as the current enclosed drain and overland flow paths are undersized and/or in poor condition to adequately serve the future development.

A key objective of this hydraulic study will be to evaluate if the flow of the Sam Craig and John Holleran Arms could be diverted north along the east side of SR 37 to the Musselman Drain to free up capacity in the Elwood Wilson Drain Craig/Holleran Arms as well as further downstream in the watershed. This diversion could be an open channel or a piped system. Because of the proximity to SR 37, this potential drain diversion will need to meet both the drainage specifications of Hamilton County and the Indiana Department of Transportation (INDOT). The potential impacts to the designated wetland areas on the west side of SR 37 will also be identified and reviewed as a part of this study. In addition, there are two closed drains in an adjacent watershed to the north (the Monarch Springs Arm and WS Burnau Arm) that drain north to the Musselman Drain. It may be possible to divert some of the Craig/Holleran Drain watershed areas north into these two arms provided these arms have available capacity and are at the proper elevation.

The Fishers Oak Wood residential development, referred to herein as the Oak Wood Community, on the south east corner of 186th Street and Promise Road, experiences frequent flooding and standing water for extended periods of time. This hydraulic study will include an investigation into the reason for these issues and a solution to improving the drainage through this neighborhood.

The objectives of this study were to:

- Investigate the possibility of diverting a portion of the drainage shed north to the Musselman Drain and, if so, determine if any adverse flooding issues would result in the Musselman watershed.
- Develop a stormwater runoff model to simulate existing runoff and flooding potential and estimate possible increases in runoff that may be caused by future development.
- Define existing and potential future flooding problems in the watershed.
- Evaluate possible regional detention basins and their effectiveness in controlling future flood peaks. Include an economic analysis of such basins for the whole basin, owners of tracts adjacent to the drain and those owners of tracts not adjacent to the drain. Also review possible multi-use application of regional detention sites.
- Develop a set of solutions to existing and potential future flooding problems under existing and future development conditions. These solutions may include system capacity increases, roadway crossing improvements, surface or underground detention, two stage ditching, cut off channels and/or diverting runoff to other drainage watersheds.
- Identify wetland areas.
- Obtain public input regarding the study.
- Develop engineering construction plans for the Elwood Wilson Drain, Sam Craig and John Holleran Arms based on results of the hydraulic study (under future addendum or separate contract).
- Identify financing mechanisms for implementation of needed improvements.

1.2 Data Collection and Review

ESRI GIS Shape Files were downloaded from the Hamilton County Geographic Information System Data Download Server. This included building footprints, regulated drains, soil types, roads, and 1 foot contours. These files were loaded into the program Esri® ArcMap™ 10.5 and used to determine the boundary of the Sam Craig and John Holleran Arms watershed and the sub-watersheds. Aerial photography was added to identify land use types in the project area. The City of Noblesville provided a figure from their 2007 Sanitary Sewer Masterplan which identified the existing sanitary sewer and future sewer locations. The City of Noblesville's website includes a Future Land Use Map that was used to identify the future land use of undeveloped parcels of land. The Noblesville maps and figures are included in Attachment 1.

A field visit was conducted on March 23, 2017. The existing culverts in the watershed were inspected and photographed. Areas with evidence of poor drainage were identified and noted. Williams Creek Consulting was retained as a subconsultant to perform a wetland investigation of the project area.

Previous plans and studies in the watershed were collected and reviewed. As-built drawings for the Peterson and Burnau Arms of the Musselman Drain were used to review the existing capacity of the stormwater system to the north. As-built drawings of the drain around the Hamilton County Juvenile Service Center were used to establish the capacity of the downstream system west of SR 37.

2.0 HYDROLOGIC ANALYSIS

2.1 Hydrologic Model Development

The hydrologic analysis of the watershed was performed using HEC-HMS, version 3.5. HEC-HMS is a computer model developed by the U.S. Army Corp of Engineers capable of simulating runoff from various land uses and soil types, combining subbasin hydrographs, and routing flow.

2.2 Watershed Delineation

The Hamilton County GIS 1 foot interval contour data was used to delineate the overall watershed and subbasins of the Sam Craig and John Holleran Arms. A map of the delineation, including the 12 subbasins, can be found in Attachment 2. The total watershed area is approximately 1.33 square miles. Subbasins 01 through 10 are primarily agricultural land with a few single family residences. Subbasin 07 is an exception to this; half of the basin is a residential development and the other half is agricultural. Subbasins 11 and 12, west of SR 37, are institutional property where a school is located. The watersheds of the three culvert crossings under SR 37 are individually each less than 1 square mile. Drainage areas less than 1 square mile are not within the jurisdiction of the Indiana Department of Natural Resources (IDNR). IDNR does not have jurisdiction of any part of the watershed east of SR 37.

2.3 Subbasin Parameters

Per the Hamilton County Stormwater Management Technical Standards Manual, the runoff rates and contributing drainage areas were determined based on the Natural Resource Conservation Service (NRCS) Technical Release 55 (TR-55) time of concentration and curve number calculation methodologies. Attachment 2 shows the delineation of subbasins, time of concentration paths, and basins labels. Attachment 3 includes the curve number, time of concentration, and lag time calculation worksheets for each of the subbasins and reaches.

Subbasin curve numbers were determined using the weighted average of curve numbers assigned to individual sub-areas of homogeneous land use and soil types. Existing condition land use was identified using aerial photography through the county's GIS and a site visit. The hydrologic soil types in the area are mainly type B or D. The individual curve numbers for each land use and soil type were selected from tables in SCS TR-55, Urban Hydrology for Small Watersheds, 1986. Subbasin parameters are summarized in Table 2-1.

Table 2-1 – Subbasin Hydrologic Parameters

Subbasin	Area (Sq Mi)	Lag Time (min)	Curve Number
01	0.16	28.6	74.2
02	0.06	15.8	78.6
03	0.09	27.4	78.2
04	0.11	38.2	78.3
05	0.05	20.8	77.5
06	0.12	45.9	77.5
07	0.11	17.4	75.0
08	0.19	37.7	73.7
09	0.12	38.4	76.2
10	0.24	33.2	76.3
11	0.03	9.8	73.0
12	0.06	17.3	74.3

Future development of the watershed was determined using the Future Land Use Map available on the City of Noblesville's website. Subbasins 01 through 10 are primarily agricultural lands which could be developed into single family residential developments.

2.4 Design Storm Events

Per the Hamilton County Stormwater Management Technical Standards Manual, the watershed has been evaluated for the 100-year flow condition to ensure that all buildings are properly located outside the 100-year flood boundary and that flow paths are confined to designated areas with sufficient regulated drain easement.

A design storm event is defined by precipitation depth, duration, and the time distribution. Precipitation depths were taken from the Rainfall Frequency Atlas of the Midwest, Bulletin 71. The storm durations ranging between 1 and 24 hours were modeled to determine the controlling storm event at recurrence intervals of 100 and 10 years. The precipitation distribution curve for the storm events was developed using the Huff Curves. The rainfall recurrence intervals, depths, and time distributions (Huff Curves) are included in Attachment 4.

2.5 Existing Condition Model Results

The hydrologic model was developed to simulate the 10 and 100-year storm events. Storm durations of 1, 3, 6, 12, and 24 hours were evaluated to determine the critical storm duration (the duration that produces the highest peak flow rates). The 6 hour storm was the critical storm for the Sam Craig and John Holleran Arms.

The peak discharge was determined at locations along the drain where the subbasins converged together. Table 2-2 lists the peak discharges along the drain. Figure 2-1 shows the locations where the flows were applied, and the existing Q100 discharges at those locations. In the figure, the overall watershed is outlined in red, the subbasins are outlined in yellow, and the regulated drain is a light blue line.

Table 2-2 – Existing Condition Peak Discharges

	Flow 1	Flow 2	Flow 3	Flow 4	Flow 5	Flow 6	Flow 7
Existing Q10 (cfs)	43.7	61.6	124.5	169.0	260.3	35.1	59.0
Existing Q100 (cfs)	104.6	144.5	284.5	384.0	591.4	81.7	144.1

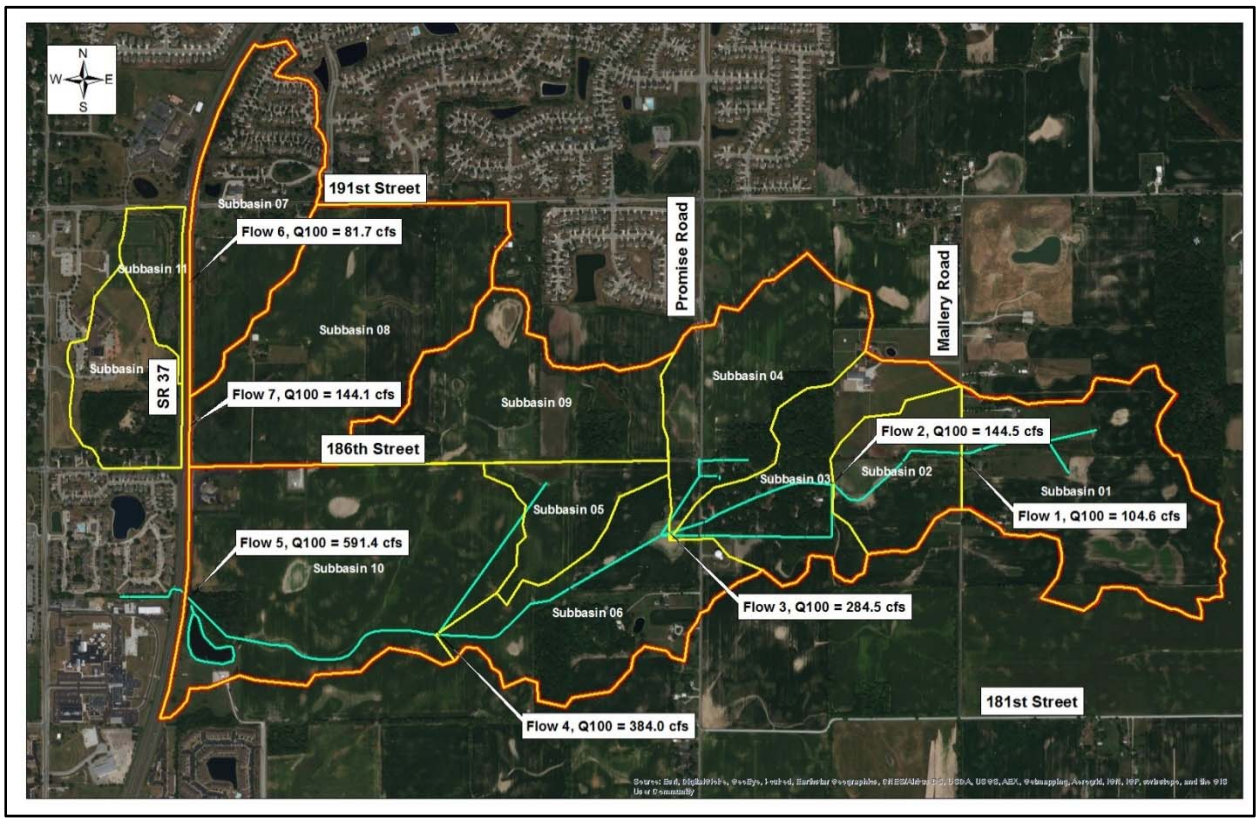


Figure 2-1 – Discharge Location Map

The calculated peak discharges were compared with IDNR's coordinated discharges, the Flood Insurance Study (FIS), and neighboring watersheds. The FIS did not provide a discharge for a watershed one square mile in area but did list a 1% annual chance discharge of 240 cfs for a drainage area of 1.95 square miles along the Wilson Drain, at SR 37. IDNR's coordinated discharge graph of the Wilson Drain also did not list a discharge for a one square mile area, but listed a discharge of 670 cfs for a two square mile drainage area. A watershed study was completed in 2016 for the neighboring regulated drain to the south, the E.M. Hare Arm of the Elwood Wilson Drain. The E.M. Hare Arm has a watershed area of 0.99 square miles, similar to the 0.94 square mile drainage area at the SR 37 culvert south of 186th Street. The E.M. Hare had a calculated peak discharge of 580 cfs, close to the 591 cfs calculated for the Craig-Holleran Drain. The discharge values from the FIS and the coordinated discharge graph are widely inconsistent. The more conservative discharge values calculated with HEC-HMS will be used for the evaluation.

2.6 Future Development Results

Per the Hamilton County Stormwater Management Technical Standards Manual, the allowable release rate for a newly developed property is 0.1 cfs per acre for a 10-year storm event and 0.3 cfs per acre for a 100-year storm event. Subbasins 01 through 10 are currently agricultural land and are zoned such that they could become single family residential developments in the future. Table 2-3 lists the acreage and allowable release rates for each of the sub basins of the watershed identified in Figure 2-1.

Table 2-3 – Post-Development Peak Discharges with Hamilton County Detention Policy Implemented

	Flow 1	Flow 2	Flow 3	Flow 4	Flow 5	Flow 6	Flow 7
Area (acres)	101.2	139.6	267.1	371.3	603.4	70.8	123.6
Developed Q10 (cfs)	10.1	14.0	26.7	37.1	60.3	7.1	12.4
Developed Q100 (cfs)	30.4	41.9	80.1	111.4	181.0	21.3	37.1

2.7 Existing and Future System Problems

Deficiencies in the drainage system were identified by the developed models. This study includes an evaluation of the existing regulated drain and its functionality. Culverts located within the watershed boundary, both along the regulated drain and in other locations, were evaluated for flow capacity and the integrity of the structures. Roadway locations that are prone to stormwater overtopping were identified as well as properties with poorly defined drainage routes that frequently pond after rain events.

One limitation of the existing regulated drain system is the capacity of the culvert under SR 37. This culvert is located at the downstream end of the watershed and is a controlling factor in the development of any solution. The culvert under SR 37, 1,275 feet south of 186th Street, is a 4 foot wide by 5 foot high concrete box culvert. The culvert is in good condition and free of weeds and debris, but is undersized for the existing peak discharge of the watershed. The structure has a flow capacity of 230 cfs, while the watershed upstream of the culvert has a Q100 peak discharge of 591 cfs. A detention pond is located upstream of this structure on the east side of SR 37. During smaller rain events, such as a Q10 storm which produces a peak discharge of 260 cfs, stormwater will stage upstream of the culvert and be stored in the detention pond. During a Q100 storm, the detention pond's capacity is exceeded and stormwater stages and overflows to the adjacent farm field. The ponding water is not at risk of overtopping the roadway of SR 37, but will overflow south across the boundary of the Craig Holleran watershed and into the E.M. Hare watershed.

Increasing the culvert capacity at this location is not as simple as constructing a larger culvert under SR 37. Approximately 80 feet further downstream the flow through this culvert is routed to a 5 foot diameter CMP. This pipe is 500 feet long and runs along the northern boundary of the jail complex. The flow is routed around the north and west border of the complex through a 54 inch RCP and a parallel 18 inch RCP. If the culvert under SR 37 were enlarged this downstream system would need to be increased in size to compensate for the increased flow downstream.

The reach of the regulated drain evaluated begins east of Mallery Road and extends to SR 37. The drain is a closed field tile ranging in size from 7 inches to 18 inch diameter pipe. During large rain events the system quickly reaches capacity and the majority of flow travels overland along poorly defined low land paths in the topography. Ponding in the agricultural fields is common. To improve the existing condition and to accommodate future development, the capacity of the drain will need to be increased.

The drain passes through the center of the Oak Wood Community, which is near the intersection of Promise Road and 186th Street. This community historically has had issues with poor drainage. In 1992, a 12 inch diameter storm sewer was added along the north and south border of the neighborhood to help provide relief. The improvements did not completely resolve the issues and drainage is still an issue for the community. The regulated drain and the two 12 inch diameter arms come to a junction downstream of the community on the west side of Promise Road. Stormwater pools at this location after large storm events. The junction point of the drains is a bottle neck for the upstream stormwater. Promise Road between 181st Street and 186th Street is documented on the County's "Roads That Flood List". This segment of road was closed in 2013, 2015, and 2017 because of water across the road.

On May 4 - 5, 2017 a large rain event occurred, and the watershed was visited to directly observe existing drainage problems. Attachment 5 is a map documenting the location of flooding areas, roadway overtopping, and photographs of the visit. According to the National Weather Service Advanced Hydrologic Prediction Services, Radar Precipitation Estimates, May 4 - 5, 2017, approximately 3 to 4 inches of rain fell over a two day period.

Many of the culverts in the watershed were found to be undersized or poorly maintained. An in-depth evaluation of each culvert is included in Section 3.3 Culvert Evaluation. This section includes the results of hydraulic modeling and improvement recommendations for each culvert.

3.0 SOLUTION DEVELOPMENT

3.1 Introduction

In this chapter, solutions to minimize the occurrence of existing stormwater problems and to accommodate future development are evaluated. Existing culverts within the watershed were evaluated for their condition and capacity. Channel improvements were proposed which will improve conveyance capacity. Potential regional detention sites were identified and evaluated for their impact on reducing flows downstream. Conflicts with existing utilities and wetlands are discussed. The ability for future development to connect to the drain has been investigated. An estimated cost to complete the developed solutions are included. To the extent possible, the recommended improvements will be located within the existing easement of the regulated drain. The existing easement is 75 feet from the center of the drain on each side.

3.2 Regional Detention Basin Options

Part of this study included the evaluation of regional detention basins within the watershed. Regional detention basins could be beneficial to reduce peak flow rates. The location of detention ponds with the potential to produce the highest benefit are areas of depressed topography with large upstream drainage areas. The areas identified as potential locations for regional detention are shown in Figure 3-1, with blue hatched polygons. Property lines are outlined in gray.

Figure 3-1 – Regional Detention Sites

Regional Detention Site 1 is located in watershed subbasin 02. This is a naturally depressed area located adjacent to the John Holleran Drain that spans 2 parcels. Water typically pools in this area after rain events. This area is located upstream of the Oak Wood Community which experiences frequent flooding. Placing a

regional detention pond at this location would help lower the peak discharge that passes through and around the Oak Wood Community. The discharge from both subbasins 01 and 02 would be attenuated at this location and could reduce the peak discharge from 145 cfs to 42 cfs during the Q100 storm event.

Regional Detention Site 2 is in watershed subbasin 04. This area is located north of the Oak Wood Community and drains to the Fisher Oakwood Arm which connects to the Sam Craig Arm downstream of the community. A detention pond at this location could be used to attenuate flow from subbasin 04, into the Fisher Oakwood Arm or the flow could be diverted to the Peterson Arm of the Musselman Drain to the north, reducing flow in the Fishers Oakwood Arm and the main tile.

Regional Detention Site 3 is an alternate site for Regional Detention Site 2 and would be part of a system to divert flow from subbasin 04. Flow from subbasin 04 could not be connected directly to the Peterson Arm without attenuation, as the Peterson Arm is already designed to flow at full capacity during a Q100 rain event. The depressed area is located on two parcels on either side of Promise Road. The peak discharge of 78 cfs from subbasin 04 of the Craig Holleran Drain would be redirected and stored until the Peterson Arm has adequate capacity to accept the flow. By redirecting flow from subbasin 04 to the Peterson Arm, relief would be provided to the drainage system bottle neck at the junction of the Fishers Oakwood and John Holleran Arms.

Regional Detention Site 4 is in subbasin 05. This is a depressed area that collects flow from subbasin 05 and would route the flow. A detention pond at this location would reduce subbasin 05's Q100 discharge from 35 cfs to 9 cfs.

Regional Detention Site 5 is in watershed subbasin 10 and would consist of two ponds. The ponds are located along the surface water flow path from subbasin 09 to the Sam Craig Arm. Detention at this location would reduce the Q100 peak discharge originating from subbasin 09 from 81.2 cfs to 23.7 cfs.

Regional Detention Site 6 is also in watershed subbasin 10 and is located adjacent to the existing detention pond for the Correctional Facility. This site also would receive flow from the entire watershed. A pond at this location could store 10 acre-feet of floodwater and reduce the footprint of the surface flow floodplain in this area. Detention at this location would also eliminate the occurrence of floodwater spilling over from the Sam Craig watershed to the E.M. Hare watershed to the south during a Q100 event.

Significant benefits can be achieved by adding regional detention throughout the watershed. Additional evaluation of the benefits and costs of combinations of regional detention options is included in Chapter 4.0 (Section 4.5) of this report. Each regional detention basin would provide the benefit of reducing peak flow in the drain at the SR 37 culvert crossing by delaying the timing of the peak flow from the watershed until after the peak of the storm has passed. Regional Detention Sites 2 and 3 have the added benefit of diverting flow out of the watershed and reducing the peak flows at the outlet.

3.3 Culvert Evaluation

Per the Hamilton County Stormwater Management Technical Standards Manual, culverts shall be capable of accommodating, without overtopping the road, peak runoff from a 100-year frequency storm when crossing under a road. Two existing culverts, on Mallery Road and 186th Street, critical to the solutions developed in this study, were evaluated with the hydraulic program HY-8 version 7.30. HY-8 model results are provided in Attachment 6. In Figure 3-2, the location of the existing culverts in the watershed are shown with a gold star.

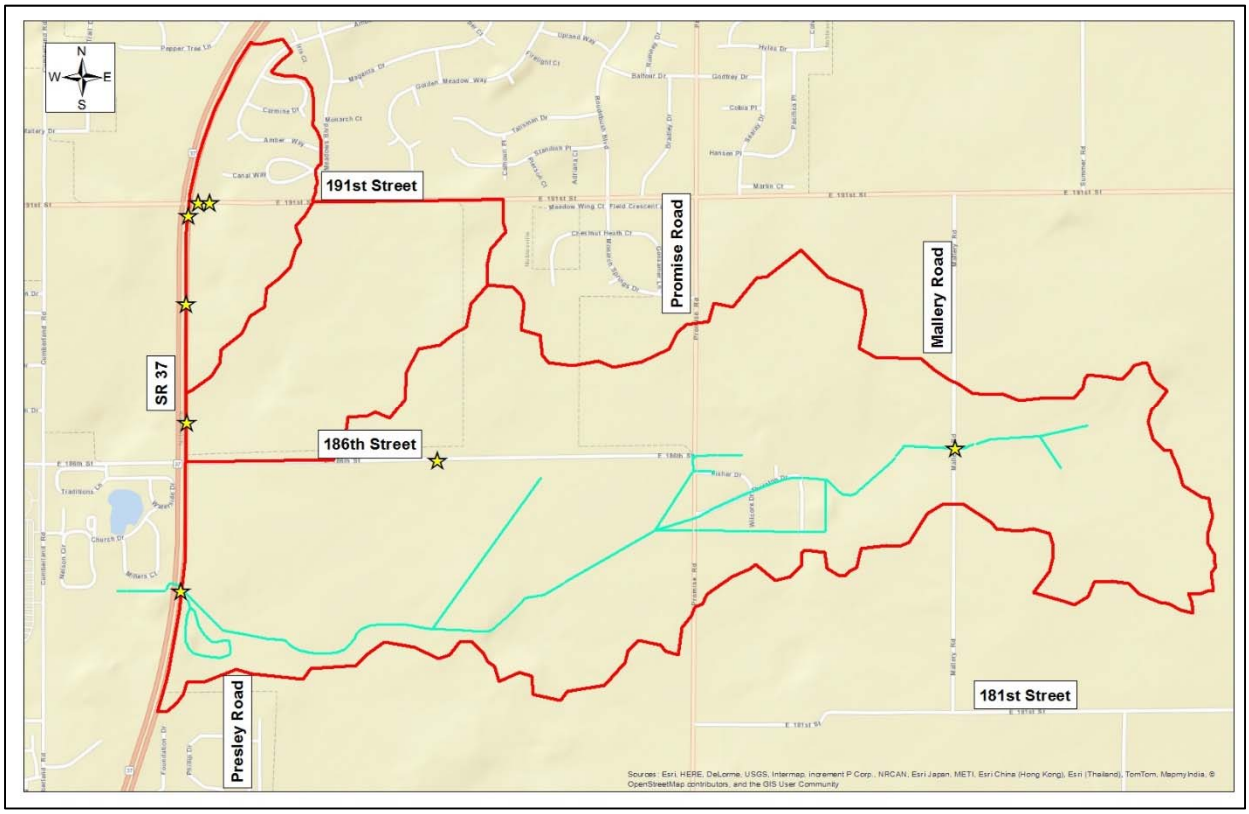


Figure 3-2 – Existing Culvert Locations

The existing culvert under Mallery Road, 2,570 feet south of 191st Street, is a 24 inch CMP. Watershed subbasin 01 is upstream of this structure. The existing channel both upstream and downstream of this structure is poorly defined. The existing Q100 peak discharge at this location is 104.6 cfs. The future Q100 peak discharge assuming full development with stormwater detention would be 30.4 cfs. To accommodate the existing peak discharge this culvert would need to be replaced with a 3 foot by 5 foot concrete box culvert and the channel would need to be lowered 3 feet from the invert of the existing culvert. To accommodate the future peak discharge this culvert would need to be replaced with a 30 inch diameter RCP and the channel would need to be lowered 3 feet from the existing culvert invert. Figures 3-3 and 3-4 show the upstream and downstream ends of the existing culvert.

Figure 3-3 – Upstream of Mallery Road Culvert

Figure 3-4 – Downstream of Mallery Road Culvert

The existing culvert under 186th Street, 2,570 feet east of SR 37, is an 18 inch CMP. This structure is not directly connected to the regulated drain. This structure connects watershed subbasin 09 to subbasin 10. The existing channel downstream of this structure is poorly defined and stormwater pools in a depressed area following large rain events. The existing Q100 peak discharge at this location is 81.2 cfs. The future Q100 peak discharge assuming full development (with detention) would be 23.7 cfs. To accommodate the existing peak discharge this culvert would need to be replaced with a 3 foot by 4 foot concrete box culvert and the channel would need to be lowered 2 feet below the invert of the existing culvert. To accommodate the future peak discharge (full development with detention) this culvert would need to be replaced with a 24 inch diameter RCP and the channel would need to be lowered 2 feet below the existing culvert invert. Figures 3-5 and 3-6 show the upstream and downstream ends of the culvert.

Figure 3-5– 186th Street, Upstream

Figure 3-6 – 186th Street, Downstream

Four culverts within the watershed cross under SR 37, flowing from east to west. SR 37 - Culvert 1 (see Figure 3-7) crosses 1,275 feet south of 186th Street and directly connects the Sam Craig Arm from the east side to the west side of the road. The existing structure is a 4 foot wide by 5 foot high concrete box culvert with an upstream drainage area of 0.94 square miles. This structure was originally built to serve as both a cattle crossing and a drainage structure. This structure is undersized for the existing conditions peak discharge of this watershed. Without the flood relief provided by the adjacent detention pond and the overland flow spillway to the E.M. Hare watershed, this structure would need to be a 12 foot wide by 6 foot high concrete box culvert to accommodate the existing flow. The existing box culvert is large enough to handle the Q100 peak discharge of 181.0 cfs for the future fully developed watershed with detention. Figure 3-6 shows the culvert. Because of the complexity of modeling this culvert in conjunction with the adjacent detention pond and the overland flow spillway to the south, this structure was modeled with the program XP-SWMM rather than HY-8. The discharge hydrograph for the design storm, created in HEC-HMS, was imported to XP-SWMM. Within the model the geometry of the culvert, detention pond, and storage area in the adjacent field were defined by nodes.

Figure 3-7 – SR 37 Culvert 1

SR 37 - Culvert 2 (see Figure 3-8) crosses 420 feet north of 186th Street and connects subbasin 08 to the west side of the road. The culvert outlets to a designated wetland area. The existing structure is an elliptical CMP with a span of 71 inches and a rise of 47 inches and an upstream drainage area of 0.23 square miles. This structure is sized appropriately to accommodate the existing Q100 peak discharge of 144.3 cfs. Rust was visible on the bottom side of the culvert. The culvert appears to be structurally sound. No upgrades or improvements are recommended for this structure.

Figure 3-8 – SR 37 Culvert 2

SR 37 - Culvert 3 (see Figure 3-9) crosses 740 feet south of 191st Street and connects the south half of subbasin 07 to the west side of the road. The culvert outlets to a designated wetland area. The existing structure is a 24 inch CMP with an upstream drainage area of 0.05 square miles. The drainage area is primarily agricultural land. Water will stage upstream of this structure from the Q100 peak discharge of 39.7 cfs; but the runoff is contained within the ditch right of way. The structure has sufficient capacity for the Q100 post development flow from subbasin 07 without staging in the ditch. The only defined channel to this structure is along SR 37.

Figure 3-9 – SR 37 Culvert 3

SR 37 - Culvert 4 (see Figure 3-10) crosses 170 feet south of 191st Street and connects the north half of subbasin 07 to the west side of the road. The culvert outlets to a designated wetland area. The existing structure is a 24 inch CMP with an upstream drainage area of 0.06 square miles. The drainage area is a fully developed single family residential community. The stormwater runoff is regulated by a detention pond north of 191st Street. This structure is sized appropriately to accommodate the existing Q100 peak discharge of 10.8 cfs. The bent metal end section is restricting the inlet and needs to be repaired.

Figure 3-10 – SR 37 Culvert 4

There are two culverts on 191st Street upstream of SR 37 Culvert 4. The first structure is just east of SR 37. The structure is a 15 inch CMP located in the roadside ditch. The upstream inlet on the north side of 191st Street appears sound, is clear of vegetation, and protected with rip rap at the opening. The outlet of the culvert has slight bends at the top. Downstream of this culvert is a channel lined with rip rap. This culvert receives flow that runs off of SR 37. This structure does not have any issues and has sufficient capacity. Figure 3-11 shows the culvert.

Figure 3-11 – 191st Street Culvert, Looking South

The second culvert on 191st Street is located 200 feet east of SR 37. This structure is a 24 inch reinforced concrete pipe (RCP). The culvert is an overflow for the detention pond next to the Fire Station. The inlet to the pipe is obstructed with accumulated sediment and is estimated to be functioning at 50 percent of its capacity. The outlet is open and free of debris and weeds. This culvert has sufficient capacity for existing and future flows. Figure 3-12 shows the culvert.

Figure 3-12 – 191st Street Culvert, From Pond

3.4 Regulated Drain Improvements

Most of the land use within the Sam Craig and John Holleran Arm watershed is currently agricultural. Conveyance improvements are needed for both the current condition of the land and to prepare for future development. The existing and future conveyance needs of the watershed can be met by replacing the existing closed field tile system with a combination of new storm sewer pipe and open channel drainage. In this section, we identify the required system improvements necessary to convey a 100 year storm event within the watershed. Advantages and disadvantages of diverting existing flow north to the Musselman Drain are also discussed in section 3.5.

Per the Hamilton County Stormwater Technical Standards Manual, the required side slopes of an open channel should be graded at a slope of 3:1. Grass waterways and rip rap lined channels would both have a Manning roughness coefficient of 0.035. The channel slope will be designed such that the flow velocities stay between a minimum of 2 feet per second and a maximum of 4 feet per second in vegetated swales. The capacity of the proposed drain segments was verified using the Manning's equation. The capacity calculations are included in Attachment 7. A detailed explanation of the proposed drain improvements follows.

Improvements were evaluated in five main segments beginning at the upstream end of the regulated drain and proceeding downstream to the culvert at SR 37. A profile figure was created to illustrate the topography of the existing ground compared to the flow line of the proposed drain improvements and is included in Attachment 8. Figure 3-13 is a plan view with the end point of each drain segment labeled.

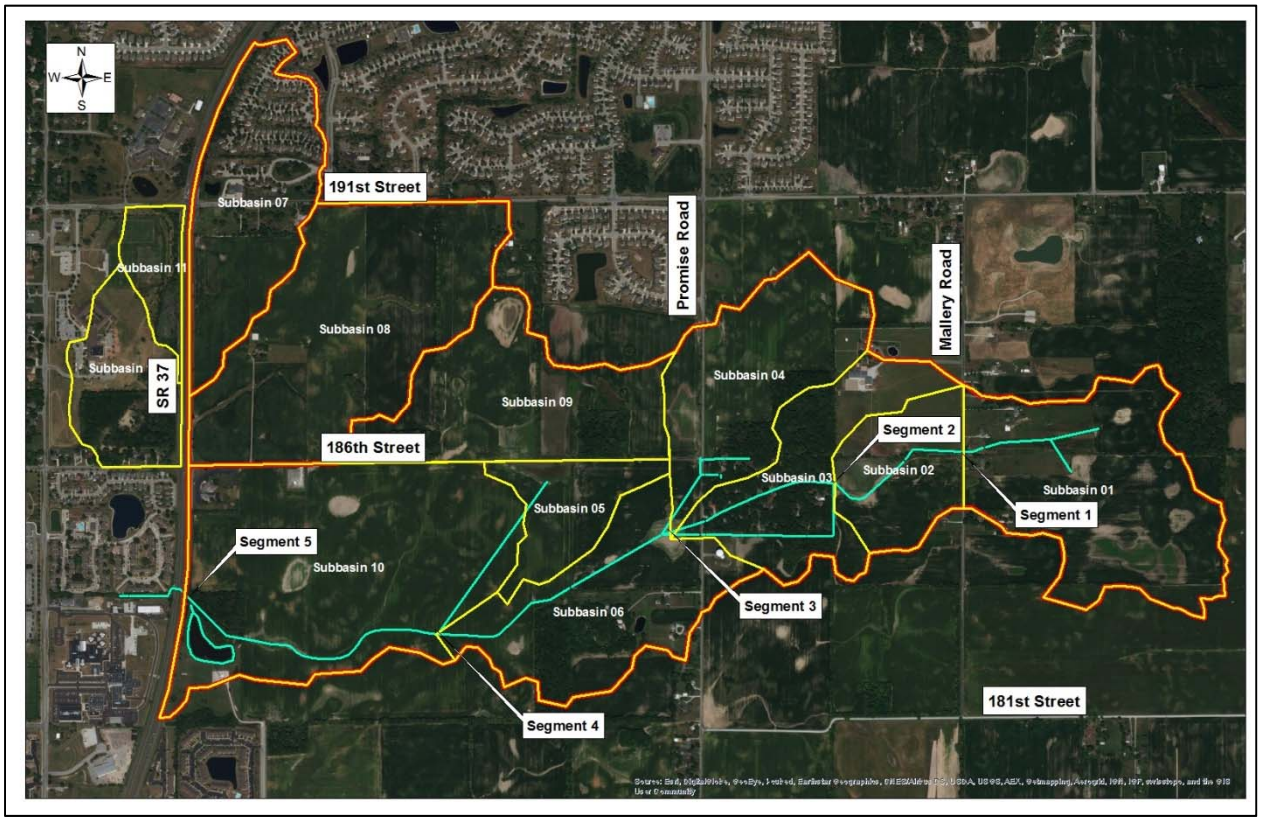


Figure 3-13 – Drain Segments

Segment 1 of the drain improvements begins 1,300 feet upstream of Mallery Road and extends to Mallery Road. The drain will begin at an invert elevation of 805.5 feet, which is 5 feet lower than the existing ground,

and will have a continuous slope of 0.0031 feet per foot (0.30%). The downstream end of the segment will have an elevation of 803.2 feet on the east side of Mallery Road. One option is to construct this segment as an open channel with a depth between 3 to 5 feet and a bottom width of 3 feet for the segment. This would provide a flow capacity of 118 cfs, which is adequate to convey the existing Q100 peak discharge of 105 cfs. The existing 24 inch CMP under Mallery Road will need to be replaced. If Segment 1 is constructed as an open channel a 4 foot high by 5 foot wide concrete box would be required to convey the existing Q100 peak discharge. The recommended flow line of the channel will allow the new structure to be placed without raising the grade of the road. An advantage of an open channel compared to a buried pipe system is that it provides more flexability and would cost less if the drain has to be moved in the future to accommodate a specific development plan.

Because Segment 1 is in the upper portion of the watershed, the County could consider sizing this portion of the drain for the fully developed Q100 peak discharge of 30 cfs. This option would not convey the existing Q100 peak discharge but would increase the existing capacity of the drain and prepare it for the future developed flow rate. The developed flow rate could be conveyed with a 36 inch RCP and would be less expensive than excavating an open channel designed to convey the undeveloped Q100 discharge. The existing 24 inch CMP under Mallery Road will still need to be replaced. If closed pipe is used for Segment 1, the 36 inch pipe could be continued under Mallery Road to the west side of the road.

Segment 2 is located between Mallery Road and the Oak Wood Community, along the current drain alignment. The segment will begin at an elevation of 803.0 feet. An open channel and a closed pipe system were both evaluated for this segment. For a channel, the drain would have a minimum depth of 3 feet, a bottom width of 4 feet, and a continuous bottom slope of 0.0023 feet per foot (0.23%). The segment would have a total length of 1,500 feet and end at an elevation of 799.50 feet. The flow capacity of an open channel would be 114 cfs which exceeds the existing Q100 peak discharge of 105 cfs. If the drain were to be designed to receive the developed peak discharge a 36 inch RCP could be used. This pipe would have a capacity of 32 cfs which is adequate to convey the allowable release rate of 30 cfs from the fully developed upstream watershed.

From the end of Segment 2, the John Holleran Arm passes directly through the center of the Oak Wood Community. The Fishers Oakwood Arm, constructed in 1992, routes flow from the John Holleran Arm south of the community and then to the west to allow a portion of the upstream watershed to bypass the community. The segment of the John Holleran through the community would remain. The proposed route of Segment 3 will replace the southern link of Fishers Oakwood Arm. This option would be the least disruptive to the community. The drain will cross Promise Road at the southern border of the community and rejoin the John Holleran Arm 400 feet west of Promise Road. Segment 3 begins at an elevation of 799.50 feet and ends at an elevation of 794.00 feet. An open channel would require a minimum depth of 3.5 feet with a bottom width of 4 feet. The channel will have a continuous slope of 0.0024 feet per foot (0.24%). The flow capacity of the channel would be 165 cfs which exceeds the Q100 design discharge of 145 cfs. The existing Oakwood Arm Drain under Promise Road is a 12 inch RCP and part of a closed storm system. A 6 foot wide by 4 foot high concrete box culvert would be required to convey the channel under Promise Road. The topography along this route is uneven and cuts as deep as 10 feet would be necessary, possibly requiring additional regulated drain easement to be acquired. Another option would be to construct a closed pipe system to convey the developed peak discharge of 42 cfs. This could be accomplished with a 42” RCP and would not require any additional easement. The closed pipe system would route the flow under Promise Road and not require an open channel.

Segment 4 begins at the junction of the John Holleran and Fishers Oakwood Arms. This point is located about 400 feet west of Promise Road. Further downstream (approximately 900 feet) the John Holleran Arm becomes

the Sam Craig Arm. Segment 4 ends at the junction of the Sam Craig and Hammond Arms. The channel dimensions could be reduced by considering upstream detention and developed discharge rates. The starting flow line elevation for this segment is 794.00 feet. Segment 4 should be constructed as an open channel drain. An open channel at this location could be constructed at a lower cost than a closed pipe system. For the existing peak discharge the channel would need a minimum depth of 4 feet, a channel bottom width of 6 feet, and a continuous slope of 0.0031 feet per foot (0.31%). Segment 4 has a total length of 2,600 feet and ends at a flow line elevation of 786.00 feet.

Segment 5 connects the drain to the SR 37 Culvert 1. The starting flow line elevation for this segment is 786.00 feet. The channel will need a minimum depth of 4.5 feet, a bottom width of 8 feet, and a continuous slope of 0.0031 feet per foot (0.31%). Segment 5 has a total length of 2,875 feet and ends at the existing invert of the culvert under SR 37 (elevation of 777.00 feet). The existing detention pond southeast (upstream) of the culvert will continue to provide stormwater storage support for the drain. The channel dimensions could be further reduced by considering upstream detention and developed discharge rates.

3.5 Flow Diversion to the Musselman Drain

The watershed for the Musselman Drain is directly north of the watershed for the Sam Craig and Holleran Arms of the Elwood Wilson Drain. Diverting flow north from the Craig-Holleran watershed to the Musselman Drain was investigated at 3 locations. The goal of this investigation was to identify if utilizing potential available capacity in the Musselman Drain could reduce existing flooding on the Craig-Holleran Drain and/or reduce the size of the future improvements to the drain. Two connection points evaluated were the WS Burnau and Peterson Arms of the Musselman Drain. Redirecting flow north along SR 37 in a new channel or closed structure to the Musselman Drain was also evaluated.

The WS Burnau Arm of the Musselman Drain begins 1,600 feet south of 191st Street and runs parallel to Mallery Road offset 250 feet to the west. A branch of the regulated drain, the WS Burnau Arm -1, begins 660 feet south of 191st Street and 650 feet east of Mallery Road. Arm-1 is routed north and west and joins with the WS Burnau Arm north of 191st Street. The drain's watershed is predominately agricultural land with a small mix of single family residential homes. The WS Burnau Arm and Arm-1 are closed field tile systems. The pipe size and material for both arms south of 191st Street are 24 inch diameter HDPE. As-built drawings for the WS Burnau Arm were provided by Hamilton County. Figure 3-14 shows the location of the Drain.

A field investigation was conducted on May 5th, 2017 following a heavy rain event to visually inspect the performance of this drain. Ponding water was observed along the WS Burnau both north and south of 191st Street. The regulated drain runs along the western boundary of the flooded house in Figure 3-15. The photograph was taken from 191st Street looking south. The photograph location is identified in Figure 3-14.

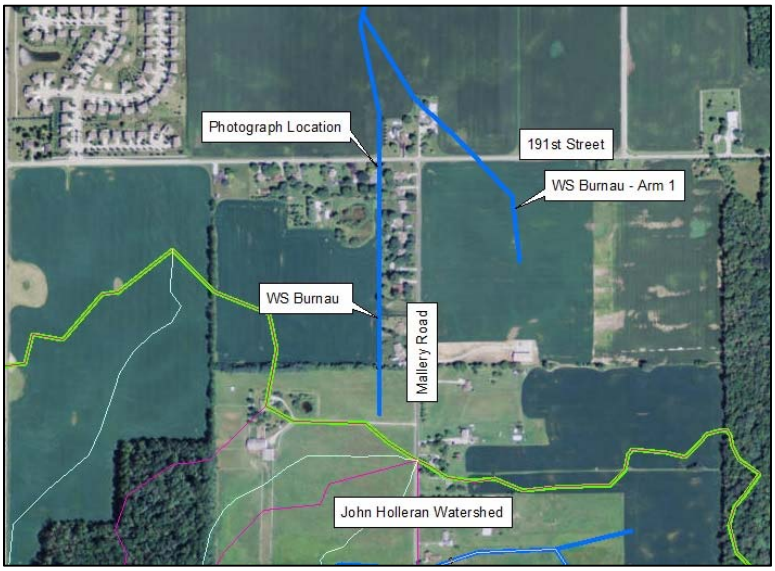


Figure 3-14 –WS Burnau Arm Location Map

Figure 3-15 – WS Burnau Arm Flooding (5/5/2017)

Based on the field observations of the existing flooding, it is evident that the WS Burnau Arm does not currently have any additional capacity to receive diverted flow from the Craig-Holleran Drain. Future upgrades and improvements to the WS Burnau Arm may accommodate a diversion from the Craig Holleran Drain.

The Peterson Arm of the Musselman Drain begins 1,000 feet south of 191st Street on the west side of Round Bush Boulevard. The Arm routes flow north to the Musselman Drain. The drain's watershed is predominately single family residential homes with a small mix of agricultural fields. The drain begins as a 36 inch RCP and is connected to a detention pond in the Monarch Springs development. As-built drawings show the size and

inverts of the pipe segments. Design calculations for the detention pond and the regulated drain were not available to indicate the available capacity of the system during a 100 year event. The property south of the Monarch Springs development is presently undeveloped land. This location, identified as Regional Detention Site 3 in Section 3.2, could potentially be used for additional detention of flow diverted from subbasin 04 of the John Holleran watershed, as discussed in Section 3.2. Land within subbasin 04, identified as Regional Detention Site 2 in Section 3.2, was also identified as a potential location for detention before diverting the flow to the Peterson Arm. The detention would be designed to attenuate flow until after the peak of the storm had passed and capacity becomes available in the Peterson Arm.

The topography of the existing land is favorable for the diversion route. The ground is 5 feet higher at the beginning of the diversion compared to the end elevation. The invert of the beginning of the Peterson Arm is 10 feet lower than the ground where Regional Detention Site 3 could be potentially located. The capacity of the Peterson Arm should be determined before any further consideration of this option. Figure 3-16 illustrates the route that the flow would be diverted to the Peterson Arm. The pipe capacity of the Peterson Arm would dictate the amount of detention required.

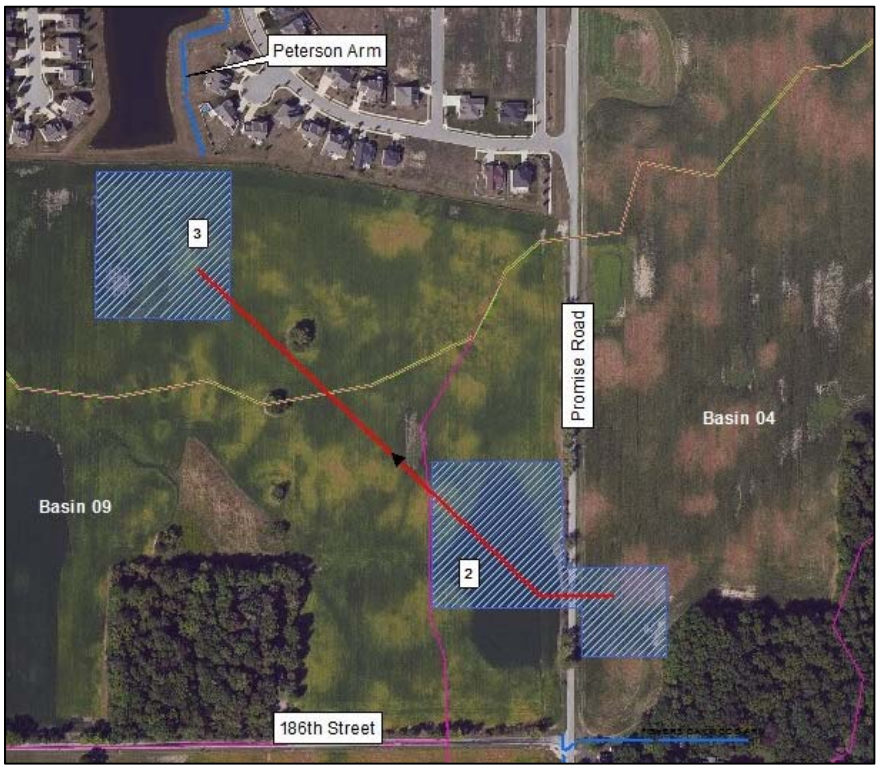


Figure 3-16 – Potential Diversion Route

The John Holleran Arm would benefit from flow diversion and/or detention. Detention could be located at either site 2 or 3, shown in Figure 3-16. Subbasin 04 is immediately upstream of the bottle neck junction of the John Holleran and the Fishers Oakwood Arms. Runoff overtops Promise Road north of 186th Street and floods the adjacent fields during rain events. Figure 3-17 is a photograph of the flooding extent on Promise Road during the May 4 - 5, 2017 rain event.

Figure 3-17 – Promise Road Flooding North of 186th Street (5/5/2017)

Redirecting flow north to the Musselman Drain along SR 37 was investigated. The right-of-way of the highway along SR 37 is maintained by the state so the design requirements for the drainage improvements were evaluated with both INDOT and Hamilton County standards. Topographic feasibility of redirecting the flow was evaluated and the property acquisition necessary to construct the flow diversion was determined. Figure 3-18 shows the location of the Elwood Wilson Drain culverts between the Sam Craig Arm and the Musselman Drain.

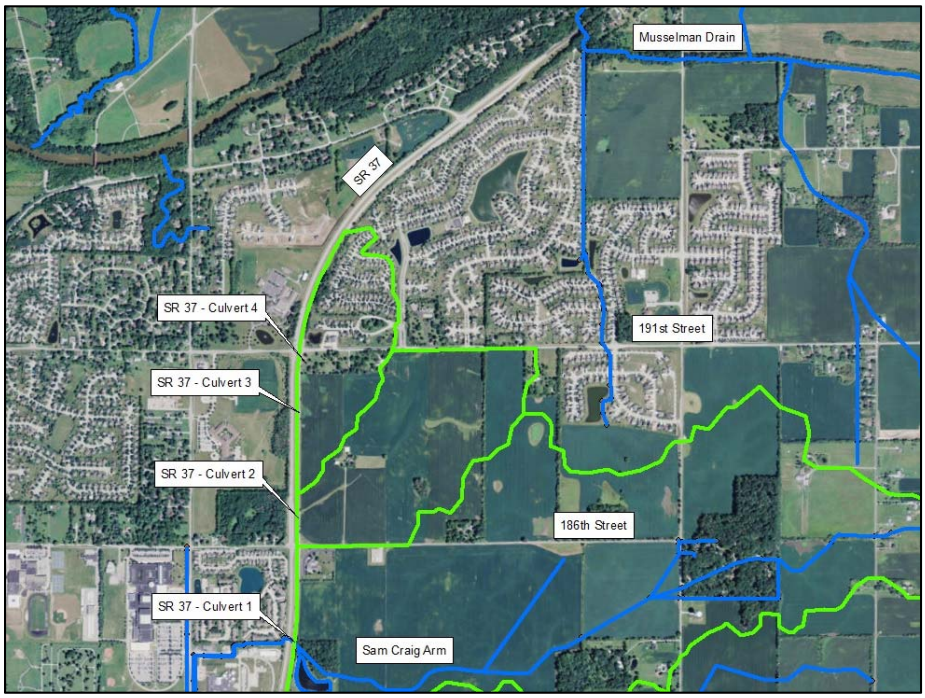


Figure 3-18 – Musselman Drain Location Map

INDOT design manual includes the following design requirements:

- Adequate clear zone must be provided.
- The side slopes of the channel should not exceed the soil or lining's angle of repose and should be 3H:1V or flatter.
- The design discharge for a permanent roadside channel should be based on a 10% annual exceedance probability (EP).
- If a natural stream or drainage ditch enters the side ditch, the design should be for a 1% annual EP.
- The desirable channel freeboard should be 1 foot, or two velocity heads, whichever is greater, measured from the top of bank.
- Variance from 1 foot should be justified in hydraulic report.

The biggest challenge in diverting flow north to the Musselman Drain as part of this option is that the natural grade of the land does not flow to the north. The investigation considered the required depths at different points along the channel to divert flow north, the required width of an open channel, and any right-of-way acquisition needs to construct such a diversion channel. A closed pipe system was also investigated.

SR 37 Culvert 1 is located 1,275 feet south of 186th Street and is the furthest south of the four culverts crossing under SR 37. The culvert has an invert of 779.12 feet. The total distance to the Musselman Drain from the culvert is 9,900 feet. The Musselman Drain has a flow line elevation of 758.0 feet at SR 37. A channel directly connecting these two locations with a constant slope would have a grade of 0.21%. A proposed channel would reach its deepest cut 1,800 feet north of 191st Street where the existing ditch has a flow line of 788.0 feet. At this location, a new channel would have a flow line depth of 766.5 feet, which is 21.5 feet lower than the existing ground. To meet the channel side slope requirements an open channel would need to be 129 feet wide at this location. From the edge of pavement, SR 37's right-of-way ends 30 feet to the east. An additional 100 feet of right-of-way would need to be acquired to the east, which would affect 20 homes and 54 privately owned yards. A figure comparing the existing ground to the slope of a new channel between Culvert 1 and the Musselman Drain is shown in Attachment 9. An open cut channel from Culvert 1 to the Musselman Drain is not recommended.

For a closed pipe system to be considered advantageous it would need to reroute at least 100 cfs of peak discharge away from Culvert 1. At a slope of 0.21% the storm sewer would need to be a 66 inch diameter circular concrete pipe. The unit price of 66 inch RCP is $200 per linear foot which comes to a material cost of $1.98 million. Excavation, backfill, and property acquisition cost would also need to be included. The benefit of constructing a closed storm system between Culvert 1 and the Musselman Drain does not justify the cost. Reduction of peak discharge at Culvert 1 can be accomplished more efficiently and for lower cost by constructing detention upstream in the watershed.

Redirecting flow from Culverts 2, 3 and 4 was also considered. The benefit of redirecting flow from these culverts is less significant as they do not directly connect to the Sam Craig Arm, but rather cross SR 37 to the north into wetland areas and are then routed to the Elwood Wilson Drain to the south. Unlike Culvert 1, these three culverts are appropriately sized for their upstream watersheds. Redirecting flow would have an adverse effect on the existing wetlands west of SR 37. Currently a Q100 storm event sends 49.6 acre-feet of water through the wetland areas. If subbasins 07 and 08 are redirected to the north the total volume of stormwater from a Q100 event would be reduced to 11.4 acre-feet of water, or 23% of the existing total. Based on the inverts of the culverts a redirected drain would require a flowline depth between 17 and 24 feet at the deepest

point. The effort and cost of redirecting Culverts 2, 3, or 4 north to the Musselman Drain cannot be justified. Diverting flow from these culverts is not recommended.

3.6 Wetland Investigation

A Natural Resource Assessment was performed by the subconsultant Williams Creek Consulting to identify wetlands in the project area. Five wetlands were identified, four located at least partially within the easement of the regulated drain. These areas are considered "Waters of the U.S." and potential impacts would likely be considered subject to regulation by the Indiana Department of Environmental Management (IDEM) and United States Army Corp of Engineers (USACE). Six additional potential wetland areas were identified within the watershed boundary and two areas of interest. The complete Natural Resource Assessment is included in Attachment 10 of this report.

Limiting the disturbance of wetland areas with construction activity for flood control improvements should be considered to avoid a lengthy permitting process, mitigation, and increased project costs. Where possible, the proposed horizontal alignment of the improved drain should be shifted to avoid the designated wetland areas while remaining within the regulated drain easement.

3.7 Utility Conflicts

Construction of the new channel for the Sam Craig and John Holleran Arms will need to be coordinated with existing utilities to prevent service interruptions to local customers. Indiana Code IC 36-9-27-48 states that public utilities which must be relocated to accommodate the construction or reconstruction of a regulated drain will be paid for by the public utility. Some of the utilities that could be impacted included the following.

An Indiana American Elevated Water Tank is located next to the drain on Promise Road. The waterline is required to have a minimum cover of 5 feet below the proposed channel.

According to the 2007 Noblesville Sanitary Sewer Masterplan, provided by the City of Noblesville, a sanitary sewer is proposed under Promise Road and would intersect the drain south of 186th Street. A sanitary sewer is also proposed on Mallery Road and would intersect the drain. Proposed sanitary sewers will also be located within the watershed along SR 37, 186th Street, and 191st Street. A minimum 5 feet of separation is required between sanitary and storm facilities. Design of these systems should accommodate the recommendations in this study.

The electric lines that cross the path of the drain are located on overhead lines and will not conflict with the proposed improvements. An electric pole is located at the south west corner of the Oak Wood Community and may need to be relocated to accommodate the proposed improvements. Care must be exercised while working near all electrical facilities.

3.8 Property Access Solutions

Converting the existing drain from a field tile to an open channel will eliminate access from the adjacent public roadway or from other parts of the property for two properties. Potential new access locations have been identified and are discussed in this section.

One property is owned by Kreagcroft Incorporated and is located on the south side of 186th Street between SR 37 and Promise Road. The new channel will eliminate access to the southern portion of this property. Figure 3-19 shows the property outlined in yellow, with the drain represented with a light blue line. A proposed access crossing is shown with a purple line in the figure. The location of the access point needs to be agreed upon

with the property owner and will need to be wide enough to support farming equipment. A 10 foot wide by 5 foot high box culvert would be used under this crossing.

Figure 3-19 – Property Access (1)

The second property is owned by the Jeffery Roudebush and is located west of Mallery Road. Elimination of access would only be an issue if the drain is constructed as an open channel and the northwest corner is not used as a detention pond. Figure 3-20 shows the property outlined in yellow, with the drain represented with a light blue line. A 5 foot wide by 3 foot high box culvert would be used under this crossing. The final location of this crossing would be agreed upon by the property owner.

Figure 3-20 – Property Access (2)

3.9 Future Development Accessibility

Based on current zoning, it is anticipated that the agricultural land in this watershed will be developed into residential communities in the future. One of the goals of this project is to propose a system that will allow these future developments to outlet their stormwater to the Sam Craig and John Holleran Arms by gravity flow. Elevations were evaluated for the furthest reaches of the watershed and verify that an invert depth of 3.5 feet for the drain would serve any point in the watershed at an appropriate slope by gravity. Below is a list of the furthest reaches in each subbasin, their distance to connect to the drain, the required slope, and the assumed invert at the most upstream point in the subbasin.

- Subbasin 01 – Distance 2,700 feet, at a slope of 0.6%, invert 813.5
- Subbasin 02 – Distance 740 feet, at a slope of 1.2%, invert 811.5
- Subbasin 03 – Distance 2,100 feet, at a slope of 0.9%, invert 811.5
- Subbasin 04 – Distance 2,500 feet, at a slope of 0.4%, invert 805.5
- Subbasin 05 – Distance 1,200 feet, at a slope of 0.9%, invert 799.5
- Subbasin 06 – Distance 1,300 feet, at a slope of 1.0%, invert 799.5
- Subbasin 07 – Distance 800 feet, at a slope of 2.0%, invert 791.5
- Subbasin 08 – Distance 4,300 feet, at a slope of 0.5%, invert 793.5
- Subbasin 09 – Distance 3,500 feet, at a slope of 0.4%, invert 800.5
- Subbasin 10 – Distance 2,300 feet, at a slope of 0.6%, invert 792.5

4.0 DESIGN ALTERNATIVES

4.1 Alternatives Analysis

Three main system configuration alternatives were investigated. Alternative 1 is to replace the existing regulated drain with an open channel. Alternative 2 is a combination of closed pipe and open channel. Alternative 3 is an open channel over an underdrain pipe. Additional detention improvements were investigated and could be used in combination with proposed alternatives to realize greater benefit. A cost estimate was prepared for each of the improvement alternatives. Per the AACE Cost Estimating Classes this project would be considered a Class 3 Estimate. This means the level of design is at approximately 10% - 40% complete. Class 3 project have an expected cost accuracy range that could be 10% - 20% lower to 10% - 30% higher. A detailed breakdown of the cost estimate with individual pay items is included in Attachment 11

4.2 Alternative 1

Alternative 1 proposes to replace the existing field tile drain with an open channel. All five segments of the drain would be sized to convey the existing peak discharge of a Q100 event. The dimensions of the channel and grade of the flow line are discussed in Section 3.4 Channel Improvements. The culvert under Mallery Road would be replaced with a 5 foot by 3 foot concrete box and the culvert under Promise Road would be replaced with a 6 foot by 4 foot concrete box. Two new culverts would be constructed to provide property access to segments of land separated by the new channel. The banks of the channel would be seeded and covered with a 20 foot wide filter strip. The estimated construction cost of Alternative 1 is $1,124,000 with a total project cost of $1,384,000 (including non-construction costs).

The average annual maintenance cost of Alternative 1 is estimated to be $1,150 per year. This was estimated based on historical maintenance records from Hamilton County. It is assumed that this cost would increase at a rate of 3% per year. Over a 50 year time period it would be expected that 2 major maintenance events would occur, costing approximately $10,000 each. The total maintenance cost of this alternative would be approximately $185,000 over a 50 year period.

4.3 Alternative 2

Alternative 2 proposes to replace the existing field tile drain with a combination of open channel with filter strips and closed storm pipe. For this alternative, Segments 1, 2, and 3 would be designed to convey the required Q100 discharge assuming full development build out of the watershed through a closed storm pipe system. Segments 4 and 5 at the downstream end of the drain would be designed for the existing Q100 peak discharge and conveyed with an open channel. Designing Segments 1, 2, and 3 for the fully developed peak discharge will reduce the size requirement for the storm pipe in these segments compared to the required size for the existing peak Q100. Designing these segments for the lower discharge is reasonable because they are at the upstream end of the watershed and it will more than double the existing capacity of the regulated drain. Existing drainage flow will not be adversely affected and the new system will have sufficient capacity for future development connections.

The storm pipe in Segments 1 and 2 would be a 36 inch RCP. The pipe in Segment 3 would be a 42 inch RCP. The dimensions of the channel and grade of the flow line for Segments 4 and 5 are discussed in Section 3.4 Channel Improvements. A new culvert would be constructed to provide property access to land separated by the new channel. The estimated construction cost of Alternative 2 is $1,107,000 with a total project cost of $1,363,000 (including non-construction costs).

The average annual maintenance cost of Alternative 2 is estimated to be $600 per year, roughly half of Alternative 1. This was estimated based on historical maintenance records from Hamilton County. It is assumed that this cost would increase at a rate of 3% per year. Over a 50 year time period it would be expected that 2 major maintenance events would occur, costing approximately $10,000 each. The total maintenance cost of this alternative would be approximately $97,500 over a 50 year period.

4.4 Alternative 3

Alternative 3 proposes to replace the existing field tile drain with an open channel with filter strips over an underdrain pipe. A 36 inch RCP storm line would be constructed along the alignment of the drain to convey lower flows. An open channel would be located above the pipe to provide the necessary conveyance for the existing Q100 peak discharge. The underdrain pipe will allow the dimensions of the open channel to be reduced compared to Alternative 1. In Segment 1, the channel will have a bottom width of 3 feet and a minimum depth of 2.5 feet. In Segment 2, the channel will have a bottom width of 4 feet and a minimum depth of 2.5 feet. In Segment 3, the channel will have a bottom width of 3 feet and a minimum depth of 4 feet. In Segment 4, the channel will have a bottom width of 4 feet and a minimum depth of 4 feet. In Segment 5 the channel will have a bottom width of 7 feet and a minimum depth of 4.5 feet.

The culvert under Mallery Road would be replaced with a 5 foot by 3 foot concrete box and the culvert under Promise Road would be replaced with a 6 foot by 4 foot concrete box. Two new culverts would be constructed to provide property access to segments of land separated by the new channel. The estimated construction cost of Alternative 3 is $2,020,000 with a total project cost of $2,484,000 (including non-construction costs).

Constructing the pipe under the open channel to reduce the channel size increases the cost of the project by approximately $1,000,000. Alternative 3 is not recommended.

4.5 Additional Improvement Opportunities

Additional opportunities to make improvements to the regulated drain beyond improving the conveyance of the main channel were investigated. Six sites were identified to potentially locate regional detention basins. The locations are shown in Figure 4-1. The detention facilities have been sized to contain the flows from the Q100 event storm. The emergency overflow weir elevation of all detention pond would be set a minimum 2 feet below the lowest adjacent grade of any residential or commercial building.

Figure 4-1 – Regional Detention Sites

Regional Detention Site 1 is located upstream of the Oak Wood Community. Two different options were investigated for this detention site. Option 1 is to construct detention over a 7 acre area capable of detaining 21 acre-feet of stormwater. This dry bottom pond would provide adequate storage to contain the entire existing Q100 peak event within the basin. Property would need to be obtained in fee from two parcels to proceed with this option. The estimated property acquisition and construction cost of Regional Detention Site 1 – Option 1 is $995,000.

Option 2 is to construct detention over a 4 acre area capable of detaining 14 acre-feet of stormwater. This would provide adequate storage to contain 66% of the existing Q100 peak event within the basin. Property would need to be obtained from one parcel to proceed with this option. The estimated property acquisition and construction cost of Regional Detention Site 1 – Option 2 is $637,000.

Regional Detention Site 2 is located north of the Oak Wood Community in subbasin 04. The site would include a 4.8 acre footprint capable of detaining 16.8 acre-feet of stormwater. This would provide adequate storage to contain the entire existing Q100 peak event within the basin. Property would need to be obtained from one or two parcels to depending on the exact location of the detention site. Per County requirements the detention facility would need to be separated from the nearest road right-of-way by a minimum of 50 feet. The estimated property acquisition and construction cost of Regional Detention Site 2 is $702,000.

Regional Detention Site 3 is located outside of the Craig Holleran Watershed. The site is in the watershed of the Peterson Arm of the Musselman Drain. This site could be used to detain flow diverted from subbasin 04 prior to entering the Peterson Arm and releasing as capacity becomes available in the drain. The site would include a 4.8 acre footprint capable of detaining 16.8 acre-feet of stormwater. This would provide enough

storage to contain all of the flow diverted from subbasin 04. This option would require property acquisition. The estimated property acquisition and construction cost of Regional Detention Site 3 is $829,000 and includes the cost of diverting flow via a 36 inch diameter RCP from subbasin 04.

Regional Detention Site 4 is in subbasin 05, south of 186th Street. The site would include a 3.3 acre footprint capable of detaining 6.7 acre-feet of stormwater. This would provide adequate storage to contain the entire existing Q100 peak event for subbasin 05 within the basin. Property would need to be obtained to proceed with this option. The estimated property acquisition and construction cost of Regional Detention Site 4 is $340,000.

Regional Detention Site 5 is in subbasin 10, south of 186th Street. The site would include a 4.5 acre footprint capable of detaining 17.5 acre-feet of stormwater. This would provide adequate storage to contain the entire existing Q100 peak event from subbasin 09 upstream. Property would need to be obtained to proceed with this option. The estimated construction cost of Regional Detention Site 5 is $842,000.

Regional Detention Site 6 is in subbasin 10, east of SR 37 and adjacent to the existing correction facility detention pond. The site would include a 3.2 acre footprint capable of detaining 12.8 acre-feet of stormwater. This would detain an adequate volume of runoff, within the basin, to reduce the occurrence of overflow to the E.M. Hare watershed to the south. An evaluation of a potential solar field at the site was completed in June 2017 and is included in Attachment 12. Property would need to be obtained to proceed with this option. The estimated property acquisition and construction cost of Regional Detention Site 6 is $859,000.

4.6 Potential Funding Sources

Adequate local funding sources will be required to implement the recommendations in this study. Primary funding sources include regulated drain funds, tax supported funds, special assessments, and user fees. Many Indiana communities use general funds, supported by property taxes, to fund stormwater improvement projects. General obligation, revenue, or special assessment bonds are often issued to finance large capital improvement programs. Repayment is normally through the general fund, special assessment district income and utility revenues.

Indiana Code (IC 36-9-27) governs regulated drains and the requirements for construction and reconstruction. The costs for the construction or reconstruction are divided among the parcels of property within the watershed and directly associated with regulated drain being (re)constructed. Reconstructing a regulated drain is the only way to: covert from an open drain to a tiled drain (or vice versa), increase the size of the drain, add an extension to the drain, change the alignment of the drain, construct drainage detention basins or provide for erosion control and for grade stabilization, or lower the drain per Section 34 of the above-referenced Code. Section 88 (2) allows for a 20 year collection for urban lands. Section 97.5 allows the board to obtain a bank load

The Hamilton County Drainage Board may transfer an amount up to 75% of the maintenance fund balance to a reconstruction fund that covers the same watershed as the maintenance fund.

Segments of the project could be funded by a developer or TIF funds.

5.0 RECOMMENDATION

5.1 Recommendation

Improvements are needed to the Sam Craig and John Holleran Arms of the Elwood Wilson Drain for it to function at a capacity that can reduce existing drainage problems and to accommodate flows from future development. Improvements will also offset the effects of increases in intensity and frequency of larger storm events in the future. Existing problems with the drain were identified with this investigation that need to be addressed for the safety and wellbeing of the local residents in the watershed. The recommended improvements will focus on the solutions that provide the greatest benefit for the cost to the community in both the short and long term.

Increasing the capacity of the regulated drain is necessary to provide some relief of existing issues and to allow future development to connect to the drain. Alternatives 1 and 2 accomplish this goal for a similar cost. Alternative 3 is significantly more expensive without providing additional benefit and therefore is not recommended. Alternative 2 proposes to replace the existing drain with a combination of closed pipe and open channel improvements. Alternative 2 is recommended because it will be less disruptive to the existing property owners along the drain.

In addition to the improvements to the regulated drain, regional detention is recommended to reduce flooding on private property, over roads, and reduce the peak discharge to the regulated drain. Regional Detention Site 1 will provide the greatest benefit to the Oak Wood Community. Most of the upstream watershed will pass through this pond. In combination with the improved capacity of the drain, this pond will provide immediate noticeable benefit to the Oak Wood Community which has been plagued with flooding for decades.

Additional detention is also recommended at Regional Detention Site 6, adjacent to the existing detention for the correctional facility. The improved conveyance along the drain will allow stormwater to be routed downstream more efficiently. The capacity of the culvert at SR 37 will be the same and therefore additional storage at this location would be beneficial to reduce flooding. This area is already prone to flooding and therefore is not an ideal location to be developed and would be well suited for an expansion of the existing detention pond. The detention would provide further benefit by limiting occurrences of spill over to the south (into the E. M. Hare watershed).

Alternative 2 has a total project cost of $1,363,000. Regional Detention Site 1, option 1, has a total project cost of $995,000. Regional Detention Site 6 has a total project cost of $859,000. The total cost of implementing drain Alternative 2 along with Regional Detention Sites 1 and 6 is $3,217,000. These are the minimum improvements recommended for the Sam Craig and John Holleran Arms.

Additional detention sites were identified that could provide benefit above what is recommended in this study. Regional Detention Site 2 would help detain flow upstream of the Oak Wood Community from subbasin 04. Detention at this location would reduce the peak flow of the stormwater passing through the community and lengthen the time for the peak flow to reach the bottleneck point downstream where the Fishers Oakwood Arm and John Holleran Arms come together. A detention facility at site 2 is estimated to cost $702,000.

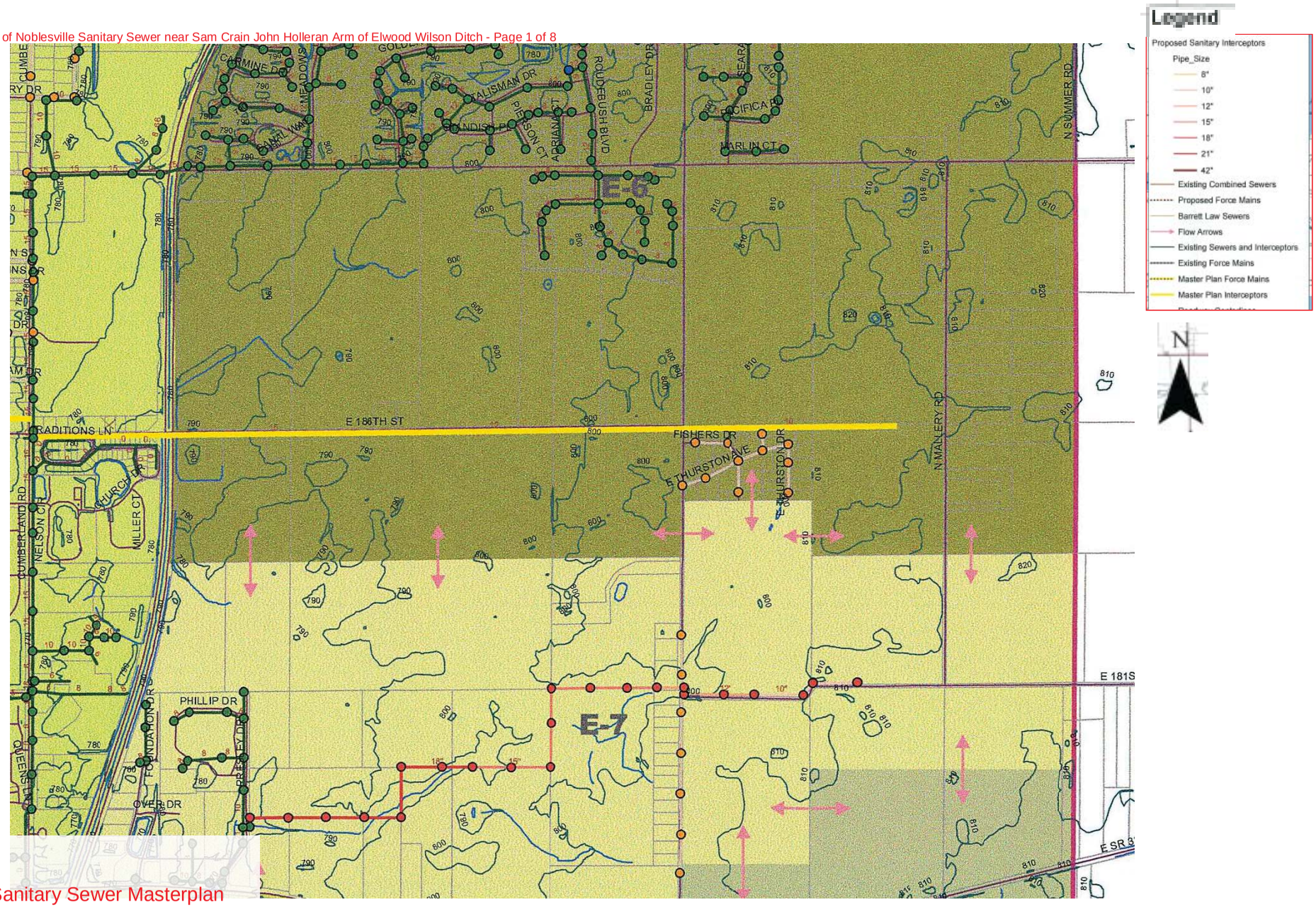
The Peterson Arm of the Musselman Drain has sufficient capacity for its existing drainage area, but the available capacity to receive additional flow is not known. Therefore, diverting flow from the John Holleran Arm to the Peterson Arm and Regional Detention Site 3 is not recommended at this time.

Regional Detention Sites 4 and 5 would provide benefit to the watershed. Both sites are in the western half of the watershed and would provide less benefit compared to the detention sites which were recommended. Regional Detention Site 4 would cost $340,000. Regional Detention Site 5 would cost $842,000. As the watershed develops these ponds could be incorporated into the drainage plans of the future developments.

ATTACHMENT 1:

Data Provided by the City of Noblesville

Figure 1A - Sanitary Sewer Master Plan



4/14/2017

2007 Noblesville Sanitary Sewer Masterplan

Note that Masterplan is currently being updated

Existing Sanitary Near Sam Craig/John Holleran Arm of Elwood Wilson Drain

Prepared By:
CITY OF NOBLESVILLE
Department of Engineering

Path: S:\HCSO\Sam Craig John Hollerans Arms - Elwood Wilson 2016 CD Study 2017-04-14.mxd

Disclaimer
This exhibit is based on information and data available from numerous sources and is without warranty or any representation of accuracy, correctness, or timeliness. The user of this information assumes all liability for their dependence on this information.

Date: 4/14/2017

Figure 1B - Existing Sanitary Sewer

Existing Sanitary Near Sam Craig/John Holleran Arm of Elwood Wilson Drain

Prepared By:
CITY OF NOBLESVILLE
Department of Engineering

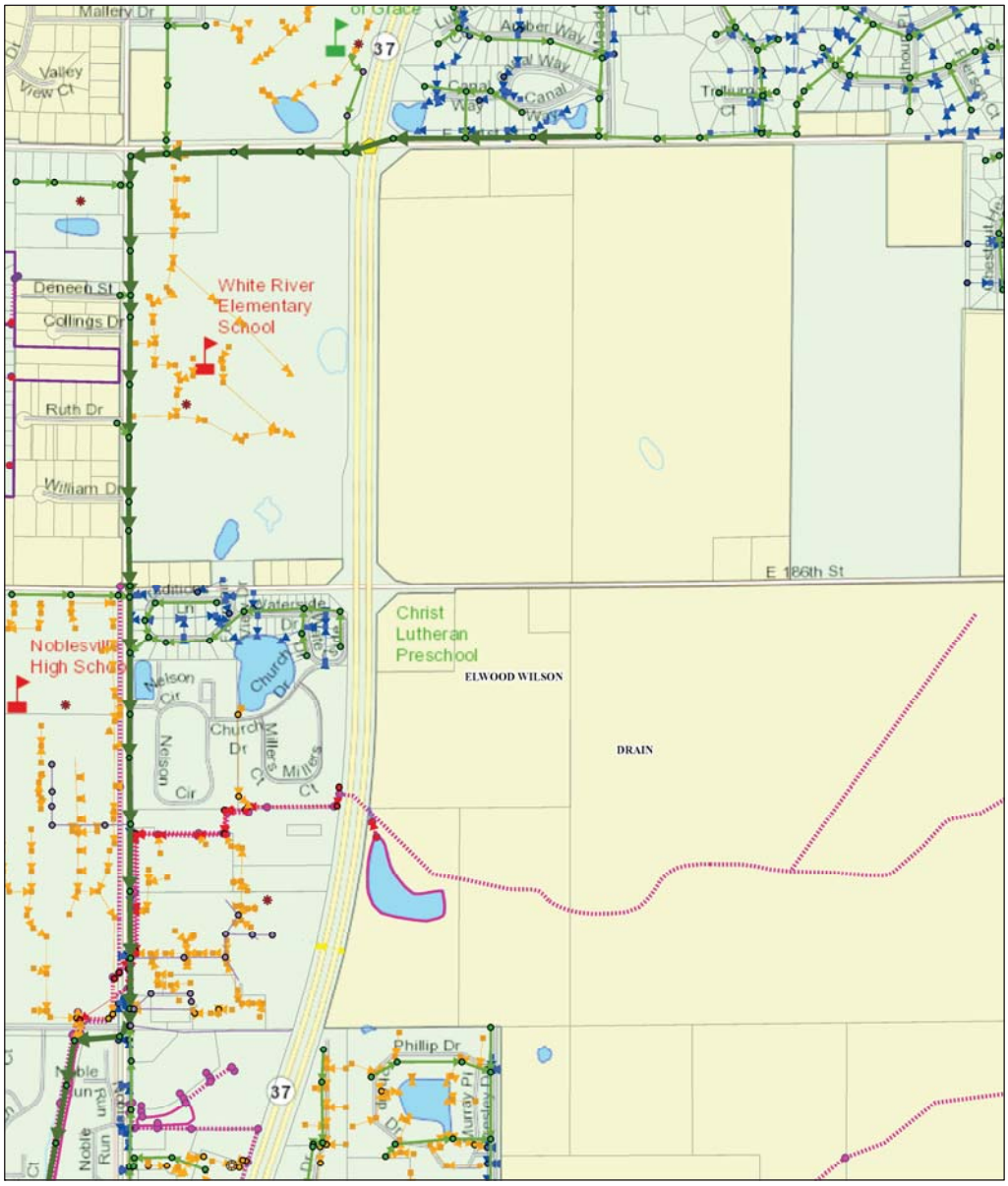
Path: S:\HCSO\Sam Craig John Hollerans Arms - Elwood Wilson 2016 CD Study 2017-04-14.mxd

Disclaimer
This exhibit is based on information and data available from numerous sources and is without warranty or any representation of accuracy, correctness, or timeliness. The user of this information assumes all liability for their dependence on this information.

Date: 4/14/2017

Figure 1C - Existing Sanitary Sewer

City of Noblesville



April 14, 2017

1:7,200

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Municipal	State	Control Panel	Regulated Drains Waterways
Private	Municipal	Control panel/ photocell	Regulated Drains Drainage Pool
san_grease_traps	County	Handhole	Subdivision Drainage Structures
san_Force_mains	Private	Pedestal	CLOSED DRAIN
Municipal	State	Street Light Lines	MUNICIPAL DRAIN
Private	storm_BMP_Poly	Conduit	OPEN DRAIN
san_interceptor	Municipal	Noblesville	SSD
Municipal	County	Hamilton County	Subdivision Drain Waterway
Private	Private	INDOT	Subdivision Drain Drainage Pool
Municipal	State	<all other values>	Regulated Subdivision Boundary
County	comb_CSO_Outfalls	MUNICIPAL MANHOLE	Parcels
Private	comb_inlet	Drain Name	
State	comb_mh	CLOSED DRAIN	
Municipal	comb_gravitylines	MUNICIPAL DRAIN	
County	comb_interceptor	OPEN DRAIN	
Private	Lift Stations	SSD	

Basemap information here

Figure 1D - Existing Sanitary

City of Noblesville

April 14, 2017

1:7,200

0 0.075 0.15 0.3 mi

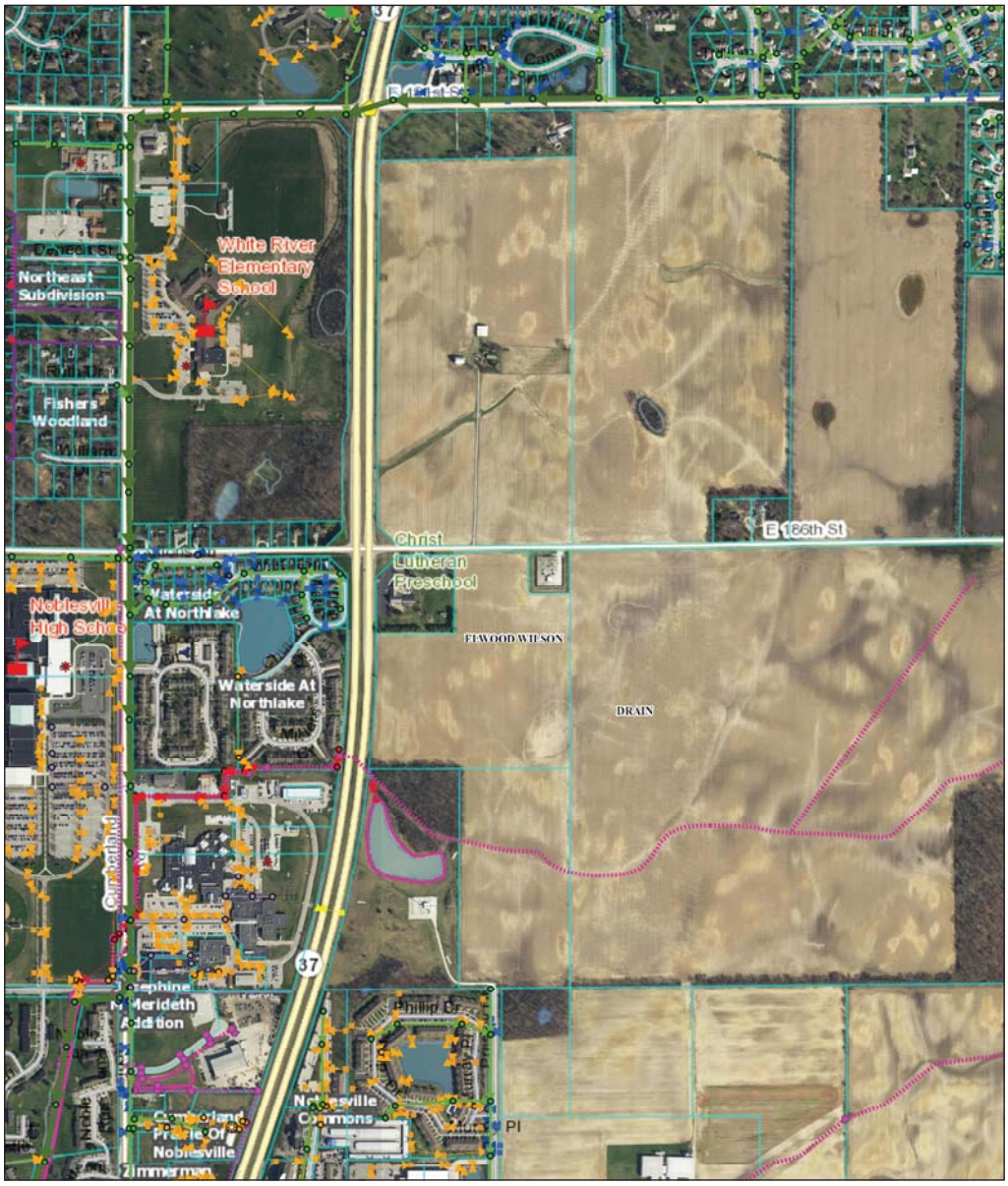
0 0.125 0.25 0.5 km

Municipal	State	Control Panel	Regulated Drains Waterways
Private	Municipal	Control panel/ photocell	Regulated Drains Drainage Pool
san_grease_traps	County	Handhole	Subdivision Drainage Structures
san_Force_mains	Private	Pedestal	CLOSED DRAIN
Municipal	State	Street Light Lines	MUNICIPAL DRAIN
Private	storm_BMP_Poly	Conduit	OPEN DRAIN
san_interceptor	Municipal	Noblesville	SSD
Municipal	County	Hamilton County	Subdivision Drain Waterway
Private	Private	INDOT	Subdivision Drain Drainage Pool
Municipal	State	<all other values>	Regulated Subdivision Boundary
County	comb_CSO_Outfalls	MUNICIPAL MANHOLE	Parcels
Private	comb_inlet	Drain Name	
State	comb_mh	CLOSED DRAIN	
Municipal	comb_gravitylines	MUNICIPAL DRAIN	
County	comb_interceptor	OPEN DRAIN	
Private	Lift Stations	SSD	

Basemap information here

Figure 1E - Existing Sanitary Sewer

City of Noblesville



April 14, 2017

1:7,200

0 0.075 0.15 0.3 mi

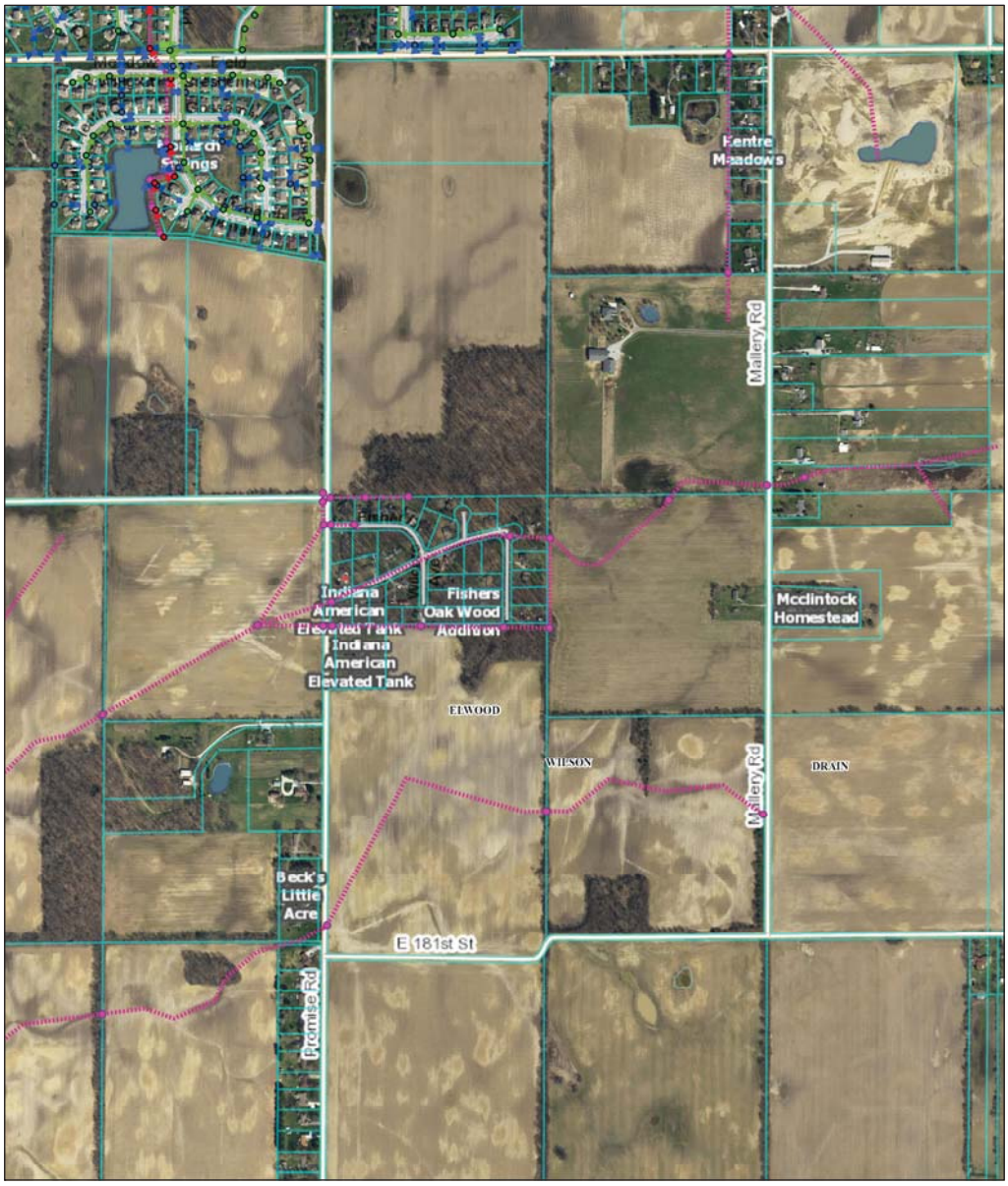
0 0.125 0.25 0.5 km

Municipal	State	Control Panel	Regulated Drains Waterways
Private	Municipal	Control panel/ photocell	Regulated Drains Drainage Pool
san_grease_traps	County	Handhole	Subdivision Drainage Structures
san_Force_mains	Private	Pedestal	CLOSED DRAIN
Municipal	State	Street Light Lines	MUNICIPAL DRAIN
Private	storm_BMP_Poly	Conduit	OPEN DRAIN
san_interceptor	Municipal	Noblesville	SSD
Municipal	County	Hamilton County	Subdivision Drain Waterway
Private	Private	INDOT	Subdivision Drain Drainage Pool
Municipal	State	<all other values>	Regulated Subdivision Boundary
County	comb_CSO_Outfalls	MUNICIPAL MANHOLE	Parcels
Private	comb_inlet	Drain Name	
State	comb_mh	CLOSED DRAIN	
Municipal	comb_gravitylines	MUNICIPAL DRAIN	
County	comb_interceptor	OPEN DRAIN	
Private	Lift Stations	SSD	

Basemap information here

Figure 1F - Existing Sanitary Sewer

City of Noblesville



April 14, 2017

1:7,200

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Municipal
Private
san_grease_traps
san_Force_mains
Municipal
Private
san_interceptor
Municipal
Private
Municipal
County
Private
State
Municipal
County
Private
State
Municipal
County
Private
State
Municipal
County
Private
State
Municipal
County
Private
comb_CSO_Outfalls
comb_inlet
comb_mh
comb_gravitylines
comb_interceptor
Lift Stations
Control Panel
Control panel/ photocell
Handhole
Pedestal
Street Light Lines
Conduit
Noblesville
Hamilton County
INDOT
<all other values>
MUNICIPAL MANHOLE
Drain Name
CLOSED DRAIN
MUNICIPAL DRAIN
OPEN DRAIN
SSD
Regulated Drains Waterways
Regulated Drains Drainage Pool
Subdivision Drainage Structures
CLOSED DRAIN
MUNICIPAL DRAIN
OPEN DRAIN
SSD
Subdivision Drain Waterway
Subdivision Drain Drainage Pool
Regulated Subdivision Boundary
Parcels

Basemap information here

Figure 1G - Existing Sanitary Sewer

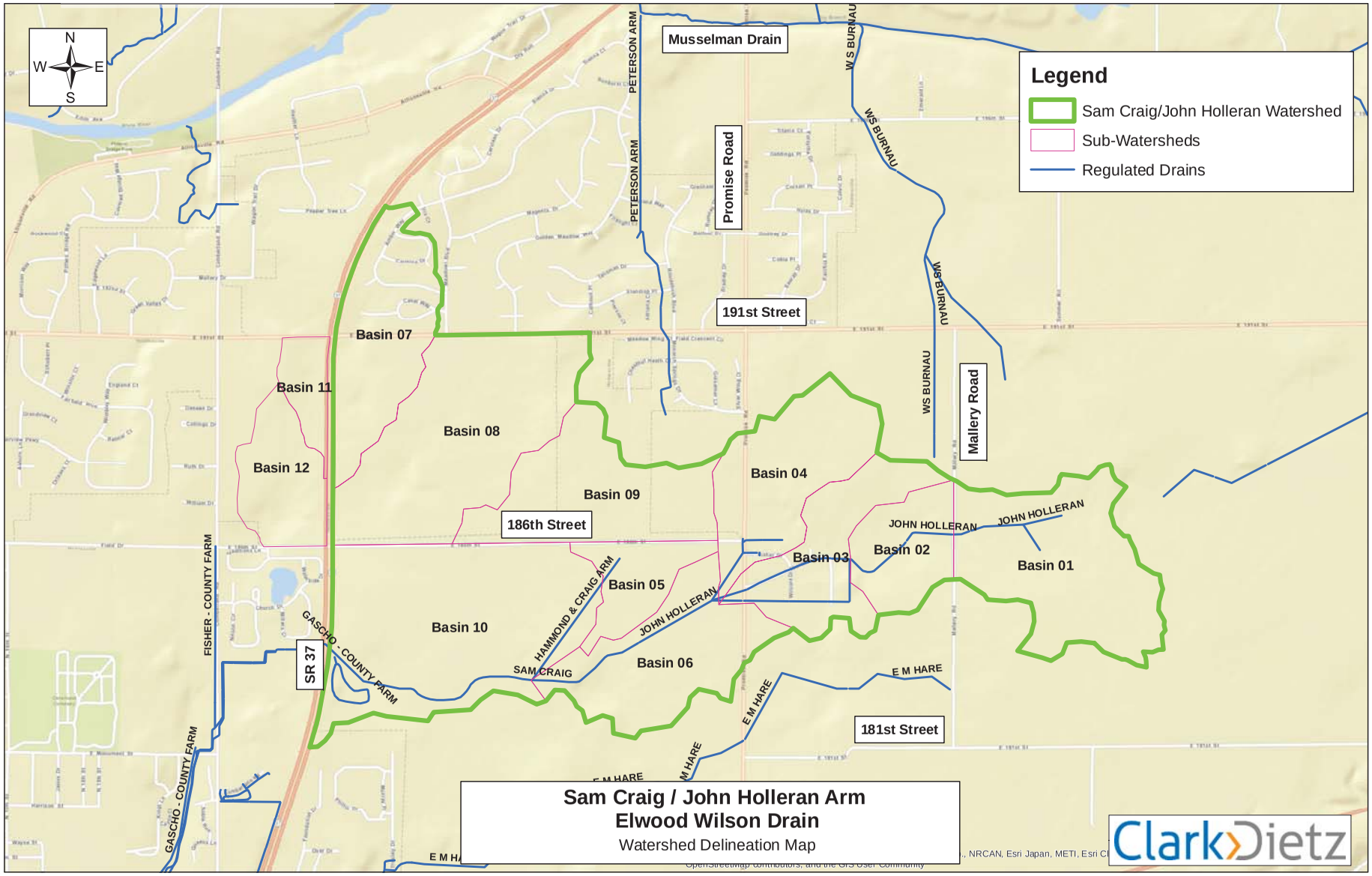


Figure 1H - Subbasins

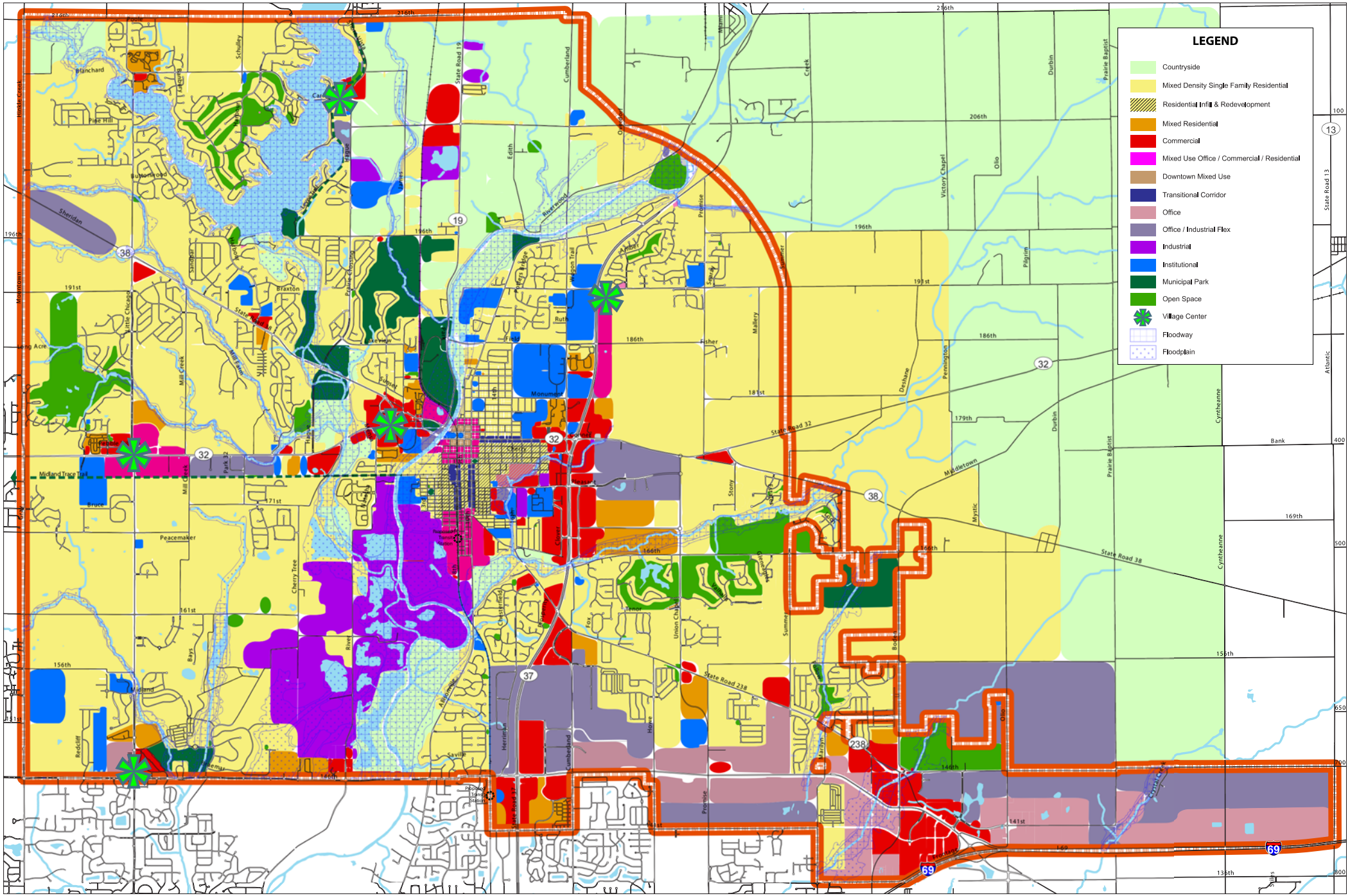
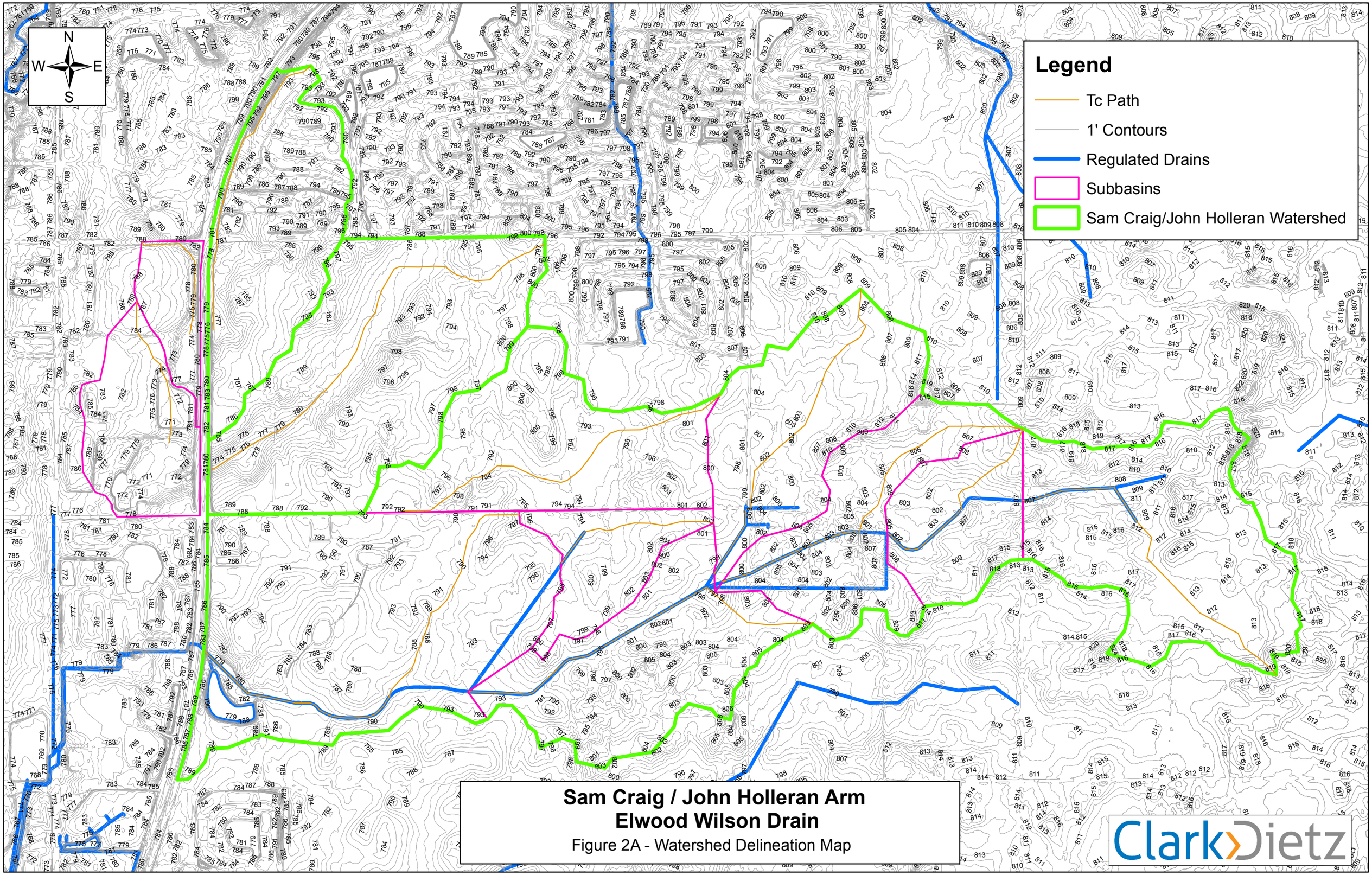
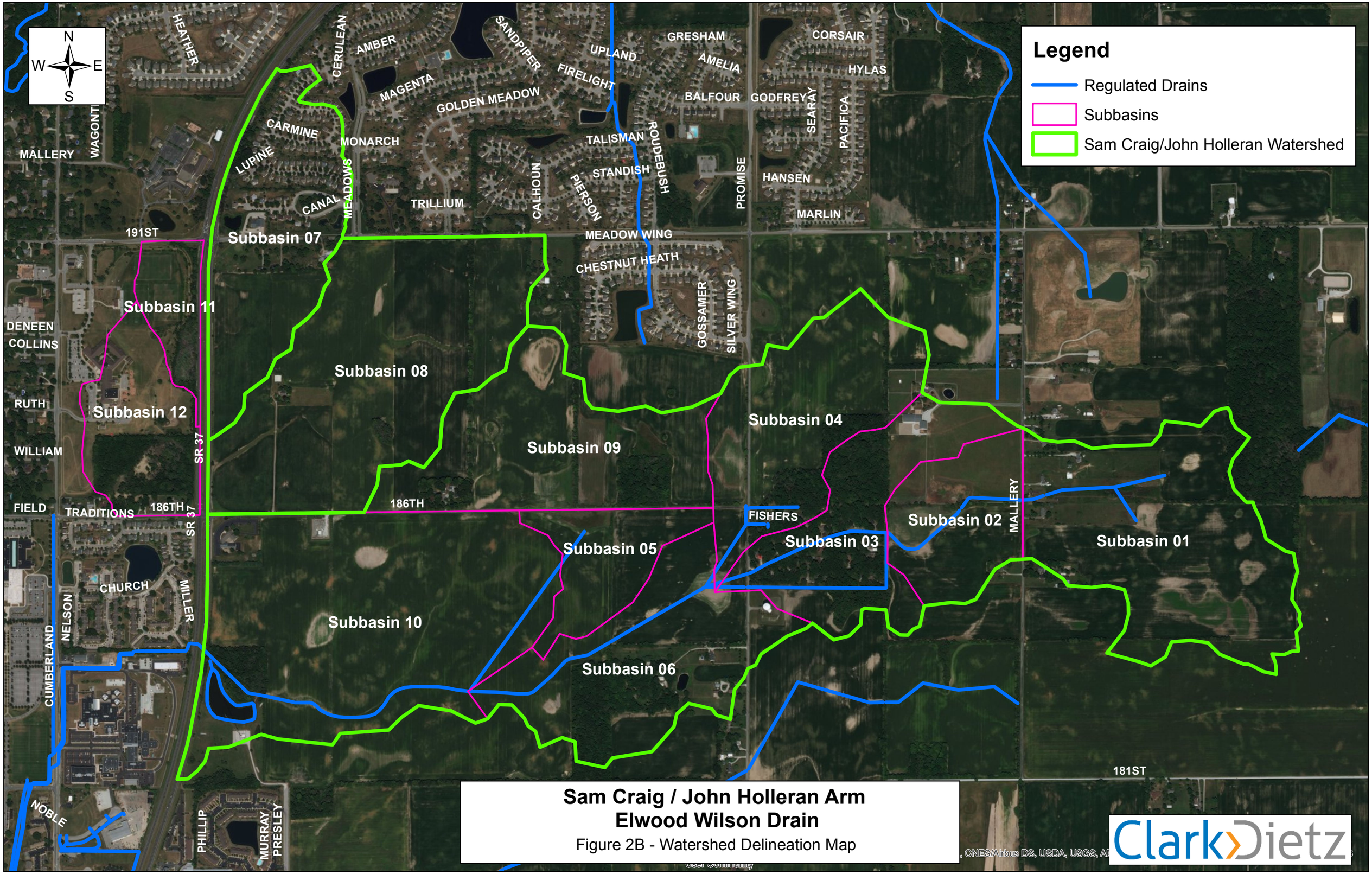


Figure 1I - Noblesville Zoning Map

ATTACHMENT 2:

Watershed Delineation


N
W
E
S
Legend
Tc Path
1' Contours
Regulated Drains
Subbasins
Sam Craig/John Holleran Watershed
Sam Craig / John Holleran Arm
Elwood Wilson Drain
Figure 2A - Watershed Delineation Map
ClarkDietz



Sam Craig / John Holleran Arm
Elwood Wilson Drain

Figure 2B - Watershed Delineation Map

ClarkDietz

ATTACHMENT 3:

Curve Number and Lag Time Calculations

ClarkDietz

Project//	Craig-Holleran Arm		
Project No.//	H0210170		
Subject//	Hydrology	Page//	of
Prepared By//	BEP	Date//	2/2/2017
Checked By//	HP	Date//	6/15/2017

Watershed Site Data: Basin 01

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	3526330	80.95	5828.64
Commercial	B	92		0.00	0.00
Forest	B	65		0.00	0.00
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72		0.00	0.00
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	881582	20.24	1679.78
Commercial	D	95		0.00	0.00
Forest	D	79		0.00	0.00
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92		0.00	0.00
		Totals =	4,407,912	101.19	7508.43
		Area Sq. Mi. =	0.1581		
				Weighted C :	74.2

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

Project//	Craig-Holleran Arm		
Project No.//	H0210170		
Subject//	Hydrology	Page//	of
Prepared By//	BEP	Date//	2/2/2017
Checked By//	HP	Date//	6/15/2017

Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	Surface Description	Ag Land	
2	Manning's Roughness Coeff.,...n (See Figure 202-2B)	0.170	
	Max. Flow Elev.(ft)=	820.3	
	Min. Flow Elev. (ft)=	817.0	
3	Flow length, L .....ft.	75.2	
4	Two-yr 24hr Rainfall[1] , P2...in.	2.98	
5	Land Slope (ft/ft)=	0.0439	
6	Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.	0.109 hr	

Shallow Concentration Flow

7	Surface description (paved or unpaved).....	unpaved	
	Max. Elevation, …….ft	817.00	
	Min Elevation, ……..ft	809.20	
8	Flow length, L.....ft.	2071.4	
9	Watercourse slope, s.....ft/ft	0.0038	
10	Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)	0.99	
11	Tt = L/(3600 V).....Computed Tt..hr.	0.581 hr	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	2
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	1.249046	0

		1	2
12	Cross sectional flow area, a.....ft^2	33.00	
13	Wetted perimeter, Pw.....ft	16.32	
14	Hydraulic radius, r=a/Pw Compute r....ft	2.02	
	Max. Elev of channel, ……..(ft) =	809.20	
	Min. Elev of channel, ……..(ft) =	806.00	
15	Channel slope length,s.....ft/ft	0.00249	
16	Manning's roughness coeff.,n .Based on stream type	0.035	
17	V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s	3.40	
18	Flow length from shallow to Structure, L .....ft.	1286	
19	Tt = L/(3600 V).....Computed Tt..hr.	0.105 hr	
20	Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19	**0.795 hr**	

or

Time of Concentration **47.7 min**

Lag Time 28.6 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

ClarkDietz

Project//	Craig-Holleran Arm		
Project No.//	H0210170		
Subject//	Hydrology	Page//	of
Prepared By//	BEP	Date//	2/8/2017
Checked By//	HP	Date//	6/15/2017

Watershed Site Data: Basin 02

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	668399	15.34	1104.79
Commercial	B	92		0.00	0.00
Forest	B	65		0.00	0.00
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72		0.00	0.00
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	1002598	23.02	1910.37
Commercial	D	95		0.00	0.00
Forest	D	79		0.00	0.00
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92		0.00	0.00
		Totals =	1,670,997	38.36	3015.16
		Area Sq. Mi. =	0.0599		
				Weighted C :	78.6

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

Project//	Craig-Holleran Arm		
Project No.//	H0210170		
Subject//	Hydrology	Page//	of
Prepared By//	BEP	Date//	2/8/2017
Checked By//	HP	Date//	6/15/2017

Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	*Surface Description .....*	*Ag Land*	
2	*Manning's Roughness Coeff.,...n (See Figure 202-2B)*	*0.170*	
	Max. Flow Elev.(ft)=	*815.2*	
	Min. Flow Elev. (ft)=	*814.0*	
3	*Flow length, L .....ft.*	*86.2*	
4	*Two-yr 24hr Rainfall[1] , P2...in.*	*2.98*	
5	*Land Slope (ft/ft)=*	*0.0139*	
6	*Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.*	*0.192 hr*	

Shallow Concentration Flow

7	*Surface description (paved or unpaved).....*	*unpaved*	
	Max. Elevation, …….ft	*814.00*	
	Min Elevation, ……..ft	*802.00*	
8	*Flow length, L.....ft.*	*980.2*	
9	*Watercourse slope, s.....ft/ft*	*0.0122*	
10	*Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)*	*1.79*	
11	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.153 hr*	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	*2*
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	*1.249046*	*0*

		1	2
12	*Cross sectional flow area, a.....ft^2*	*33.00*	
13	*Wetted perimeter, Pw.....ft*	*16.32*	
14	*Hydraulic radius, r=a/Pw Compute r....ft*	*2.02*	
	Max. Elev of channel, ……..(ft) =	*802.00*	
	Min. Elev of channel, ……..(ft) =	*800.50*	
15	*Channel slope length,s.....ft/ft*	*0.00162*	
16	*Manning's roughness coeff.,n .Based on stream type*	*0.035*	
17	*V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s*	*2.74*	
18	*Flow length from shallow to Structure, L .....ft.*	*924*	
19	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.094 hr*	
20	*Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19*	***0.438 hr***	

or

Time of Concentration ***26.3 min***

Lag Time 15.8 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

ClarkDietz

Project//	Craig-Holleran Arm		
Project No.//	H0210170		
Subject//	Hydrology	Page//	of
Prepared By//	BEP	Date//	2/8/2017
Checked By//	HP	Date//	6/15/2017

Watershed Site Data: Basin 03

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	496787	11.40	821.14
Commercial	B	92		0.00	0.00
Forest	B	65	245500	5.64	366.33
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72	497550	11.42	822.40
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	496787	11.40	946.59
Commercial	D	95		0.00	0.00
Forest	D	79	245500	5.64	445.24
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92	497550	11.42	1050.84
		Totals =	2,479,674	56.93	4452.53
		Area Sq. Mi. =	0.0889		
				Weighted C :	78.2

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

Project//	Craig-Holleran Arm		
Project No.//	H0210170		
Subject//	Hydrology	Page//	of
Prepared By//	BEP	Date//	2/8/2017
Checked By//	HP	Date//	6/15/2017

Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	*Surface Description .....*	*Ag Land*	
2	*Manning's Roughness Coeff.,...n (See Figure 202-2B)*	*0.170*	
	Max. Flow Elev.(ft)=	*815.2*	
	Min. Flow Elev. (ft)=	*814.5*	
3	*Flow length, L .....ft.*	*81.7*	
4	*Two-yr 24hr Rainfall[1] , P2...in.*	*2.98*	
5	*Land Slope (ft/ft)=*	*0.0086*	
6	*Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.*	*0.223 hr*	

Shallow Concentration Flow

7	*Surface description (paved or unpaved).....*	*unpaved*	
	Max. Elevation, …….ft	*814.50*	
	Min Elevation, ……..ft	*801.00*	
8	*Flow length, L.....ft.*	*2052.3*	
9	*Watercourse slope, s.....ft/ft*	*0.0066*	
10	*Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)*	*1.31*	
11	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.436 hr*	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	*2*
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	*1.249046*	*0*

		1	2
12	*Cross sectional flow area, a.....ft^2*	*33.00*	
13	*Wetted perimeter, Pw.....ft*	*16.32*	
14	*Hydraulic radius, r=a/Pw Compute r....ft*	*2.02*	
	Max. Elev of channel, ……..(ft) =	*801.00*	
	Min. Elev of channel, ……..(ft) =	*796.50*	
15	*Channel slope length,s.....ft/ft*	*0.00317*	
16	*Manning's roughness coeff.,n .Based on stream type*	*0.035*	
17	*V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s*	*3.83*	
18	*Flow length from shallow to Structure, L .....ft.*	*1418*	
19	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.103 hr*	
20	*Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19*	***0.762 hr***	

or

Time of Concentration ***45.7 min***

Lag Time 27.4 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

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Watershed Site Data: Basin 04

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	1043938	23.97	1725.52
Commercial	B	92		0.00	0.00
Forest	B	65	132000	3.03	196.97
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72	54400	1.25	89.92
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	1565907	35.95	2983.71
Commercial	D	95		0.00	0.00
Forest	D	79	198000	4.55	359.09
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92	81600	1.87	172.34
		Totals =	3,075,844	70.61	5527.54
		Area Sq. Mi. =	0.1103		
				Weighted C :	78.3

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

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Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	Surface Description	Ag Land	
2	Manning's Roughness Coeff.,...n (See Figure 202-2B)	0.170	
	Max. Flow Elev.(ft)=	809.0	
	Min. Flow Elev. (ft)=	808.6	
3	Flow length, L .....ft.	83.2	
4	Two-yr 24hr Rainfall[1] , P2...in.	2.98	
5	Land Slope (ft/ft)=	0.0048	
6	Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.	0.285 hr	

Shallow Concentration Flow

7	Surface description (paved or unpaved).....	unpaved	
	Max. Elevation, …….ft	808.60	
	Min Elevation, ……..ft	800.00	
8	Flow length, L.....ft.	2473.9	
9	Watercourse slope, s.....ft/ft	0.0035	
10	Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)	0.95	
11	Tt = L/(3600 V).....Computed Tt..hr.	0.722 hr	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	2
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	1.249046	0

		1	2
12	Cross sectional flow area, a.....ft^2	33.00	
13	Wetted perimeter, Pw.....ft	16.32	
14	Hydraulic radius, r=a/Pw Compute r....ft	2.02	
	Max. Elev of channel, ……..(ft) =	800.00	
	Min. Elev of channel, ……..(ft) =	797.50	
15	Channel slope length,s.....ft/ft	0.00329	
16	Manning's roughness coeff.,n .Based on stream type	0.035	
17	V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s	3.90	
18	Flow length from shallow to Structure, L .....ft.	760	
19	Tt = L/(3600 V).....Computed Tt..hr.	0.054 hr	
20	Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19	**1.062 hr**	

or

Time of Concentration **63.7 min**

Lag Time 38.2 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

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Watershed Site Data: Basin 05

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	627396	14.40	1037.02
Commercial	B	92		0.00	0.00
Forest	B	65		0.00	0.00
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72		0.00	0.00
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	627396	14.40	1195.45
Commercial	D	95		0.00	0.00
Forest	D	79		0.00	0.00
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92		0.00	0.00
		Totals =	1,254,792	28.81	2232.47
		Area Sq. Mi. =	0.0450		
				Weighted C :	77.5

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

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Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	*Surface Description .....*	*Ag Land*	
2	*Manning's Roughness Coeff.,...n (See Figure 202-2B)*	*0.170*	
	Max. Flow Elev.(ft)=	*803.6*	
	Min. Flow Elev. (ft)=	*803.2*	
3	*Flow length, L .....ft.*	*85.6*	
4	*Two-yr 24hr Rainfall[1] , P2...in.*	*2.98*	
5	*Land Slope (ft/ft)=*	*0.0047*	
6	*Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.*	*0.296 hr*	

Shallow Concentration Flow

7	*Surface description (paved or unpaved).....*	*unpaved*	
	Max. Elevation, …….ft	*803.20*	
	Min Elevation, ……..ft	*794.50*	
8	*Flow length, L.....ft.*	*1191.9*	
9	*Watercourse slope, s.....ft/ft*	*0.0073*	
10	*Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)*	*1.38*	
11	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.240 hr*	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	*2*
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	*1.249046*	*0*

		1	2
12	*Cross sectional flow area, a.....ft^2*	*33.00*	
13	*Wetted perimeter, Pw.....ft*	*16.32*	
14	*Hydraulic radius, r=a/Pw Compute r....ft*	*2.02*	
	Max. Elev of channel, ……..(ft) =	*794.50*	
	Min. Elev of channel, ……..(ft) =	*794.00*	
15	*Channel slope length,s.....ft/ft*	*0.00135*	
16	*Manning's roughness coeff.,n .Based on stream type*	*0.035*	
17	*V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s*	*2.50*	
18	*Flow length from shallow to Structure, L .....ft.*	*369*	
19	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.041 hr*	
20	*Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19*	***0.577 hr***	

or

Time of Concentration ***34.6 min***

Lag Time 20.8 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

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Watershed Site Data: Basin 06

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	1039378	23.86	1717.98
Commercial	B	92		0.00	0.00
Forest	B	65	274800	6.31	410.06
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72		0.00	0.00
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	1559068	35.79	2970.68
Commercial	D	95		0.00	0.00
Forest	D	79	412200	9.46	747.56
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92		0.00	0.00
		Totals =	3,285,446	75.42	5846.27
		Area Sq. Mi. =	0.1178		
				Weighted C :	77.5

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

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Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	*Surface Description .....*	*Ag Land*	
2	*Manning's Roughness Coeff.,...n (See Figure 202-2B)*	*0.170*	
	Max. Flow Elev.(ft)=	*803.2*	
	Min. Flow Elev. (ft)=	*802.6*	
3	*Flow length, L .....ft.*	*88.2*	
4	*Two-yr 24hr Rainfall[1] , P2...in.*	*2.98*	
5	*Land Slope (ft/ft)=*	*0.0068*	
6	*Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.*	*0.260 hr*	

Shallow Concentration Flow

7	*Surface description (paved or unpaved).....*	*unpaved*	
	Max. Elevation, …….ft	*802.60*	
	Min Elevation, ……..ft	*797.00*	
8	*Flow length, L.....ft.*	*2597.7*	
9	*Watercourse slope, s.....ft/ft*	*0.0022*	
10	*Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)*	*0.75*	
11	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.963 hr*	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	*2*
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	*1.249046*	*0*

		1	2
12	*Cross sectional flow area, a.....ft^2*	*33.00*	
13	*Wetted perimeter, Pw.....ft*	*16.32*	
14	*Hydraulic radius, r=a/Pw Compute r....ft*	*2.02*	
	Max. Elev of channel, ……..(ft) =	*797.00*	
	Min. Elev of channel, ……..(ft) =	*789.50*	
15	*Channel slope length,s.....ft/ft*	*0.00704*	
16	*Manning's roughness coeff.,n .Based on stream type*	*0.035*	
17	*V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s*	*5.71*	
18	*Flow length from shallow to Structure, L .....ft.*	*1066*	
19	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.052 hr*	
20	*Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19*	***1.276 hr***	

or

Time of Concentration ***76.5 min***

Lag Time 45.9 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

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Watershed Site Data: Basin 07

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	963000	22.11	1591.74
Commercial	B	92		0.00	0.00
Forest	B	65		0.00	0.00
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72	1612851	37.03	2665.87
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	107000	2.46	203.88
Commercial	D	95		0.00	0.00
Forest	D	79		0.00	0.00
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92	403213	9.26	851.60
		Totals =	3,086,064	70.85	5313.08
		Area Sq. Mi. =	0.1107		
				Weighted C :	75.0

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

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Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	*Surface Description .....*	*Ag Land*	
2	*Manning's Roughness Coeff.,...n (See Figure 202-2B)*	*0.170*	
	Max. Flow Elev.(ft)=	*795.2*	
	Min. Flow Elev. (ft)=	*794.0*	
3	*Flow length, L .....ft.*	*90.3*	
4	*Two-yr 24hr Rainfall[1] , P2...in.*	*2.98*	
5	*Land Slope (ft/ft)=*	*0.0133*	
6	*Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.*	*0.203 hr*	

Shallow Concentration Flow

7	*Surface description (paved or unpaved).....*	*unpaved*	
	Max. Elevation, …….ft	*794.00*	
	Min Elevation, ……..ft	*787.00*	
8	*Flow length, L.....ft.*	*908.3*	
9	*Watercourse slope, s.....ft/ft*	*0.0077*	
10	*Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)*	*1.42*	
11	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.178 hr*	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	*2*
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	*1.249046*	*0*

		1	2
12	*Cross sectional flow area, a.....ft^2*	*33.00*	
13	*Wetted perimeter, Pw.....ft*	*16.32*	
14	*Hydraulic radius, r=a/Pw Compute r....ft*	*2.02*	
	Max. Elev of channel, ……..(ft) =	*787.00*	
	Min. Elev of channel, ……..(ft) =	*776.00*	
15	*Channel slope length,s.....ft/ft*	*0.00581*	
16	*Manning's roughness coeff.,n .Based on stream type*	*0.035*	
17	*V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s*	*5.19*	
18	*Flow length from shallow to Structure, L .....ft.*	*1893*	
19	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.101 hr*	
20	*Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19*	***0.482 hr***	

or

Time of Concentration ***28.9 min***

Lag Time 17.4 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

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Watershed Site Data: Basin 08

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	5624969	129.13	9297.47
Commercial	B	92		0.00	0.00
Forest	B	65		0.00	0.00
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72		0.00	0.00
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	992642	22.79	1891.40
Commercial	D	95		0.00	0.00
Forest	D	79		0.00	0.00
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92		0.00	0.00
		Totals =	6,617,610	151.92	11188.87
		Area Sq. Mi. =	0.2374		
				Weighted C :	73.7

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

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Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	Surface Description	Ag Land	
2	Manning's Roughness Coeff.,...n (See Figure 202-2B)	0.170	
	Max. Flow Elev.(ft)=	797.6	
	Min. Flow Elev. (ft)=	797.0	
3	Flow length, L .....ft.	85.0	
4	Two-yr 24hr Rainfall[1] , P2...in.	2.98	
5	Land Slope (ft/ft)=	0.0071	
6	Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.	0.249 hr	

Shallow Concentration Flow

7	Surface description (paved or unpaved).....	unpaved	
	Max. Elevation, …….ft	797.00	
	Min Elevation, ……..ft	783.00	
8	Flow length, L.....ft.	2934.3	
9	Watercourse slope, s.....ft/ft	0.0048	
10	Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)	1.11	
11	Tt = L/(3600 V).....Computed Tt..hr.	0.731 hr	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	2
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	1.249046	0

		1	2
12	Cross sectional flow area, a.....ft^2	33.00	
13	Wetted perimeter, Pw.....ft	16.32	
14	Hydraulic radius, r=a/Pw Compute r....ft	2.02	
	Max. Elev of channel, ……..(ft) =	783.00	
	Min. Elev of channel, ……..(ft) =	775.00	
15	Channel slope length,s.....ft/ft	0.00613	
16	Manning's roughness coeff.,n .Based on stream type	0.035	
17	V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s	5.33	
18	Flow length from shallow to Structure, L .....ft.	1305	
19	Tt = L/(3600 V).....Computed Tt..hr.	0.068 hr	
20	Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19	**1.048 hr**	

or

Time of Concentration **62.9 min**

Lag Time 37.7 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

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Watershed Site Data: Basin 09

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	1828605	41.98	3022.49
Commercial	B	92		0.00	0.00
Forest	B	65	144600	3.32	215.77
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72	91200	2.09	150.74
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	1219070	27.99	2322.84
Commercial	D	95		0.00	0.00
Forest	D	79	96400	2.21	174.83
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92	60800	1.40	128.41
		Totals =	3,440,675	78.99	6015.08
		Area Sq. Mi. =	0.1234		
				Weighted C :	76.2

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

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Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	*Surface Description .....*	*Ag Land*	
2	*Manning's Roughness Coeff.,...n (See Figure 202-2B)*	*0.170*	
	Max. Flow Elev.(ft)=	*804.2*	
	Min. Flow Elev. (ft)=	*800.6*	
3	*Flow length, L .....ft.*	*77.0*	
4	*Two-yr 24hr Rainfall[1] , P2...in.*	*2.98*	
5	*Land Slope (ft/ft)=*	*0.0468*	
6	*Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.*	*0.108 hr*	

Shallow Concentration Flow

7	*Surface description (paved or unpaved).....*	*unpaved*	
	Max. Elevation, …….ft	*800.60*	
	Min Elevation, ……..ft	*792.50*	
8	*Flow length, L.....ft.*	*2789.0*	
9	*Watercourse slope, s.....ft/ft*	*0.0029*	
10	*Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)*	*0.87*	
11	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.891 hr*	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	*2*
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	*1.249046*	*0*

		1	2
12	*Cross sectional flow area, a.....ft^2*	*33.00*	
13	*Wetted perimeter, Pw.....ft*	*16.32*	
14	*Hydraulic radius, r=a/Pw Compute r....ft*	*2.02*	
	Max. Elev of channel, ……..(ft) =	*792.50*	
	Min. Elev of channel, ……..(ft) =	*791.30*	
15	*Channel slope length,s.....ft/ft*	*0.00173*	
16	*Manning's roughness coeff.,n .Based on stream type*	*0.035*	
17	*V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s*	*2.83*	
18	*Flow length from shallow to Structure, L .....ft.*	*694*	
19	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.068 hr*	
20	*Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19*	***1.067 hr***	

or

Time of Concentration ***64.0 min***

Lag Time 38.4 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

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Watershed Site Data: Basin 10

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	3717412	85.34	6144.48
Commercial	B	92		0.00	0.00
Forest	B	65	145200	3.33	216.67
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72	139800	3.21	231.07
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	2478275	56.89	4722.15
Commercial	D	95		0.00	0.00
Forest	D	79	96800	2.22	175.56
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92	93200	2.14	196.84
		Totals =	6,670,687	153.14	11686.77
		Area Sq. Mi. =	0.2393		
				Weighted C :	76.3

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

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Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	Surface Description	Ag Land	
2	Manning's Roughness Coeff.,...n (See Figure 202-2B)	0.170	
	Max. Flow Elev.(ft)=	797.2	
	Min. Flow Elev. (ft)=	794.5	
3	Flow length, L .....ft.	86.1	
4	Two-yr 24hr Rainfall[1] , P2...in.	2.98	
5	Land Slope (ft/ft)=	0.0313	
6	Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.	0.139 hr	

Shallow Concentration Flow

7	Surface description (paved or unpaved).....	unpaved	
	Max. Elevation, …….ft	794.50	
	Min Elevation, ……..ft	785.90	
8	Flow length, L.....ft.	2298.2	
9	Watercourse slope, s.....ft/ft	0.0037	
10	Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)	0.99	
11	Tt = L/(3600 V).....Computed Tt..hr.	0.647 hr	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	2
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	1.249046	0

		1	2
12	Cross sectional flow area, a.....ft^2	33.00	
13	Wetted perimeter, Pw.....ft	16.32	
14	Hydraulic radius, r=a/Pw Compute r....ft	2.02	
	Max. Elev of channel, ……..(ft) =	785.90	
	Min. Elev of channel, ……..(ft) =	778.00	
15	Channel slope length,s.....ft/ft	0.00381	
16	Manning's roughness coeff.,n .Based on stream type	0.035	
17	V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s	4.20	
18	Flow length from shallow to Structure, L .....ft.	2075	
19	Tt = L/(3600 V).....Computed Tt..hr.	0.137 hr	
20	Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19	**0.923 hr**	

or

Time of Concentration **55.4 min**

Lag Time 33.2 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

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Watershed Site Data: Basin 11

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	464342	10.66	767.51
Commercial	B	92		0.00	0.00
Forest	B	65	108800	2.50	162.35
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72	0	0.00	0.00
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	116086	2.66	221.19
Commercial	D	95		0.00	0.00
Forest	D	79	27200	0.62	49.33
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92	0	0.00	0.00
		Totals =	716,428	16.45	1200.38
		Area Sq. Mi. =	0.0257		
				Weighted C :	73.0

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

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Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	*Surface Description .....*	*Ag Land*	
2	*Manning's Roughness Coeff.,...n (See Figure 202-2B)*	*0.170*	
	Max. Flow Elev.(ft)=	*789.0*	
	Min. Flow Elev. (ft)=	*785.5*	
3	*Flow length, L .....ft.*	*41.1*	
4	*Two-yr 24hr Rainfall[1] , P2...in.*	*2.98*	
5	*Land Slope (ft/ft)=*	*0.0851*	
6	*Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.*	*0.051 hr*	

Shallow Concentration Flow

7	*Surface description (paved or unpaved).....*	*unpaved*	
	Max. Elevation, …….ft	*785.50*	
	Min Elevation, ……..ft	*773.00*	
8	*Flow length, L.....ft.*	*1272.5*	
9	*Watercourse slope, s.....ft/ft*	*0.0098*	
10	*Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)*	*1.60*	
11	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.221 hr*	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	*2*
b =	0.0 ft	
d =	0.0 ft	
SS =	0:1	
Angle =	*0*	*0*

		1	2
12	*Cross sectional flow area, a.....ft^2*	*#DIV/0!*	
13	*Wetted perimeter, Pw.....ft*	*#DIV/0!*	
14	*Hydraulic radius, r=a/Pw Compute r....ft*	*0.00*	
	Max. Elev of channel, ……..(ft) =	*0.00*	
	Min. Elev of channel, ……..(ft) =	*0.00*	
15	*Channel slope length,s.....ft/ft*	*#DIV/0!*	
16	*Manning's roughness coeff.,n .Based on stream type*	*0*	
17	*V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s*	*#DIV/0!*	
18	*Flow length from shallow to Structure, L .....ft.*	*0*	
19	*Tt = L/(3600 V).....Computed Tt..hr.*	*0.000 hr*	
20	*Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19*	***0.273 hr***	

or

Time of Concentration ***16.4 min***

Lag Time 9.8 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

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Watershed Site Data: Basin 12

Geographic Area Descriptions	Soil Type	Runoff Curve (C)	Area (Sq. Ft.)	Area (acres) (A)	CxA
Road	N/A	98		0.00	0.00
Agriculture	A	67		0.00	0.00
Forest	A	36		0.00	0.00
HD-Residential	A	54		0.00	0.00
LD-Residential	A	46		0.00	0.00
Agriculture	B	72	28350	0.65	46.86
Commercial	B	92		0.00	0.00
Forest	B	65	486500	11.17	725.95
Grass/Pasture	B	61		0.00	0.00
HD-Residential	B	85		0.00	0.00
LD-Residential	B	72	678497	15.58	1121.48
Agriculture	C	83		0.00	0.00
Commercial	C	94		0.00	0.00
Forest	C	73		0.00	0.00
Grass/Pasture	C	79		0.00	0.00
HD-Residential	C	80		0.00	0.00
LD-Residential	C	77		0.00	0.00
Agriculture	D	83	12150	0.28	23.15
Commercial	D	95		0.00	0.00
Forest	D	79	208500	4.79	378.13
Grass/Pasture	D	80		0.00	0.00
LD-Residential	D	92	290785	6.68	614.15
		Totals =	1,704,782	39.14	2909.73
		Area Sq. Mi. =	0.0612		
				Weighted C :	74.3

Note - Curve Numbers taken from *Urban Hydrology for Small Watersheds,* Technical Release TR 55, United States of Agriculture, Natural Resources Conservation Service, Tat

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Time of Concentration:

Sheet Flow (Applicable to Tc only)

1	Surface Description	Ag Land	
2	Manning's Roughness Coeff.,...n (See Figure 202-2B)	0.170	
	Max. Flow Elev.(ft)=	788.4	
	Min. Flow Elev. (ft)=	788.0	
3	Flow length, L .....ft.	84.4	
4	Two-yr 24hr Rainfall[1] , P2...in.	2.98	
5	Land Slope (ft/ft)=	0.0047	
6	Tt = 0.007 (nL)^0.8/P2^0.5 * S^0.4 Computed Tt....hr.	0.290 hr	

Shallow Concentration Flow

7	Surface description (paved or unpaved).....	unpaved	
	Max. Elevation, …….ft	788.00	
	Min Elevation, ……..ft	771.50	
8	Flow length, L.....ft.	1216.9	
9	Watercourse slope, s.....ft/ft	0.0136	
10	Average velocity, V ..ft/s(INDOT eq 29-7.7 or7.8)	1.88	
11	Tt = L/(3600 V).....Computed Tt..hr.	0.180 hr	

Channel Flow

Trapezoidal Channel Geometry (Estimated from Survey/Quad maps)

	1	2
b =	10.0 ft	
d =	3.0 ft	
SS =	3:1	
Angle =	1.249046	0

		1	2
12	Cross sectional flow area, a.....ft^2	33.00	
13	Wetted perimeter, Pw.....ft	16.32	
14	Hydraulic radius, r=a/Pw Compute r....ft	2.02	
	Max. Elev of channel, ……..(ft) =	771.50	
	Min. Elev of channel, ……..(ft) =	771.00	
15	Channel slope length,s.....ft/ft	0.00315	
16	Manning's roughness coeff.,n .Based on stream type	0.035	
17	V =(1.49 r^2/3 s^1/2)/n Computed V...ft/s	3.82	
18	Flow length from shallow to Structure, L .....ft.	159	
19	Tt = L/(3600 V).....Computed Tt..hr.	0.012 hr	
20	Watershed or Subarea Tc or Tt (add Tt in steps 6, 11, and 19	**0.482 hr**	

or

Time of Concentration **28.9 min**

Lag Time 17.3 min

Notes

1) - 2-year 24 hour rainfall was taken from NOAA Atlas 14, Volume 2

ATTACHMENT 4:

Rainfall Depths and Distributions

Table 2. Continued

Rainfall (inches) for given recurrence interval

Section	Duration	2-month	3-month	4-month	6-month	9-month	1-year	2-year	5-year	10-year	25-year	50-year	100-year
04	10-day	2.32	2.80	3.22	3.79	4.36	4.74	5.43	6.47	7.33	8.50	9.48	10.65
04	5-day	1.85	2.21	2.50	2.90	3.34	3.63	4.24	5.15	5.97	7.25	8.31	9.55
04	72-hr	1.64	1.93	2.18	2.53	2.91	3.16	3.76	4.53	5.34	6.43	7.45	8.55
04	48-hr	1.53	1.79	1.99	2.30	2.65	2.88	3.38	4.12	4.75	5.77	6.66	7.65
04	24-hr	1.45	1.68	1.84	2.13	2.42	2.63	3.12	3.83	4.47	5.39	6.17	7.01
04	18-hr	1.36	1.58	1.73	2.00	2.27	2.47	2.93	3.60	4.20	5.07	5.80	6.59
04	12-hr	1.26	1.47	1.60	1.85	2.11	2.29	2.71	3.33	3.89	4.69	5.37	6.10
04	6-hr	1.08	1.26	1.38	1.60	1.81	1.97	2.34	2.87	3.35	4.04	4.63	5.26
04	3-hr	0.92	1.08	1.18	1.36	1.55	1.68	2.00	2.45	2.86	3.45	3.95	4.49
04	2-hr	0.84	0.98	1.07	1.24	1.41	1.53	1.81	2.22	2.59	3.13	3.58	4.07
04	1-hr	0.68	0.79	0.87	1.00	1.14	1.24	1.47	1.80	2.10	2.53	2.90	3.29
04	30-min	0.53	0.62	0.68	0.79	0.89	0.97	1.15	1.42	1.65	1.99	2.28	2.59
04	15-min	0.39	0.45	0.50	0.58	0.65	0.71	0.84	1.03	1.21	1.46	1.67	1.89
04	10-min	0.30	0.35	0.38	0.45	0.51	0.55	0.66	0.80	0.94	1.13	1.30	1.47
04	5-min	0.18	0.20	0.22	0.26	0.29	0.32	0.37	0.46	0.54	0.65	0.74	0.84
05	10-day	2.13	2.56	2.95	3.47	3.99	4.34	5.06	6.07	6.96	8.36	9.57	10.86
05	5-day	1.73	2.07	2.34	2.71	3.12	3.39	3.97	4.86	5.66	6.91	8.07	9.44
05	72-hr	1.52	1.79	2.02	2.34	2.70	2.93	3.45	4.27	5.04	6.15	7.17	8.31
05	48-hr	1.42	1.66	1.85	2.14	2.47	2.68	3.18	3.94	4.63	5.65	6.56	7.55
05	24-hr	1.35	1.57	1.72	1.99	2.26	2.46	2.92	3.64	4.25	5.16	5.95	6.84
05	18-hr	1.27	1.48	1.62	1.87	2.13	2.31	2.74	3.42	3.99	4.85	5.59	6.43
05	12-hr	1.18	1.37	1.50	1.73	1.97	2.14	2.54	3.17	3.70	4.49	5.18	5.95
05	6-hr	1.02	1.18	1.29	1.50	1.70	1.85	2.19	2.73	3.19	3.87	4.46	5.13
05	3-hr	0.86	1.00	1.10	1.27	1.44	1.57	1.87	2.33	2.72	3.30	3.81	4.38
05	2-hr	0.79	0.92	1.00	1.16	1.32	1.43	1.69	2.11	2.46	2.99	3.45	3.97
05	1-hr	0.64	0.74	0.81	0.94	1.07	1.16	1.37	1.71	2.00	2.43	2.80	3.21
05	30-min	0.50	0.58	0.64	0.74	0.84	0.91	1.08	1.35	1.57	1.91	2.20	2.53
05	15-min	0.36	0.42	0.46	0.53	0.61	0.66	0.79	0.98	1.15	1.39	1.61	1.85
05	10-min	0.29	0.33	0.36	0.42	0.48	0.52	0.61	0.76	0.89	1.08	1.25	1.44
05	5-min	0.17	0.19	0.21	0.24	0.28	0.30	0.35	0.44	0.51	0.62	0.71	0.82
06	10-day	2.13	2.57	2.96	3.48	4.00	4.35	5.00	6.00	6.82	8.30	9.55	11.05
06	5-day	1.62	1.93	2.19	2.54	2.92	3.17	3.75	4.68	5.50	6.90	8.20	9.68
06	72-hr	1.45	1.70	1.92	2.22	2.56	2.78	3.30	4.15	4.98	6.06	7.25	8.55
06	48-hr	1.36	1.59	1.77	2.06	2.36	2.57	3.01	3.73	4.40	5.54	6.55	7.70
06	24-hr	1.26	1.47	1.61	1.86	2.12	2.30	2.76	3.37	3.89	4.65	5.29	6.05
06	18-hr	1.19	1.38	1.51	1.75	1.99	2.16	2.59	3.17	3.66	4.37	4.97	5.69
06	12-hr	1.10	1.28	1.40	1.62	1.84	2.00	2.40	2.93	3.38	4.05	4.60	5.26
06	6-hr	0.95	1.10	1.20	1.39	1.58	1.72	2.07	2.53	2.92	3.49	3.97	4.54
06	3-hr	0.81	0.94	1.03	1.19	1.35	1.47	1.77	2.16	2.49	2.98	3.39	3.87
06	2-hr	0.73	0.85	0.93	1.08	1.22	1.33	1.60	1.95	2.26	2.70	3.07	3.51
06	1-hr	0.59	0.69	0.76	0.87	0.99	1.08	1.30	1.58	1.83	2.19	2.49	2.84
06	30-min	0.47	0.54	0.60	0.69	0.78	0.85	1.02	1.25	1.44	1.72	1.96	2.24
06	15-min	0.34	0.40	0.43	0.50	0.57	0.62	0.75	0.91	1.05	1.26	1.43	1.63
06	10-min	0.26	0.31	0.34	0.39	0.44	0.48	0.58	0.71	0.82	0.98	1.11	1.27
06	5-min	0.15	0.18	0.20	0.23	0.26	0.28	0.33	0.40	0.47	0.56	0.63	0.73

Project Area is in Section 05

Table 10. Median Time Distributions of Heavy Storm Rainfall at a Point

	Cumulative storm rainfall (percent) for given storm type			
Cumulative storm time (percent)	*First-quartile*	*Second-quartile*	*Third-quartile*	*Fourth-quartile*
5	16	3	3	2
10	33	8	6	5
15	43	12	9	8
20	52	16	12	10
25	60	22	15	13
30	66	29	19	16
35	71	39	23	19
40	75	51	27	22
45	79	62	32	25
50	82	70	38	28
55	84	76	45	32
60	86	81	57	35
65	88	85	70	39
70	90	88	79	45
75	92	91	85	51
80	94	93	89	59
85	96	95	92	72
90	97	97	95	84
95	98	98	97	92

ATTACHMENT 5:

Problem Areas

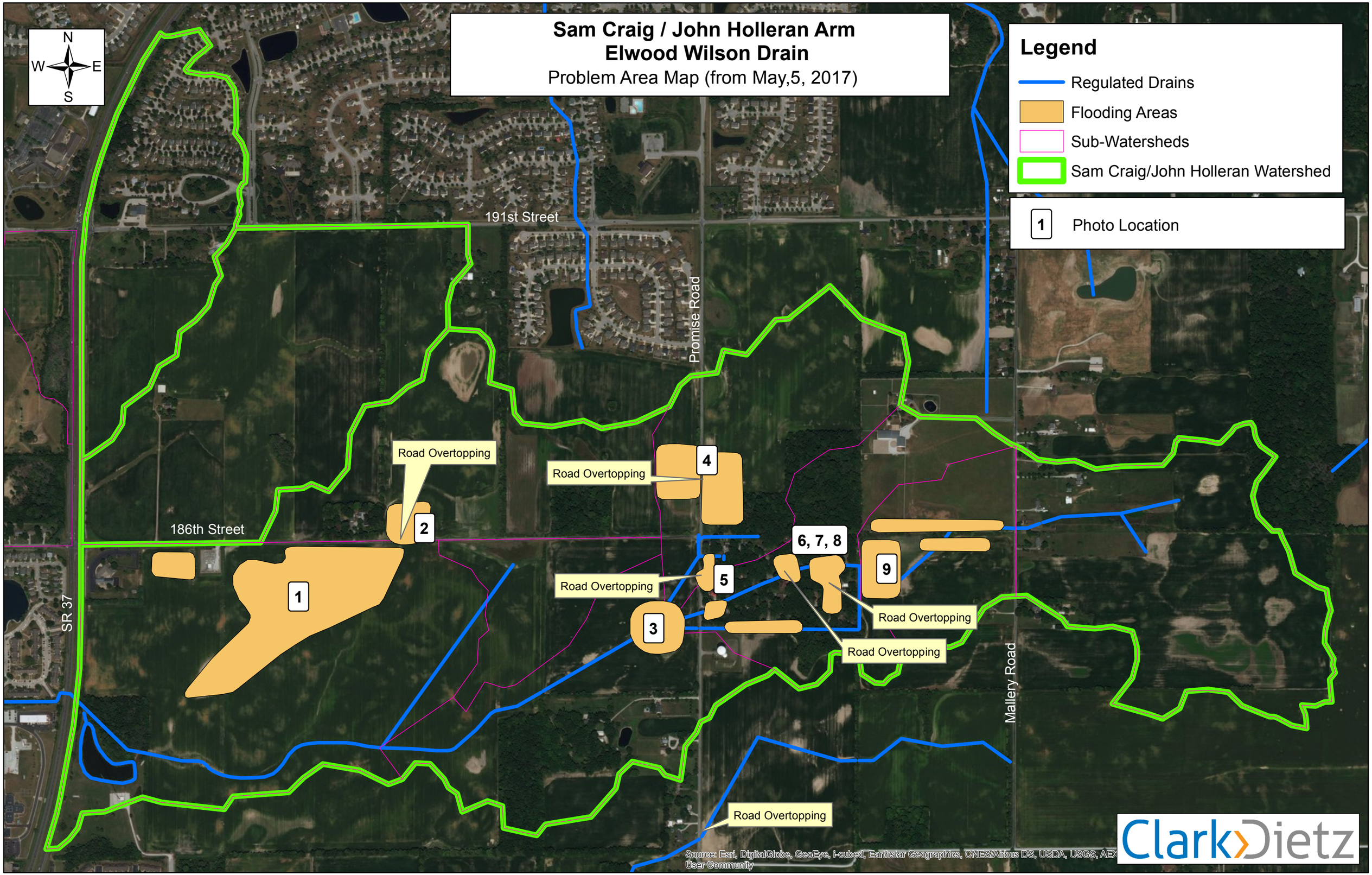
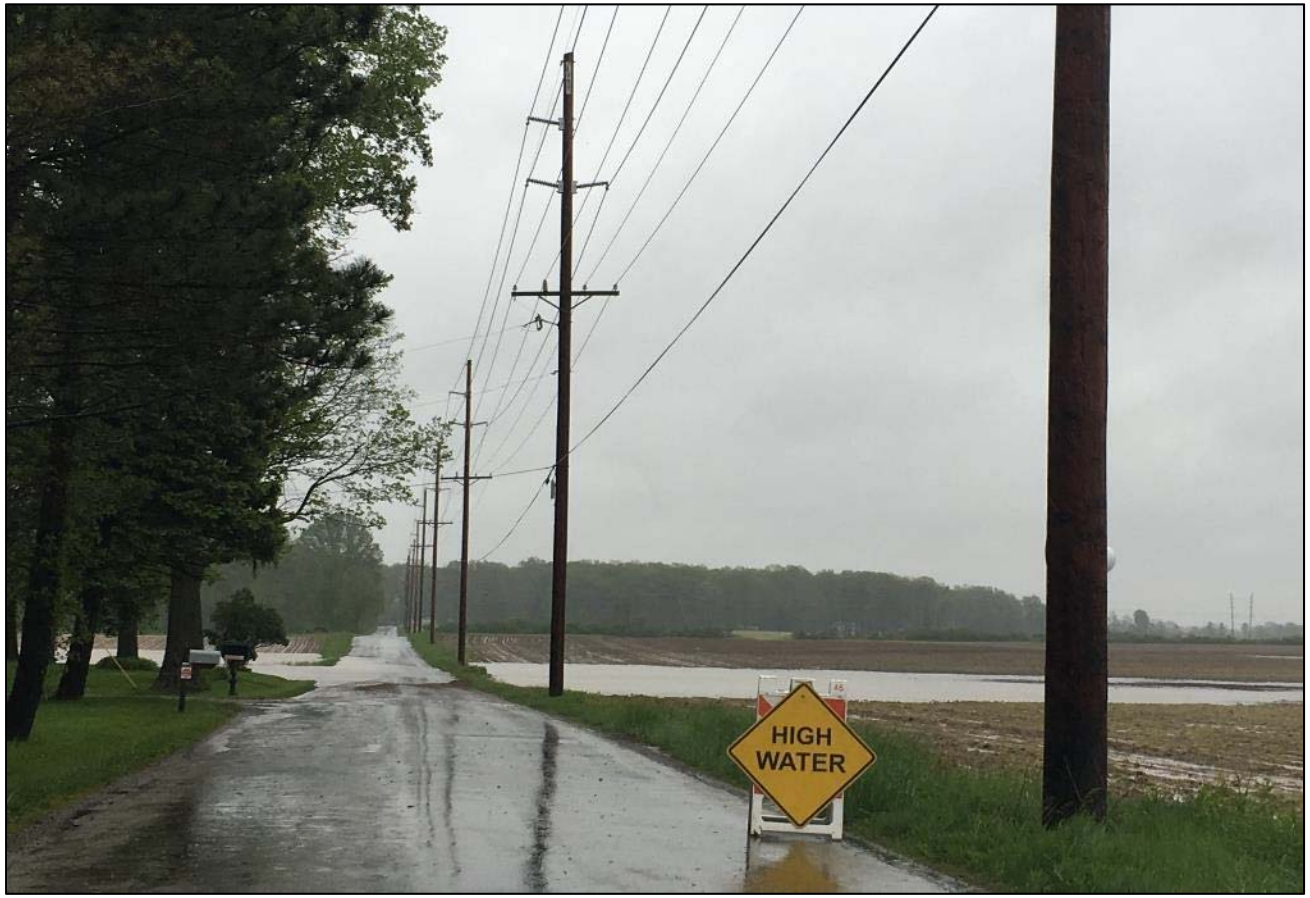

Sam Craig / John Holleran Arm
Elwood Wilson Drain
Problem Area Map (from May,5, 2017)
N
W
E
S
Legend
Regulated Drains
Flooding Areas
Sub-Watersheds
Sam Craig/John Holleran Watershed
1
Photo Location
191st Street
Promise Road
186th Street
SR 37
Mallery Road
Road Overtopping
Road Overtopping
Road Overtopping
Road Overtopping
Road Overtopping
Road Overtopping
1
2
3
4
5
6, 7, 8
9
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX
User Community
ClarkDietz

Photo 1: Farm Field, Looking South from 186th Street

(5/05/2017)

Photo 2: 186th Street High Water Flooding, Looking East



(5/05/2017)

Photo 3: Across from Oak Wood Community, Drains Junction, Looking West

(5/05/2017)

Photo 4: Promise Road Flooding, North of 186th Street, Looking North

(5/05/2017)

Photo 5: Promise Road Flooding, South of 186th Street, Looking North

(5/05/2017)

Photo 6: Fishers Oak Wood Community Flooding, Looking East

(5/05/2017)

Photo 7: Fishers Oak Wood Community Road Flooding, Looking East

(5/05/2017)

Photo 8: Fishers Oak Wood Community Flooding

(5/05/2017)

Photo 9: Flooding Upstream of Oak Wood Community, Looking West from Mallery Road

(5/05/2017)

ATTACHMENT 6:

HY-8 Output

HY-8 Culvert Analysis Report

Project Notes

Project Title: Sam Craig – John Holleran Arms

Designer: BEP

Project Date: 6/13/17

Notes:

Project Units: U.S. Customary Units

Outlet Control Option: Profiles

Exit Loss Option: Standard Method

Crossing Notes: Mallery Road – Existing Structure - Q100 peak discharge

Crossing Discharge Data

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

Minimum Flow: 0 cfs

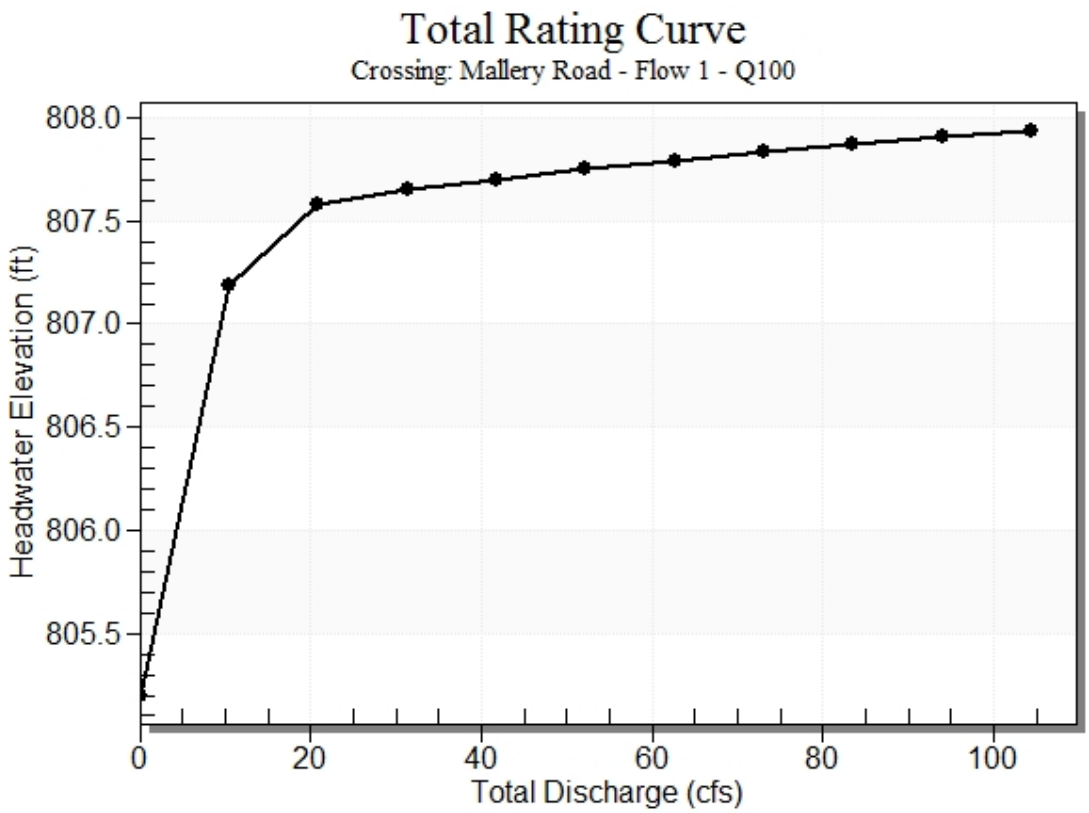
Design Flow: 104.4 cfs

Maximum Flow: 104.4 cfs

Table 1 - Summary of Culvert Flows at Crossing: Mallery Road - Flow 1 - Q100

Headwater Elevation (ft)	Total Discharge (cfs)	Existing Q100 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
805.20	0.00	0.00	0.00	1
807.19	10.44	10.44	0.00	1
807.58	20.88	13.70	7.08	13
807.65	31.32	14.21	16.98	5
807.70	41.76	14.61	26.98	4
807.75	52.20	14.97	37.16	4
807.79	62.64	15.28	47.14	3
807.83	73.08	15.57	57.38	3
807.87	83.52	15.83	67.63	3
807.91	93.96	16.02	77.91	3
807.94	104.40	16.13	88.26	3
807.50	13.02	13.02	0.00	Overtopping

Rating Curve Plot for Crossing: Mallery Road - Flow 1 - Q100



Culvert Notes: Existing Q100

Table 2 - Culvert Summary Table: Existing Q100

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	805.20	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
10.44	10.44	807.19	1.882	1.986	2-M2c	1.564	1.155	1.155	0.499	5.557	1.612
20.88	13.70	807.58	2.328	2.383	7-M2c	2.000	1.329	1.329	0.728	6.177	1.995
31.32	14.21	807.65	2.404	2.448	7-M2c	2.000	1.354	1.354	0.904	6.275	2.248
41.76	14.61	807.70	2.467	2.502	7-M2c	2.000	1.374	1.374	1.050	6.353	2.441
52.20	14.97	807.75	2.522	2.549	7-M2c	2.000	1.390	1.390	1.177	6.422	2.599
62.64	15.28	807.79	2.572	2.591	7-M2c	2.000	1.405	1.405	1.291	6.482	2.735
73.08	15.57	807.83	2.619	2.632	7-M2c	2.000	1.418	1.418	1.394	6.538	2.854
83.52	15.83	807.87	2.661	2.669	3-M2t	2.000	1.430	1.490	1.490	6.307	2.960
93.96	16.02	807.91	2.693	2.705	3-M2t	2.000	1.438	1.579	1.579	6.023	3.056
104.40	16.13	807.94	2.712	2.740	3-M2t	2.000	1.443	1.662	1.662	5.781	3.145

****

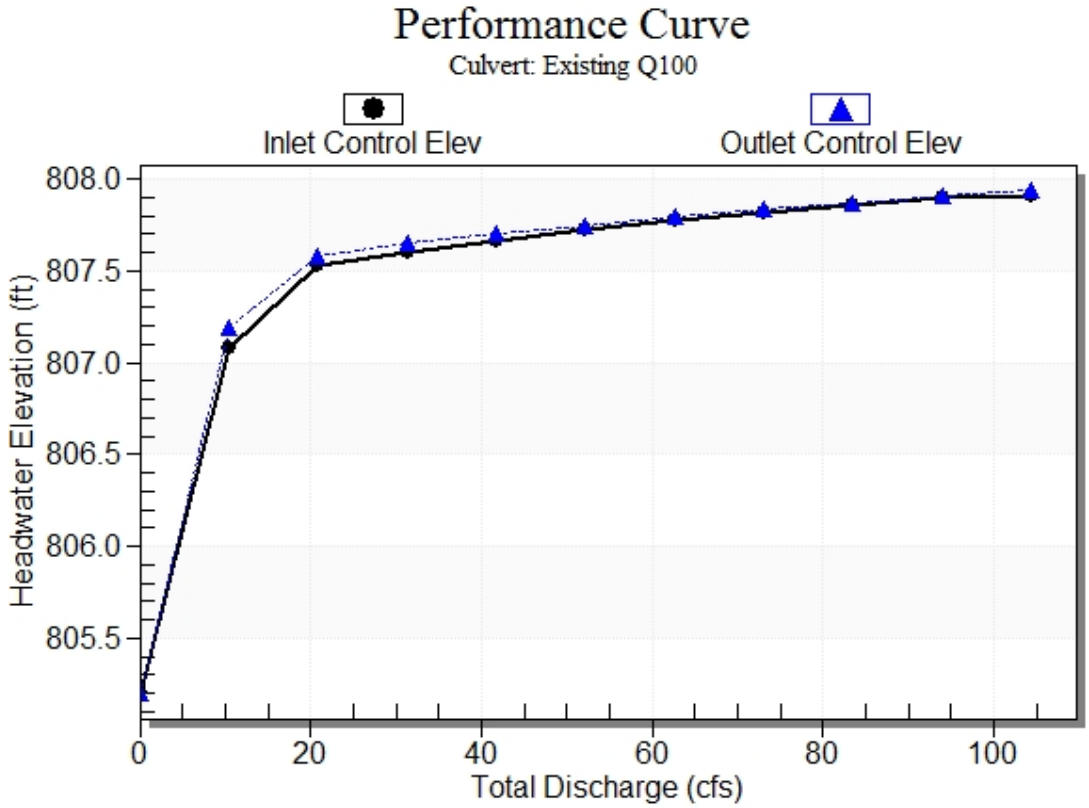
Straight Culvert

Inlet Elevation (invert): 805.20 ft, Outlet Elevation (invert): 805.00 ft

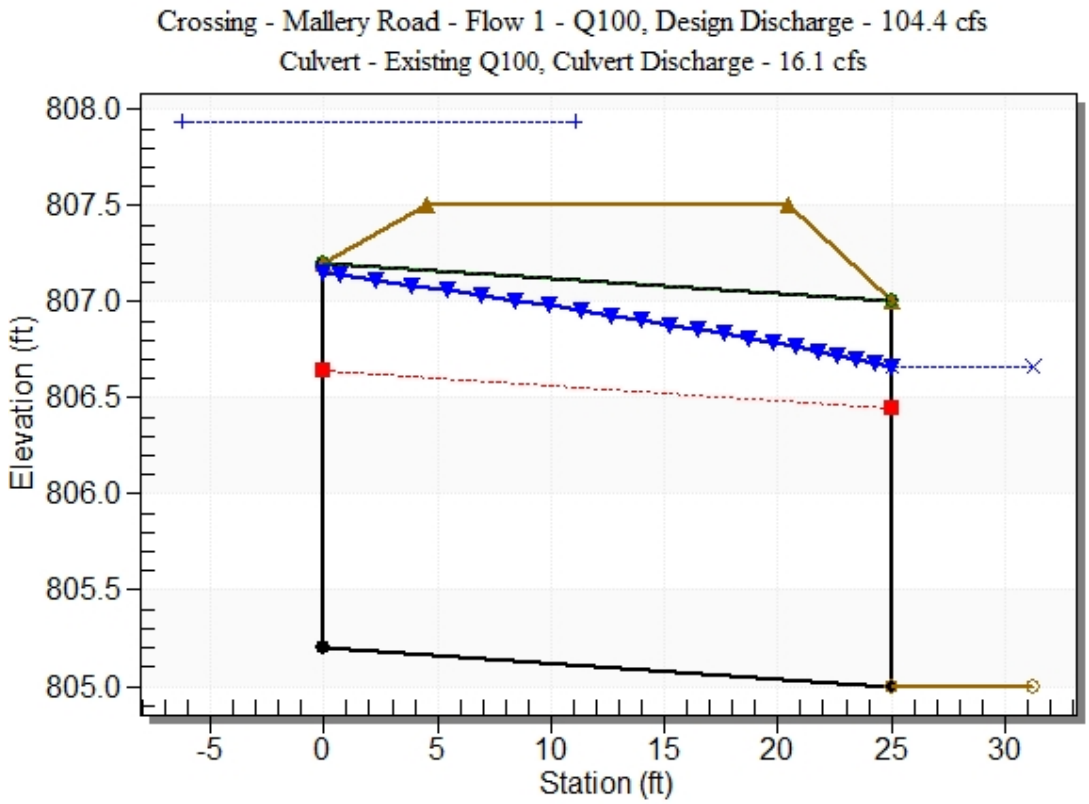
Culvert Length: 25.00 ft, Culvert Slope: 0.0080

****

Culvert Performance Curve Plot: Existing Q100



Water Surface Profile Plot for Culvert: Existing Q100



Site Data - Existing Q100

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 805.20 ft

Outlet Station: 25.00 ft

Outlet Elevation: 805.00 ft

Number of Barrels: 1

Culvert Data Summary - Existing Q100

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Mallery Road - Flow 1 - Q100)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	805.00	0.00	0.00	0.00	0.00
10.44	805.50	0.50	1.61	0.25	0.45
20.88	805.73	0.73	1.99	0.36	0.47
31.32	805.90	0.90	2.25	0.45	0.48
41.76	806.05	1.05	2.44	0.52	0.49
52.20	806.18	1.18	2.60	0.59	0.50
62.64	806.29	1.29	2.73	0.64	0.51
73.08	806.39	1.39	2.85	0.70	0.51
83.52	806.49	1.49	2.96	0.74	0.52
93.96	806.58	1.58	3.06	0.79	0.52
104.40	806.66	1.66	3.14	0.83	0.53

Tailwater Channel Data - Mallery Road - Flow 1 - Q100

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

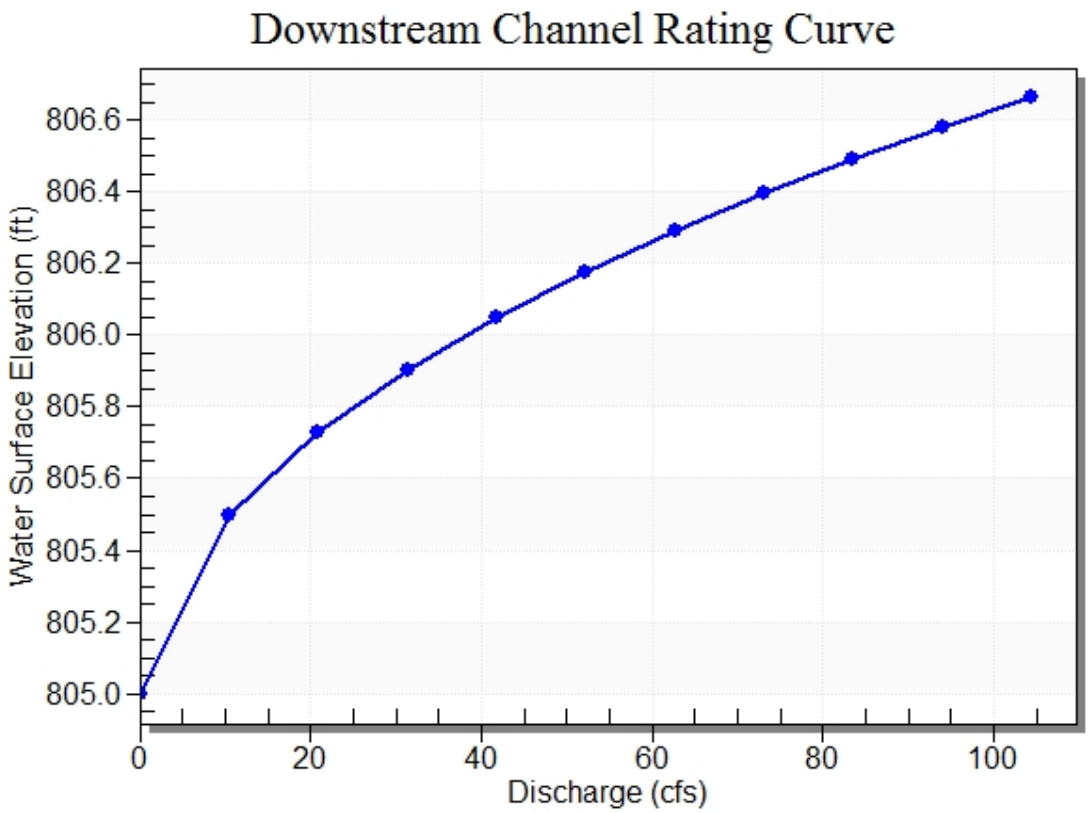
Side Slope (H:V): 6.00 (_:1)

Channel Slope: 0.0080

Channel Manning's n: 0.0450

Channel Invert Elevation: 805.00 ft

Tailwater Rating Curve Plot for Crossing: Mallery Road - Flow 1 - Q100



Roadway Data for Crossing: Mallery Road - Flow 1 - Q100

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 807.50 ft

Roadway Surface: Paved

Roadway Top Width: 16.00 ft

Crossing Notes: Mallery Road - Q100 Proposed 3’ x 5’ Box Culvert

Crossing Discharge Data

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

Minimum Flow: 0 cfs

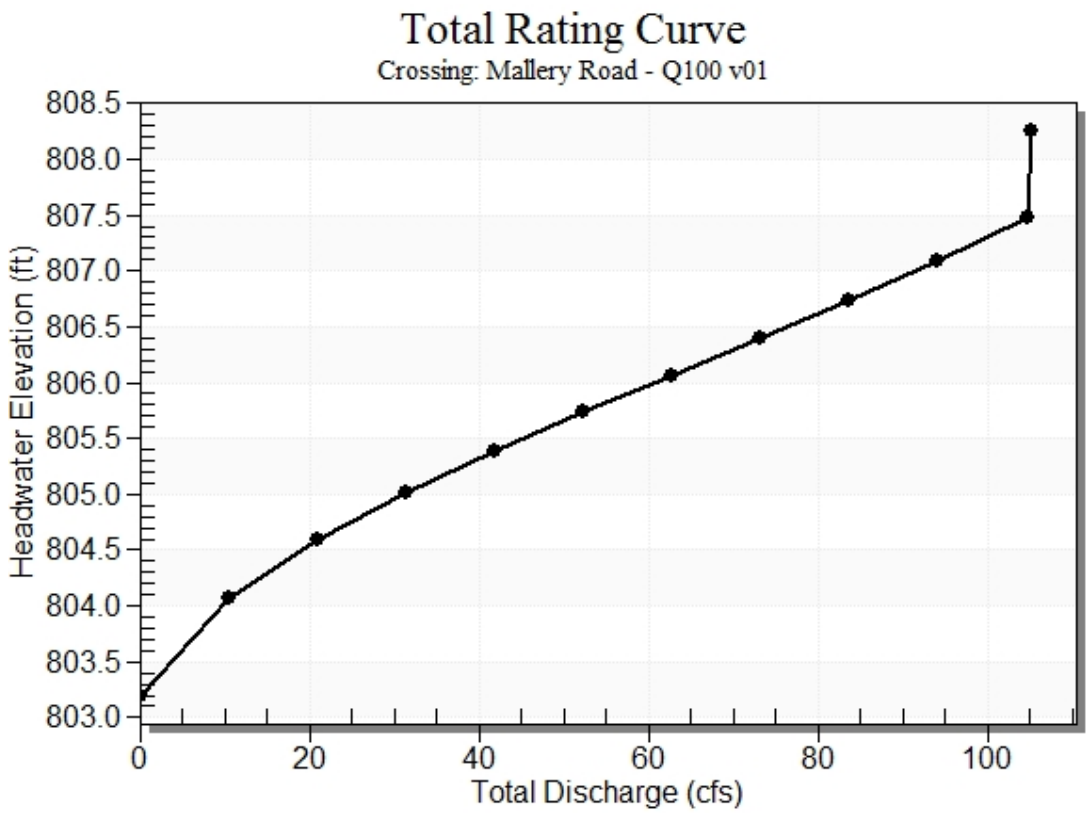
Design Flow: 104.6 cfs

Maximum Flow: 104.6 cfs

Table 4 - Summary of Culvert Flows at Crossing: Mallery Road - Q100 v01

Headwater Elevation (ft)	Total Discharge (cfs)	Proposed 3 x 5 Box Discharge (cfs)	Roadway Discharge (cfs)	Iterations
803.20	0.00	0.00	0.00	1
804.08	10.46	10.46	0.00	1
804.59	20.92	20.92	0.00	1
805.01	31.38	31.38	0.00	1
805.39	41.84	41.84	0.00	1
805.73	52.30	52.30	0.00	1
806.06	62.76	62.76	0.00	1
806.40	73.22	73.22	0.00	1
806.74	83.68	83.68	0.00	1
807.10	94.14	94.14	0.00	1
807.48	104.60	104.60	0.00	1
807.50	105.11	105.11	0.00	Overtopping

Rating Curve Plot for Crossing: Mallery Road - Q100 v01



Culvert Notes: Proposed 3 x 5 Box

Table 5 - Culvert Summary Table: Proposed 3 x 5 Box

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	803.20	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
10.46	10.46	804.08	0.876	0.326	1-S2n	0.377	0.514	0.405	0.499	5.168	1.613
20.92	20.92	804.59	1.390	0.665	1-S2n	0.603	0.816	0.655	0.729	6.391	1.996
31.38	31.38	805.01	1.812	0.979	1-S2n	0.791	1.069	0.873	0.905	7.188	2.249
41.84	41.84	805.39	2.186	1.291	1-S2n	0.958	1.296	1.073	1.051	7.802	2.442
52.30	52.30	805.73	2.532	1.608	1-S2n	1.118	1.503	1.259	1.178	8.308	2.601
62.76	62.76	806.06	2.864	1.936	1-S2n	1.266	1.698	1.435	1.292	8.744	2.736
73.22	73.22	806.40	3.196	2.279	5-S2n	1.412	1.881	1.604	1.396	9.129	2.855
83.68	83.68	806.74	3.537	2.636	5-S2n	1.551	2.057	1.766	1.491	9.476	2.962
94.14	94.14	807.10	3.896	3.012	5-S2n	1.687	2.225	1.923	1.580	9.793	3.058
104.60	104.60	807.48	4.280	3.712	5-S2n	1.819	2.386	2.074	1.664	10.084	3.146

****

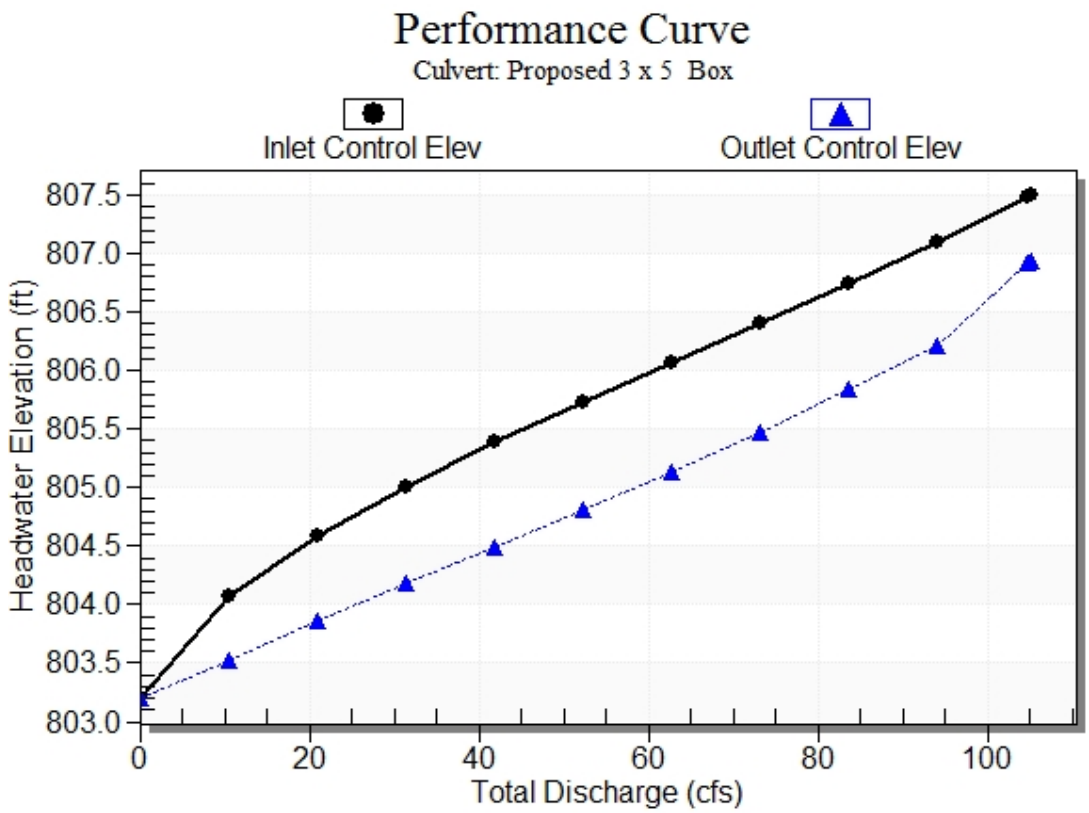
Straight Culvert

Inlet Elevation (invert): 803.20 ft, Outlet Elevation (invert): 803.00 ft

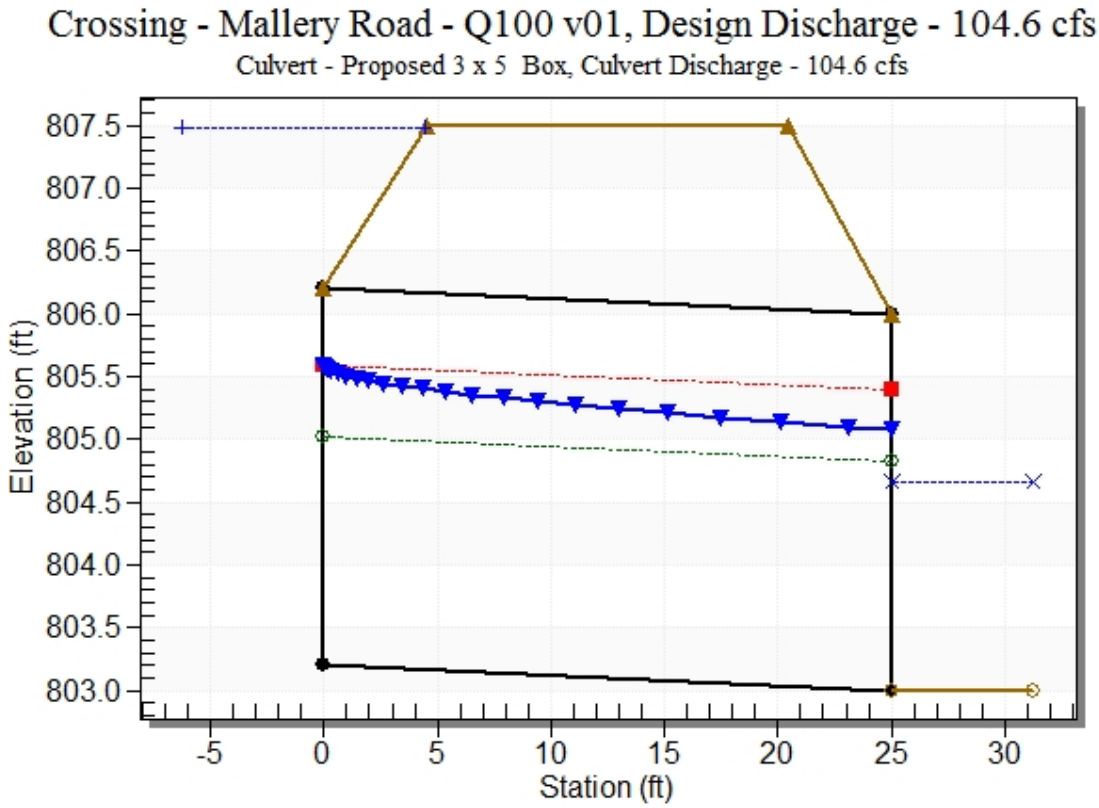
Culvert Length: 25.00 ft, Culvert Slope: 0.0080

****

Culvert Performance Curve Plot: Proposed 3 x 5 Box



Water Surface Profile Plot for Culvert: Proposed 3 x 5 Box



Site Data - Proposed 3 x 5 Box

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 803.20 ft

Outlet Station: 25.00 ft

Outlet Elevation: 803.00 ft

Number of Barrels: 1

Culvert Data Summary - Proposed 3 x 5 Box

Barrel Shape: Concrete Box

Barrel Span: 5.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: Mallery Road - Q100 v01)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	803.00	0.00	0.00	0.00	0.00
10.46	803.50	0.50	1.61	0.25	0.45
20.92	803.73	0.73	2.00	0.36	0.47
31.38	803.90	0.90	2.25	0.45	0.48
41.84	804.05	1.05	2.44	0.52	0.49
52.30	804.18	1.18	2.60	0.59	0.50
62.76	804.29	1.29	2.74	0.64	0.51
73.22	804.40	1.40	2.86	0.70	0.51
83.68	804.49	1.49	2.96	0.74	0.52
94.14	804.58	1.58	3.06	0.79	0.52
104.60	804.66	1.66	3.15	0.83	0.53

Tailwater Channel Data - Mallery Road - Q100 v01

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

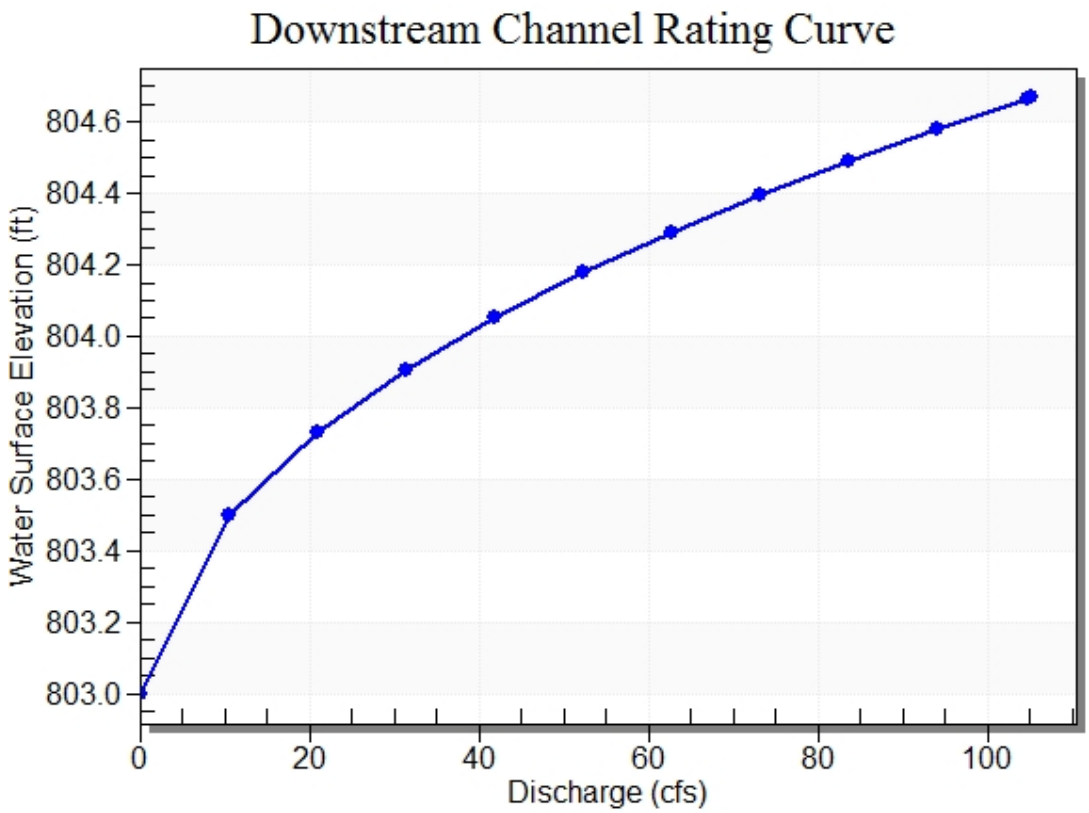
Side Slope (H:V): 6.00 (_:1)

Channel Slope: 0.0080

Channel Manning's n: 0.0450

Channel Invert Elevation: 803.00 ft

Tailwater Rating Curve Plot for Crossing: Mallery Road - Q100 v01



Roadway Data for Crossing: Mallery Road - Q100 v01

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 807.50 ft

Roadway Surface: Paved

Roadway Top Width: 16.00 ft

Crossing Notes: Mallery Road - Developed Q100, 30” RCP

Crossing Discharge Data

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

Minimum Flow: 0 cfs

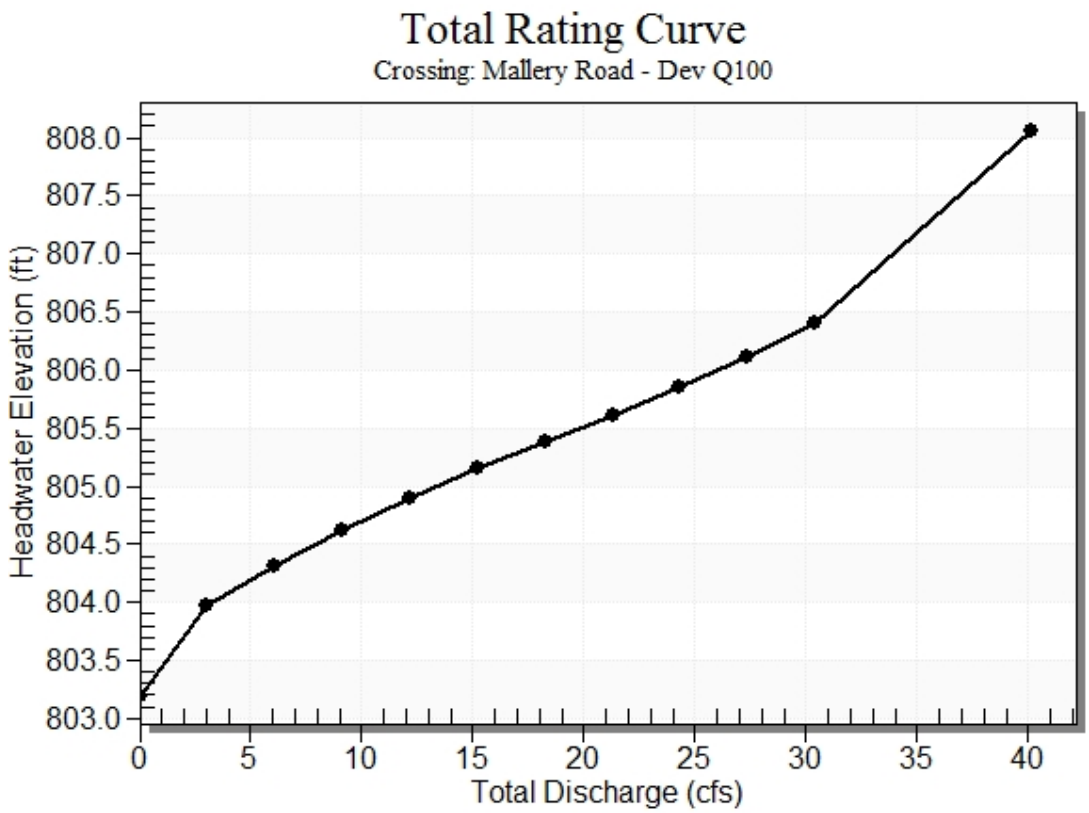
Design Flow: 30.4 cfs

Maximum Flow: 30.4 cfs

Table 7 - Summary of Culvert Flows at Crossing: Mallery Road - Dev Q100

Headwater Elevation (ft)	Total Discharge (cfs)	Proposed 30" RCP Discharge (cfs)	Roadway Discharge (cfs)	Iterations
803.20	0.00	0.00	0.00	1
803.97	3.04	3.04	0.00	1
804.32	6.08	6.08	0.00	1
804.62	9.12	9.12	0.00	1
804.90	12.16	12.16	0.00	1
805.15	15.20	15.20	0.00	1
805.38	18.24	18.24	0.00	1
805.61	21.28	21.28	0.00	1
805.86	24.32	24.32	0.00	1
806.11	27.36	27.36	0.00	1
806.40	30.40	30.40	0.00	1
807.50	40.13	40.13	0.00	Overtopping

Rating Curve Plot for Crossing: Mallery Road - Dev Q100



Culvert Notes: Proposed 30" RCP

Table 8 - Culvert Summary Table: Proposed 30" RCP

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	803.20	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
3.04	3.04	803.97	0.772	0.378	1-S2n	0.465	0.568	0.477	0.247	4.687	1.071
6.08	6.08	804.32	1.116	0.653	1-S2n	0.657	0.813	0.687	0.368	5.552	1.354
9.12	9.12	804.62	1.419	0.893	1-S2n	0.808	1.002	0.856	0.462	6.125	1.544
12.16	12.16	804.90	1.698	1.132	1-S2n	0.946	1.170	1.004	0.543	6.592	1.691
15.20	15.20	805.15	1.947	1.366	1-S2n	1.068	1.313	1.138	0.613	6.989	1.812
18.24	18.24	805.38	2.182	1.607	1-S2n	1.187	1.443	1.263	0.677	7.333	1.915
21.28	21.28	805.61	2.415	1.860	1-S2n	1.299	1.565	1.382	0.736	7.645	2.006
24.32	24.32	805.86	2.656	2.122	5-S2n	1.412	1.675	1.495	0.790	7.944	2.087
27.36	27.36	806.11	2.914	2.399	5-S2n	1.523	1.781	1.605	0.841	8.212	2.161
30.40	30.40	806.40	3.196	2.998	5-S2n	1.637	1.877	1.713	0.890	8.491	2.228

****

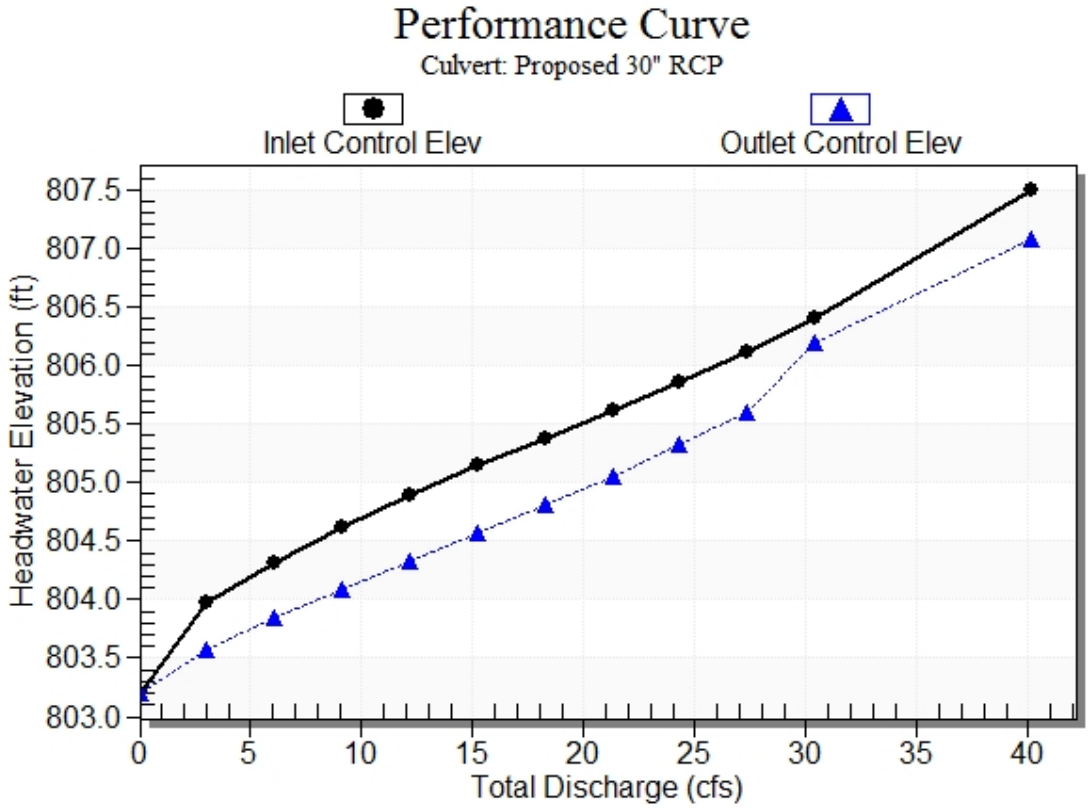
Straight Culvert

Inlet Elevation (invert): 803.20 ft, Outlet Elevation (invert): 803.00 ft

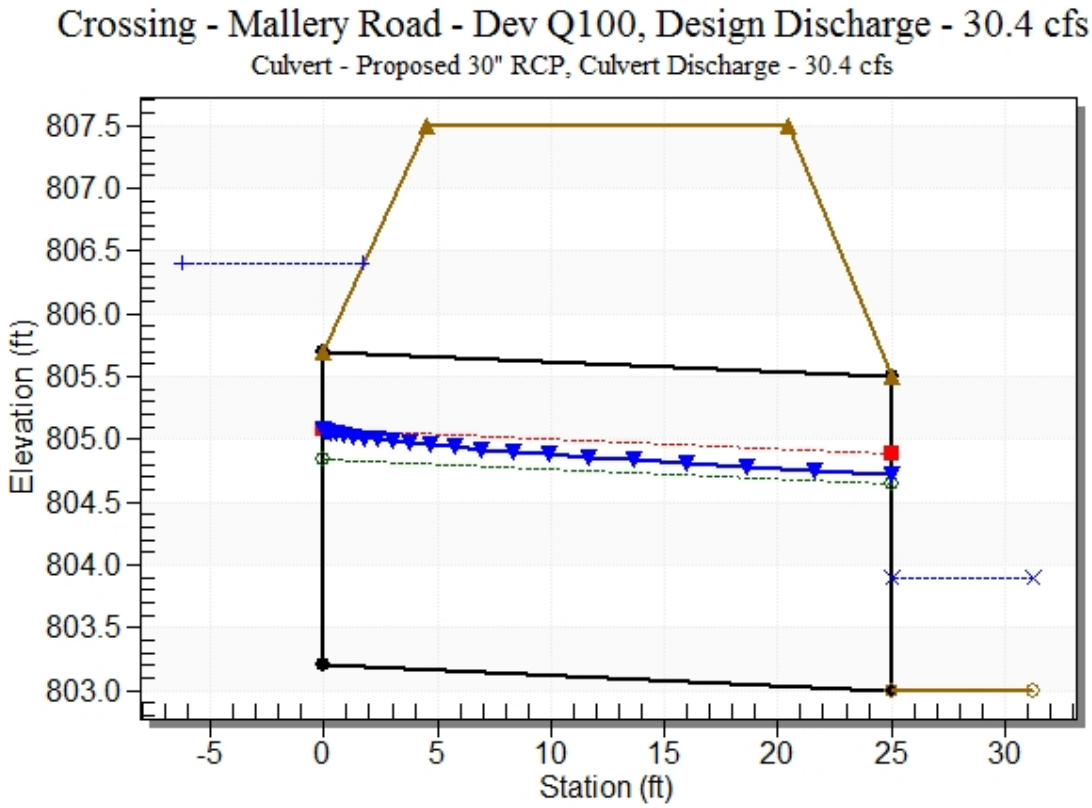
Culvert Length: 25.00 ft, Culvert Slope: 0.0080

****

Culvert Performance Curve Plot: Proposed 30" RCP



Water Surface Profile Plot for Culvert: Proposed 30" RCP



Site Data - Proposed 30" RCP

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 803.20 ft

Outlet Station: 25.00 ft

Outlet Elevation: 803.00 ft

Number of Barrels: 1

Culvert Data Summary - Proposed 30" RCP

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

Table 9 - Downstream Channel Rating Curve (Crossing: Mallery Road - Dev Q100)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	803.00	0.00	0.00	0.00	0.00
3.04	803.25	0.25	1.07	0.12	0.40
6.08	803.37	0.37	1.35	0.18	0.43
9.12	803.46	0.46	1.54	0.23	0.44
12.16	803.54	0.54	1.69	0.27	0.45
15.20	803.61	0.61	1.81	0.31	0.46
18.24	803.68	0.68	1.92	0.34	0.47
21.28	803.74	0.74	2.01	0.37	0.47
24.32	803.79	0.79	2.09	0.39	0.48
27.36	803.84	0.84	2.16	0.42	0.48
30.40	803.89	0.89	2.23	0.44	0.48

Tailwater Channel Data - Mallery Road - Dev Q100

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

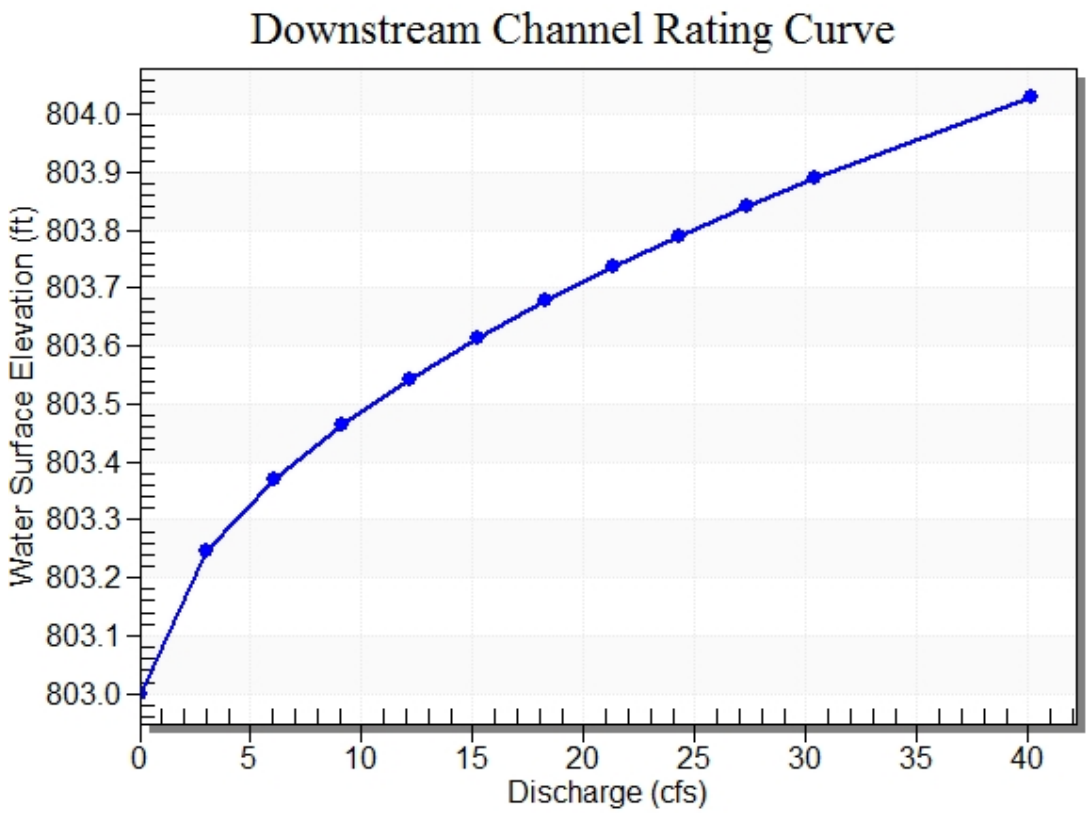
Side Slope (H:V): 6.00 (_:1)

Channel Slope: 0.0080

Channel Manning's n: 0.0450

Channel Invert Elevation: 803.00 ft

Tailwater Rating Curve Plot for Crossing: Mallery Road - Dev Q100



Roadway Data for Crossing: Mallery Road - Dev Q100

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 807.50 ft

Roadway Surface: Paved

Roadway Top Width: 16.00 ft

HY-8 Culvert Analysis Report

Project Notes

Project Title: Sam Craig – John Holleran Arms

Designer: BEP

Project Date: 6/13/17

Notes:

Project Units: U.S. Customary Units

Outlet Control Option: Profiles

Exit Loss Option: Standard Method

Crossing Notes: Promise Road, Proposed Culvert – Q100 Existing Peak Discharge

Crossing Discharge Data

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

Minimum Flow: 0 cfs

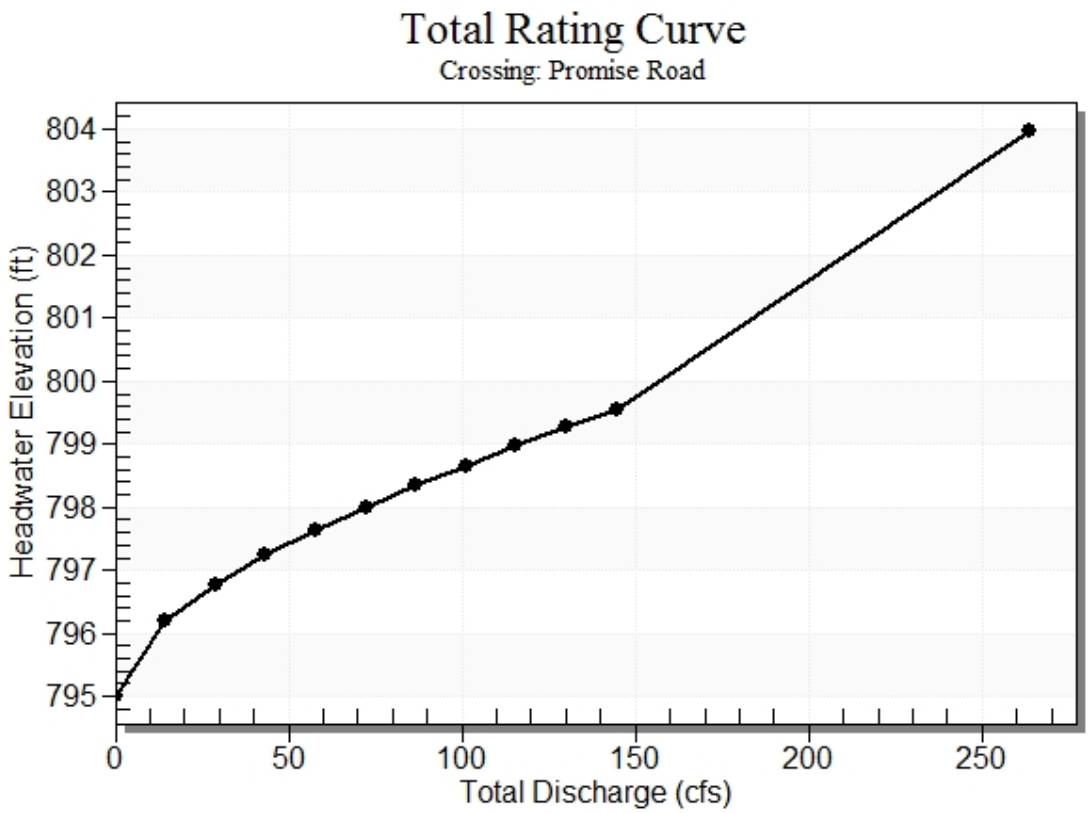
Design Flow: 144.5 cfs

Maximum Flow: 144.5 cfs

Table 1 - Summary of Culvert Flows at Crossing: Promise Road

Headwater Elevation (ft)	Total Discharge (cfs)	6 x 4 Box Discharge (cfs)	Roadway Discharge (cfs)	Iterations
795.02	0.00	0.00	0.00	1
796.21	14.45	14.45	0.00	1
796.78	28.90	28.90	0.00	1
797.24	43.35	43.35	0.00	1
797.63	57.80	57.80	0.00	1
798.00	72.25	72.25	0.00	1
798.34	86.70	86.70	0.00	1
798.66	101.15	101.15	0.00	1
798.97	115.60	115.60	0.00	1
799.27	130.05	130.05	0.00	1
799.56	144.50	144.50	0.00	1
803.00	263.78	263.78	0.00	Overtopping

Rating Curve Plot for Crossing: Promise Road



Culvert Notes: 6 x 4 Box

Table 2 - Culvert Summary Table: 6 x 4 Box

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	795.02	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
14.45	14.45	796.21	0.968	1.187	3-M1t	0.619	0.565	1.135	1.135	2.122	1.720
28.90	28.90	796.78	1.536	1.760	3-M1t	0.987	0.896	1.591	1.591	3.027	2.070
43.35	43.35	797.24	2.013	2.215	3-M1t	1.301	1.175	1.926	1.926	3.751	2.302
57.80	57.80	797.63	2.423	2.614	3-M1t	1.589	1.423	2.199	2.199	4.380	2.480
72.25	72.25	798.00	2.800	2.978	3-M1t	1.861	1.651	2.434	2.434	4.947	2.626
86.70	86.70	798.34	3.153	3.317	3-M1t	2.119	1.865	2.642	2.642	5.469	2.752
101.15	101.15	798.66	3.492	3.640	3-M1t	2.369	2.067	2.830	2.830	5.957	2.862
115.60	115.60	798.97	3.823	3.949	3-M1t	2.614	2.259	3.002	3.002	6.418	2.961
130.05	130.05	799.27	4.153	4.248	7-M1t	2.853	2.444	3.161	3.161	6.856	3.051
144.50	144.50	799.56	4.488	4.539	7-M1t	3.086	2.621	3.310	3.310	7.276	3.134

****

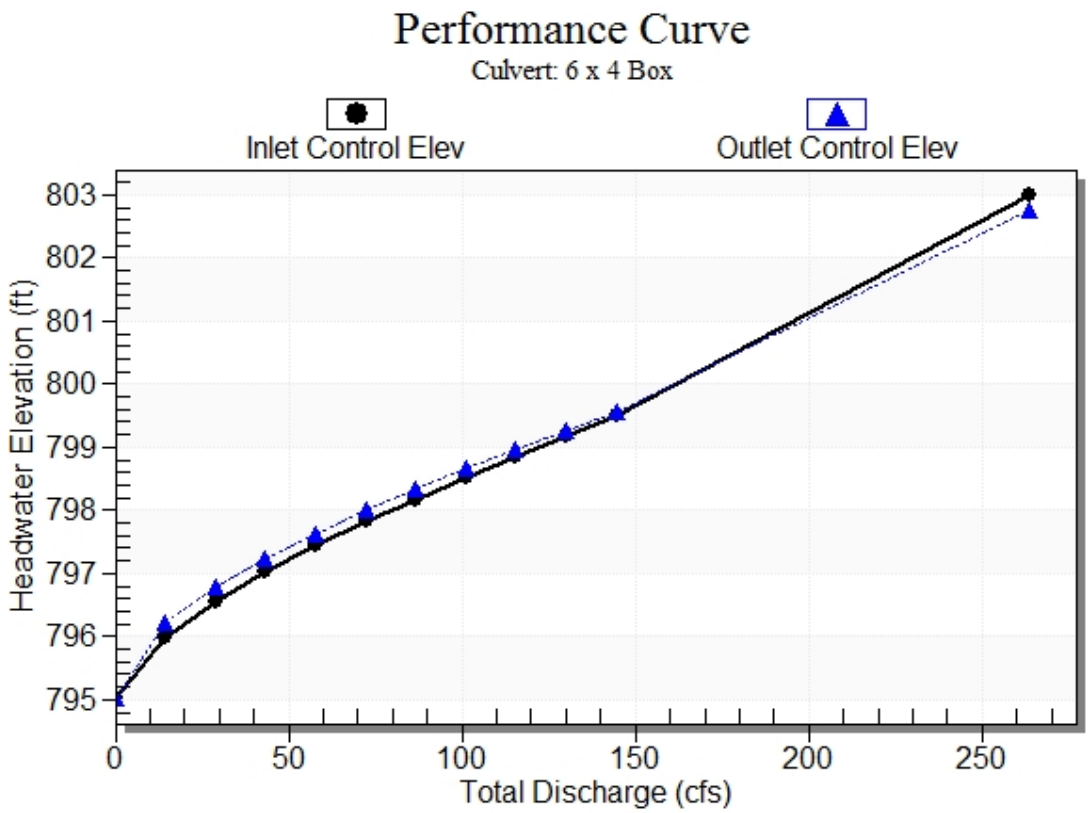
Straight Culvert

Inlet Elevation (invert): 795.02 ft, Outlet Elevation (invert): 794.95 ft

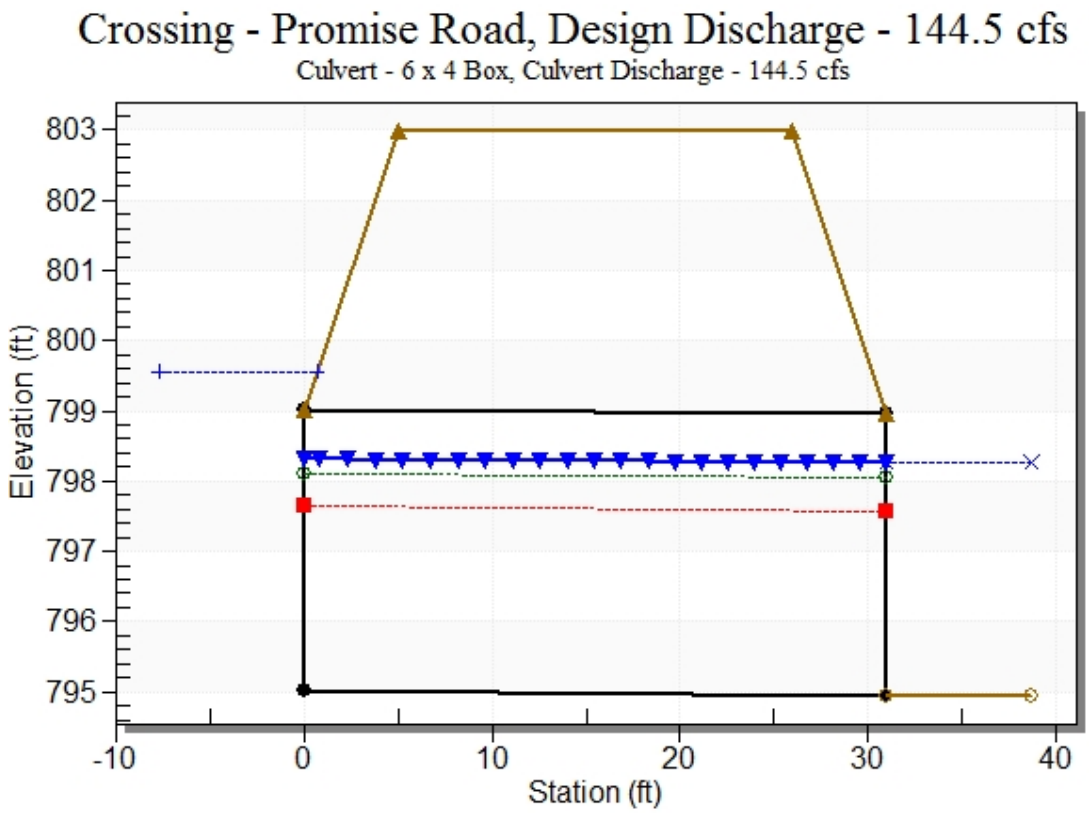
Culvert Length: 31.00 ft, Culvert Slope: 0.0023

****

Culvert Performance Curve Plot: 6 x 4 Box



Water Surface Profile Plot for Culvert: 6 x 4 Box



Site Data - 6 x 4 Box

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 795.02 ft

Outlet Station: 31.00 ft

Outlet Elevation: 794.95 ft

Number of Barrels: 1

Culvert Data Summary - 6 x 4 Box

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 4.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Promise Road)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	794.95	0.00	0.00	0.00	0.00
14.45	796.08	1.13	1.72	0.17	0.34
28.90	796.54	1.59	2.07	0.24	0.36
43.35	796.88	1.93	2.30	0.29	0.37
57.80	797.15	2.20	2.48	0.33	0.38
72.25	797.38	2.43	2.63	0.36	0.38
86.70	797.59	2.64	2.75	0.40	0.38
101.15	797.78	2.83	2.86	0.42	0.39
115.60	797.95	3.00	2.96	0.45	0.39
130.05	798.11	3.16	3.05	0.47	0.39
144.50	798.26	3.31	3.13	0.50	0.40

Tailwater Channel Data - Promise Road

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 4.00 ft

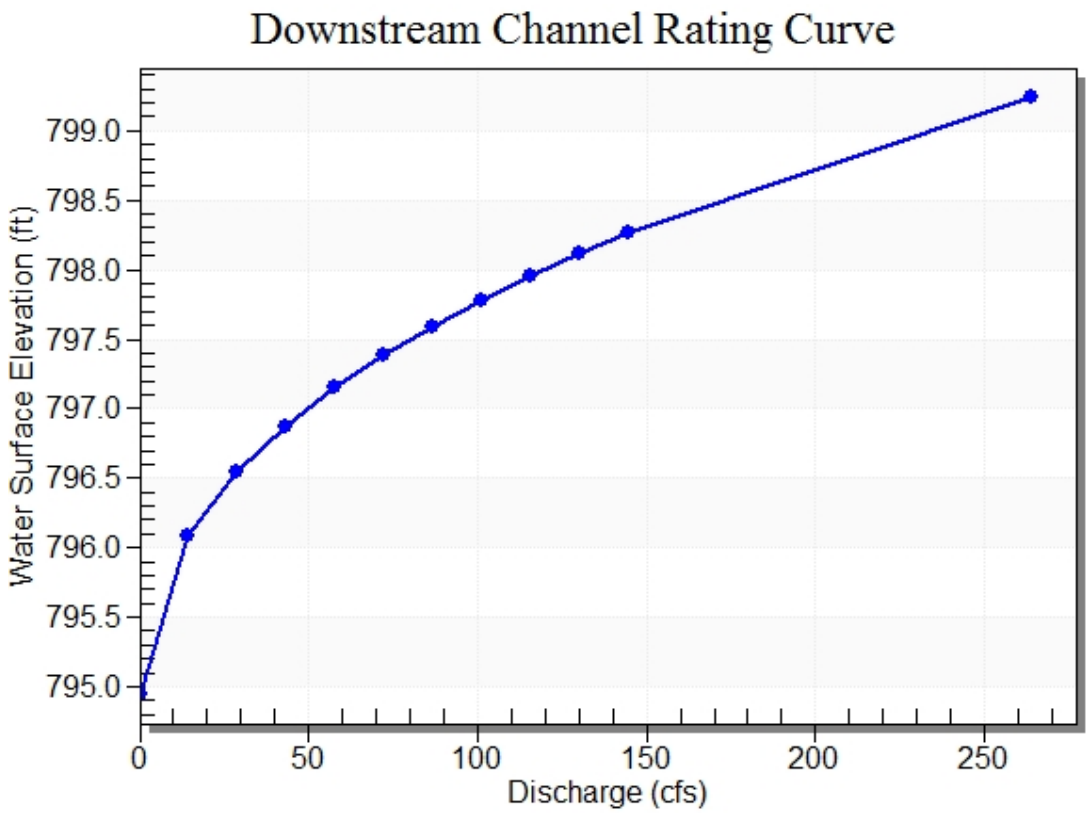
Side Slope (H:V): 3.00 (_:1)

Channel Slope: 0.0024

Channel Manning's n: 0.0350

Channel Invert Elevation: 794.95 ft

Tailwater Rating Curve Plot for Crossing: Promise Road



Roadway Data for Crossing: Promise Road

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 803.00 ft

Roadway Surface: Paved

Roadway Top Width: 21.00 ft

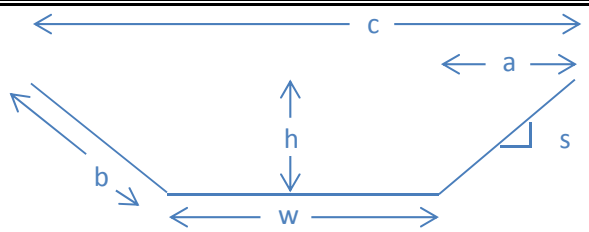
ATTACHMENT 7:

Capacity Calculations

Segment 1 - Open Channel, Existing Peak Discharge
Max Flow, Mannings Equation

Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 5/12/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

n =	0.035	(manning's roughness coefficient)					
A =	36	(Area, square feet)					
P =	21.97	(Wet Perimeter, feet)					
R =	1.64	(Hydraulic Radius, feet)	R = A / P		h =	3 feet	(height)
S =	0.0030769	(Slope, ft/ft)	(2 ft of drop over 650 ft)		w =	3 feet	(width)
					s =	3 : 1	(side slope)
Q =	**118.1 CFS**		Q_{100} =	104.6 cfs	a =	9 feet	
					b =	9.49 feet	
V =	3.28 ft/s				c =	21 feet	

Area =	13650 sq ft	0.31 acres		68.25	
Volume =	23,400 cu ft	867 cu yd			
US inv	805.05	DS inv	803.20		

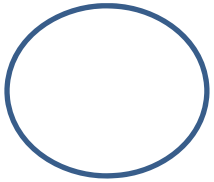
Channel Size required to convey existing Q100 discharge
The new channel would begin along the existing John Holleran Drain 650 feet upsteam of Mallary Road.
This section of the channel would flow to Mallery Road.

Segment 1 - Closed Pipe, Developed Peak Discharge
Max Flow, Mannings Equation

Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/5/2017

36" Diameter RCP

Q = (1.49 / n)*A*R^(2/3) * S^(1/2)



n =	0.013	(manning's roughness coefficient)					
A =	7.065	(Area, square feet)					
P =	9.42	(Wet Perimeter, feet)					
R =	0.75	(Hydraulic Radius, feet)	R = A / P	d =	3	feet	(diameter)
S =	0.00250	(Slope, ft/ft)		r =	1.5	feet	(radius)

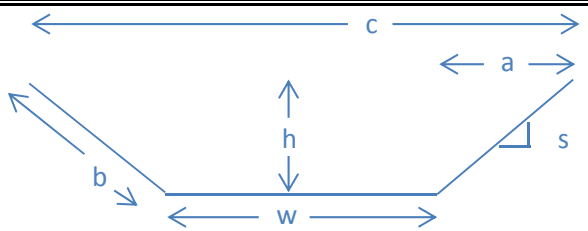
Q = 33.4 CFS Q_{100} = 30.4 cfs

V = 4.73 ft/s

Segment 1 - Open Channel Combined with 36" Underdrain
Max Flow, Mannings Equation

Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/7/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

n =	0.035	(manning's roughness coefficient)			h =	2.5	feet	(height)
A =	26.25	(Area, square feet)			w =	3	feet	(width)
P =	18.81	(Wet Perimeter, feet)			s =	3 : 1		(side slope)
R =	1.40	(Hydraulic Radius, feet)	R = A / P		a =	7.5	feet	
S =	0.0030769	(Slope, ft/ft)	(2 ft of drop over 650 ft)		b =	7.91	feet	
Q =	**77.4**	**CFS**	Q_{100} =	104.6 cfs	c =	18	feet	
			$Q_{combined}$ =	110.8 cfs				
V =	2.95	ft/s						

Area =	11700	sq ft	0.27	acres	58.5
Volume =	17,063	cu ft	632	cu yd	

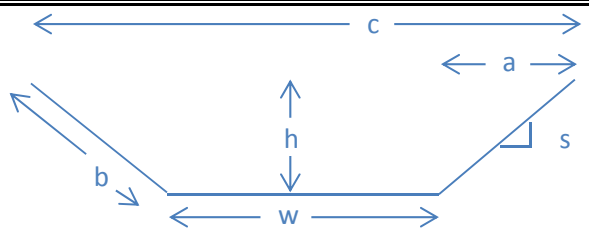
US inv	805.05	DS inv	803.20

Channel Size required to convey existing Q100 discharge
The new channel would begin along the existing John Holleran Drain 650 feet upsteam of Mallary Road.
This section of the channel would flow to Mallery Road.
36" pipe would reduce the volume of excavated material by 235 cu yds (27.1%). Height reduced by 0.5 ft.

Segment 2 - Open Channel, Existing Peak Discharge
Max Flow, Mannings Equation

Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 5/12/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

n =	0.035	(manning's roughness coefficient)					
A =	39	(Area, square feet)					
P =	22.97	(Wet Perimeter, feet)					
R =	1.70	(Hydraulic Radius, feet)	R = A / P		h =	3 feet	(height)
S =	0.0023333	(Slope, ft/ft)	(3.5 ft of drop over 1500 ft)		w =	4 feet	(width)
					s =	3 : 1	(side slope)
Q =	**114.1 CFS**		Q_{100} =	104.6 cfs	a =	9 feet	
					b =	9.49 feet	
V =	2.93 ft/s				c =	22 feet	

Area =	33000 sq ft	0.76 acres	165		
Volume =	58,500 cu ft	2167 cu yd			
US inv	803.00	DS inv	799.50		

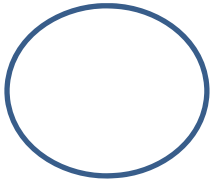
The segment would begin at Mallary Road. 1500 feet long to the residential development.

Segment 2 - Closed Pipe, Developed Peak Discharge
Max Flow, Mannings Equation

Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/5/2017

36" Diameter RCP

Q = (1.49 / n)*A*R^(2/3) * S^(1/2)



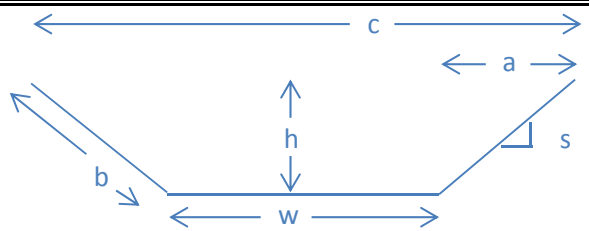
n =	0.013	(manning's roughness coefficient)					
A =	7.065	(Area, square feet)					
P =	9.42	(Wet Perimeter, feet)					
R =	0.75	(Hydraulic Radius, feet)	R = A / P	d =	3	feet	(diameter)
S =	0.00233	(Slope, ft/ft)		r =	1.5	feet	(radius)

Q = 32.3 CFS Q_{100} = 30.4 cfs

V = 4.57 ft/s

Segment 2 - Open Channel Combined with 36" Underdrain
Max Flow, Mannings Equation
Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/7/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

n =	0.035	(manning's roughness coefficient)			h =	2.5	feet	(height)
A =	28.75	(Area, square feet)			w =	4	feet	(width)
P =	19.81	(Wet Perimeter, feet)			s =	3 : 1		(side slope)
R =	1.45	(Hydraulic Radius, feet)	R = A / P		a =	7.5	feet	
S =	0.0023333	(Slope, ft/ft)	(3.5 ft of drop over 1500 ft)		b =	7.91	feet	
Q =	**75.8**	**CFS**	Q_{100} =	104.6 cfs	c =	19	feet	
			$Q_{combined}$ =	108.1 cfs				
V =	2.64	ft/s						

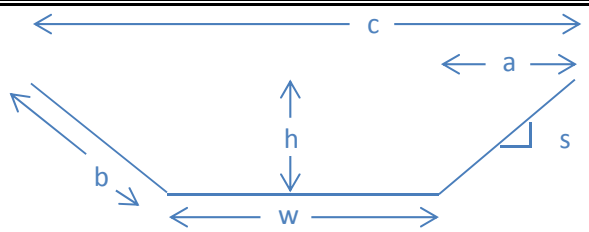
Area =	28500	sq ft	0.65	acres	142.5
Volume =	43,125	cu ft	1597	cu yd	

US inv	803.00	DS inv	799.50

The segment would begin at Mallary Road. 1500 feet long to the residential development.
36" pipe would reduce the volume of excavated material by 570 cu yds (26.3%). Height reduced by 0.5 ft.

Segment 3 - Open Channel, Existing Peak Discharge
Max Flow, Mannings Equation
Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/13/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

n =	0.035	(manning's roughness coefficient)					
A =	50.75	(Area, square feet)					
P =	26.14	(Wet Perimeter, feet)					
R =	1.94	(Hydraulic Radius, feet)	R = A / P		h =	3.5 feet	(height)
S =	0.0024017	(Slope, ft/ft)	(6 ft of drop over 2290 ft)		w =	4 feet	(width)
					s =	3 : 1	(side slope)
Q =	**164.8 CFS**		Q_{100} =	144.5 cfs	a =	10.5 feet	
					b =	11.07 feet	
V =	3.25 ft/s				c =	25 feet	

Area =	57250 sq ft	1.31 acres	286.25		
Volume =	116,218 cu ft	4304 cu yd			
US inv	799.50	DS inv	794.00		

The segment begins at the east border of the residential development. Drain would flow south and west along Oakwood Arm. Drain would cross Promise road and end at the junction of the John Holleran Arm and the Oakwood Arms.

Topography of this route not ideal for open ditch. Would result in very deep cuts.

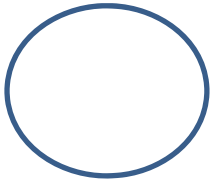
For this segment the average cut will be 6.1 feet. The width of the channel will range between 65 ft and 25 ft.
Additional easement will not be required.
The volume of cut required to achieve this channel is 11,537 cu yds.

Segment 3 - Closed Pipe, Developed Peak Discharge
Max Flow, Mannings Equation

Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/5/2017

42" Diameter RCP

Q = (1.49 / n)*A*R^(2/3) * S^(1/2)



n =	0.013	(manning's roughness coefficient)					
A =	9.61625	(Area, square feet)					
P =	10.99	(Wet Perimeter, feet)					
R =	0.875	(Hydraulic Radius, feet)	R = A / P	d =	3.5	feet	(diameter)
S =	0.00240	(Slope, ft/ft)		r =	1.75	feet	(radius)

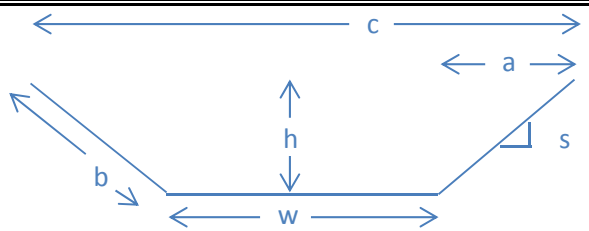
Q = 49.4 CFS

V = 5.14 ft/s

Existing Holleran Drain, through Oak Wood Community
Oakwood Arms around north and south boarder of community are 12 inch RCP.

Segment 3 - Open Channel Combined with 36" Underdrain
Max Flow, Mannings Equation
Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/7/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

n =	0.035	(manning's roughness coefficient)					
A =	39	(Area, square feet)					
P =	22.97	(Wet Perimeter, feet)					
R =	1.70	(Hydraulic Radius, feet)	R = A / P		h =	3 feet	(height)
S =	0.0024017	(Slope, ft/ft)	(6 ft of drop over 2290 ft)		w =	4 feet	(width)
					s =	3 : 1	(side slope)
Q =	**115.8 CFS**		Q_{100} =	144.5 cfs	a =	9 feet	
			$Q_{combined}$ =	148.5 cfs	b =	9.49 feet	
V =	2.97 ft/s				c =	22 feet	

Area =	50380 sq ft	1.16 acres	251.9		
Volume =	89,310 cu ft	3308 cu yd			
US inv	799.50	DS inv	794.00		

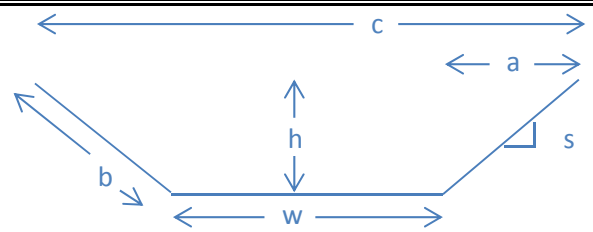
The segment begins at the east border of the residential development. Drain would flow south and west along Oakwood Arm. Drain would cross Promise road and end at the junction of the John Holleran Arm and the Oakwood Arms.

36" pipe would reduce the volume of excavated material by 996 cu yds (23.1%). Height reduced by 0.5 ft.
The Average cut for this section would be 5.6 feet, total volume would be 9,879 cu yds.

Segment 4 - Open Channel, Existing Peak Discharge
Max Flow, Mannings Equation

Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/6/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

n =	0.035	(manning's roughness coefficient)					
A =	72	(Area, square feet)					
P =	31.30	(Wet Perimeter, feet)					
R =	2.30	(Hydraulic Radius, feet)	R = A / P		h =	4 feet	(height)
S =	0.0030769	(Slope, ft/ft)	(8 ft of drop over 2600 ft)		w =	6 feet	(width)
					s =	3 : 1	(side slope)
Q =	**296.3 CFS**		Q_{100} =	284.5 cfs	a =	12 feet	
					b =	12.65 feet	
V =	4.12 ft/s				c =	30 feet	

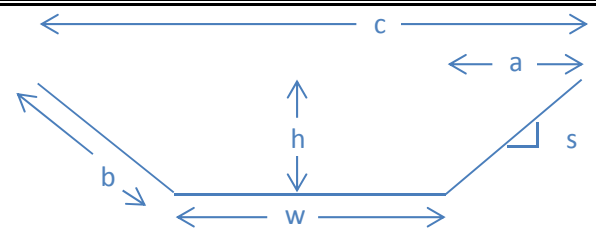
Area =	78000	sq ft	1.79	acres	390
Volume =	187,200	cu ft	6933	cu yd	

US inv 794.00 DS inv 786.00

The segment begins at the junction of the John Holleran and the Oakwood Arms.
The segment ends 2600 feet downstream

Segment 4 - Open Channel Combined with 36" Underdrain
Max Flow, Mannings Equation
Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/7/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

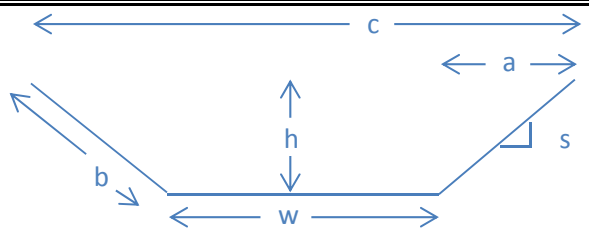
n =	0.035	(manning's roughness coefficient)					
A =	64	(Area, square feet)					
P =	29.30	(Wet Perimeter, feet)					
R =	2.18	(Hydraulic Radius, feet)	R = A / P		h =	4 feet	(height)
S =	0.0030769	(Slope, ft/ft)	(8 ft of drop over 2600 ft)		w =	4 feet	(width)
					s =	3 : 1	(side slope)
Q =	**254.4 CFS**		Q_{100} =	284.5 cfs	a =	12 feet	
			$Q_{combined}$ =	291.5 cfs	b =	12.65 feet	
V =	3.98 ft/s				c =	28 feet	

Area =	72800 sq ft	1.67 acres	364		
Volume =	166,400 cu ft	6163 cu yd			
US inv	794.00	DS inv	786.00		

The segment begins at the junction of the John Holleran and the Oakwood Arms.
The segment ends 2600 feet downstream
36" pipe would reduce the volume of excavated material by 770 cu yds (11.1%). Width reduced by 2 ft

Segment 5 - Open Channel, Existing Peak Discharge
Max Flow, Mannings Equation
Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 6/6/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

n =	0.035	(manning's roughness coefficient)			h =	4.5	feet	(height)
A =	96.75	(Area, square feet)			w =	8	feet	(width)
P =	36.46	(Wet Perimeter, feet)			s =	3 : 1		(side slope)
R =	2.65	(Hydraulic Radius, feet)	R = A / P		a =	13.5	feet	
S =	0.0023972	(Slope, ft/ft)	(9 ft of drop over 2870 ft)		b =	14.23	feet	
Q =	**386.5**	**CFS**	Q_{100} =	384 cfs	c =	35	feet	
V =	4.00	ft/s						

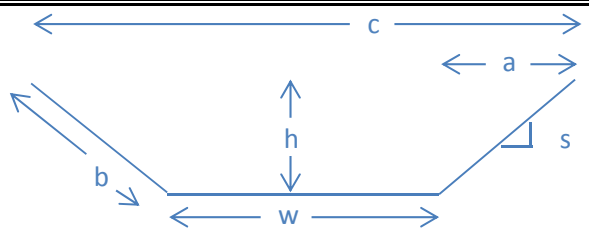
Area =	100450	sq ft	2.31	acres	502.25
Volume =	277,673	cu ft	10284	cu yd	
US inv	786.00	DS inv	779.12		

The segment begins at the end of segment 4. The segment ends 700 feet upstream of SR37.

Segment 5 - Open Channel Combined with 36" Underdrain
Max Flow, Mannings Equation

Project: Sam Craig - John Holleran Arms, Elwood Wilson Drain Hydraulic Study
Made By: BEP
Date: 5/12/2017

Trapezoidal Ditch



Q = (1.49 / n)*A*R^(2/3) * S^(1/2)

n =	0.035	(manning's roughness coefficient)					
A =	92.25	(Area, square feet)					
P =	35.46	(Wet Perimeter, feet)					
R =	2.60	(Hydraulic Radius, feet)	R = A / P		h =	4.5 feet	(height)
S =	0.0023972	(Slope, ft/ft)	(9 ft of drop over 2870 ft)		w =	7 feet	(width)
					s =	3 : 1	(side slope)
Q =	**363.7 CFS**		Q_{100} =	384 cfs	a =	13.5 feet	
			$Q_{combined}$ =	396.4 cfs	b =	14.23 feet	
V =	3.94 ft/s				c =	34 feet	

Area =	97580	sq ft	2.24	acres	487.9
Volume =	264,758	cu ft	9806	cu yd	

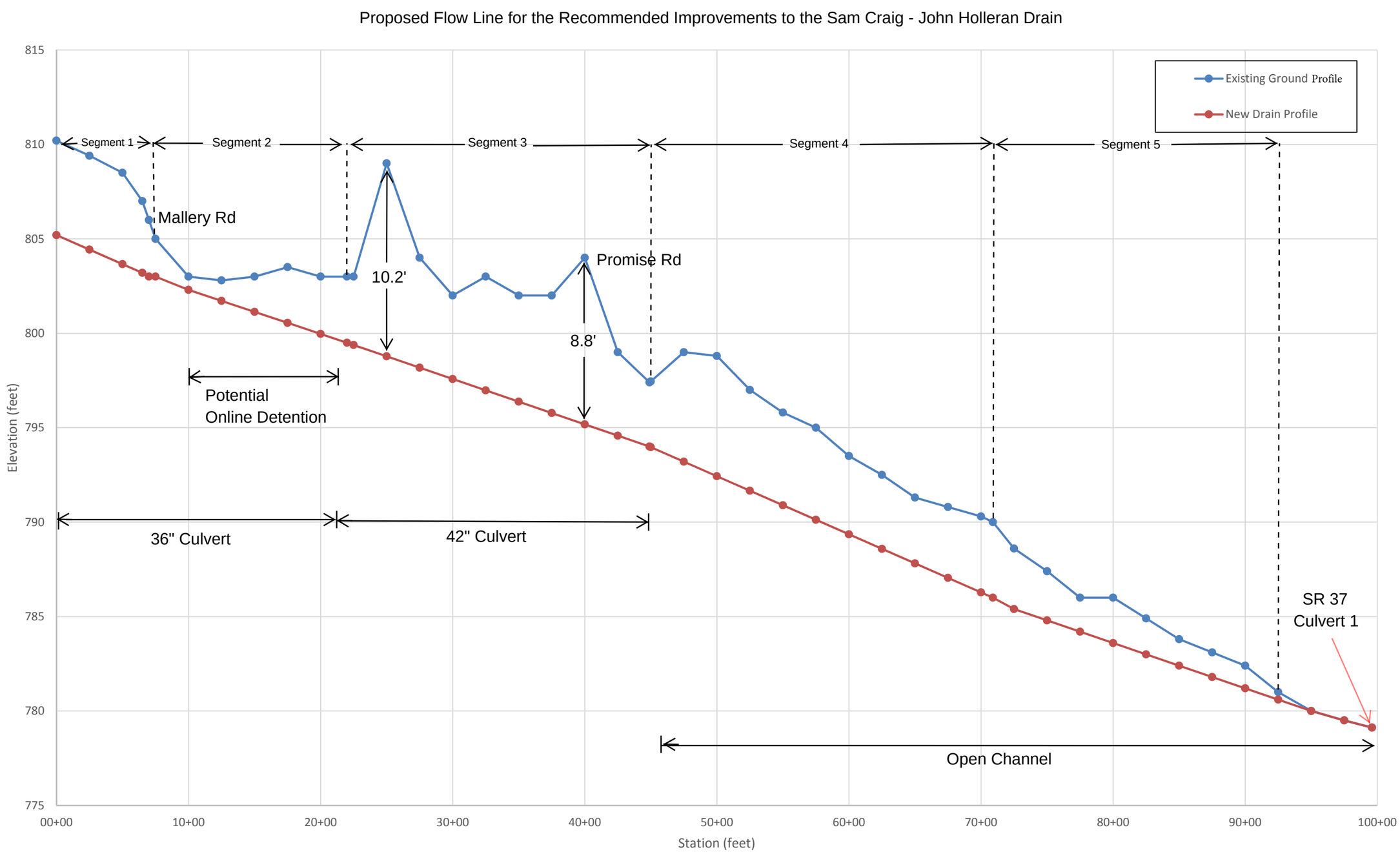
US inv 786.00 DS inv 779.12

36" pipe under channel would reduce volume of excavation by 478 cu yd (4.6%). Width reduced by 1 ft.

ATTACHMENT 8:

Drain Profile Figure

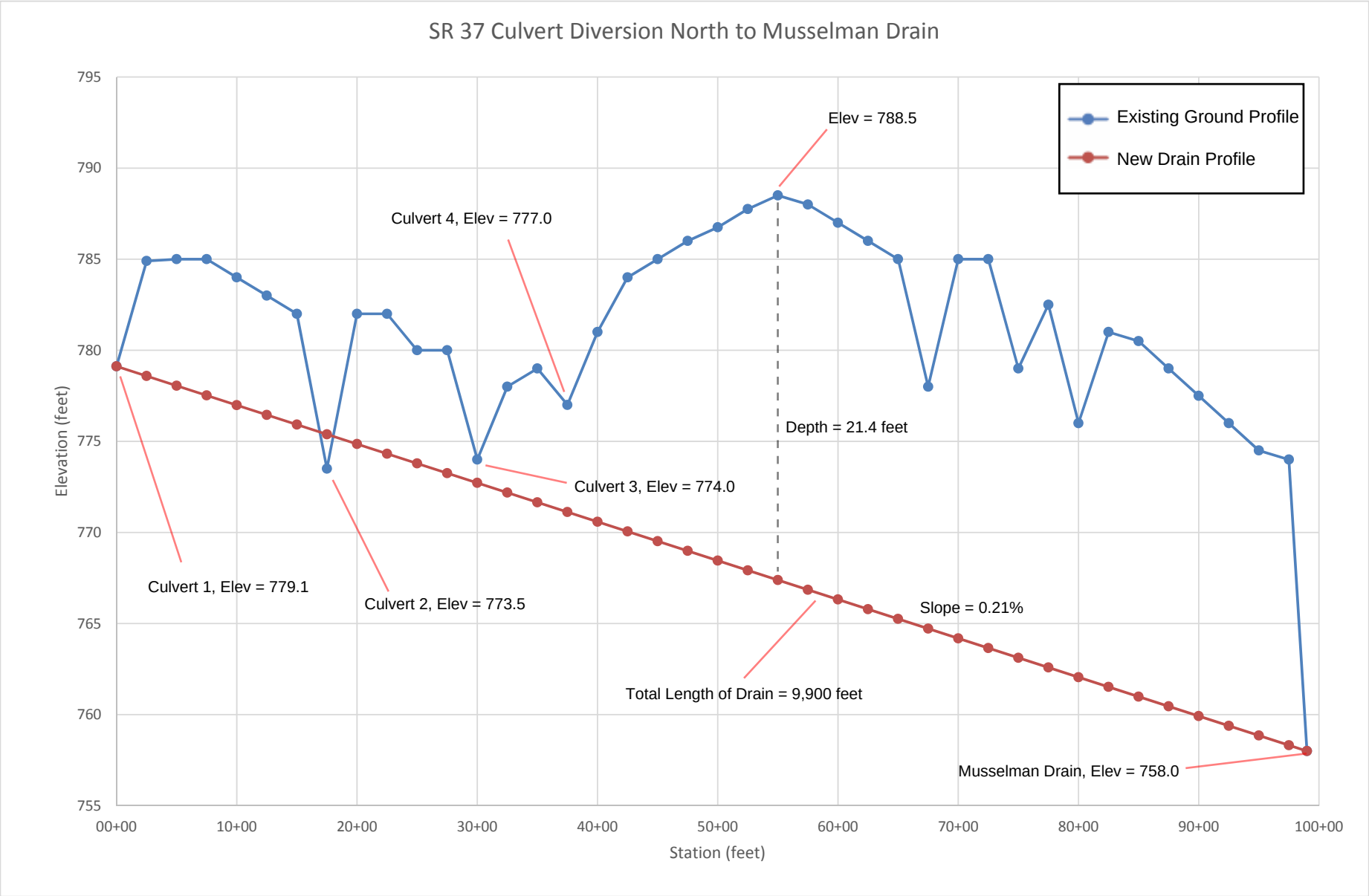
Attachment 8



ATTACHMENT 9:

Diversion Profile Figure

Attachment 9



ATTACHMENT 10:

Natural Resource Assessment

WILLIAMS CREEK
CONSULTING

Natural Resource Assessment — Sam Craig-John Holleran Arm

Noblesville, Hamilton County, Indiana

Prepared For:

Clark Dietz, Inc.

8900 Keystone Crossing

Suite 900

Indianapolis, Indiana 46240

ClarkDietz
Engineering Quality of Life™

June 2017

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Infrastructure · Science · Technology

21 May 2017

Mr. Brian Powers
Clark Dietz, Inc.
8900 Keystone Crossing
Suite 900
Indianapolis, IN 46240

RE: Natural Resource Consulting Services
Sam Craig/John Holleran Arm- Noblesville, Indiana

Dear Mr. Powers:

The purpose of this project was to complete the requested Natural Resource Due Diligence Services for the approximately 1.5 square miles of land that comprises the Sam Craig/John Holleran Arm of the Elwood Wilson drain near the intersection of State Road 37 and 186th Street (SITE) in Noblesville, Hamilton County, Indiana. The SITE is currently comprised of agricultural row crops, woods, and residential development and is for a watershed study. The SITE is more specifically located in the Noblesville, Indiana USGS 7.5-Minute Quadrangle Map (**Figure 1**).

Based on the USGS map the SITE is between 780 and 820 feet above sea level. Six (6) wetlands were observed during the field visit along the Sam Craig/John Holleran Drain. A possible five (5) additional wetlands were identified from a distance during the field visit and through a desktop review. These could not be field verified due to lack of property access. Two (2) areas along the drain in agriculture fields were holding a significant amount of water due to recent heavy rains. A two (2) acre open water feature is located in the southwest corner of the watershed boundary.

The scope of work included determining if wetlands and/or jurisdictional "waters" were present within the inspection limits on SITE using the U.S. Army Corps of Engineers (USACE) methodology described in the *Corps of Engineers Wetland Delineation Manual, 1987* (1987 Manual) and Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Midwest Region, 2008 (2008 Supplement). The purpose of the desktop review and SITE investigation was to identify areas that would qualify as wetland or a "waters of the US" by the USACE.

Definitions

A "waters of the U.S." can be described as any waterway that appears to have a "clear, natural line impressed on the bank"[1] that is caused by variations in water levels over a period of time. The USACE is the final authority on the determination of whether a waterway qualifies for jurisdiction under the Clean Water Act, but can include ephemeral streams and drainage ditches, as well as large rivers. Several indicators that may be considered in determining an ordinary high water mark include, but are not limited to, changes in soil character, destruction of terrestrial vegetation, historical or recorded data, presence of litter and/or debris, scour, and water staining.

Wetlands are defined in the 1987 Manual as, "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances

[1] U.S. Army Corps of Engineers, *Regulatory Guidance Letter*, No. 05-05, date 7-12-05

do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."[2] The 1987 Manual outlines the protocol for distinguishing wetland areas from "upland" areas. Wetland areas are delineated according to three primary criteria: vegetation, soil, and hydrology. An area is determined to qualify as a wetland if it meets the following "general diagnostic environmental characteristics:"

- Hydrophytic vegetation
- Hydrology
- Hydric Soil

Desktop Review

National Wetland Inventory

Williams Creek reviewed the applicable National Wetland Inventory (NWI) map and associated key to determine the presence or absence or potential wetland areas at the SITE (**Figure 2 and 3**). Seventeen (17) aquatic features are mapped within the SITE boundary.

Natural Resource Conservation Service Soil Survey

The Natural Resources Conservation Service (NRCS) Web Soil Survey of Johnson County provides aerial photography on which distinct soil unit boundaries are mapped. Review of the map indicates that six (6) soil units are mapped within the SITE boundary: Brookston silty clay loam, 0 to 2 percent slopes, Crosby silt loam, fine-loamy subsoil, 0 to 2 percent slopes, Fox loam, 0 to 2 percent slope, Miami silt loam, 2 to 6 percent slope, Ockley silt loam, 2 to 6 percent slope, and Patton silty clay loam, 0 to 2 percent slope (**Figure 4**). All of the soil units are included in the NRCS list of soils considered hydric in Hamilton County, suggesting the increased potential for the presence of wetlands within the SITE boundary.

Aerial Photography

Aerial photography provides a visual overview of the SITE and can provide information to assist in identifying land use practices, terrain, drainage, vegetated areas, wetlands, habitats, etc. Certain features, such as variegated soil patterns, may suggest the presence of wetlands.

Williams Creek reviewed a 2016 aerial photograph of the SITE from the NRCS Geospatial Data Gateway website (**Figure 5**). The SITE is predominantly active agricultural land. Approximately eighty (80) acres of woods is located in the watershed boundary. Ten (10) potential areas of inundation is located in the watershed. Low-lying dark areas appear to be located in the agricultural fields, but do not appear to be aquatic features based on the aerial photography.

Flood Insurance Rate Map

The Federal Emergency Management Agency (FEMA) was developed in 1979 to reform disaster relief and recovery, civil defense, and to prepare and mitigate for natural hazards. The Mitigation Division of FEMA manages the National Flood Insurance Program which provides guidance on how to lessen the impact of disasters on communities through flood insurance, floodplain management, and flood hazard mapping. Proper floodplain management has the ability to minimize the extent of flooding and flood damage and improve stormwater quality by reducing stormwater velocities and erosion. The one (1) percent annual chance flood (100 year flood) boundary must be kept free of encroachment as the national standard for the program.

Williams Creek reviewed digital Flood Insurance Rate Map (FIRM) data from the Natural Resource Conservation Service Geospatial Data Gateway projected over aerial photography (**Figure 6**). The FIRM indicates that there are no flood zones mapped within the SITE boundary.

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[2] U.S. Army Corps of Engineers Wetlands Delineation Manual, (1987 Manual).

Data Points

A Williams Creek staff scientist conducted a SITE investigation on 10 May 2017. The SITE boundary is approximately 850 acres in size. During the SITE investigation, Williams Creek observed the majority of the land being used for agricultural production. Field observed wetlands, potential wetlands, areas of interest, and photograph locations are presented in **Figure 7**. The areas and locations of the wetland are estimated from the field visit and desktop review due to the lack of property access beyond the seventy (70) foot right-of-way of the drains. Wetland A through F were verified during the field visit. Five (5) potential wetland areas were observed from a distance outside the right-of-way.

Wetland A

This DP was located in the center portion of the SITE. The dominant vegetation present consisted of uptight sedge (*Carex stricta*, OBL), common fox sedge (*Carex vulpinoidea*, FACW), and Dudley's rush (*Juncus dudleyi*, FACW) which did meet the hydrophytic vegetation criterion. Three (3) inches of standing water is an indication of hydrology. Examination of the soil profile using a Munsell Color Chart revealed a matrix color of 10YR 2/1 silty clay loam from 0 to 4 inches and 10YR 3/1 with 10YR 5/6 of silty clay loam from 4 to 18, which did meet the hydric soil criterion. Since all three (3) criteria were met, this area did qualify as a wetland.

Wetland B

This DP was located in the southwest portion of the SITE. The dominant vegetation present consisted of Virginia wild rye (*Elymus virginicus*, FACW), uptight sedge (*Carex stricta*, OBL), and reed canary grass (*Phalaris arundinacea*, FACW) which did meet the hydrophytic vegetation criterion. Three (3) inches of standing water is an indication of hydrology. Examination of the soil profile using a Munsell Color Chart revealed a matrix color of 10YR 2/1 silty clay loam from 0 to 3 inches and 10YR 2/1 with 10YR 4/6 of silty clay loam from 3 to 18, which did meet the hydric soil criterion. Since all three (3) criteria were met, this area did qualify as a wetland.

Wetland C

This DP was located in the center portion of the SITE. The dominant vegetation present consisted of reed canary grass (*Phalaris arundinacea*, FACW), silver maple (*Acer saccharinum*, FACW), and gray dogwood (*Cornus racemosa*, FAC) which did meet the hydrophytic vegetation criterion. Three (3) inches of standing water is an indication of hydrology. Examination of the soil profile using a Munsell Color Chart revealed a matrix color of 10YR 2/1 silty clay loam from 0 to 4 inches and 10YR 3/1 with 10YR 5/6 of silty clay loam from 4 to 18, which did meet the hydric soil criterion. Since all three (3) criteria were met, this area did qualify as a wetland.

Wetland D

This DP was located in the west portion of the SITE. The dominant vegetation present consisted of red maple (*Acer rubrum*, FAC), American sycamore (*Plantanus occidentalis*, FACW), Gray's sedge (*Carex grayi*, FACW), and small spike false nettle (*Boehhmeria* cylindrical, OBL) which did meet the hydrophytic vegetation criterion. Five (5) inches of standing water is an indication of hydrology. Examination of the soil profile using a Munsell Color Chart revealed a matrix color of 10YR 2/1 silt loam from 0 to 18 inches which did meet the hydric soil criterion. Since all three (3) criteria were met, this area did qualify as a wetland.

Wetland E

This DP was located in the west portion of the SITE. The dominant vegetation present consisted of eastern cottonwood (*Populus deltoides*, FAC), silver maple (*Acer saccharinum*, FACW), late goldenrod (*Solidago gigantea*, FACW), and silky dogwood (*Cornus amomum*, FACW) which did meet the hydrophytic vegetation criterion. Five (5) inches of standing water is an indication of hydrology. Examination of the soil profile using a Munsell Color Chart revealed a matrix color of 10YR 2/1 silty clay loam from 0 to 4 inches and 10YR 3/1 with 10YR 5/6 of silty clay loam from 4 to 18, which did meet the hydric soil criterion. Since all three (3) criteria were met, this area did qualify as a wetland.

Areas of Interest

Many portions of the SITE were inaccessible due to access to the SITE limited the Hamilton County drainage easements. As a result, Williams Creek conducted visual inspections where possible and desktop review to identify areas of potential wetlands or other "waters of the U.S." as areas of interest. Areas of interest based on visual inspection and desktop review are described below. Physical inspection of the areas of interest would be necessary in order to verify the presence or absence of wetlands.

Area of Interest 1

This DP was located in the agriculture field southwest to the Promise Road and 186th Street intersection. A significant amount of water (6 to 12 inches) was standing in the field due to large amounts of rain in the days prior to the field inspection. A large riser pipe is located in the field along the drain. Due to the amount of precipitation in the previous days, the drain/tile was backing up and flooding the field. A review of historical aerial photos shows the flooded area in the field has been farmed every four out of five years. During wet summers, the historical photos shows stunted or no crops. The previous year's crop was soybeans (*Glycine max*, UPL). No hydrophytic vegetation was identified.

Area of Interest 2

This DP was located in the east portion of the SITE. A significant amount of water (6 to 12 inches) was standing in the field due to large amounts of rain in the past days. This area is a digressional area is adjacent to Wetland E. Review of historical photos shows the flooded area in the field has been farmed every four out of five years. During wet summers, the historical photos shows stunted or no crops. The previous year's crop was corn (*Zea mays*, UPL). No hydrophytic vegetation was identified.

Potential Off-Site Wetland 1

This potential location is in the northwest portion of the SITE. It is a depression area with trees and shrubs surrounded by an agricultural field. This area was viewed from 186th Street due to lack of property access. From a distance, the trees looked like cottonwoods, maple, and dead ash which are typical wetland tree species. From a number of aerial photographs, there appears to be standing water during the wet season. From the NRCS Web Soil Survey, this area has Brookston silty clay loam soil which is a hydric soil.

Potential Off-Site Wetland 2

This potential location is in the northwest portion of the SITE. It is a depression area with herbaceous plants surrounded by an agricultural field. This area was viewed from 186th Street due to lack of property access. From a distance, the vegetation looked like cattails and reed canary grass which are hydrophytic vegetation. From the NRCS Web Soil Survey, this area has Brookston silty clay loam soil which is a hydric soil. From historical aerial photographs, this area is consistently being farmed around due to its persistent inundation.

Potential Off-Site Wetland 3

This potential location is in the northwest portion of the SITE. It is a depression area surrounded by an agricultural field. This area was attempted to be viewed from 186th Street due to lack of property access. This potential wetland could not be seen from the road due to topography. From the NRCS Web Soil Survey, this area has Crosby silt loam soil which is a hydric soil. From historical aerial photographs, this area is consistently being farmed around due to its persistent inundation with the exception of a few dry years.

Potential Off-Site Wetland 4

This potential location is just northwest of the intersection of 186th Street and Promise Road. This is a woodlot with wet signatures from aerial photographs on the north side of the property. This area was attempted to be viewed from 186th Street due to lack of property access. This potential wetland could not be seen from the road due vegetation. From the NRCS Web Soil Survey, this area has Crosby silt loam soil which is a hydric soil. From historical aerial photographs, this area is consistently being farmed

around due to its persistent inundation with the exception of a few dry years.

Potential Off-Site Wetland 5

This potential feature is located in the southern portion of the SITE. This is a wooded area seen from a distance off the drain right-of-way. From the right-of-way, possible cottonwoods and maples appear to be present in the woods. From the NRCS Web Soil Survey, this area has Crosby silt loam soil which is a hydric soil. The NWI maps show a presence possible of wetlands on their maps.

Potential Off-Site Wetland 6

This DP was located in the west portion of the SITE. It is a depression area with herbaceous plants surrounded by an agricultural field. From the NRCS Web Soil Survey, this area has Brookston silty clay loam soil which is a hydric soil. From historical aerial photographs, this area is constantly being farmed around due to its persistent inundation.

Open Water Pond

A 2.02 acres pond is located in the southwest corner of the SITE.

Drainage Features, Streams, and Other Potential "Waters of the U.S."

The Sam Craig/John Holleran arm of the Elwood Wilson Drain runs through this watershed. No other stream or other potential "Waters of the U.S." was located on the SITE.

SITE Photos

During the field reconnaissance of the inspection limits on 10 May 2017, Williams Creek obtained photographs to document existing conditions and areas of interest. See **Figure 7** for photograph locations.

Photo 1: Wetland A

Photo 2: Looking East

Photo 3: Looking West

Photo 4: Looking Southwest

Photo 5: Looking West

Photo 6: Sediment Deposit Area

Photo 7: Wetland B Looking East

Photo 8: Wetland B Looking West

Photo 9: Wetland B Looking East

Photo 10: Culvert to Pond

Photo 11: Culvert Under State Road 37

Photo 12: Potential Off-Site Wetland 1

Photo 13: Potential Off-Site Wetland 2

Photo 14: Wetland C

Photo 15: Area of Interest 1

Photo 16: Looking East

Photo 17: Wetland D

Photo 18: Area of Interest 2

Photo 19: Wetland E

Conclusions

Based on the criteria established by the USACE 1987 manual and the 2008 Midwest Supplement, five (5) wetland areas were identified within the right-of-way of the Sam Craig/John Holleran Arm of the Elwood Wilson Drain boundary. These five (5) wetlands were verified via a field visit. Another six (6) potential wetlands were identified within the watershed. These six (6) potential wetlands could not be field verified due to lack of property access. They were identified by desktop review and from a distance in the field. Two (2) other areas were identified as areas of interest. These areas held a significant amount of water at the time of the field visit due to heavy rains in the previous days. These two areas are farmed yearly except for above average wet years. A 2.02 acre open water pond is located in the southwest corner of the watershed.

The type of permit required for proposed impacts to wetlands will depend on the extent of impacts proposed. For up to 1.0 acre of impacts, a USACE Regional General Permit (RGP) with Section 401 Water Quality Certification (WQC) to IDEM will likely be necessary. If proposed impacts total 0.10 acre or less, then a RGP Notification to IDEM will likely be necessary.

There is a possibility that more wetlands may occur in this watershed. More property access would be needed to verify these potential wetlands.

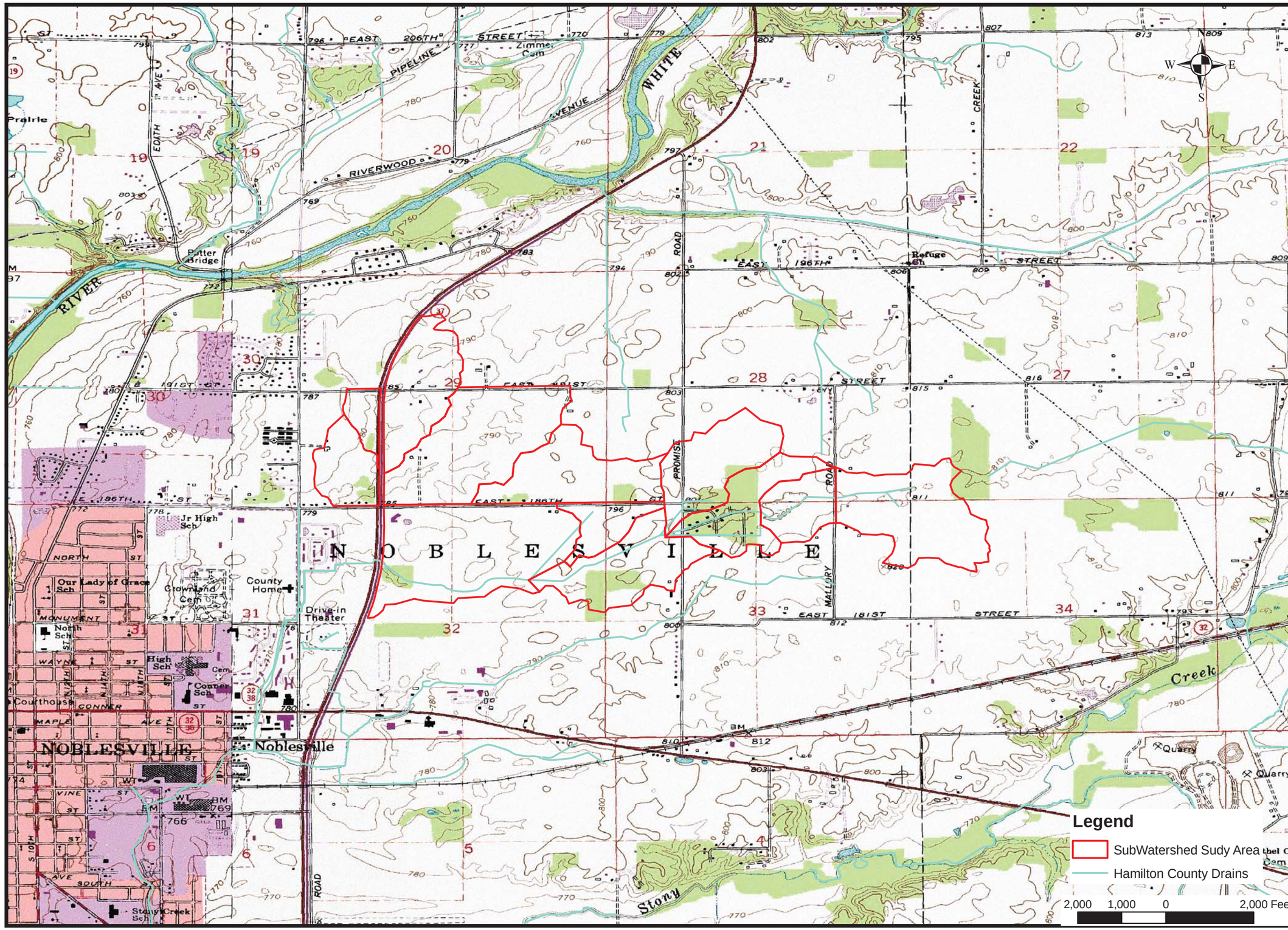
Williams Creek appreciates the opportunity to be of service to Clark Dietz, Inc. and looks forward to working together in the future. If you have any questions or comments concerning the preliminary natural resource assessment, please contact me at your earliest convenience.

Best regards,
Williams Creek Consulting, Inc.

Brian E. Catt
Senior Project Manager

Figures

WILLIAMS CREEK
CONSULTING



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WILLIAMS CREEK CONSULTING

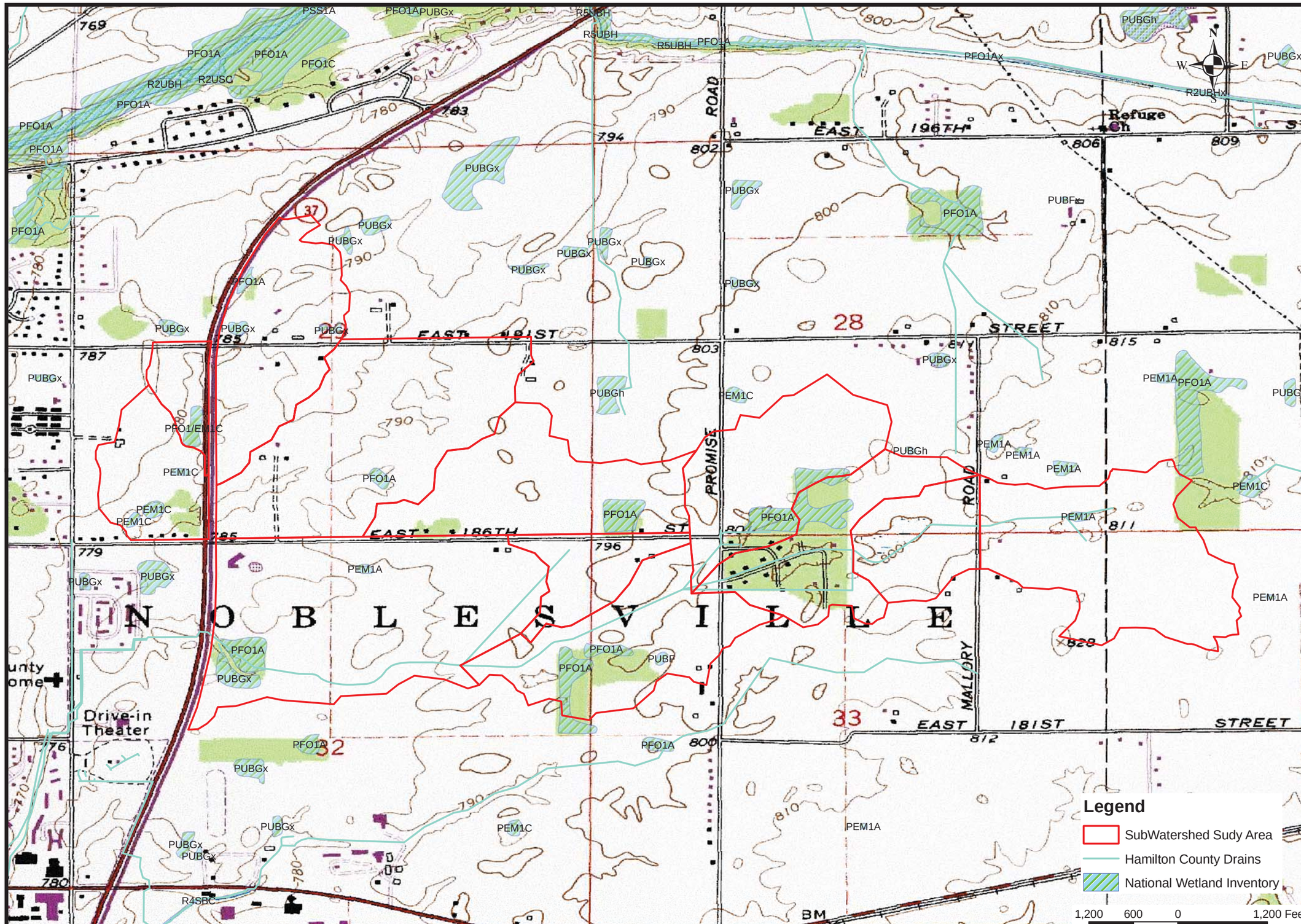
DWN BY: NDH
CHKD BY: BC
SCALE:
DATE: MAY 2017

Sam Clark/John Holleran Arm Watershed Study
Noblesville, Hamilton County, Indiana

Figure 1
USGS Topographic Map
Noblesville Quadrangle

PROJECT NUMBER
01.1252

MAP NUMBER
1 OF 7



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CHKD BY: BC
SCALE:
DATE: MAY 2017

Sam Clark/John Holleran Arm Watershed Study
Noblesville, Hamilton County, Indiana

Figure 2
National Wetland Inventory Map
Noblesville Quadrangle

PROJECT NUMBER
01.1252

MAP NUMBER
2 OF 7

SYSTEM

P-PALUSTRINE

CLASS	RB-ROCK BOTTOM	UB-UNCONSOLIDATED BOTTOM	AB-AQUATIC BED	US-UNCONSOLIDATED SHORE	ML-MOSS-LICHEN	EM-EMERGENT	SS-SCRUB-SHRUB	FO-FORESTED	OW-OPEN WATER/ *UNKNOWN BOTTOM*
Subclass	1 Bedrock 2 Rubble 3 Mud 4 Organic	1 Cobble-Gravel 2 Sand	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular 5 *Unknown Submergent* 6 *Unknown Surface*	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	1 Moss 2 Lichen	1 Persistent 2 Nonpersistent	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*	1 Broad-Leaved Deciduous 2 Needle –Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*	

MODIFIERS

In order to more adequately describe wetland and deepwater habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

WATER REGIME				WATER CHEMISTRY			SOIL	SPECIAL MODIFIERS
Non-Tidal		Tidal		Coastal Halinity	Inland Salinity	pH Modifiers for All Fresh Water		
A Temporarily Flooded	H Permanently Flooded	K *Artificially Flooded*	*S Temporary-Tidal	1 Hyperhaline	7 Hypersaline		g Organic	b Beaver
B Saturated	J Intermittently Flooded	L Subtidal	*R Seasonal-Tidal	2 Euhaline	8 Eusaline	a Acid	n Mineral	d *Partially Drained/Ditched*
C Seasonally Flooded	L Artificially Flooded	M Irregularly Exposed	*T Semipermanent-Tidal	3 Mixohaline *(Brackish)*	9 Mixosaline	t Circumneutral		f Farmed
D Seasonally Flooded/ *Well Drained*	W Intermittently Flooded/Temporary	N Regularly Flooded	V Permanent-Tidal	4 Polyhaline	0 Fresh	i Alkaline		h Diked/Impounded
		P Irregularly Flooded	U *Unknown*	5 Mesohaline				r Artificial Substrate
E *Seasonally Flooded/ Saturated*	Y Saturated/Semipermanent/ Seasonal			6 Oligohaline				s Spoil
				0 Fresh				x Excavated
F Semipermanently Flooded	Z Intermittently Exposed/ Permanent							
G Intermittently Exposed	U *Unknown*	*These water regimes are only used in tidally influenced, freshwater systems.						

NOTE: Italicized items were added for mapping by National Wetlands Inventory program.

et

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WILLIAMS CREEK CONSULTING

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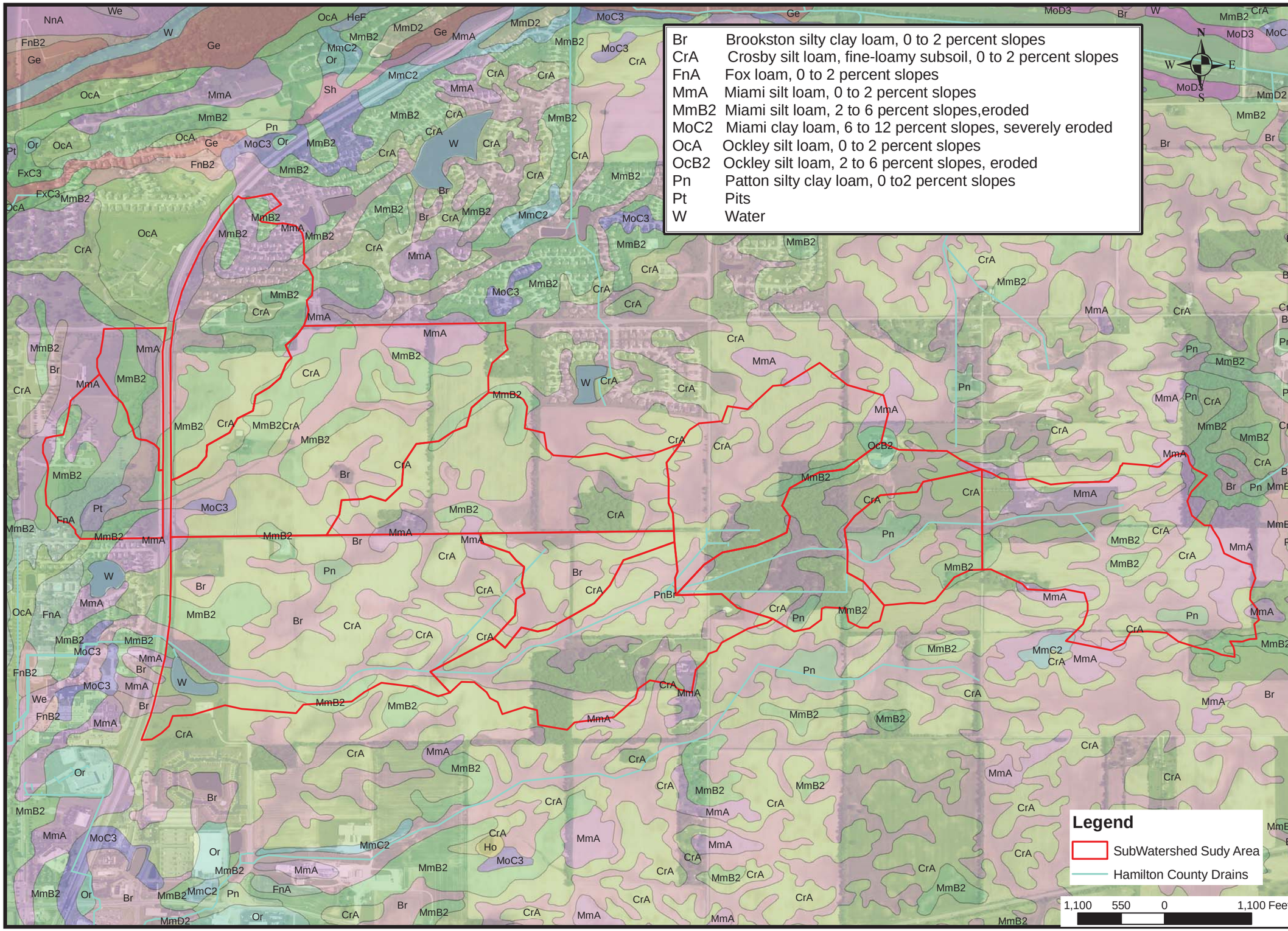
CHKD BY: BC
SCALE:
DATE: MAY 2017

Sam Clark/John Holleran Arm Watershed Study
Noblesville, Hamilton County, Indiana

Figure 3
Key to National Wetland Inventory Map
Noblesville Quadrangle

PROJECT NUMBER
01.1252

MAP NUMBER
3 OF 7



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DWN BY: NDH
CHKD BY: BC
SCALE:
DATE: MAY 2017

Sam Clark/John Holleran Arm
Watershed Study
Noblesville, Hamilton County, Indiana

Figure 4
NRCS Soil Survey for Hamilton County
NRCS Websoil Survey

PROJECT NUMBER
01.1252

MAP NUMBER
4 OF 7

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WILLIAMS CREEK
CONSULTING

DWN BY: NDH
CHKD BY: BC
SCALE:
DATE: MAY 2017

Sam Clark/John Holleran Arm
Watershed Study
Noblesville, Hamilton County, Indiana

Figure 5
2016 Aeral Photograph
NRCS Geospatial Gateway

PROJECT NUMBER
01.1252

MAP NUMBER
5 OF 7

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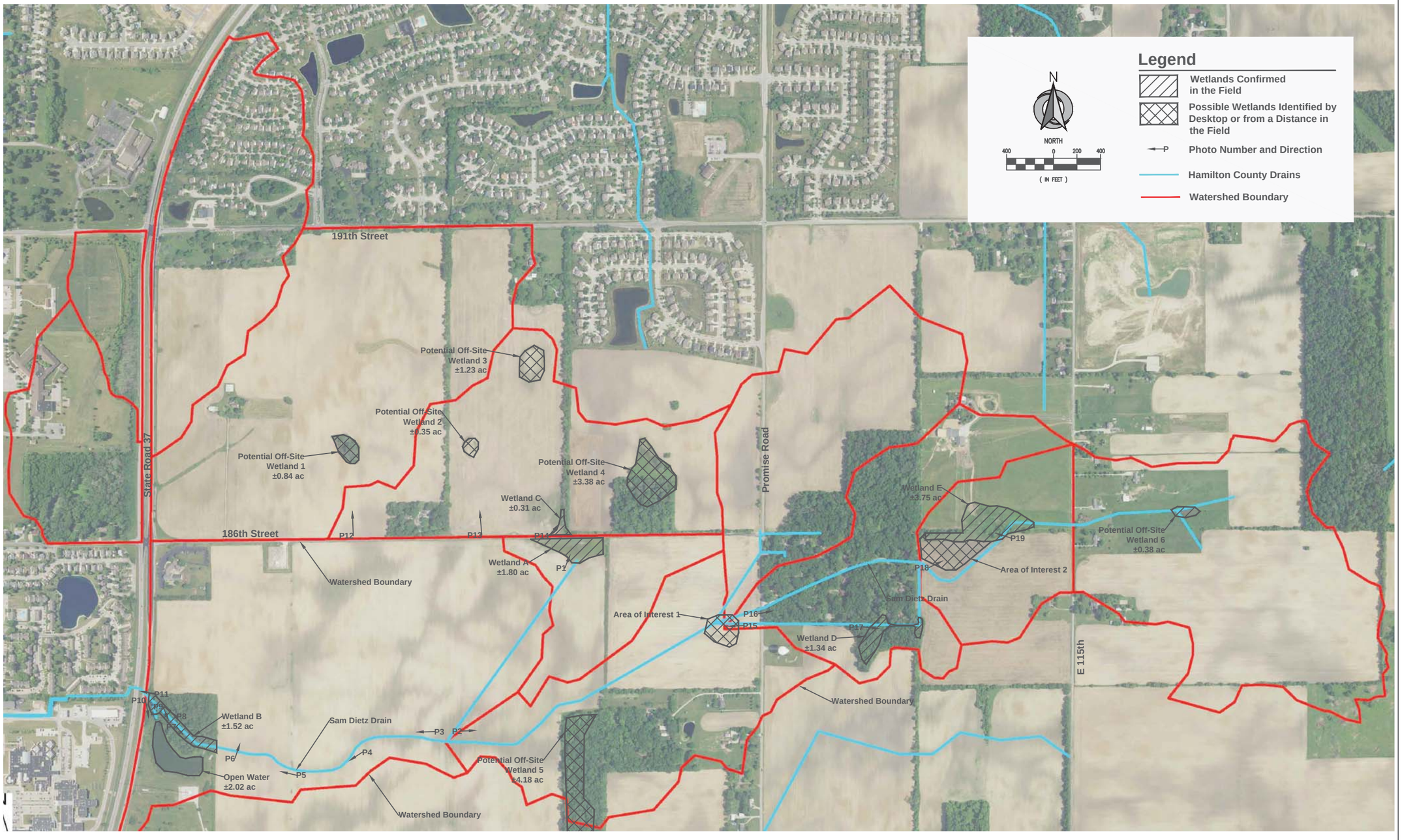
DWN BY: NDH
CHKD BY: BC
SCALE:
DATE: MAY 2017

Sam Clark/John Holleran Arm
Watershed Study
Noblesville, Hamilton County, Indiana

Figure 6
FEMA Flood Insuance Rate Map
NRCS Geospatial Data Gateway

PROJECT NUMBER
01.1252

MAP NUMBER
6 OF 7



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DWN BY:	NDH
CHKD. BY:	BC
SCALE:	AS SHOWN
DATE:	05.11.2017

REVISIONS

Sam Craig/John Holleran Arm
State Road 37 and 186th Street
Noblesville, IN

Natural Resource Assessment

PROJECT NUMBER
01.1252

DRAWING NUMBER
Figure 7

SHEET 7 7 OF

Appendix A

Data Forms

WILLIAMS CREEK
CONSULTING

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Sam Craig/John Holleran Arm City/County: Hamilton Sampling Date: 10 May 2017

Applicant/Owner: Clark Dietz, Inc. State: IN Sampling Point: Wet A

Investigator(s): N. Houk Section, Township, Range: Sec 32 T 19N R5E

Landform (hillside, terrace, etc.): Depression Local relief (concave, convex, none): Concave

Slope (%): 0-2 Lat: 40* 03' 29.070" N Long: 85* 58'39.374" W Datum: NAD 83

Soil Map Unit Name: Brookston silty clay loam NWI classification: PEM

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area within a Wetland?** **Yes** X **No** ____
Hydric Soil Present?	Yes X	No ____	
Wetland Hydrology Present?	Yes X	No ____	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: N/A)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
		=Total Cover	

Sapling/Shrub Stratum (Plot size: N/A)			
1.			
2.			
3.			
4.			
5.			
		=Total Cover	

Herb Stratum (Plot size: 5')			
1. *Carex stricta*	40	Yes	OBL
2. *Carex vulpinoidea*	20	Yes	FACW
3. *Juncus dudleyi*	10	No	FACW
4. *Phalaris arundinacea*	2	No	FACW
5. *Juncus effusus*	5	No	OBL
6. *Typha latifolia*	10	No	OBL
7. *Typha angustifolia*	5	No	OBL
8. *Ranunculus hispidus*	5	No	FAC
9. *Asclepias incarnata*	2	No	OBL
10.			
	99	=Total Cover	

Woody Vine Stratum (Plot size: N/A)			
1.			
2.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	62	x 1 =	62
FACW species	32	x 2 =	64
FAC species	5	x 3 =	15
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	99 (A)		141 (B)

Prevalence Index = B/A = 1.42

Hydrophytic Vegetation Indicators:

- ____ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- X 3 - Prevalence Index is ≤3.0[1]
- ____ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ____ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ____

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: Wet A

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 2/1	100					Loamy/Clayey	
4-18	10YR 3/1	95	10YR 4/6	5	C	M	Loamy/Clayey	Prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 5 cm Mucky Peat or Peat (S3)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ? Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ? Coast Prairie Redox (A16)
- ___ Iron-Manganese Masses (F12)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (F22)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** ___

Remarks:

This data form is revised from Midwest Regional Supplement Version 2.0 to include the NRCS Field Indicators of Hydric Soils, Version 7.0, 2015 Errata. (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051293.docx)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- X Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Gauge or Well Data (D9)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes X	No ___	Depth (inches): 3
Water Table Present?	Yes X	No ___	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): ___

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Sam Craig/John Holleran Arm City/County: Hamilton Sampling Date: 10 May 2017

Applicant/Owner: Clark Dietz, Inc. State: IN Sampling Point: Wet B

Investigator(s): N. Houk Section, Township, Range: Sec 32 T 19N R5E

Landform (hillside, terrace, etc.): Depression Local relief (concave, convex, none): Concave

Slope (%): 0-2 Lat: 40* 03' 13.550" N Long: 85* 59' 21.127" W Datum: NAD 83

Soil Map Unit Name: Brookston silty clay loam NWI classification: PEM

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area within a Wetland?** **Yes** X **No** ____
Hydric Soil Present?	Yes X	No ____	
Wetland Hydrology Present?	Yes X	No ____	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: N/A)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
		=Total Cover	

Sapling/Shrub Stratum (Plot size: N/A)			
1.			
2.			
3.			
4.			
5.			
		=Total Cover	

Herb Stratum (Plot size: 5')			
1. *Elymus virginicus*	20	Yes	FACW
2. *Carex stricta*	20	Yes	OBL
3. *Phalaris arundinacea*	15	Yes	FACW
4. *Sanicula odorata*	10	No	FAC
5. *Geum laciniatum*	5	No	FACW
6. *Impatiens capensis*	5	No	FACW
7. *Fraxinus pennsylvanica*	10	No	FACW
8. *Erigeron philadelphicus*	10	No	FACW
9. *Galium aparine*	5	No	FACU
10.			
	100	=Total Cover	

Woody Vine Stratum (Plot size: N/A)			
1.			
2.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	20	x 1 =	20
FACW species	65	x 2 =	130
FAC species	10	x 3 =	30
FACU species	5	x 4 =	20
UPL species	0	x 5 =	0
Column Totals:	100 (A)		200 (B)

Prevalence Index = B/A = 2.00

Hydrophytic Vegetation Indicators:

- ____ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- X 3 - Prevalence Index is ≤3.0[1]
- ____ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ____ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ____

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: Wet B

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-3	10YR 2/1	100					Loamy/Clayey	
3-18	10YR 2/1	95	10YR 4/6	5	C	M	Loamy/Clayey	Prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 5 cm Mucky Peat or Peat (S3)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ? Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ? Coast Prairie Redox (A16)
- ___ Iron-Manganese Masses (F12)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (F22)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** ___

Remarks:

This data form is revised from Midwest Regional Supplement Version 2.0 to include the NRCS Field Indicators of Hydric Soils, Version 7.0, 2015 Errata. (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051293.docx)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- X Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Gauge or Well Data (D9)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes X	No ___	Depth (inches): 4
Water Table Present?	Yes X	No ___	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): ___

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Sam Craig/John Holleran Arm City/County: Hamilton Sampling Date: 10 May 2017

Applicant/Owner: Clark Dietz, Inc. State: IN Sampling Point: Wet C

Investigator(s): N. Houk Section, Township, Range: Sec 29 T 19N R5E

Landform (hillside, terrace, etc.): Depression Local relief (concave, convex, none): Concave

Slope (%): 0-2 Lat: 40* 03' 31.226" N Long: 85* 58' 40.494" W Datum: NAD 83

Soil Map Unit Name: Brookston silty clay loam NWI classification: PFO

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area within a Wetland?** **Yes** X **No** ____
Hydric Soil Present?	Yes X	No ____	
Wetland Hydrology Present?	Yes X	No ____	

Remarks:
Meets all wetland criteria

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. *Acer saccharinum*	30	Yes	FACW
2. *Celtis occidentalis*	30	Yes	FAC
3.			
4.			
5.			
	60	=Total Cover	
Sapling/Shrub Stratum (Plot size: 15')			
1. *Cornus racemosa*	40	Yes	FAC
2.			
3.			
4.			
5.			
	40	=Total Cover	
Herb Stratum (Plot size: 5')			
1. *Phalaris arundinacea*	75	Yes	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	75	=Total Cover	
Woody Vine Stratum (Plot size: N/A)			
1.			
2.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	105	x 2 =	210
FAC species	70	x 3 =	210
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	175 (A)		420 (B)

Prevalence Index = B/A = 2.40

Hydrophytic Vegetation Indicators:

- ____ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- X 3 - Prevalence Index is ≤3.0[1]
- ____ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ____ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ____

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: Wet C

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 2/1	100					Loamy/Clayey	
4-18	10YR 3/1	95	10YR 4/6	5	C	M	Loamy/Clayey	Prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 5 cm Mucky Peat or Peat (S3)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ? Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ? Coast Prairie Redox (A16)
- ___ Iron-Manganese Masses (F12)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (F22)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** ___

Remarks:

This data form is revised from Midwest Regional Supplement Version 2.0 to include the NRCS Field Indicators of Hydric Soils, Version 7.0, 2015 Errata. (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051293.docx)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- X Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Gauge or Well Data (D9)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes X	No ___	Depth (inches): 0.5
Water Table Present?	Yes X	No ___	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): ___

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Sam Craig/John Holleran Arm City/County: Hamilton Sampling Date: 10 May 2017

Applicant/Owner: Clark Dietz, Inc. State: IN Sampling Point: Wet D

Investigator(s): N. Houk Section, Township, Range: Sec 33 T 19N R5E

Landform (hillside, terrace, etc.): Depression Local relief (concave, convex, none): Concave

Slope (%): 0-2 Lat: 40* 03' 23.364" N Long: 85* 58' 06.542" W Datum: NAD 83

Soil Map Unit Name: Brookston silty clay loam NWI classification: PFO

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area within a Wetland?** **Yes** X **No** ____
Hydric Soil Present?	Yes X	No ____	
Wetland Hydrology Present?	Yes X	No ____	

Remarks:
Meets all wetland criteria

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. *Acer rubrum*	40	Yes	FAC
2. *Platanus occidentalis*	20	Yes	FACW
3.			
4.			
5.			
	60	=Total Cover	
Sapling/Shrub Stratum (Plot size: 15')			
1. *Cornus amomum*	20	Yes	FACW
2. *Cornus racemosa*	10	Yes	FAC
3. *Sambucus nigra*	5	No	FAC
4. *Ulmus americana*	5	No	FACW
5.			
	40	=Total Cover	
Herb Stratum (Plot size: 5')			
1. *Carex grayi*	20	Yes	FACW
2. *Carex stricta*	10	No	OBL
3. *Boehmeria cylindrica*	20	Yes	OBL
4. *Ribes americanum*	5	No	FACW
5. *Ranunculus hispidus*	5	No	FAC
6. *Toxicodendron radicans*	5	No	FAC
7. *Barbarea vulgaris*	5	No	FAC
8.			
9.			
10.			
	70	=Total Cover	
Woody Vine Stratum (Plot size: N/A)			
1.			
2.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 6 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	30	x 1 =	30
FACW species	70	x 2 =	140
FAC species	70	x 3 =	210
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	170 (A)		380 (B)

Prevalence Index = B/A = 2.24

Hydrophytic Vegetation Indicators:

- ____ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- X 3 - Prevalence Index is ≤3.0[1]
- ____ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ____ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ____

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: Wet D

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	10YR 2/1	95	10YR 5/6	5	C	M	Loamy/Clayey	Prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 5 cm Mucky Peat or Peat (S3)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ? Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ? Coast Prairie Redox (A16)
- ___ Iron-Manganese Masses (F12)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (F22)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** ___

Remarks:

This data form is revised from Midwest Regional Supplement Version 2.0 to include the NRCS Field Indicators of Hydric Soils, Version 7.0, 2015 Errata. (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051293.docx)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- X Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Gauge or Well Data (D9)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes X	No ___	Depth (inches): 4
Water Table Present?	Yes X	No ___	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): ___

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Sam Craig/John Holleran Arm City/County: Hamilton Sampling Date: 10 May 2017

Applicant/Owner: Clark Dietz, Inc. State: IN Sampling Point: Wet E

Investigator(s): N. Houk Section, Township, Range: Sec 33 T 19N R5E

Landform (hillside, terrace, etc.): Depression Local relief (concave, convex, none): Concave

Slope (%): 0-2 Lat: 40* 03' 31.079" N Long: 85* 57' 52.369" W Datum: NAD 83

Soil Map Unit Name: Brookston silty clay loam NWI classification: PEM/PFO

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area within a Wetland?** **Yes** X **No** ____
Hydric Soil Present?	Yes X	No ____	
Wetland Hydrology Present?	Yes X	No ____	

Remarks:
Meets all wetland criteria

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. *Acer saccharinum*	20	Yes	FACW
2. *Populus deltoides*	30	Yes	FAC
3.			
4.			
5.			
	50	=Total Cover	
Sapling/Shrub Stratum (Plot size: 15')			
1. *Cornus amomum*	30	Yes	FACW
2. *Morus alba*	10	Yes	FAC
3.			
4.			
5.			
	40	=Total Cover	
Herb Stratum (Plot size: 5')			
1. *Solidago gigantea*	20	Yes	FACW
2. *Typha angustifolia*	10	No	OBL
3. *Geum laciniatum*	10	No	FACW
4. *Carex stricta*	10	No	OBL
5. *Phalaris arundinacea*	20	Yes	FACW
6.			
7.			
8.			
9.			
10.			
	70	=Total Cover	
Woody Vine Stratum (Plot size: N/A)			
1.			
2.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 6 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	20	x 1 =	20
FACW species	100	x 2 =	200
FAC species	40	x 3 =	120
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	160 (A)		340 (B)

Prevalence Index = B/A = 2.13

Hydrophytic Vegetation Indicators:

____ 1 - Rapid Test for Hydrophytic Vegetation
X 2 - Dominance Test is >50%
X 3 - Prevalence Index is ≤3.0[1]
____ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
____ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ____

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: Wet E

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 2/1	100					Loamy/Clayey	
4-18	10YR 2/1	95	10YR 5/6	5	C	M	Loamy/Clayey	Prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 5 cm Mucky Peat or Peat (S3)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ? Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ? Coast Prairie Redox (A16)
- ___ Iron-Manganese Masses (F12)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (F22)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** ___

Remarks:

This data form is revised from Midwest Regional Supplement Version 2.0 to include the NRCS Field Indicators of Hydric Soils, Version 7.0, 2015 Errata. (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051293.docx)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- X Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Gauge or Well Data (D9)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes X	No ___	Depth (inches): 5
Water Table Present?	Yes X	No ___	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): ___

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

ATTACHMENT 11:

Cost Estimate

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Alternative 1 - Open Channel - Cost Estimate

Last Revised: June, 2017

Total Opinion of Probable Costs: **$1,384,300**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$15,000	$15,000
2	Temporary Silt Fence	19,820	LF	$1	$19,800
3	Tree Removal (4" and over)	44	EA	$900	$39,600
4	Linear Ditch Grading	31,788	CYS	$26	$826,500
	Structures				
5	5 x 3 Box Culvert (Mallery)	25	LF	$417	$10,400
6	Asphalt Pavement Restoration (Mallery)	11	TON	$70	$800
7	5 x 3 Box Culvert (Property Access 1)	15	LF	$417	$6,300
8	Gravel Drive - Compacted Agg No. 53 (Access 1)	15	TON	$37	$500
9	6 x 4 Box Culvert (Promise)	28	LF	$650	$18,200
10	Asphalt Pavement Restoration (Promise)	22	TON	$70	$1,500
11	10 x 5 Box Culvert (Property Access 2)	15	LF	$1,020	$15,300
12	Revetment Rip Rap	40	TON	$50	$2,000
13	Gravel Drive - Compacted Agg No. 53 (Access 2)	20	TON	$37	$700
14	Pipe End Section, Dia. 12"	1	EA	$475	$500
15	Pipe End Section, Dia. 15"	1	EA	$487	$500
	Restoration				
16	Slope Stabilization Seed Mix	1,412	LB	$90	$127,100
17	20' Filter Strips	19,820	LF	$2	$39,600
	Construction Subtotal				**$1,124,300**
				Legal Costs(3%) =	$34,000
				Design and Bidding Services(10%) =	$113,000
				Inspection and Staking Services(10%)=	$113,000
				Total Project Cost =	**$1,384,300**

Notes

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Alternative 2 - Closed System/Open Channel Combination - Cost Estimate

Last Revised: June, 2017

Total Opinion of Probable Costs: **$1,363,400**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$15,000	$15,000
2	Temporary Silt Fence	19,820	LF	$1	$19,800
3	Tree Removal (4" and over)	30	EA	$900	$27,000
4	Linear Ditch Grading	17,217	CYS	$26	$447,600
	Structures				
5	36 IN Concrete Circular Pipe	4,440	LF	$95	$421,800
6	Asphalt Pavement Restoration (Mallery)	11	TON	$70	$800
7	Asphalt Pavement Restoration (Promise)	22	TON	$70	$1,500
8	10 x 5 Box Culvert (Property Access 2)	15	LF	$1,020	$15,300
9	Revetment Rip Rap	10	TON	$50	$500
10	Gravel Drive - Compacted Agg No. 53 (Access 2)	20	TON	$37	$700
11	Pipe End Section, Dia. 12"	1	EA	$475	$500
12	Pipe End Section, Dia. 15"	1	EA	$487	$500
13	Pipe End Section, Dia. 36"	1	EA	$1,301	$1,300
14	Catch Basin	6	EA	$2,152	$12,900
15	Manhole	8	EA	$2,787	$22,300
	Restoration				
16	Slope Stabilization Seed Mix	892.3	LB	$90	$80,300
17	20' Filter Strips	19,820	LF	$2	$39,600
	Construction Subtotal				**$1,107,400**
				Legal Costs(3%) =	$34,000
				Design and Bidding Services(10%) =	$111,000
				Inspection and Staking Services(10%)=	$111,000
				Total Project Cost =	**$1,363,400**

Notes

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Alternative 3 - Open Channel with 36" Under Drain - Cost Estimate

Last Revised: June, 2017

Total Opinion of Probable Costs: **$2,484,500**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$15,000	$15,000
2	Temporary Silt Fence	19,820	LF	$1	$19,800
3	Tree Removal (4" and over)	44	EA	$900	$39,600
4	Linear Ditch Grading	28,077	CYS	$26	$730,000
	Structures				
5	36 IN Concrete Circular Pipe	9,910	LF	$95	$941,500
6	5 x 3 Box Culvert (Mallery)	25	LF	$417	$10,400
7	Asphalt Pavement Restoration (Mallery)	11	TON	$70	$800
8	5 x 3 Box Culvert (Property Access 1)	15	LF	$417	$6,300
9	Gravel Drive - Compacted Agg No. 53 (Access 1)	15	TON	$37	$500
10	6 x 4 Box Culvert (Promise)	28	LF	$650	$18,200
11	Asphalt Pavement Restoration (Promise)	22	TON	$70	$1,500
12	10 x 5 Box Culvert (Property Access 2)	15	LF	$1,020	$15,300
13	Revetment Rip Rap	40	TON	$50	$2,000
14	Gravel Drive - Compacted Agg No. 53 (Access 2)	20	TON	$37	$700
15	Pipe End Section, Dia. 12"	1	EA	$475	$500
16	Pipe End Section, Dia. 15"	1	EA	$487	$500
17	Manhole	18	EA	$2,787	$50,200
	Restoration				
18	Slope Stabilization Seed Mix	1,412	LB	$90	$127,100
19	20' Filter Strips	19,820	LF	$2	$39,600
	Construction Subtotal				**$2,019,500**
				Legal Costs(3%) =	$61,000
				Design and Bidding Services(10%) =	$202,000
				Inspection and Staking Services(10%)=	$202,000
				Total Project Cost =	**$2,484,500**

Notes

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Detention Pond 1 - Option 1 (7 Acre Footprint) - Cost Estimate

Last Revised: May, 2018

Total Opinion of Probable Costs: **$995,100**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$5,000	$5,000
2	Temporary Silt Fence	2,000	LF	$1	$2,000
3	Tree Removal (4" and over)	10	EA	$900	$9,000
4	Common Excavation	33,900	CYS	$25	$847,500
5	Grading	1	LS	$5,000	$5,000
6	Additional Easement Acquisition	6	Acres	$20,650	$113,600
	Restoration				
7	Slope Stabilization Seed Mix	100	LB	$90	$9,000
8	20' Filter Strips	2,000	LF	$2	$4,000
	Construction Subtotal				**$995,100**

Notes: Subbasin 1 produces 21 Acre-Ft of water during a Q100 event.
Estimate is for a 7 acre pond, 3 ft deep.
This would contain entire storm.
Pond would cross 2 properties.
Excavation cost includes removal of spoils

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Detention Pond 1 - Option 2 (4 Acre Footprint) - Cost Estimate

Last Revised: May, 2018

Total Opinion of Probable Costs: **$636,900**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$5,000	$5,000
2	Temporary Silt Fence	1,700	LF	$1	$1,700
3	Tree Removal (4" and over)	0	EA	$900	$0
4	Common Excavation	22,500	CYS	$25	$562,500
5	Grading	1	LS	$5,000	$5,000
6	Additional Easement Acquisition	3	Acres	$20,650	$51,600
	Restoration				
7	Slope Stabilization Seed Mix	85	LB	$90	$7,700
8	20' Filter Strips	1,700	LF	$2	$3,400
	Construction Subtotal				**$636,900**

Notes: Subbasin 1 produces 21 Acre-Ft of water during a Q100 event.
Estimate is for a 4 acre pond, 3.5 ft deep.
This would contain 2/3 of the storm.
Pond would be located on a single property
Excavation cost includes removal of spoils

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Detention Pond 2 - Cost Estimate

Last Revised: May, 2018

Total Opinion of Probable Costs: **$702,400**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$5,000	$5,000
2	Temporary Silt Fence	2,300	LF	$1	$2,300
3	Tree Removal (4" and over)	0	EA	$900	$0
4	Common Excavation	23,000	CYS	$25	$575,000
5	Grading	1	LS	$5,000	$5,000
6	Additional Easement Acquisition	5	Acres	$20,650	$99,100
	Structures				
7	12 IN Concrete Circular Pipe	20	LF	$35	$700
8	Asphalt Pavement Restoration (Promise)	5	TON	$70	$300
	Restoration				
9	Slope Stabilization Seed Mix	115	LB	$90	$10,400
10	20' Filter Strips	2,300	LF	$2	$4,600
	Construction Subtotal				**$702,400**

Notes: Subbasin 4 produces 16.8 Acre-Ft of water during a Q100 event.
Estimate is for a 4.8 acre pond, 3.5 ft deep.
This would contain the Q100 storm.
Pond could be located across 1 or 2 properties connected by a 12" equalizer pipe
Excavation cost includes removal of spoils

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Detention Pond 3 and Diversion - Cost Estimate

Last Revised: May, 2018

Total Opinion of Probable Costs: **$828,600**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$5,000	$5,000
2	Temporary Silt Fence	2,300	LF	$1	$2,300
3	Tree Removal (4" and over)	0	EA	$900	$0
4	Common Excavation	23,000	CYS	$25	$575,000
5	Grading	1	LS	$5,000	$5,000
6	Additional Easement Acquisition	5	Acres	$20,650	$99,100
	Structures				
6	Catch Basin	1	EA	$2,152	$2,200
7	36 IN Concrete Circular Pipe	1,300	LF	$95	$123,500
8	12 IN Concrete Circular Pipe	35	LF	$35	$1,200
9	Asphalt Pavement Restoration (Promise)	5	TON	$70	$300
	Restoration				
10	Slope Stabilization Seed Mix	115	LB	$90	$10,400
11	20' Filter Strips	2,300	LF	$2	$4,600
	Construction Subtotal				**$828,600**

Notes: Subbasin 4 produces 16.8 Acre-Ft of water during a Q100 event.
Estimate is for a 4.8 acre pond, 3.5 ft deep.
This would contain the Q100 storm.
Pond would be located in Peterson Watershed
Excavation cost includes removal of spoils

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Detention Pond 4 - Cost Estimate

Last Revised: May, 2018

Total Opinion of Probable Costs: **$340,100**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$5,000	$5,000
2	Temporary Silt Fence	1,800	LF	$1	$1,800
3	Tree Removal (4" and over)	0	EA	$900	$0
4	Common Excavation	10,600	CYS	$25	$265,000
5	Grading	1	LS	$5,000	$5,000
6	Additional Easement Acquisition	3	Acres	$20,650	$51,600
	Restoration				
7	Slope Stabilization Seed Mix	90	LB	$90	$8,100
8	20' Filter Strips	1,800	LF	$2	$3,600
	Construction Subtotal				**$340,100**

Notes: Subbasin 5 produces 6.7 Acre-Ft of water during a Q100 event.
Estimate is for a 3.3 acre pond, 2 ft deep.
This would contain all of the Q100 storm.
Pond would be located on a single property
Excavation cost includes removal of spoils

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Detention Pond 5 - Cost Estimate

Last Revised: May, 2018

Total Opinion of Probable Costs: **$842,200**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$5,000	$5,000
2	Temporary Silt Fence	1,900	LF	$1	$1,900
3	Tree Removal (4" and over)	0	EA	$900	$0
4	Common Excavation	29,000	CYS	$25	$725,000
5	Grading	1	LS	$5,000	$5,000
6	Additional Easement Acquisition	5	Acres	$20,650	$92,900
	Restoration				
7	Slope Stabilization Seed Mix	95	LB	$90	$8,600
8	20' Filter Strips	1,900	LF	$2	$3,800
	Construction Subtotal				**$842,200**

Notes: Subbasin 9 produces 17.5 Acre-Ft of water during a Q100 event.
Estimate is for a 4.5 acre pond, 4 ft deep.
This would contain all of the Q100 storm.
Pond would be located on a single property
Excavation cost includes removal of spoils

Hamilton County - Elwood Wilson Drain, Sam Craig and John Holleran Arms Hydraulic Study
Detention Pond 6 (Enlarge Existing Jail Complex Detention Pond) - Cost Estimate

Last Revised: May, 2018

Total Opinion of Probable Costs: **$859,100**

ITEM No.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
	Site Work				
1	Clearing and Grubbing	1	LS	$5,000	$5,000
2	Temporary Silt Fence	1,400	LF	$1	$1,400
3	Tree Removal (4" and over)	0	EA	$900	$0
4	Common Excavation	30,900	CYS	$25	$772,500
5	Grading	1	LS	$5,000	$5,000
6	Additional Easement Acquisition	3	Acres	$20,650	$66,100
	Restoration				
7	Slope Stabilization Seed Mix	70	LB	$90	$6,300
8	20' Filter Strips	1,400	LF	$2	$2,800
	Construction Subtotal				**$859,100**

Notes: Propose to double capacity of existing pond
Estimate is for a 3.2 acre pond, 4 ft deep.
Excavation calculated in solar evaluation
Excavation cost includes removal of spoils

ATTACHMENT 12:

Solar Field Evaluation

ClarkDietz
Engineering Quality of Life™

Memo

To: Kenton Ward
From: Brian Powers
Date: June 30, 2017
Subject: Craig Holleran Pond – Solar Field Evaluation

Per your request, Clark Dietz has looked at the potential location of a solar field just east of the existing Craig Holleran detention pond. This included evaluating the capacity of the existing pond, the capacity of the downstream culvert under SR 37, the need for additional detention, and any adverse effects on the hydrology of the watershed by developing this area.

This area is prone to flooding during a Q100 event. This is primarily due to the undersized culvert under SR 37. For comparison, the Craig Holleran Arm watershed is 0.94 square miles at SR 37. The E.M Hare Arm watershed is 0.99 square miles at SR 32. The two watersheds are nearly equal in size, they are both predominantly agricultural fields, and they have similar topography. The Q100 discharge for the EM Hare is about 580 cfs, the Q100 discharge for the Craig/Holleran is about 590 cfs. By comparison the two watersheds are very similar.

The EM Hare culvert under SR 32 is a 16 foot wide by 10 foot high structure. The Craig Holleran culvert under SR 37 is a 4 foot wide by 5 foot high box. This 4' x 5' box, which was originally designed as a cattle crossing and drainage culvert, is undersized for the flow of this watershed and causes water to back up and pond on the east side of SR 37 during large storm events.

For a Q10 storm, the detention pond east of SR 37, which was constructed for the jail complex, contains the stormwater that backs up. But during a Q100 event, the pond is not large enough to contain all the water that backs up and the pond overflows. Headwater is not at risk of reaching the SR 37 roadway. The Q100 headwater elevation is 3 feet lower than the edge of pavement. The headwater will back up in the upstream farmland and then flow overland south to the EM Hare watershed. This overflow point is located east of the existing detention pond where the solar field is proposed. See Attachment A for the full footprint of the Q100 floodplain.

Because this is a flood prone area we would caution against raising the grade east of the existing detention pond in a way that would fill in this overflow path to the south. The designers of the solar field would also need to consider the potential for ponding water in this area.

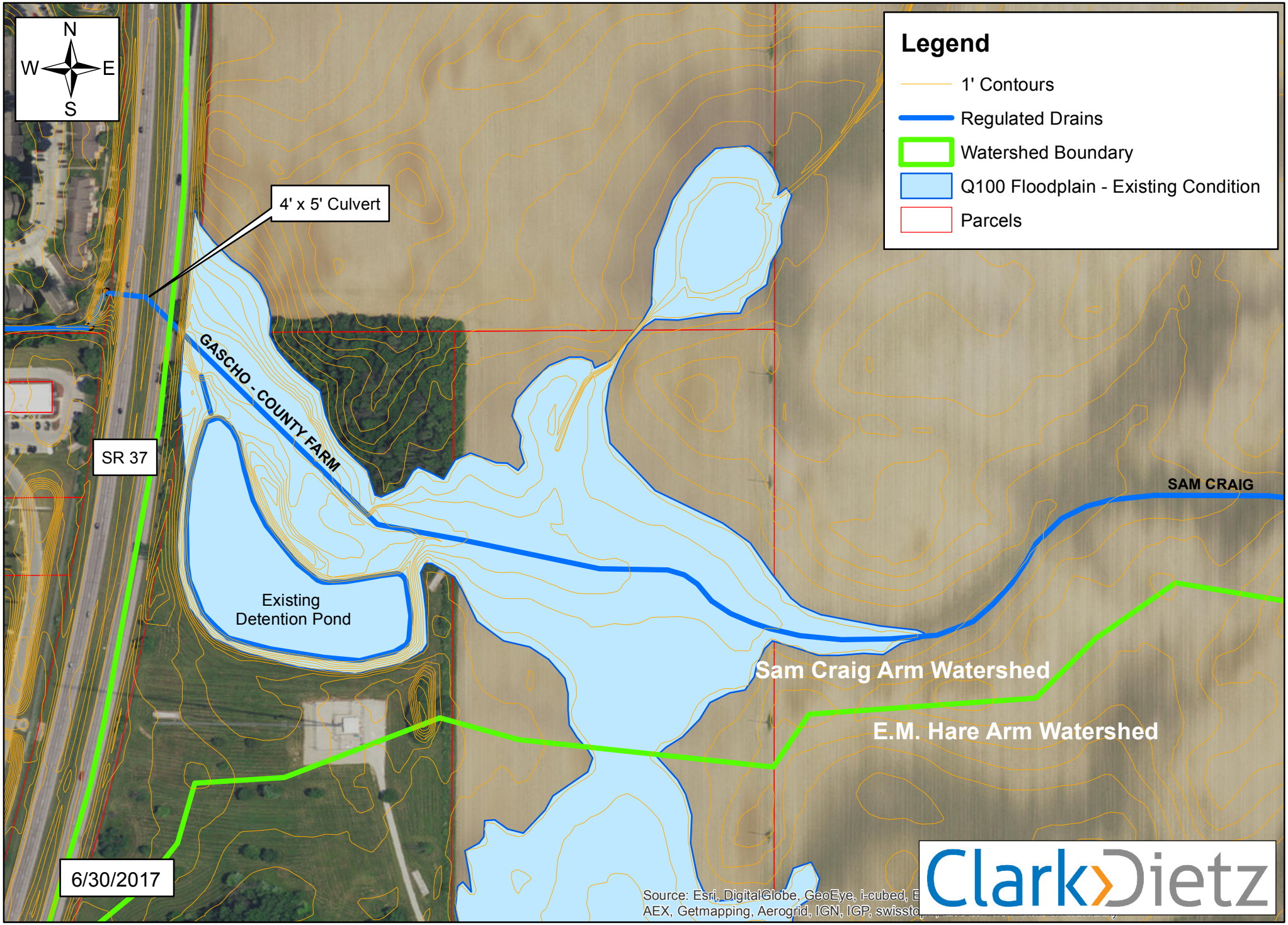
Adding detention will reduce the size of the existing floodplain. The best location to add detention would be directly east of the existing pond. The area east of the pond would require the least excavation and would not disturb existing wetland areas to the north of the pond. Constructing a detention area equal in size to the existing pond would require about 3.2 acres of land. A pond this size would lower the headwater elevation upstream of SR 37 by about 0.5 feet for a Q100 event. As a result, the Q100 storm would no longer overflow into the EM Hare watershed, but it would still overflow the detention ponds and flood adjacent land. The ideal location for the detention area is identified in Attachment B. The reduction in the size of the floodplain is shown in Attachment C.

An alternative solution would be to construct detention further upstream in the watershed and slow down how quickly the water reaches the structure at SR 37. The drawback would be less stormwater will pass through the detention area the further upstream in the watershed it is constructed.

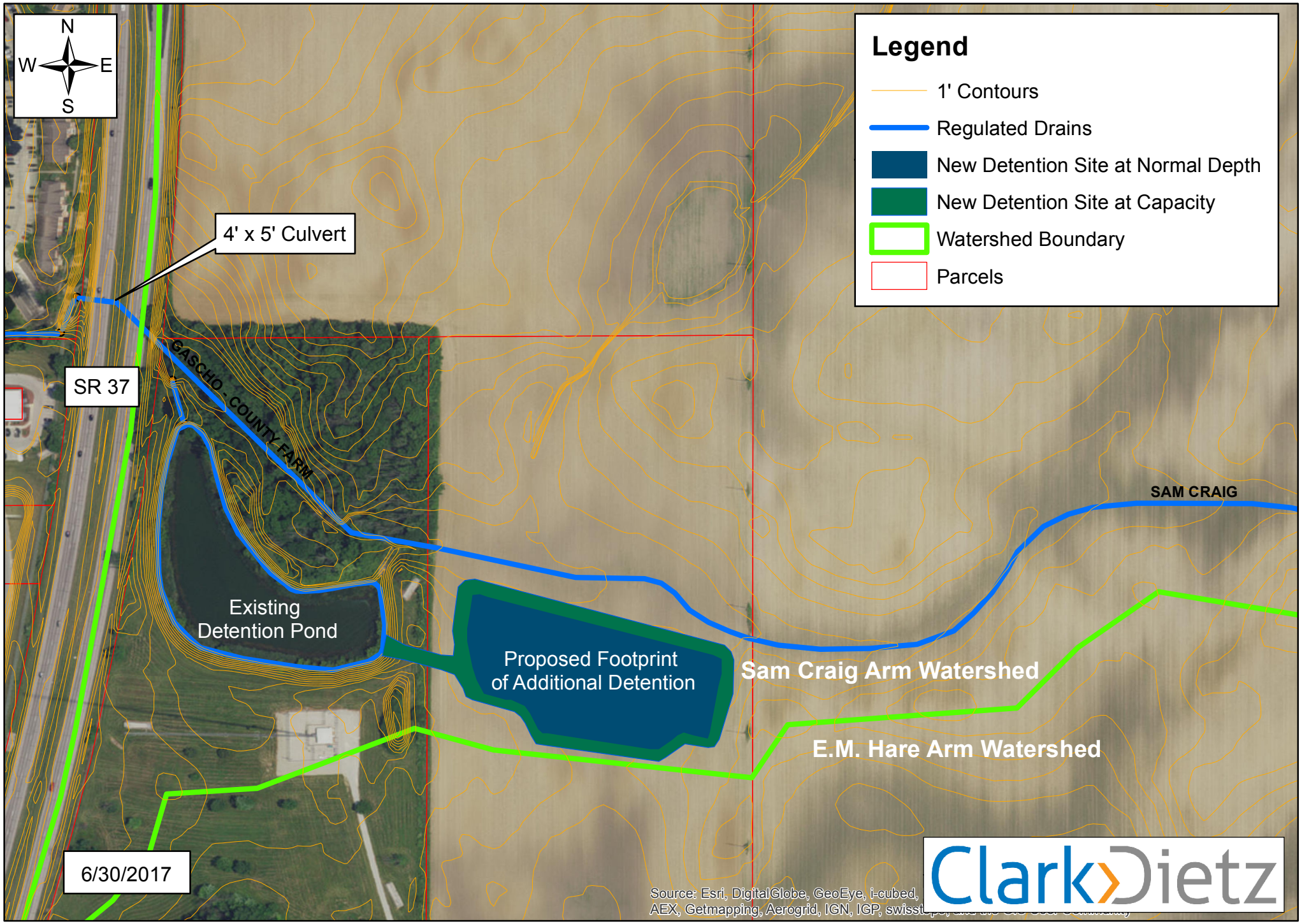
Flooding could also be reduced by enlarging the culvert under SR 37. This option would have adverse impacts downstream, as all the facilities downstream of SR 37 were designed based on this culvert. Upsizing the SR 37 structure would not be the recommended solution.

In conclusion, there are benefits to constructing additional detention east of the existing pond. The benefits would be realized immediately. Currently a Q100 event will result in 10 acre-feet of floodwater overflowing to the E.M. Hare watershed with a peak discharge rate of 116 cfs. The proposed pond would eliminate all overflow to the E.M. Hare watershed. Protecting the properties to the south, that would be inundated by the overflowing flood water, is the greatest benefit that would be realized by the additional detention. Minimal flow reduction will be provided to the downstream system to the west or SR 37. The peak flow rate would only be reduced from 193 cfs to 188 cfs. The floodplain footprint east of SR 37 would be reduced. In the future, as additional improvements are constructed further upstream in the watershed, the ponding area upstream of the SR 37 culvert would continue to be reduced. It should be noted that this area will still be prone to flooding even with additional detention. Ponding water in this area needs to be considered with any new development and the overflow to the south should not be filled in prior to the completion of flood improvements.

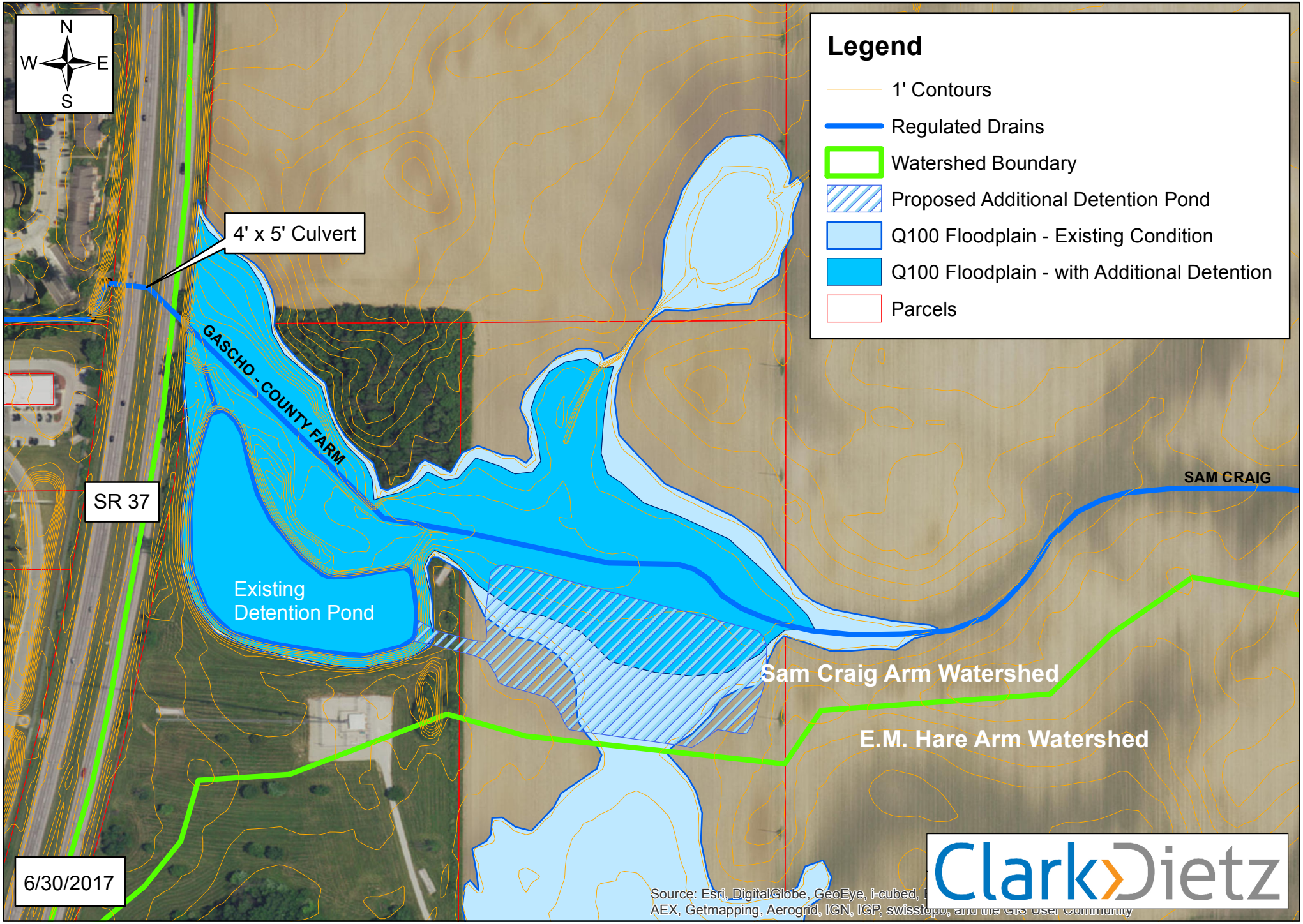
Attachment A
Existing Conditions 100-Year Floodplain



Attachment B
Proposed Additional Detention Pond Storage



Attachment C
100-Year Floodplain with and without Additional Detention Pond Storage



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