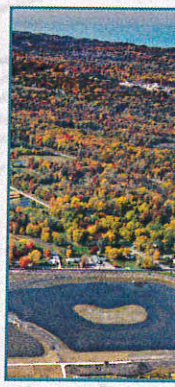


CHRISTOPHER B. BURKE ENGINEERING, LTD. - INDIANA

Stony Creek Watershed

Stormwater Master Plan

Prepared For:
Hamilton County Surveyor,
City of Noblesville

February 2005

Stony Creek Watershed

Stormwater Master Plan

Prepared for

Hamilton County Surveyor
One Hamilton County Square
Noblesville, Indiana 46060

City of Noblesville
16 South 10th Street
Noblesville, Indiana 46060

February 2005

Prepared by

Christopher B. Burke Engineering, Ltd.
115 West Washington Street, Suite 1368 South
Indianapolis, Indiana 46204

CBBEL Project No. 02-449

TABLE OF CONTENTS

Page

LIST OF TABLES iv

LIST OF EXHIBITS vi

LIST OF APPENDICES vi

1. INTRODUCTION 1
1.1 WATERSHED DESCRIPTION 1
1.2 PURPOSE AND SCOPE 2
1.3 ORGANIZATION OF THIS DOCUMENT 3

2. PAST/ONGOING CAPITAL IMPROVEMENT AND MAINTENANCE PROJECTS 5
2.1 CAPITAL IMPROVEMENT PROJECTS 5
2.2 MAINTENANCE PROJECTS AND RECONSTRUCTION PROJECTS 5

3. INVENTORY OF FLOODING CONCERNS AND POTENTIAL DAMAGES 7
3.1 PUBLIC INPUT 7
3.2 AGENCY INPUT 9
3.3 REVIEW OF PREVIOUS STUDIES 12
3.4 SUMMARY OF LOCATION AND SEVERITY OF CONCERN AREAS 12

4. HYDROLOGIC MODELING 14
4.1 REVIEW OF EXISTING MODELS 14
4.2 HEC-HMS COMPUTER MODEL 14
4.3 DESIGN STORM PARAMETERS 14
4.4 SUBBASIN PARAMETERS 15
4.4.1 Subbasin Drainage Area 15
4.4.2 Subbasin Curve Number 17
4.4.3 Subbasin Time of Concentration and Lag Time 17
4.5 SUBBASIN CHANNEL ROUTING 21
4.6 FLOOD STORAGE ROUTING 21
4.7 INITIAL MODELING RESULTS 21
4.8 MODEL CALIBRATION 21

5. HYDRAULIC MODELING 36
5.1 REVIEW OF EXISTING MODELS 36
5.2 HEC-RAS COMPUTER MODEL 36
5.3 HEC-RAS INPUT DATA FOR STONY CREEK 37
5.3.1 Topographic Base Map and Cross Section Location Data 37
5.3.2 Cross Section Geometric Data 37
5.3.3 Manning's Roughness Coefficients 37
5.3.4 Bridge Data 37
5.3.5 Flow Data 37
5.3.6 Starting Water Surface Elevations 37
5.4 DUPLICATE EFFECTIVE MODEL 38
5.5 CORRECTED EFFECTIVE MODEL 38
5.6 EXISTING-CONDITION MODEL 38

5.7 FINAL RESULTS OF STONY CREEK MODELING 39
5.8 HEC-RAS INPUT DATA FOR WHEELER-WHEELER AND WILLIAM LEHR DITCH 39
5.8.1 Topographic Base Map 39
5.8.2 Flow Data 39
5.8.3 Starting Water Surface Elevations 40
5.8.4 Manning's Roughness Coefficient 40
5.8.5 Calibration 41
5.8.6 Cross Section Geometry Data 41
5.8.7 Ineffective Flow and Bridge Obstructions 41
5.8.8 Bridges 41
5.8.9 Culverts 41
5.8.10 Critical Depths 41
5.8.11 Floodway 41
5.8.12 Check-RAS 42
5.9 FLOODPLAIN AND FLOODWAY 42

6. EVALUATION OF STORMWATER QUALITY AND NPDES PHASE 2 ISSUES 43
6.1 IDEM 305(b) REPORT 43
6.2 IDEM 303(d) LIST OF IMPAIRED STREAMS 44
6.3 DR. CLAUDE BAKER'S FINDINGS AND CONCLUSIONS 45
6.3.1 Stony Creek Water Quality Monitoring 45
6.3.2 Stony Creek Habitat Assessment 48
6.3.2.1 RBP Results 48
6.3.2.2 QHEI Results 49
6.3.3 Stony Creek Biomonitoring 49
6.3.4 Recommendations 49
6.3.5 Conclusions 51
6.4 USFW SURVEY OF FISH COMMUNITIES AND HABITAT QUALITY IN TRIBUTARIES TO THE UPPER RIVER 51
6.4.1 Study Design 52
6.4.2 Study Results 52
6.4.3 Conclusions 53
6.5 HEALTH DEPARTMENT STUDIES 53
6.5.1 On-Site Wastewater Treatment/Septic System 53
6.5.2 Lack of Septic System Understanding 54
6.5.3 Poor Soil Conditions 54
6.5.4 Small Lot Sizes 54
6.5.5 Illicit Connections and Discharges 54
6.5.6 Potential Solutions 55
6.6 NPDES PHASE 2 ISSUES 55

7. PLAN FORMULATION/EVALUATION CRITERIA 56
7.1 TECHNICAL CRITERIA 56
7.2 ENVIRONMENTAL CRITERIA 56
7.3 INSTITUTIONAL CRITERIA 56
7.4 ECONOMIC CRITERIA 57

8. INITIAL SCREENING OF POTENTIAL ALTERNATIVE SOLUTIONS 58

9. DETAILED EVALUATION OF PROMISING SOLUTIONS 65

9.1 Continue Strict Enforcement of Requirements for On-Site Detention 65

9.2 Adopt Unit discharge release Rates Based on Existing Conditions 71

9.3 Construct Regional Detention Ponds in Each Approximately 500-acre subwatershed . 73

9.4 Construct Major Flood Control Basins 75

9.5 Add Stony Creek and William Locke Ditch to Hamilton County Regulated Drain Rolls and Implement an Ongoing Maintenance Program 77

9.6 Continue Ongoing Maintenance of Regulated Drains in the Watershed 78

9.7 Implement the Recommended Water Quality BMPS to Address Phase 2 Requirements 79

9.8 Maintain the Current USGS Stream Gage on Stony Creek and Add Additional Gages at Key Locations in the Watershed 80

9.9 Revise the Hydraulic Modeling of Stony Creek Using Updated Hydrology and County Contour Mapping; Extend the Model Upstream to County the Line 81

9.10 Complete Hydraulic Analysis and Floodplain/Floodway Mapping of Unstudied Major Streams in the Stony Creek Watershed 81

9.11 Enlarge Existing Stream Crossings to Convey the Full 100-year Flow with no Road Overtopping 82

9.12 Allow no Development within the Limits of the Floodplain 83

10. FINAL SCREENING OF PROMISING SOLUTIONS 84

11. FUNDING CONSIDERATIONS 87

12. CONCLUSIONS AND THE PROPOSED IMPLEMENTATION PLAN 88

12.1 CONCLUSIONS 88

12.2 PROPOSED IMPLEMENTATION PLAN 89

13. REFERENCES 93

LIST OF TABLES

Table No. **Page No.**

1. Summary of Completed and Ongoing Ditch Maintenance, Reconstruction, and Capital Improvement Projects 6

2. Summary of Flooding Concerns from Residents 8

3. Summary of Flooding Concerns from City and County Officials 9

4. 24-Hour TP-40 Rainfall Depths for Various Return Periods 15

5. Watershed Area Summary at Select Locations 16

6. Calculated Subbasin Parameters Summary 18

7. Comparison of Initial HEC-HMS Results to Stream Gage Analyses 22

8. Calibrated Subbasin Parameters Summary for Existing Conditions (with Depressional Storage) Modeling 24

9. Comparison of Calibrated (Base Conditions without Depressional Storage) HEC-HMS Results to Stream Gage Analyses 27

10. Summary of Unit Discharge Rates for each Subbasin 28

11. Design Flow (Base Condition without Depressional Storage Modeling Subbasin Parameters Summary 31

12. Summary of Proposed Design (Base Condition without Depressional Storage) Flow Rates at Specific Locations 34

13. Peak Discharges Used in the Regulatory Stony Creek Hydraulic Model 38

14. Peak Discharges Used in the Wheeler-Wheeler Drain and William Lehr Ditch HEC-RAS Models of Existing Conditions 40

15. 2002 305(b) Results for the Stony Creek Watershed 43

16. 2002 303(d) Listed Streams within Hamilton County's MS4 Area for the Stony Creek Watershed 45

17. Stony Creek Monitoring Sites 46

18. Water Quality Results from 9 Stations on Stony Creek, Hamilton County, Indiana During High Dischargs, Base Flow and Fall Flow Sampling Periods 47

19. Stony Creek Watershed Study Recommendations 50

20. Initial Screening of Potential Alternatives 59

21. Short List of Possible Master Plan Components 63

22. Future-Condition Hydrologic Parameters 65

23. Comparison of Existing-Condition and Future-Condition 100-Year Flow Rates at Various Locations Assuming Current County Guidelines 69

24. Comparison of Existing-Condition and Future-Condition 100-Year Flow Rates at Various Locations Assuming Allowable Unit Discharge Release Rates 71

25. Comparison of Existing-Condition and Alternative 3 Conditions 73

26. Comparison of Existing-Condition and Alternative 4 Conditions 75

27. Comparison of the Short-Listed Alternatives 83

LIST OF EXHIBITS

Exhibit No.

1. Location Map
2. Regulated Drains
3. Watershed Delineation Map
4. Watershed Delineation Map with Depressional Area Delineations
5. Topographic Work Map for Wheeler-Wheeler Drain
6. Topographic Work Map for William Lehr Ditch
7. Stony Creek Watershed 305b Priority Watershed
8. Stony Creek Watershed 303d Impaired Waters
9. Stony Creek Bioassessment
10. Proposed Unit Discharge Release Rates
11. Candidate Plan Component 3, Location of Proposed Regional Ponds
12. Candidate Plan Component 4, Location of Proposed Flood Control Basins
13. Candidate Plan Component 5, Proposed Additional Regulated Drains
14. Candidate Plan Component 10, Proposed Streams to be Studied

LIST OF APPENDICES

1. Detailed Description of Flooding Concerns Expressed During the Public Meetings
2. Coordinated Discharge Curves for Stony Creek and Elwood Wilson Ditch
3. Support Calculations for Subbasin Watershed Parameters
4. Initial HEC-HMS Hydrologic Model Output
5. Stream Gage Analysis
6. Revised Curve Number Calculations
7. Calibrated Base-Conditions HEC-HMS Model Output

8. Base-Condition HEC-HMS Model Output

9. Duplicate Effective HEC-2 Model for Stony Creek

10. Corrected Effective HEC-RAS Model for Stony Creek

11. Existing-Condition HEC-RAS Model for Stony Creek

12. CD containing HEC-HMS and HEC-RAS Models

13. Determination of 500-year Flow Rates

14. Photographs of Wheeler-Wheeler Drain and William Lehr Ditch

15. Survey Data

16. HEC-RAS Models for Wheeler-Wheeler Drain and William Lehr Ditch

17. Future-Condition Curve Number Calculations

18. Future-Condition HEC-HMS Model Output

19. On-Site Detention Conditions HEC-HMS Model Output

20. Alternative 2 Conditions HEC-HMS Model Output

21. Regional Detention Ponds Alternative HEC-HMS Model Output

22. Flood Control Basins Alternative HEC-HMS Model Output

EXECUTIVE SUMMARY

Introduction and Focus of the Study

This report presents the results of the Christopher B. Burke Engineering, Ltd. (CBBEL) analysis of the Stony Creek watershed. The Stony Creek Watershed encompasses approximately 57 square miles at the confluence with the White River and includes areas in the City of Noblesville and unincorporated areas of Hamilton County as well as areas in Madison County. The watershed is shown on **Exhibit 1**. The plan was developed for long term use by the City and County for assistance with stormwater regulatory decisions, zoning decisions, and decisions relating to development in the watershed. Future development in the watershed should be reviewed with the Master Plan to ensure consistency and to properly evaluate potential impacts.

Summary of the Issues

Several meetings were held with residents of the watershed and with local agency officials to identify known stormwater (quantity and quality) concerns affecting the Stony Creek Watershed. Based on the results of the meetings, the extent of existing flooding problems in the watershed is limited to some streambank erosion and other local flooding problems. However, based on an assessment completed as part of this study (presented in Chapter 6), there are existing water quality problems, and also several concerns associated with potential future problems that may result from development if no mitigating steps are taken. There are also concerns about the adequacy of the existing County stormwater and drainage ordinance for this watershed.

Recommendations

Based on the results of the detailed analysis of the watershed and the issues described above, the following Master Plan components are recommended:

1. Adopt the allowable 100-year and 10-year unit discharge release rates calculated with this Master Plan for each subwatershed (shown on **Exhibit 10**). This would include updating County and City ordinances to include the appropriate unit discharge release rates.

2. Continue strict enforcement of drainage ordinance requirements for on-site detention with new development. Coordinate City and County ordinance requirements regarding on-site detention for new developments to ensure consistency in the watershed.

3. Implement the recommended water quality BMPs presented in Chapter 6. These include: continue pursuing a cooperative effort with regard to public education and outreach; continue analyses of water quality issues through 319 grant funding and other ongoing grant funding that may be available; develop programs and guidelines to fund the water quality BMPs; develop specific priorities based on the

need and required permits (if any); and continue monitoring water quality and compliance with requirements in the watershed.

4. Allow no development within the floodplain limits by strictly enforcing this existing requirement of the Hamilton County Surveyor's office.

5. Continue ongoing maintenance of regulated drains in the watershed.

6. Add the full reach of Stony Creek, and Locke Ditch downstream of 211th Street to the Hamilton County Surveyor Regulated Drain rolls for ongoing maintenance.

7. Construct regional detention ponds for upstream watersheds of about 500 acres in areas where a regional approach is desired either by the County/City, or by developers. It is recommended that the City of Noblesville and Hamilton County assist and encourage potential developers within the Stony Creek Watershed to design and construct multi-purpose regional ponds within sub-watersheds shown for reference on **Exhibit 11** through forming private-public partnerships.

   When construction of such large-scale projects is not feasible for particular developments, the developers should be required to construct sub-regional detention ponds to control all on-site and off-site runoff from areas upstream of the site. Sub-regional detention ponds would be for upstream watersheds of about 200 acres in size. In this case, the County and the City of Noblesville could assist these developers with arrangements that would make it possible for the developers to recoup part of their expenses from the upstream developers, who would no longer be required to provide on-site detention.

   When regional or sub-regional ponds are not feasible or practical, on-site detention ponds should be required. The noted regional ponds, sub-regional ponds, and on-site detention ponds should all be sized according to unit discharge release rates provided in Exhibit 10. When two or more sub-watersheds are affected, an area-weighted average unit discharge release rate should be calculated.

8. Maintain the current USGS stream gage and add additional gages at key locations in the watershed. It is recommended that additional gages be added at Atlantic Road crossing of Stony Creek and the 196th Street crossing of William Locke Ditch.

9. Revise hydrologic and hydraulic modeling of Stony Creek using updated hydrology and county contour mapping; extend the hydraulic model upstream to the county line.

10. Complete the hydraulic analysis and floodplain/floodway mapping of William Locke Ditch, Weaver and Hooke Ditch, Ethel Ogle Michaels Ditch, Harvey Gwinn Ditch, and James I. Teter Ditch.

Details regarding the analysis are presented in the following sections and appendices.

1.0 INTRODUCTION

Hamilton County Indiana has experienced tremendous growth over the recent past, and that growth is expected to continue. In an effort to render more effective opinions regarding environmental and flooding concerns due to urbanization, the Hamilton County Drainage Board and City of Noblesville retained Christopher B. Burke Engineering, Ltd., to develop the Stony Creek Watershed Master Plan. This master plan can effectively assist these government entities by identifying and analyzing stormwater management concerns as this watershed continues to develop, and provide alternatives to manage those concerns.

This Master Plan has been developed for long term use by the City and County for assistance with stormwater regulatory decisions, zoning decisions, and decisions relating to development in the watershed. It is the intent of this plan that the data and study, including the results of the detailed analyses, will help guide proper stormwater management as urbanized development occurs within the watershed. Any future changes to the modeling, due to better data, construction, or other City/County acknowledged activity should be incorporated into the base condition modeling and related analyses developed for this Master Plan to fully understand the impacts of those changes. All work proposed in the watershed should be reviewed with the Master Plan to ensure consistency and to properly evaluate the potential impacts.

The process of developing this Master Plan included:

- Identifying existing flooding problems,
- Analyzing the stormwater quality in the watershed,
- Evaluating the impacts of future development,
- Analyzing and evaluating alternatives for appropriate stormwater management issues,
- Evaluating the U.S. EPA NPDES Phase 2 stormwater regulation issues as related to the watershed, and
- Selecting recommended plans based on the comparison of the studied alternatives.

Exhibit 1 highlights the location of the Stony Creek watershed.

1.1 WATERSHED DESCRIPTION

The Stony Creek Watershed encompasses a relatively large drainage area, approximately 57 square miles at the confluence with the White River. It includes areas in the City of Noblesville and unincorporated areas of Hamilton County as well as areas in Madison County. Most of the watershed is located within Hamilton County and includes several sub-watersheds for the regulated drains tributary to the main stream. These include the William Lehr Ditch, the Wheeler-Wheeler Drain, the William Locke Ditch, the Elwood Wilson Ditch, and others. There are also several tributary streams that are not currently regulated drains. **Exhibit 2** shows the regulated drains in the

Stony Creek Watershed based on information obtained from the Hamilton County Surveyor's Office.

1.2 PURPOSE AND SCOPE

The purpose of this report is to present findings and observations, and provide recommended alternatives based on the results of detailed analyses. The scope of the study included identifying the stormwater management issues within the watershed, both existing and anticipated, that could arise with continued development. These issues include both flooding issues and stormwater quality issues.

To evaluate flooding issues, a comprehensive hydrologic model of the entire watershed was developed to analyze the impacts of current detention/retention policies as well as the impacts of assumed future development. The model was used to evaluate potential alternatives including local and regional detention/retention basins. This modeling was combined with hydraulic modeling to assess the potential impacts of new development within the urban, rural, agricultural, and other undeveloped areas of the watershed and evaluate alternatives for addressing areas of concern.

The water quality issues were identified by completing an evaluation of the stormwater quality in the watershed. In order to complete the evaluation, seven sites along Stony Creek and one each on William Lock Ditch and William Lehr Ditch were sampled to establish baseline data. Biological data, in the form of habitat evaluation and macroinvertebrate sampling, was collected. Additionally, physical observations concerning the dimensions, geometry, stability, siltation, and riparian zone were completed and chemical data was collected, once after a rainfall event and again during base flow conditions. Dr. Claude Baker and his assistants completed the data collection and analysis and prepared a detailed report titled Biomonitoring, Water Quality and Habitat Assessment for the Stony Creek Watershed, Hamilton County, Indiana, dated February 2004. This analysis will serve as a base line for evaluating the effect of water quality enhancement measures as they are implemented in the future. Related to the evaluation of water quality is the evaluation of the NPDES Phase 2 stormwater issues and how the work completed for this Master Plan fits in with the requirements of the State of Indiana Rule 13 requirements.

Specific activities included identifying alternatives for effective stormwater management, evaluating the alternatives for their technical effectiveness, economic feasibility, institutional/social acceptance, and environmental impacts, and recommending a plan of action based on these evaluations. The scope of the study is reconnaissance in nature, offering project features with a planning-level of detail. The estimated project costs are provided only for the purpose of comparing alternatives and providing a cost range. They are not detailed, design-level cost estimates that would be required for initiating the funding of specific projects.

The hydrologic modeling and revised hydraulic model of Stony Creek developed for this Master Plan were intended to assist in evaluating the performance of alternatives.

While these models may produce more realistic results than the existing regulatory models, they are not intended as a substitute for the effective regulatory model for Stony Creek.

This master plan also included the development of detailed modeling of the Wheeler-Wheeler Drain and William Lehr Ditch. These models were completed in accordance with IDNR modeling guidelines and include the delineation of the floodway, and the one percent chance floodplain limits along both streams. If desired, these analyses could be included in future separate reports and submitted to FEMA, through the IDNR, to get official Flood Insurance Rate Maps published.

1.3 ORGANIZATION OF THIS DOCUMENT

This report is divided into several chapters, sections, and appendices based on the topic being presented. A brief summary of the contents of each chapter is presented below:

- Chapter 1, **Introduction**, presents the purpose and scope of the project and a description of the project location.
- Chapter 2, **Past/Ongoing Capital Improvement and Maintenance Projects**, provides a summary of the capital improvement projects implemented by the Hamilton County Surveyor's Office in recent years and also ongoing Hamilton County Surveyor's Office maintenance projects within the watershed.
- Chapter 3, **Inventory of Flooding Concerns and Potential Damages**, summarizes the location and severity of flooding concerns based on information gathered from public input, local agency input, and review of previous studies.
- Chapter 4, **Hydrologic Modeling**, presents the methodology, assumptions, and the results of computer modeling that was used to evaluate the watershed and analyze the effectiveness of the alternatives.
- Chapter 5, **Hydraulic Modeling**, presents the methodology and the results of computer modeling that was used to evaluate the effectiveness of alternatives.
- Chapter 6, **Evaluation of Stormwater Quality and NPDES Phase 2 Issues**, presents the methodology and the results of the evaluation of stormwater quality in the watershed, the Phase 2 requirements that have been met through the completion of this Master Plan, and also the general nature and extent of efforts needed in this watershed towards meeting the requirements of the six minimum control measures.
- Chapter 7, **Plan Formulation/Evaluation Criteria**, summarizes the criteria by which the suggested alternative solutions were formulated and screened.

- Chapter 8, **Detailed Evaluation of Alternatives**, provides a description of each alternative, summarizes the results of the detailed evaluation of each, and recommends whether the alternative should be included as a component of the recommended watershed plan.

- Chapter 9, **Final Screening of Alternatives**, provides a tabulated summary of each alternative's advantages and disadvantages, and whether the alternative is recommended to be a part of the Master Plan.

- Chapter 10, **Funding Considerations**, provides a brief general discussion of funding mechanisms that may be pursued for funding of the recommended plan.

- Chapter 11, **Conclusions and the Recommended Implementation Plan**, provides a summary of conclusions of the study and a prioritized list of actions to be followed in order to implement the recommended plan components.

- Chapter 12, **References**, lists a summary of reference material used for developing the plan.

2.0 PAST/ONGOING CAPITAL IMPROVEMENT AND MAINTENANCE PROJECTS

The purpose of this chapter is to summarize the past and ongoing drainage work performed in the Stony Creek watershed. The information for this chapter was obtained from the Hamilton County Surveyor's Office and previous engineering reports.

2.1 CAPITAL IMPROVEMENT PROJECTS

Capital Improvement Projects involve construction of stormwater conveyance systems that improve the existing drainage conditions. Examples of Capital Improvement Projects include storm drain construction, detention pond construction, levees, lift stations, and major ditch excavation/reconstruction.

Based on information gathered by CBBEL, the Hamilton County Drainage Board and Surveyor's Office have maintained very accurate records of their proactive drainage improvement projects on the regulated drains within the watershed. **Table 1** summarizes the Capital Improvement Projects initiated by the Hamilton County Surveyor's Office over the past 20 years.

2.2 MAINTENANCE AND RECONSTRUCTION PROJECTS

Maintenance and reconstruction projects involve the restoration of stormwater conveyance systems to their designed condition. Preventive maintenance projects generally are performed on a regular recurring basis. Examples are ditch restoration, dredging, debris removal, and mowing. Unscheduled maintenance projects are required when portions of drainage facilities randomly fail. Examples of unscheduled maintenance projects are riprap placement, inlet repairs, and pipe failure repairs. The Hamilton County Surveyor's Office provides preventive and unscheduled maintenance as part of their ongoing regulated drain maintenance program. Maintenance and reconstruction work that has been performed on the regulated drains in the watershed is documented in Table 1.

Table 1
Summary of Completed and Ongoing Ditch Maintenance, Reconstruction, and Capital Improvement Projects

Project	Description	Date
William Lehr Ditch	Dredged from Marylyn Road to 156th Street with the construction of Cedar Path and Deer path developments. Work performed by developers.	2000-2001
Wheeler & Wheeler	Debris Removal and typical maintenance work as necessary.	Ongoing
Booth-Zeis Drain	Typical maintenance work as necessary. Also, in May 1996, the outlet was reconstructed as part of an INDOT project on State Road 38.	Ongoing
John McCarty Drain	Typical maintenance work as necessary. Also, in May 1996, the outlet was reconstructed as part of an INDOT project on State Road 38.	Ongoing
S.E Carpenter	Plans have been developed; surveyor is working with land owners to get reconstruction done.	Upcoming
A.J. Huffman	Reconstructed	1984
James I Teter	Typical maintenance work as necessary. Also, this drain was reconstructed in 1980.	Ongoing
N.H. Teter	Typical maintenance work as necessary. Also, this drain was reconstructed in 1981.	Ongoing
Charles Huffman	Portions of tile repaired. Typical maintenance work as necessary. Also, this drain was reconstructed in 1997.	Ongoing
Frank Huffman	Typical maintenance work as necessary.	Ongoing
William Locke	Portions of tile repaired. Typical maintenance work as necessary. Also, arm 1 of this drain was reconstructed in 1995.	Ongoing
Elwood Wilson	Portions of tile repaired and ditch cleaned. Typical maintenance work as necessary. Also, this drain was reconstructed through the Fishers-Oakwood subdivision to relieve flooding, in 1993.	Ongoing

3.0 INVENTORY OF FLOODING CONCERNS AND POTENTIAL DAMAGES

Extensive effort was expended to develop a detailed inventory of known stormwater (quantity and quality) concerns affecting the Stony Creek Watershed. The purpose of this chapter is to summarize the location and severity of present and potential future flooding, stormwater management, and water quality concerns based on information gathered from public input, local agency input, and review of previous studies.

3.1 PUBLIC INPUT

As part of the development of the Stony Creek Watershed Master Plan, two public forums were held with the local residents living in the watershed. The meetings were advertised in the Noblesville Ledger during the week of April 8, and signs announcing the meetings were placed at major Stony Creek bridge crossings. The first meeting was held on May 1, 2003 at the Wayne-Fall Lions Club on East 191st Street for residents in the upper watershed. The meeting hall has a reported capacity of 80, and the meeting was standing-room-only, although only 47 people signed in. The second meeting was held at the Noblesville City Hall on May 22, 2003 to accommodate residents in the more urban lower part of the watershed. 16 residents attended this meeting. These meetings specifically focused on identifying Hamilton County citizens' concerns regarding flooding, stormwater management, and water quality.

Table 2 provides a listing of concerns expressed by the residents at the public meetings. **Appendix 1** provides a more detailed description of each concern and includes copies of the meeting summaries from both public meetings.

Table 2
Summary of Flooding Concerns from Residents

Flooding Concerns	Reported # Of Concerns	Probable Cause of Concern
Abandoned Lapel quarry is filling up and more water will be entering Stony Creek from upstream of Atlantic Road.	1	This could cause additional flows if it overflows; however, the 100-year discharge and water surface elevation were determined assuming this area drains to Stony Creek.
Prairie Baptist Road, flooding at 191st and 196th Street on East side of the road.	1	There is a low area located between Stony Creek and 191st Street, which would account for the flooding.
Pasture behind 15175 East 196th Street floods after it rains.	1	There is a drainage swale that flows through the property to Stony Creek.
Citizen is concerned that fill at the Lowes site at 166th and Cumberland Road, and Highlands at Stony Creek on State Road 38 by Stony Creek Quarry are causing additional flooding on his property, located at 18351 Pennington Road along Locke Ditch. Also, IMI walled off "old" floodplain which IDNR investigated.	1	Citizen's belief that downstream filling in the floodplain areas is causing significant enough backwater to cause flooding on his property.
Flooding of Allisonville Rd at the railroad viaduct south of the Wellington entrance, and north of the Stony Creek crossing to the Andy Mohr car dealership.	2	Backwater from White River is the main cause of flooding in this area.
Stony Creek streambank erosion behind home at 130 Stony Creek Overlook in the Wellingtons.	1	Stony Creek is not a regulated drain and is not maintained.
Ground contamination after a flood when water is stagnant for days at 130 Stony Creek Overlook in the Wellingtons.	1	Based on the 2-foot contour mapping, there is a wide flat area on the opposite side of the creek.
General concerns about fill in the floodplain and the impact of future fill on flooding and stormwater quality.	2	This could increase flood elevations if no stormwater requirements are put into affect for the developments.
Flooding in area of the 186th Street crossing of Stony Creek/Locke Ditch.	1	Beaver dams
The William Lock ditch has been dredged from the county line to 211th St., and area farmers/residents would like to see it dredged to it's confluence with Stony Creek.	1	This reach of the regulated drain is not currently on maintenance.
The Locke Dredge is plugged with trees. Trees need to be removed and channel cleaned to improve flow in creek.	1	This reach of Locke Ditch is not a regulated drain and is not maintained.

3.2 AGENCY INPUT

In addition to the public meetings, meetings were held with staff from the Noblesville's Wastewater Utility Office, Noblesville's Department of Engineering, and with the Hamilton County Surveyor's Office. **Table 3** provides a summary of the concerns discussed during these meetings.

Table 3
Summary of Flooding Concerns from City and County Officials

Flooding Concerns	Agency	Probable Cause of Concern
Local Flooding in the area of 10th Street and Greenfield Avenue in Noblesville	City of Noblesville	There is a depressional area located here.
Local Flooding in the area of 8th Street and Carbon, at the Farm Bureau Co-op in Noblesville	City of Noblesville	This is an isolated flooding area.
Local Flooding in the area of 13th Street and Logan in Noblesville	City of Noblesville	There is an isolated low area at this location.
The Corporate Park area is developing commercial, but no detailed review of stormwater detention requirements and the impact on the watershed has been completed.	City of Noblesville	There is no master plan for the Stony Creek watershed.
There may be a need for new ditches in areas of the watershed that do not currently drain properly, and do not have an adequate outlet for stormwater runoff.	City of Noblesville	There are several low areas that do not drain to the regulated drains.
There is no comprehensive plan dealing with water quality issues in the watershed, and no studies done showing how constructed wetlands can/should be incorporated into stormwater detention scenarios.	City of Noblesville	IDEM Rule 13 requirements for stormwater quality issues must be met.
Data from gaging stations will be needed in the future. Keep the current gage operational and possibly add more gages to verify the effectiveness of work in the watershed	Hamilton County Surveyor's Office	There is only one stream gage in the watershed.
Stony Creek is not on maintenance so no funds are available for HCSO to do work on the stream as needs arise.	Hamilton County Surveyor's Office	Stony Creek is not a regulated drain.
Locke Drain downstream of 211th Street is a regulated drain, but is not on a maintenance program. This section needs to be dredged.	Hamilton County Surveyor's Office	The stream is full of sediment but there are no funds because it is not on maintenance.
Stony Creek between SR 32 and SR 38 needs to be dredged, but is not on maintenance. It should be added to the Locke Drain to collect maintenance fees and do required maintenance.	Hamilton County Surveyor's Office	Stony Creek is not a regulated drain.

Flooding Concerns	Agency	Probable Cause of Concern
Wheeler-Wheeler Drain overflowed at Cumberland Road during the Labor Day 2003 floods; capacity may not be sufficient.	Hamilton County Surveyor's Office	This area is located within the 100-year floodplain.
Flow conveyance is blocked at Greenfield Avenue bridge and streambanks are eroding.	Hamilton County Surveyor's Office	Large sandbar is blocking flow, directing flow against the streambank.
Hamilton County is growing very quickly, including areas of the Stony Creek watershed. Concern that the existing ordinances may not be sufficient to account for Stormwater issues in the watershed.	Hamilton County Surveyor's Office	There is no overall master plan for the watershed.
There is no current, comprehensive master plan the city and county can use for the Stony Creek watershed. There is not an adequate way to properly evaluate proposed development based on the actual conditions in the watershed, including capacity of existing stormwater conveyances, adequate outlets, downstream impacts, etc.	Hamilton County Surveyor's Office	There is no overall master plan for the watershed.
There is no detailed study of the Wheeler Drain showing existing floodplain/floodway limits.	Hamilton County Surveyor's Office	There is no study showing the limits of the 100-year flood, so that the Special Flood Hazard Areas (SFHAs) could be determined.
There is no detailed hydrologic analysis along Wheeler Drain, nor an analysis of the existing ditch capacity, which could be used to establish specific allowable release rates for developments in the watershed.	Hamilton County Surveyor's Office	No detailed study has been done on the ditch.
There is no detailed study of the William Lehr Ditch showing existing floodplain/floodway limits.	Hamilton County Surveyor's Office	There is no study showing the limits of the 100-year flood, so that the SFHAs could be determined.
There is no detailed analysis of the William Lehr tributary tile along the western side of the watershed, which is currently developing rapidly. An allowable yield has not been calculated for this subwatershed that the county can use to regulate Stormwater discharges associated with proposed development.	Hamilton County Surveyor's Office	No detailed study has been done on the ditch.
The existing floodplain/floodway analysis of Stony Creek is old and was done using outdated methods; it does not reflect the current detailed county mapping, or recent improvements along the stream.	Hamilton County Surveyor's Office	Flood mapping is not based on current data.

Flooding Concerns	Agency	Probable Cause of Concern
The Stony Creek peak flow rates used in the FIS have not been checked based on the years of stream flow data that has been collected at the USGS gage since publication of the Flood Insurance Study (FIS). The FIS may be over- or underestimating the 100-year peak flow rates, and the associated flood elevations.	Hamilton County Surveyor's Office	Flood mapping is not based on current data.
There is no detailed hydrologic model of the Stony Creek watershed, and therefore, no way to evaluate the impacts of proposed development and associated drainage projects.	Hamilton County Surveyor's Office	The watershed has not been studied, and there is a desire to analyze alternatives for the watershed.
There are known water quality concerns along Stony Creek but a detailed evaluation of the stormwater quality within the watershed has not been completed.	Hamilton County Surveyor's Office	There must be a plan to meet the requirements of the IDEM Rule 13.
There is no data that can be used to provide guidance with regard to stormwater regulatory decisions, zoning, and development to ensure stormwater quantity and quality problems are not created or exacerbated.	Hamilton County Surveyor's Office	There is no hydrologic model available to determine the impacts of development.
It is suspected that several road crossings of streams in the watershed do not meet current county criteria of no overtopping during 100-year and more frequent storm events.	Hamilton County Surveyor's Office	There are no floodplain/floodway models for most of the streams in the watershed to show which crossings are undersized.
There has been no evaluation done in this watershed with regard to meeting the requirements of the IDEM Rule 13 on stormwater quality.	Hamilton County Surveyor's Office	A stormwater quality evaluation is required for the IDEM Rule 13.
Stony Creek is not a regulated drain downstream of State Road 38, meaning the county surveyor has no funds or rights to do maintenance work in the stream to maintain flow conveyance capacity.	Hamilton County Surveyor's Office	Stony Creek is not a regulated drain.
There are locations along Stony Creek with log jams, streambank erosion, and other issues that should be corrected to prevent future more serious problems.	Hamilton County Surveyor's Office	Stony Creek is not a regulated drain.
Specific areas causing stormwater quality problems have not been identified.	Hamilton County Surveyor's Office	The watershed must meet the requirements of the IDEM Rule 13.

Flooding Concerns	Agency	Probable Cause of Concern
Growth is happening in the watershed. Other streams in the county have experienced problems with increased flooding frequency and volume, erosion problems, encroachment on the floodplain and floodway, water quality problems, etc. We don't want the same thing to happen on Stony Creek, because there is not a master plan laying out the requirements to guide the inevitable future development	Hamilton County Surveyor's Office	There is not master plan for the watershed.

3.3 REVIEW OF PREVIOUS STUDIES

CBBEL coordinated with staff from the City of Noblesville and from Hamilton County to collect available studies in the Stony Creek Watershed. One study was found – Elwood Wilson Drainage Basin Study by DLZ Indiana, LLC, dated December 12, 2002. There were no specific existing flooding concerns mentioned in the report, and the report stated that there was "little in terms of flood potential coming from the basin." The Hamilton County Surveyor's Office also provided relevant design information regarding development projects in the watershed. The project team also collected copies of applicable Flood Insurance Studies (FIS) and coordinated with the IDNR regarding any studies they have done in the watershed. The IDNR provided copies of discharge determinations they have done previously along Stony Creek and other streams in the watershed. They also provided a digital copy of the regulatory Stony Creek hydraulic model, and a copy of the flood frequency analysis they had completed for the Stony Creek stream gage.

3.4 SUMMARY OF LOCATION AND SEVERITY OF CONCERN AREAS

Based on the results of the public meetings and meetings with local officials, the extent of existing flooding problems in the Stony Creek Watershed is relatively small. Some residents identified some streambank erosion as well as some local flooding problems. But overall, the watershed has relatively minimal flooding problems. However, based on an assessment completed as part of this study, and presented in Chapter 6, there are existing water quality problems and several concerns associated with potential future problems that may result from development if no steps are taken to prevent the future problems.

Hamilton County is growing rapidly and several residents said that they recognized the potential impacts of flooding and further reduced stormwater quality that can be caused by continued, improperly regulated development within the watershed. Although Hamilton County has adopted and enforces a stormwater drainage ordinance that limits release rates from developments, there remains a concern about the adequacy of the ordinance for this watershed, and a need for an overall stormwater master plan that

considers all the critical issues and provides guidance for local regulatory agencies to ensure future drainage and stormwater quality needs are met.

This master plan will focus on alternatives to minimize existing flooding and stormwater quality concerns, as well as addressing potential stormwater problems that could accompany future development. Addressing future concerns requires that measures such as regional stormwater detention/retention and conveyance facilities be evaluated to determine their applicability and level of effectiveness. This evaluation will consider the impact of adequate and strict enforcement of uniform stormwater and flood hazard area ordinances by all watershed jurisdictions on stormwater quality and anticipated future flow rates and volumes as the County continues to develop.

4.0 HYDROLOGIC MODELING

In order to properly evaluate potential solutions to the problems and issues discussed in the previous chapter, it is necessary to have a comprehensive hydrologic model for the basins. This chapter describes CBBEL's efforts in obtaining available basin model data and the development of the new models required for this study.

4.1 REVIEW OF EXISTING MODELS

With regard to the Master Plan's hydrologic modeling needs, one of the first tasks was to collect and evaluate any available existing modeling. Unfortunately, there were no large-scale hydrologic models readily available for this watershed. There is a published "Coordinated Discharge Curve" for Stony Creek and one for Elwood Wilson Ditch which provides regulatory discharge rate versus drainage areas values. These curves match the FIS flow rates used in the hydraulic analysis developed to map the floodplain and floodway of the streams and are included in **Appendix 2**.

4.2 HEC-HMS COMPUTER MODEL

The hydrologic analysis was completed using the USACE HEC-HMS computer model. HEC-HMS is a single storm event model that estimates runoff from hydrologic parameters input by the user. This program includes a graphical user interface, which allows the user to enter and view results and to display a schematic representation of a network of hydrologic elements. Typical HEC-HMS input parameters included rainfall duration-depth patterns, rainfall-runoff response parameters for each subbasin, and routing parameters for the subbasin hydrographs (discharges as a function of time) at specified junctions. Junctions may represent the confluence of a subbasin with another subbasin, detention storage, a channel reach, or a diversion location. The model will produce hydrographs that show incremental and peak flows and runoff volumes at specified locations.

4.3 DESIGN STORM PARAMETERS

HEC-HMS requires the user to input observed or synthesized rainfall depth-distribution relationships to produce a runoff response for a given storm. This study uses synthetic storm data.

24-hour rainfall depths for the site were based on Technical Paper 40 (TP-40) and were used in conjunction with the National Resources Conservation Service (NRCS) Type II rainfall distribution. Runoff hydrographs were calculated for the 10, 50, and 100-year design events. **Table 4** shows the design rainfall depths used in this analysis. By definition, the NRCS Type II rainfall distribution used with the 24-hour duration storm

precipitation results in the highest peak discharge and volume for each subwatershed without a need for determining a "critical" storm duration.

Table 4
24-Hour TP-40 Rainfall Depths for Various Return Periods

Return Period (Years)	10	50	100
Design Rainfall Depth (Inches)	4.20	5.3	5.72

4.4 SUBBASIN PARAMETERS

The NRCS dimensionless unit hydrograph method was selected as the basis of the rainfall-runoff generation for individual sub-areas. This method requires the following major inputs for a given subbasin: basin area, NRCS curve number (CN), and NRCS lag time. Other input parameters include the initial loss, percent impervious, and baseflow (if applicable). The development of major parameters is explained below.

4.4.1 Subbasin Drainage Area

The topographic features of an area define the path of surface runoff through that area and ultimately define the tributary drainage area for a watershed. The drainage area delineation for the outer boundary and 86 subbasins of the Stony Creek watershed was completed using the 2-foot contour mapping for Hamilton County, Indiana, dated 1998. The total drainage area of the Stony Creek watershed at the mouth (confluence with the White River) as measured for this analysis is 57.5 mi^2. This is within 1.0% of the 57.2 mi^2 shown in the USGS document Drainage Areas of Indiana Streams dated 1975, and is considered appropriate for the analysis required for this Master Plan. The subbasin drainage areas range in size from less than 0.5 mi^2 to 2.35 mi^2. The subbasin delineations are required to calculate tributary areas and develop the hydrologic analysis of the watershed at the points of interest. **Exhibit 3** Shows the overall watershed and the delineated sub-basins. A larger scale version of this map is also provided in **Appendix 3**.

It should be noted that the William Lehr Ditch watershed divide along 136th Street, just west of Marilyn Road is in a valley area adjacent to Sand Creek. Based on the existing ground elevations and the hydraulic modeling of Sand Creek, there is the potential for interbasin transfer of flow from Sand Creek to the William Lehr watershed. However, as shown on the hydrologic work map in Appendix 3, this area is an isolated low area. Flow entering the watershed from Sand Creek would spread out across the low area. Additionally, the timing of peak flow along Sand Creek would be later than the runoff from this part of the watershed. Based on these factors, the impact on peak flow rates in William Lehr Ditch would be minimal.

The total drainage area at select locations along Stony Creek and the major tributary streams is presented in **Table 5**.

Table 5
Watershed Area Summary at Select Locations

Location Description	Upstream Drainage Area (Square Miles)
Stony Creek at CR 650West (Madison County)	6.5
Stony Creek at 191st Street	18.8
Stony Creek at 186th Street	35.4
Stony Creek at State Highway 32	40.3
Stony Creek at Chapel Road	50.2
Stony Creek at confluence with West Fork White River	57.5
Elwood Wilson Ditch d/s of 19th Street	3.59
Elwood Wilson Ditch at confluence with unnamed tributary at Pleasant Street	4.46
Elwood Wilson Ditch at confluence with Stony Creek	4.76
William Locke Ditch at Prairie Baptist Road	6.3
William Locke Ditch at confluence with Stony Creek	~~33.0~~ 11.2
William Lehr Ditch d/s of SR 238	1.7
William Lehr Ditch at 156th Street	2.8
William Lehr Ditch at 166th Street	4.4
William Lehr Ditch at confluence with Stony Creek	6.36
Wheeler-Wheeler Drain upstream of Arbor Grove Boulevard	0.97
Wheeler-Wheeler Drain at confluence with Stony Creek	1.47

4.4.2 Subbasin Curve Number

The NRCS Curve Number (CN) is a precipitation loss calculation method for determining the amount of precipitation loss due to soil infiltration. Combined with an estimate of the Initial Abstraction (initial moisture storage capacity of soil and its cover), the CN will determine how much of the total rainfall depth of a given storm will end up as direct runoff. The major factors that determine CN are the hydrologic soil group, cover type or land use, treatment, hydrologic condition, and antecedent moisture condition.

Soil distribution information was derived from the soil maps for the watershed prepared by the NRCS in 1978. Soil groups identified from the NRCS soil maps were classified into four groups according to the tabular information presented in the Highway Extension and Research Project for Indiana Counties and Cities (HERPICC) manual. These categories are identified as A, B, C and D in order of decreasing permeability. Some groups of soils exhibit different permeability characteristics, depending on whether or not there is a subsurface conveyance system in place to drain infiltrated water. These soils are given a multiple group classification, such as A/D or B/D. The Stony Creek watershed contains type B, C, and D soils.

Aerial photographs of the Stony Creek Watershed indicate predominately residential, commercial, row crops, and woods. Smaller portions of the watershed consist of open spaces, wetlands, pastures, open water, and industrial land use. Details regarding the curve number calculations are contained **Appendix 3**.

4.4.3 Subbasin Time of Concentration and Lag Time

Time of concentration (Tc) is defined as the time required for the entire subbasin to contribute runoff at the subbasin outfall. The initial Tc calculations were performed by utilizing the TR-55 methodology. The NRCS TR-55 methodology considers the ground cover and slopes found in the individual subbasins to calculate travel times for various reaches of a subbasin. Consistent with CBBEL past experience with the analyses of numerous gaged streams in Indiana, these calculated values were divided by a factor 0.6 (an initial default correction factor generally applicable to areas north of U.S. 40 in Indiana) to account for Indiana-specific conditions, i.e., an extremely flat terrain and numerous depressions or obstacles to flow. Details regarding the Tc calculations for the subbasins in the watershed are also provided in Appendix 3.

An initial estimate of the NRCS Lag Time parameter was calculated by multiplying the initial calculated value of Tc by 0.6, as recommended by the computer program procedures. A summary of the calculated subbasin hydrologic parameters for the watershed is provided in **Table 6**.

Table 6
Calculated Subbasin Parameters Summary

BASIN ID	DA (MI)	DA (acres)	Lag Time (hours)	CN
Stony Creek				
SC1	0.601	385	3.2	78
SC2	0.302	195	1.7	75
SC3	0.249	159	1.6	81
SC4	0.889	569	2.5	78
SC5	0.561	359	3.1	80
SC6	0.834	534	2.1	78
SC7	0.570	365	2.8	81
SC8	0.352	225	1.4	80
SC9	0.242	155	1.6	81
SC10	0.431	276	1.7	78
SC11	0.834	534	2.2	78
SC12	0.405	259	3.2	82
SC13	0.250	160	2.1	82
SC14	0.488	312	3.6	81
SC15	0.905	579	3.8	81
SC16	0.456	292	2.4	79
SC17	0.107	68	1.3	79
SC18	0.373	239	1.3	79
SC19	1.123	719	2.3	78
SC20	0.741	474	2.3	77
SC21	0.645	413	2.4	79
SC22	0.225	144	1.2	77
SC23	0.871	557	2.1	75
SC24	0.328	210	1.6	79
SC25	0.504	323	1.2	78
SC26	0.458	293	1.7	78
SC27	0.538	344	1.3	78
SC28	0.520	333	2.6	81
SC29	0.535	342	2.1	76

BASIN ID	DA (MI)	DA (acres)	Lag Time (hours)	CN
Stony Creek – Madison Co.				
MaCo1	0.803	514	3.3	81
MaCo2	1.877	1201	5.2	81
MaCo3	2.351	1505	5.0	81
MaCo4	1.458	933	3.7	78
MaCo5	1.485	950	2.2	79
MaCo5A	0.460	294	2.0	80
MaCo6	1.479	947	7.0	81
MaCo7	1.990	1274	7.2	81
MaCo8	0.286	183	1.7	80
MaCo9	1.615	1034	4.7	80
MaCo10	0.905	579	3.3	80
MaCo11	0.911	583	3.4	84
MaCo12	1.529	979	4.6	80
MaCo13	0.501	321	2.5	80
Wheeler-Wheeler Drain				
WhWh1	0.758	485	3.2	80
WhWh2	0.215	138	1.6	80
WhWh3	0.496	317	2.3	76
William Lehr Ditch				
WmLe1	0.878	562	1.8	80
WmLe2	0.829	531	2.5	79
WmLe3	0.136	87	1.1	77
WmLe4	0.991	634	2.5	81
WmLe5	0.365	234	2.3	77
WmLe6	0.793	508	2.0	78
WmLe7	0.362	232	0.77	76
WmLe8	0.133	85	1.6	78
WmLe9	0.708	453	2.4	81
WmLe10	0.917	587	3.9	80

BASIN ID	DA (MI)	DA (acres)	Lag Time (hours)	CN
WmLe11	0.250	160	1.2	79
William Locke Ditch				
WmLo1	0.930	595	4.2	81
WmLo2	0.795	509	2.7	79
WmLo3	0.787	504	2.5	78
WmLo4	0.343	220	1.9	80
WmLo5	0.225	144	0.95	73
WmLo6	0.830	531	3.7	80
WmLo7	0.455	291	2.9	75
WmLo8	0.787	504	4.3	80
WmLo9	0.452	289	4.0	80
WmLo10	0.326	209	2.0	78
WmLo11	0.329	211	1.3	77
WmLo12	0.116	74	0.95	78
WmLo13	0.470	301	4.2	77
WmLo14	1.754	1123	6.4	80
WmLo15	0.840	538	1.9	78
WmLo16	0.768	492	3.1	82
WmLo17	0.500	320	2.0	82
WmLo18	0.715	458	2.4	78
WmLo19	0.473	303	1.4	79
Elwood-Wilson Drain				
ELW1	0.298	191	3.9	79
ELW2	0.242	155	2.3	74
ELW3	1.039	665	3.6	81
ELW4	0.495	317	3.5	79
ELW5	1.076	689	3.4	80
ELW6	0.438	280	2.2	84
ELW8	0.227	145	1.5	80
ELW9	0.650	416	2.6	75
ELW10	0.291	186	1.6	75

4.5 SUBBASIN CHANNEL ROUTING

In order to account for the existing channel storage and to properly lag the hydrographs between subbasins, the Muskingum-Cunge method, which incorporates both hydrograph translation and attenuation of peak flows, was initially selected to route hydrographs through appropriate channel reaches. The Muskingum-Cunge method requires an eight-point cross section to simulate the attenuation and storage within a given reach. Representative channel cross-section data was obtained from the county contour mapping. Other parameters, such as the reach length, Manning's roughness coefficient values, and slope, were determined from aerial photos and the county contour mapping. As will be discussed later, reach routing method was subsequently switched to Simple Lag method as part of the calibration efforts.

4.6 FLOOD STORAGE ROUTING

Flood Storage available along the channel is taken into account through the channel routing procedures described in the previous section. However, the effects of flood storage areas such as permanent depressional storage, detention basins, etc. can be simulated using reservoir routing procedures. Typical input data for such analyses include stage, storage, and discharge relationships.

For the Stony Creek watershed, no significant reservoirs exist in the watershed. Therefore, this option was not used in the analysis of existing conditions. However, the storage routing option will be used in the analysis of stormwater detention options.

4.7 INITIAL MODELING RESULTS

Utilizing the initial estimates of various needed hydrologic parameters described in Sub-sections 4.3 through 4.6, a comprehensive HEC-HMS model was developed for the watershed and executed. The preliminary results indicated significantly higher peak flow rates for the main stem of Stony Creek than the current regulatory values along this stream. A copy of input/output of this initial HEC-HMS modeling is included in **Appendix 4**.

4.8 MODEL CALIBRATION

The coordinated discharge values and the associated FIS discharge for Stony Creek were developed in the 1970's. The coordinated discharge values and the associated FIS discharge for Elwood Wilson Ditch were developed in the 1992. The available information tend to indicate that these coordinated discharge values were based, in part, on the results of gage frequency analysis performed at that time for the USGS stream gage on Stony Creek, which is located at the State Road 37 crossing in Noblesville, Indiana. The gage now has 35 years of recorded data. Based on

discussions with the USGS, the gage data at Stony Creek is reliable. Therefore, the Stony Creek gage will be used to calibrate the HEC-HMS hydrologic model for the existing conditions of the watershed.

Annual peak instantaneous discharge series for the period of record for the gage was obtained from the IDNR files. HEC-FFA, a frequency flood analysis program, was used to estimate the peak 100-year instantaneous discharge at the gage. In addition, the 1-, 3-, and 7-day average discharge series for the period of record was obtained from the USGS and was used to determine the volume associated with the 100-year frequency peak discharge. The results show a considerably smaller estimate of the peak 100-year discharge expected at the gage. A copy of the gage analysis is included in **Appendix 5**. The results from the initial HEC-HMS model run was compared to the Stony Creek gage data for both the peak discharge and the volume. **Table 7** shows a comparison of the 100-year discharge and volume calculated using HEC-HMS model with the results of the stream gage analysis.

Table 7
Comparison of Initial HEC-HMS Results to Stream Gage Analyses

Location Description	Drainage Area (sq. mi.)	HEC-HMS Model 100-YR Q (cfs)	Stream Gage 100-YR Q (CFS)	% Diff.	HEC-HMS Model Volume (ac-ft)	Stream Gage Volume (ac-ft)	% Diff.
Stony Creek at State Road 37	51.7	9,288	2,310	302	9,526	7,260	31

As shown on the table, the HEC-HMS model calculates a significantly higher 100-year peak discharge and more volume than the stream gage analysis shows.

There were two purposes for the hydrologic modeling. The first purpose was to determine unit discharge rates (discharge per developed acre) for each of the subbasins. The second purpose was to determine design flow rates at various points within the watershed for floodplain analysis and as a basis for design of infrastructure along stream/open drain corridors.

The first purpose requires that the pre-developed 2-year, 10-year, and 100-year discharges are estimated in a way that would ensure the preservation of runoff-reducing impacts of depressional areas within the watershed, as development occurs. The noted depressional areas will be discussed later in this chapter. A more realistic hydrologic model that would acknowledge these depressional areas and result in flow rates more closely matching the flow rates from the USGS gage frequency analysis would be desirable for this purpose. Therefore, to achieve the first purpose, the initial model was calibrated to approximately match the stream gage 100-year discharge estimate shown in Table 7 as discussed below.

For the NRCS dimensionless unit hydrograph method, normally two subbasin parameters are adjusted to calibrate a hydrologic model: the NRCS Curve Number and/or the time of concentration (or its multiple, Lag Time). The Curve Number determines the amount of excess runoff. Assuming the Initial Abstraction is kept unchanged, an increase or decrease in the Curve Number would result in a higher or lower total runoff volume, respectively. The changes in the Curve Number would also normally result in changes in the peak discharge estimate, however, not in a significant amount. The Lag Time plays an important role in determining the shape of the runoff hydrograph and the magnitude of the peak discharge. The NRCS dimensionless unit hydrograph method calculates the peak discharge based on the Rainfall Duration, Drainage Area, Lag Time, and a constant, 484.0, known as the "peaking factor".

Rainfall duration is related to the design storm. Typically, the drainage area can be reliably calculated. Several studies have shown that to match the observed hydrographs, the "peaking factor" may have to be lowered for basins with storage due to flat watershed slope, swamps, floodplains, and/or man-made detention facilities. However, regulatory agencies normally do not accept changing the program's default value of 484.0, mainly because no widely acceptable procedures have been established for determining the "peaking factor". This leaves the Curve Number and the Lag Time as the parameter that can be changed to achieve the volume calibration and the peak discharge calibration, respectively.

For this analysis, the first step was to calibrate the volume of the discharge hydrograph calculated by the initial HEC-HMS model to the USGS gage 1-day and 3-day frequency analyses results. After studying the topography for the watershed, it was determined that there were several depressional areas within the watershed. The areas tributary to the depressional areas are delineated on **Exhibit 4**. These low areas tend to trap a significant portion of storm precipitation prior to the initiation of runoff. To simulate this impact, the Curve Number for the areas tributary to depressional areas was reduced to 30, essentially eliminating runoff from these areas. The composite Curve Numbers for the affected sub-basins were then recalculated incorporating this change for the depressional areas. Copies of the revised curve number calculations are included in **Appendix 6**. The resulting adjusted curve numbers are listed in **Table 8**.

Next, the initial lag time values for each subbasin were increased by trial-and-error attempting to match the 100-year flow rates based on the stream gage analyses. This necessitated multiplying the initial estimates of Lag Times by a factor of 3.5. Based on CBBEL experience with the hydrologic modeling of other major watersheds in Hamilton County, this lag time correction factor appears rather large (Mud Creek Watershed lag time correction factor was 1.75). However, noting the extent of low lying/depressional areas in the watershed (as shown in Exhibit 4) and the fact that these limited outlet areas act as natural ponding areas that would considerably add to the normal travel times, the use of such high correction factor was considered by CBBEL to be justified for the purpose of defining the existing conditions of the watershed. The resulting calibrated lag times are listed in Table 8. It should be noted that the "calibrated lag time" values shown in Table 8 should <u>not</u> be viewed as a realistic measure of time it

takes for water to travel from the furthest point of the subbasins. These artificially elevated values are transitional numbers that would, in lieu of utilization of much more complex modeling techniques, result in discharge values reasonably close to the peak flow values calculated based on the stream gage analyses. Since this model will be used to determine the allowable release rates for each subbasin based on the Stony Creek gage analysis, CBBEL determined that these values are reasonable for this special purpose. Revised detailed modeling would be recommended in developing design plans for any proposed alternatives that would affect flow rates. In addition to the lag times, the channel routing method was changed from Muskingum-Cunge method to using the Simple Lag method and multiplied by 3.5 to achieve the calibration of the peak discharge value.

Table 8
Calibrated Subbasin Parameters Summary for Existing Conditions (with Depressional Storage) Modeling

BASIN ID	DA (MI)	DA (acres)	Lag Time[1] (hours)	CN[1]
Stony Creek				
SC1	0.601	385	11	78
SC2	0.302	195	6.1	75
SC3	0.249	159	5.5	81
SC4	0.889	569	8.8	69
SC5	0.561	359	11	78
SC6	0.834	534	7.2	73
SC7	0.570	365	9.7	76
SC8	0.352	225	4.7	65
SC9	0.242	155	5.5	49
SC10	0.431	276	6.0	78
SC11	0.834	534	7.6	67
SC12	0.405	259	11	76
SC13	0.250	160	7.4	82
SC14	0.488	312	13	44
SC15	0.905	579	13	70
SC16	0.456	292	8.3	51
SC17	0.107	68	4.7	79
SC18	0.373	239	4.4	79
SC19	1.123	719	8.1	67
SC20	0.741	474	8.1	62
SC21	0.645	413	8.5	76
SC22	0.225	144	4.1	73
SC23	0.871	557	7.4	47
SC24	0.328	210	5.5	64
SC25	0.504	323	4.2	78
SC26	0.458	293	6.1	30
SC27	0.538	344	4.5	78

BASIN ID	DA (MI)	DA (acres)	Lag Time[1] (hours)	CN[1]
SC28	0.520	333	9	64
SC29	0.535	342	7.3	74
Stony Creek – Madison Co.				
MaCo1	0.803	514	12	81
MaCo2	1.877	1201	18	59
MaCo3	2.351	1505	18	79
MaCo4	1.458	933	13	78
MaCo5	1.485	950	8.4	76
MaCo5A	0.460	294	7.1	80
MaCo6	1.479	947	25	64
MaCo7	1.990	1274	25	50
MaCo8	0.286	183	6	80
MaCo9	1.615	1034	16	80
MaCo10	0.905	579	12	80
MaCo11	0.911	583	12	78
MaCo12	1.529	979	16	78
MaCo13	0.501	321	8.8	80
Wheeler-Wheeler Drain				
WhWh1	0.758	485	11	53
WhWh2	0.215	138	5.6	53
WhWh3	0.496	317	8.1	72
William Lehr Ditch				
WmLe1	0.878	562	6.4	42
WmLe2	0.829	531	8.6	61
WmLe3	0.136	87	3.9	59
WmLe4	0.991	634	8.8	60
WmLe5	0.365	234	7.9	47
WmLe6	0.793	508	7.1	66
WmLe7	0.362	232	2.7	72
WmLe8	0.133	85	5.7	64
WmLe9	0.708	453	8.5	81
WmLe10	0.917	587	14	80
WmLe11	0.250	160	4.3	79
William Locke Ditch				
WmLo1	0.930	595	15	81
WmLo2	0.795	509	9.4	77
WmLo3	0.787	504	8.8	61
WmLo4	0.343	220	6.5	79
WmLo5	0.225	144	3.3	66

BASIN ID	DA (MI)	DA (acres)	Lag Time[1] (hours)	CN[1]
WmLo6	0.830	531	13	79
WmLo7	0.455	291	10	64
WmLo8	0.787	504	15	72
WmLo9	0.452	289	14	74
WmLo10	0.326	209	6.9	60
WmLo11	0.329	211	4.4	77
WmLo12	0.116	74	3.3	78
WmLo13	0.470	301	15	75
WmLo14	1.754	1123	22	54
WmLo15	0.840	538	6.8	68
WmLo16	0.768	492	11	82
WmLo17	0.500	320	6.9	78
WmLo18	0.715	458	8.3	62
WmLo19	0.473	303	4.9	62
Elwood-Wilson Drain				
ELW1	0.298	191	14	30
ELW2	0.242	155	8.1	32
ELW3	1.039	665	13	43
ELW4	0.495	317	12	79
ELW5	1.076	689	12	66
ELW6	0.438	280	7.7	51
ELW8	0.227	145	5.3	80
ELW9	0.650	416	9.1	40
ELW10	0.291	186	5.6	75

[1] These values are only transitional numbers used to bring, in lieu of utilizing more complex modeling techniques, the calculated discharges close to the peak flow estimates based on stream gage analyses. These values are not recommended for purposes other than usage prescribed in this Master Plan report.

The HEC-HMS model was revised to include the calibrated curve numbers and lag times. Copies of output from this calibrated Existing-Condition (with depressional storage) HEC-HMS model are provided in **Appendix 7.** **Table 9** shows a comparison of the 100-year discharge and volume calculated using the HEC-HMS model with the results of the stream gage analysis.

Table 9
Comparison of Calibrated (Existing Conditions with Depressional Storage) HEC-HMS Results to Stream Gage Analyses

Location Description	Drainage Area (sq. mi.)	Calibrated 100-YR Q (cfs)	Stream Gage 100-YR Q (CFS)	% Diff.	Calibrated Volume (ac-ft)	Stream Gage Volume (ac-ft)	% Diff.
USGS Gage (Stony Creek at State Road 37)	51.7	2,772	2,310	20	7,065	7,260	3

As shown in Table 9, the calculated 100-year discharge is within 20% of the discharge based on the gage analysis, and the calculated volume is within 3% of the gage analysis. The calculated 100-year discharge is still higher than the gage analysis. However, the calculated 100-year discharge is less than 2,890 cfs, which is the 5% Confidence Limit calculated in the gage analysis. It was decided that it was more reasonable to match the 5% Confidence Limits discharge than to apply a higher factor to the lag times.

Nearly 7 inches of rainfall fell over most of central Indiana during the 2003 Labor Day weekend. The recorded 24-hour rainfall depths for the rainfall gaging stations in or near the watershed ranged from 5.64 inches in Fishers, Indiana to 8.36 inches in Lapel, Indiana. Based on the gage height recorded at the Stony Creek gage, the peak discharge at the gage was preliminarily estimated by USGS to be about 2,300 cfs. While this rainfall episode may not have necessarily covered the entire watershed area, and certainly not at the same time as the model assumes, the comparison of the model-generated results and the observed flood stages/discharges at the gage may be important to validate the model and ensure that the model does not underestimate the base-condition watershed response to extreme precipitation events.

This comparison showed that the model still overestimates the amount of peak discharge and volume at the gage. However, due to the size of the watershed and the standard modeling assumptions regarding the uniformity of precipitation coverage over the watershed as well as the assumption that the storm front was stationary, such an overestimation was considered to be justified.

Based on the results of the calibrated HEC-HMS modeling of existing conditions with depressional storage in the watershed, unit discharge rates were calculated for each of the subbasins for 2, 10, and 100-year discharges, as shown in **Table 10**.

Table 10
Summary of Unit Discharge Rates for each Subbasin Based on Existing Conditions (with Depressional Storage) Modeling

Subbasin ID	Drainage Area (acres)	2-Year Discharge (cfs)	2-Year Unit Discharge Rate (cfs/acre)	10-Year Discharge (cfs)	10-Yr Unit Discharge Rate (cfs/acre)	100-Year Discharge (cfs)	100-Yr Unit Discharge Rate (cfs/acre)
Stony Creek							
SC1	385	23.7	0.06	46.4	0.12	76.2	0.20
SC2	193	15.4	0.08	32.5	0.17	55.5	0.28
SC3	159	19.7	0.12	37.4	0.23	59.9	0.38
SC4	569	23.3	0.04	54.4	0.10	99.0	0.17
SC5	359	22.1	0.06	43.3	0.12	71.1	0.20
SC6	534	33.2	0.06	72.1	0.14	125.8	0.24
SC7	365	22.0	0.06	44.7	0.12	75.1	0.21
SC8	225	10.1	0.04	27.4	0.12	53.8	0.24
SC9	155	0.7	0.005	54.5	0.35	12.9	0.08
SC10	276	26.8	0.10	53.6	0.19	88.5	0.32
SC11	534	20.7	0.04	51.3	0.10	96.2	0.18
SC12	259	14.2	0.05	28.8	0.11	48.2	0.19
SC13	160	16.6	0.10	30.9	0.19	48.9	0.31
SC14	312	0.2	0.001	3.0	0.01	9.8	0.03
SC15	579	19.2	0.03	43.3	0.07	77.1	0.13
SC16	292	1.7	0.01	8.4	0.03	21.5	0.07
SC17	68	8.5	0.12	16.8	0.24	27.4	0.40
SC18	239	31.2	0.13	61.5	0.26	100.7	0.42
SC19	719	26.8	0.04	65.9	0.09	123.3	0.17
SC20	474	11.5	0.02	32.6	0.07	65.6	0.14
SC21	413	27.4	0.07	56.1	0.14	94.3	0.23
SC22	144	13.4	0.09	29.9	0.21	52.6	0.37
SC23	557	1.5	0.002	11.0	0.02	32.8	0.06
SC24	210	7.8	0.04	21.4	0.10	42.6	0.20
SC25	323	41.1	0.13	82.7	0.26	136.8	0.42
SC26	293	0	0	0	0	1.2	0.00
SC27	344	41.7	0.12	83.7	0.24	138.4	0.40
SC28	333	9.1	0.03	23.9	0.07	46.5	0.14
SC29	342	22.5	0.07	47.9	0.14	82.6	0.24
Stony Creek – Madison Co.							
MC1	514	34.8	0.07	65.1	0.13	103.6	0.20
MC2	1201	12.5	0.01	37.7	0.03	77.8	0.06
MC3	1505	65.8	0.04	125.9	0.08	203.5	0.14
MC4	933	50.4	0.05	98.6	0.11	161.4	0.17
MC5	950	63.7	0.07	130.	0.14	219.3	0.23

Subbasin ID	Drainage Area (acres)	2-Year Discharge (cfs)	2-Year Unit Discharge Rate (cfs/acre)	10-Year Discharge (cfs)	10-Yr Unit Discharge Rate (cfs/acre)	100-Year Discharge (cfs)	100-Yr Unit Discharge Rate (cfs/acre)
MC5A	294	28.3	0.10	54.4	0.18	87.8	0.30
MC6	947	11.7	0.01	30.0	0.03	57.1	0.06
MC7	1247	2.8	0.002	14.6	0.01	37.3	0.03
MC8	183	20.0	0.11	38.6	0.21	62.4	0.34
MC9	1034	52.6	0.05	99.4	0.10	159.3	0.15
MC10	579	37.2	0.06	70.6	0.12	113.4	0.20
MC11	583	33.6	0.06	65.7	0.11	107.7	0.18
MC12	979	44.7	0.05	87.1	0.09	142.3	0.15
MC13	321	26.1	0.08	50.0	0.16	80.6	0.25
Wheeler-Wheeler Drain							
WH1	485	3.5	0.01	14.1	0.03	33.5	0.07
WH2A	113	1.1	0.01	5.3	0.05	13.3	0.12
WH2B	25	0.4	0.02	2.3	0.1	6.2	0.25
WH3	317	17.0	0.05	37.4	0.12	65.8	0.21
William Lehr Ditch							
WLe1	562	0.1	0.0001	5.5	0.01	22.2	0.04
WLe2	531	11.3	0.02	32.8	0.06	67.0	0.13
WLe3	87	2.3	0.03	8.0	0.09	17.8	0.20
WLe4	634	12.1	0.02	36.2	0.06	75.1	0.12
WLe5	234	0.6	0.003	4.5	0.02	13.2	0.06
WLe6	508	19.0	0.04	48.5	0.10	92.5	0.18
WLe7	232	27.2	0.12	62.8	0.27	112.6	0.49
WLe8	85	3.1	0.04	8.5	0.10	16.8	0.20
WLe9	453	40.1	0.09	75.5	0.17	120.5	0.27
WLe10	587	33.3	0.06	63.1	0.11	101.3	0.17
WLe11	160	21.3	0.13	42.0	0.26	68.7	0.43
William Locke Ditch							
WLo1	595	33.7	0.06	62.7	0.11	99.7	0.17
WLo2	509	33.3	0.07	66.7	0.13	110.8	0.22
WLo3	504	10.6	0.02	30.6	0.06	62.5	0.12
WLo4	220	21.3	0.10	41.7	0.19	68.1	0.31
WLo5	144	8.9	0.06	24.1	0.17	47.0	0.33
WLo6	531	30.3	0.06	58.4	0.11	94.6	0.18
WLo7	291	7.4	0.03	19.4	0.07	37.6	0.13
WLo8	504	17.1	0.03	36.8	0.07	63.9	0.13
WLo9	289	11.7	0.04	24.4	0.08	41.6	0.14
WLo10	209	4.6	0.02	14.0	0.07	29.5	0.14
WLo11	211	24.3	0.12	49.8	0.24	83.4	0.40
WLo12	74	11.4	0.15	22.9	0.31	38.0	0.51

Subbasin ID	Drainage Area (acres)	2-Year Discharge (cfs)	2-Year Unit Discharge Rate (cfs/acre)	10-Year Discharge (cfs)	10-Yr Unit Discharge Rate (cfs/acre)	100-Year Discharge (cfs)	100-Yr Unit Discharge Rate (cfs/acre)
WLo13	301	12.2	0.04	25.0	0.08	42.1	0.14
WLo14	1123	5.4	0.005	20.6	0.02	47.2	0.04
WLo15	538	24.3	0.05	59.1	0.11	109.9	0.20
WLo16	492	37.5	0.08	69.3	0.14	109.3	0.22
WLo17	320	28.0	0.09	55.7	0.17	91.9	0.29
WLo18	458	11.0	0.02	30.9	0.07	62.2	0.14
WLo19	303	9.9	0.03	29.5	0.10	60.9	0.20
Elwood-Wilson Drain							
EW1	191	0	0	0	0	0.7	0.00
EW2	155	0	0	0	0	1.0	0.01
EW3	665	0.2	0.0003	5.4	0.01	19.1	0.03
EW4	317	19.3	0.06	37.1	0.12	60.3	0.19
EW5	689	18.2	0.03	44.8	0.07	83.9	0.12
EW6	280	1.7	0.01	8.4	0.03	21.7	0.08
EW8	145	17.5	0.12	33.7	0.23	54.6	0.38
EW9	416	0	0	2.4	0.01	10.8	0.03
EW10	186	15.8	0.08	33.5	0.18	57.2	0.31

The second purpose of the HEC-HMS modeling was to verify current regulatory discharges along Stony Creek and Elwood Wilson Drain, where such regulatory flow rates have been established by the IDNR as Coordinated Discharge Curves, and to determine the design flow rates appropriate for floodplain analysis and as a basis for design of infrastructure along other major stream/open drain corridors within the watershed. Because these flow rates are to be the regulatory flow rates used to determine the 100-year water surface elevations, no depressional storage volume should be considered when calculating the peak flow rates. This is based on the IDNR requirements that only flood control projects can be considered when calculating the peak flow rates. These design discharges do not have to be calibrated to the gage analysis as they should represent a conservative estimate of near future-condition of the watershed by assuming that the low areas currently draining to the depressional areas would eventually be lost as these lands experience new development. Therefore, for the purpose of determining design discharges, the curve numbers that were revised based on depressional areas, as previously discussed, were changed back to the original curve numbers shown in Table 7 and the correction factor for lag times were reduced from 3.5 to 1.75, a regional value resulting from a previous extensive hydrologic investigation of the neighboring Mud Creek Watershed that was closely scrutinized, reviewed, and approved by both IDNR and FEMA.

Table 11 provides a summary of parameters used for the HEC-HMS model developed to calculate a conservative estimate of design flow rates to be used for future floodplain

analyses or for use in designing various infrastructure projects along major streams within the watershed. A copy of the Base-Condition HEC-HMS output is included in **Appendix 8**. The proposed design flow rates at specific locations throughout the watershed as calculated by the Stony Creek Watershed Base-Condition HEC-HMS model are summarized in **Table 12.**

Table 11
Design Flow (Base Condition without Depressional Storage)
Modeling Subbasin Parameters Summary

BASIN ID	DA (MI)	DA (acres)	Lag Time (hours)	CN
Stony Creek				
SC1	0.601	385	5.6	78
SC2	0.302	195	3.0	75
SC3	0.249	159	2.8	81
SC4	0.889	569	4.4	78
SC5	0.561	359	5.4	80
SC6	0.834	534	3.6	78
SC7	0.570	365	4.8	81
SC8	0.352	225	2.4	80
SC9	0.242	155	2.8	81
SC10	0.431	276	3.0	78
SC11	0.834	534	3.8	78
SC12	0.405	259	5.5	82
SC13	0.250	160	3.7	82
SC14	0.488	312	6.3	81
SC15	0.905	579	6.6	81
SC16	0.456	292	4.2	79
SC17	0.107	68	2.3	79
SC18	0.373	239	2.2	79
SC19	1.123	719	4.0	78
SC20	0.741	474	4.0	77
SC21	0.645	413	4.2	79
SC22	0.225	144	2.1	77
SC23	0.871	557	3.7	75
SC24	0.328	210	2.8	79
SC25	0.504	323	2.1	78
SC26	0.458	293	3.0	78
SC27	0.538	344	2.3	78
SC28	0.520	333	4.5	81
SC29	0.535	342	3.6	76

BASIN ID	DA (MI)	DA (acres)	Lag Time (hours)	CN
Stony Creek – Madison Co.				
MaCo1	0.803	514	5.8	81
MaCo2	1.877	1201	9.1	81
MaCo3	2.351	1505	8.8	81
MaCo4	1.458	933	6.5	78
MaCo5	1.485	950	3.8	79
MaCo5A	0.460	294	3.6	80
MaCo6	1.479	947	12.0	81
MaCo7	1.990	1274	13.0	81
MaCo8	0.286	183	3.0	80
MaCo9	1.615	1034	8.2	80
MaCo10	0.905	579	5.8	80
MaCo11	0.911	583	6.0	84
MaCo12	1.529	979	8.1	80
MaCo13	0.501	321	4.4	80
Wheeler-Wheeler Drain				
WhWh1	0.758	485	5.6	80
WhWh2	0.215	138	2.8	80
WhWh3	0.496	317	4.0	76
William Lehr Ditch				
WmLe1	0.878	562	3.2	80
WmLe2	0.829	531	4.3	79
WmLe3	0.136	87	1.9	77
WmLe4	0.991	634	4.4	81
WmLe5	0.365	234	4.0	77
WmLe6	0.793	508	3.6	78
WmLe7	0.362	232	1.4	76
WmLe8	0.133	85	2.8	78
WmLe9	0.708	453	4.3	81
WmLe10	0.917	587	6.8	80
WmLe11	0.250	160	2.2	79
William Locke Ditch				
WmLo1	0.930	595	7.4	81
WmLo2	0.795	509	4.7	79
WmLo3	0.787	504	4.4	78
WmLo4	0.343	220	3.2	80
WmLo5	0.225	144	1.7	73
WmLo6	0.830	531	6.5	80
WmLo7	0.455	291	5.0	75

BASIN ID	DA (MI)	DA (acres)	Lag Time (hours)	CN
WmLo8	0.787	504	7.6	80
WmLo9	0.452	289	7.0	80
WmLo10	0.326	209	3.5	78
WmLo11	0.329	211	2.2	77
WmLo12	0.116	74	1.7	78
WmLo13	0.470	301	7.4	77
WmLo14	1.754	1123	11.0	80
WmLo15	0.840	538	3.4	78
WmLo16	0.768	492	5.4	82
WmLo17	0.500	320	3.5	82
WmLo18	0.715	458	4.2	78
WmLo19	0.473	303	2.5	79
Elwood-Wilson Drain				
ELW1	0.298	191	3.4	79
ELW2	0.242	155	4.0	74
ELW3	1.039	665	6.3	81
ELW4	0.495	317	6.0	79
ELW5	1.076	689	3.9	80
ELW6	0.438	280	6.1	84
ELW8	0.227	145	2.6	80
ELW9	0.650	416	4.5	75
ELW10	0.291	186	2.8	75

Table 12
Summary of Proposed Design (Base Condition without Depressional Storage) Flow Rates at Specific Locations

Location	Drainage Area (sq. mi.)	Peak Discharges for Various Design Storm Recurrence Intervals (cfs)		
		10-year	50-year	100-year
Stony Creek				
Stony Creek CR 650West (Madison Co.)	6.5	665	950	1,065
Stony Creek at 191st Street	18.8	1,420	2,030	2,270
Stony Creek at 186th Street	35.4	2,275	3,230	3,605
Stony Creek at State Highway 32	40.3	2,480	3,515	3,920
Stony Creek at Chapel Road	50.2	2,860	4,140	4,645
Stony Creek at SR 37 (USGS Gage)	51.7	2,885	4,175	4,685
Stony Creek at confluence with West Fork White River	57.5	3,000	4,340	4,865
Elwood Wilson Ditch				
Elwood Wilson Ditch d/s of 19th Street	3.59	485	700	785
Elwood Wilson Ditch at confluence with Unnamed Tributary at Pleasant Street	4.47	600	870	975
Elwood Wilson Ditch at confluence with Stony Creek	4.76	625	910	1,025
William Locke Ditch				
William Locke Ditch at Prairie Baptist Road	6.3	705	1,030	1,155
William Locke Ditch at confluence with Stony Creek	11.4	1,170	1,710	1,925
William Lehr Ditch				
William Lehr Ditch d/s of SR 238	1.7	330	475	530
William Lehr Ditch at 156th Street	3.2	575	830	935
William Lehr Ditch at 166th Street	4.4	730	1,065	1,195
William Lehr Ditch at confluence with Stony Creek	6.36	990	1,435	1,615
Wheeler-Wheeler Drain				
Wheeler-Wheeler Drain u/s of Arbor Grove Boulevard	0.97	130	185	210
Wheeler-Wheeler Drain at confluence with Stony Creek	1.47	200	290	330

A comparison of these Base-Condition discharge estimates with that previously estimated by the IDNR indicates that the two estimates are generally similar for William Locke, William Lehr, and Wheeler-Wheeler Drain. However, the Base-Condition estimates are significantly higher than the IDNR coordinated values for Stony Creek and significantly lower than the IDNR coordinated values for Elwood Wilson Drain. Both the

IDNR and CBBEL estimates are significantly higher than the value resulting from the frequency analysis of the USGS gage data on Stony Creek.

Despite all the discrepancies between peak discharge estimates by various sources, the peak discharge estimates resulting from the Base-Condition HEC-HMS model of Stony Creek Watershed are believed to be reliable, conservative, and appropriate for the purposes of this master plan and for use in detailed floodplain studies of William Lehr Ditch and Wheeler-Wheeler Drain included in this report.

Since the calculated Stony Creek flow rates in Table 12 are so much higher than the current regulatory (FEMA and IDNR) flow rates, and the regulatory flow rates are significantly higher than the gage analysis flow rates, it is recommended that the current Stony Creek regulatory flow rates be used for future floodplain analyses that may be completed for Stony Creek. Additionally, it is recommended that the current regulatory flow rates for Elwood Wilson Ditch, which are higher than those shown in Table 12, be maintained for future floodplain analysis along that stream.

5.0 HYDRAULIC MODELING

This chapter describes CBBEL's efforts in obtaining available models and the enhancements that were made to update the Stony Creek model to evaluate the accuracy of the currently effective regulatory model. This chapter also presents the process and results of the detailed hydraulic analysis that was completed for Wheeler-Wheeler Drain and William Lehr Ditch to define the regulatory floodplain and floodway limits for both streams.

5.1 REVIEW OF EXISTING MODELING

A portion of Stony Creek and Elwood Wilson Drain have been studied and there are Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) published for the studied reach of each stream. The effective hydraulic modeling for each stream was obtained from the IDNR. These are copies of the models used to calculate the regulatory flood elevations shown in the current Flood Insurance Study (FIS). Each model was developed using the HEC-2 computer program. These models are known as the Duplicate Effective Models. For this study, the data from the Duplicate Effective Model for Stony Creek was imported into the HEC-RAS computer program. A detailed review of the modeling showed the need for a few revisions. The revisions included moving the location of some bridge sections, adjusting the ineffective flow limits based on the revised reach lengths, and a few other items discussed in the following sections. These changes were made to develop model of existing conditions to serve as a base-condition model for comparing the impacts of proposed alternatives. The Base-condition modeling was used as a basis to develop Proposed-Condition modeling for each of the alternatives.

Copies of the input data and output from the Duplicate Effective Models are provided in **Appendix 9**.

5.2 HEC-RAS COMPUTER MODEL

HEC-RAS (River Analysis System) is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. The Steady Flow Water Surface Profiles component of the modeling system is used for calculating water surface profiles for steady, gradually varied flow. HEC-RAS can handle a full network of channels, a multi-branch system, or a single river reach. The steady flow component is capable of modeling subcritical, supercritical, and mixed flow regime water surface profiles. The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy losses calculated based on friction (Manning's equation) and contraction/expansion (coefficient multiplied by the change in velocity head) of flow. The momentum equation is utilized in situations where the water surface profile is rapidly varied. These situations include mixed flow regime calculations (hydraulic jumps), hydraulics of bridges, and evaluating profiles at river confluences (stream junctions).

The effects of various obstructions such as bridges, culverts, weirs, and structures in the floodplain may be considered in the computations. The steady flow system is designed for application in floodplain management and flood insurance studies to evaluate floodway encroachments. Also, capabilities are available for assessing the change in water surface profiles due to channel improvement and levees.

5.3 HEC-RAS INPUT DATA FOR STONY CREEK

This section describes the nature and source of information that was input to or revised in the Stony Creek HEC-RAS model to develop the Base-Condition Model.

5.3.1 Topographic Base Map and Cross Section Location Data

The IDNR provided a copy of the topographic base map that was used with the hydraulic modeling.

5.3.2 Cross Section Geometry Data

The cross section geometry data was not changed from the effective model, other than reach lengths at existing stream crossing as needed to comply with current modeling guidelines.

5.3.3 Manning's Roughness Coefficients

Manning's roughness coefficients were not changed from the effective model.

5.3.4 Bridge Data

The existing bridge data was updated based on plans and in some cases, field measurements.

5.3.5 Flow Data

Flow data was not changed from the effective model. **Table 13** presents the flow rates used in the hydraulic model.

5.3.6 Starting Water Surface Elevations

The starting water surface elevations were taken from the effective model.

Table 13
Peak Discharges Used in the Regulatory Stony Creek Hydraulic Model

HEC-RAS Cross Section Reach	Approximate Drainage Area at the d/s end of Sub-reach (sq mi)	Peak Discharges for Various Design Storm Recurrence Intervals (cfs)			
		10-Year	50-Year	100-Year	500-Year
0.01 to 0.894	36.5	1,640	2,350	2,700	3,280
1.2 to 1.61	48.5	1,990	2,820	3,200	3,960
1.650 to 4.325	52.0	2,080	3,010	3,400	4,200
5.54 to 6.32	57.2	2,200	3,180	3,600	4,400

5.4 DUPLICATE EFFECTIVE MODEL

The FIS model that was obtained from the IDNR was a HEC-2 model. The HEC-2 model was converted into a HEC-RAS model. Some of the reach lengths at the crossings were revised to run the model. This model was then used as the duplicate effective model.

5.5 CORRECTED EFFECTIVE MODEL

The corrected effective model was developed by modifying the duplicate effective HEC-RAS models to incorporate the baseline conditions models from the IDNR floodway construction permits along Stony Creek. In addition, the reach lengths at the crossings were modified to meet the IDNR requirements. This corrected effective model adds additional cross sections to the effective model geometry to represent the hydraulic condition of the stream without incorporating the previously permitted and built projects along the stream. A copy of the output from this model is provided in **Appendix 10**.

5.6 EXISTING-CONDITION MODEL

The existing-condition model was developed by modifying the corrected effective model to incorporate the proposed conditions models from the IDNR floodway construction permits along Stony Creek. This model represents the existing conditions along the stream, based on the data that is in the effective model, i.e., it does not include revisions based on the latest County contour mapping. The purpose of this model is to show a comparison to the currently effective information.

5.7 FINAL RESULTS OF STONY CREEK MODELING

Utilizing the input data described in Section 5.3, a revised HEC-RAS multi-profile model was developed for Stony Creek. The resulting water surface elevations for the 10, 50, and 100-year discharges are provided in the standard HEC-RAS output table in **Appendix 11**. Appendix 11 also includes a printout of the input report, and profiles and cross sections, as well as the Project Evaluation Table that shows the 100-year water surface elevations as published in the FIS, and from the Duplicate Effective, Corrected Effective, and Existing-Condition models. A digital copy of the HEC-RAS model is provided in **Appendix 12**. The results show that the existing conditions are generally within about 0.5 feet of the effective flood elevations, except for the upstream approximately two mile reach where the existing-condition model elevations are up to 2 feet or more higher than the effective information. Based on the results of this preliminary modeling, and the fact that the effective elevations are based on analyses completed nearly 30 years ago, the need for a re-study of Stony Creek using the latest County contour mapping and actual surveyed stream crossings is indicated and should be considered in the future.

5.8 HEC-RAS INPUT DATA FOR WHEELER-WHEELER AND WILLIAM LEHR DITCH

This section describes the nature and source of information that was input to the Wheeler-Wheeler Drain and William Lehr Ditch HEC-RAS models.

5.8.1 Topographic Base Map

The Hamilton County 2-foot contour mapping was used as the topographic base map and cross section location map for this analysis.

5.8.2. Flow Data

Flow data required for the simulation of the 10, 50, and 100-year events in the models was obtained from the Base-Conditions HEC-HMS modeling presented in Chapter 4. Due to unavailability of published 500-year precipitation depth estimates, the estimates of the 500-year discharge at select locations along Wheeler-Wheeler Drain and William Lehr Ditch were obtained by extrapolating the discharge-frequency relationship of 10- through 100-year estimated values shown in Table 13 at each location. The extrapolation was performed using a lognormal paper as shown in **Appendix 13**. **Table 14** summarizes the peak discharges used in the Wheeler-Wheeler Drain and in the William Lehr Ditch HEC-RAS models and the cross sections to which they apply.

TABLE 14
Peak Discharges Used in the Wheeler-Wheeler Drain and William Lehr Ditch HEC-RAS Models of Existing Conditions

HEC-RAS Cross Section Reach	Contributing Drainage Area to Select HEC-HMS Locations (sq mi)	Peak Discharges for Various Design Storm Recurrence Intervals (cfs)			
		10-Year	50-Year	100-Year	500-Year
Wheeler-Wheeler Drain					
0.2 to 5.0	1.46	200	290	330	475
5.2 to 8.5	0.97	130	185	210	300
William Lehr Ditch					
1 to 6	6.36	990	1,435	1,615	2,315
6.25 to 9	4.4	730	1,065	1,195	1,720
9.25 to 11	3.2	575	830	935	1,335
11.25 to 14	1.7	330	475	530	755

5.8.3 Starting Water Surface Elevation

The starting water surface elevation for the Wheeler-Wheeler Drain was determined using the slope-area method. The starting water surface elevation for the William Lehr Ditch was determined using the slope-area method.

5.8.4 Manning's Roughness Coefficient

The Manning's Roughness Coefficients for Wheeler-Wheeler Drain were based on field visit and photographs. The roughness coefficients for the channel ranged from 0.035 to 0.045, and the roughness coefficients for the overbanks ranged from 0.05 to 0.07. The channel was mainly smooth clean channel with some weedy areas. The overbanks were mainly lawns and some wooded areas.

The Manning's Roughness Coefficients for William Lehr Ditch were based on field visit and photographs. The roughness coefficients for the channel ranged from 0.03 to 0.07, and the roughness coefficients for the overbanks ranged from 0.04 to 0.07. The channel ranged from a clean, smooth channel to an overgrown weedy channel. The overbanks ranged from lawns to wooded areas. Copies of photos for both streams at various locations are provided in **Appendix 14**.

5.8.5 Calibration

No applicable historic flood profiles were found for these streams that would be appropriate for calibrating the models.

5.8.6 Cross Section Geometry Data

The cross section geometry data for both streams was based on field survey information conducted by Civil Design, LLP in 2003 and additional field measurements of the crossing by CBBEL in 2003. Copies of the CBBEL field measurements are provided in **Appendix 15**. The Civil Design survey is also provided in Appendix 15.

5.8.7 Ineffective Flow and Bridge Obstructions

The ineffective flow limits were located in accordance with the IDNR guidelines.

5.8.8 Bridges

There were 7 bridge crossings along Wheeler-Wheeler Drain. The bridge data used in the model was taken from survey information and photographs prepared by CBBEL.

There were six bridge crossings along William Lehr Ditch. The bridge data used in the model was taken from survey information and photographs prepared by CBBEL.

5.8.9 Culverts

There are six culvert crossings along Wheeler-Wheeler Drain. The culvert data used in the model was taken from survey information and photographs prepared by CBBEL.

There is one culvert crossing along William Lehr Ditch. The culvert data used in the model was taken from survey information and photographs prepared by CBBEL.

5.8.10 Critical Depths

No critical depths were calculated in either of the two models.

5.8.11 Floodway

The floodway for Wheeler-Wheeler Drain was initially defined using the equal conveyance option, Method 4 then importing to Method 1. The floodway calculation is discussed further in Section 5.9.

The floodway for William Lehr Ditch was also initially defined using the equal conveyance option, Method 4 then importing to Method 1.

5.8.12 CheckRAS

The FEMA CheckRAS program was run to check both the models. Copies of the output from the CheckRAS for both models are provided with the output for those models.

5.9 FLOODPLAIN AND FLOODWAY

The main purpose for the hydraulic modeling was to develop a regulatory floodplain and floodway for both Wheeler-Wheeler Drain and William Lehr Ditch. The base-condition models were used to calculate the water surface elevations for the 10-, 50-, 100-, and 500-year storm events and to calculate the floodway for both streams. The floodway limits were initially determined using the HEC-RAS encroachment option Method 4 with 0.1 feet of surcharge. These values were imported to Method 1 and adjusted as needed to provide a smooth floodway with no surcharges greater than 0.14 feet, in accordance with the IDNR criteria. The resulting elevations and floodway surcharges along with other floodway data area shown in the HEC-RAS Standard Table "Encroachment 3" provided in **Appendix 16** for both streams.

The limits of the HEC-RAS floodway and floodplain were delineated on the base map (1" = 200') provided as **Exhibit 5** for Wheeler-Wheeler Drain and **Exhibit 6** for William Lehr Ditch.

6.0 EVALUATION OF STORMWATER QUALITY AND NPDES PHASE 2 ISSUES

The purpose of this chapter is to summarize the IDEM water quality issues, Dr. Baker's conclusions and recommendations, the United States Fish and Wildlife Service (USFW) survey, and the interview with the Hamilton County Health Department.

6.1 IDEM WATER QUALITY ISSUES (305(b) REPORT)

The IDEM Office of Water Quality's surface water quality monitoring strategy is designed to describe the overall environmental quality of each major river basin in the state and to identify monitored water bodies that do not fully support designated uses. The surface water monitoring strategy was revised in 2001 to continue to meet the goal of assessing all waters of the state within five years, while enhancing support of other Office of Water Quality programs.

The 305(b) report is compiled by the IDEM at a frequency prescribed by the US EPA, but at least every four years. The report provides a compilation and summary of all of the IDEM's water quality monitoring and assessment data (compiled from AIMS database and other datasets/reports within the IDEM). All IDEM water quality data is evaluated by the IDEM's 305(b) Coordinator and interpreted for each 14-digit HUC subwatershed. Each subwatershed is given a water quality rating relative to its streams status in meeting Indiana's Water Quality Standards (WQS). WQS are set at levels necessary for protecting a waterway's designated use(s), such as swimmable, fishable, or drinkable. Each subwatershed is given a rating of fully, partially, or not supportive of its designated uses. An excerpt from the 305(b) report for the Hamilton County's MS4 area within the Stony Creek Watershed is included in **Table 15**.

Table 15
2002 305(b) Results for the Stony Creek Subwatersheds

Watershed Name	14 Digit HUC	Use Support	Cause (stressor) Rating
Stony Creek – William Lock Ditch	05120201070050	F – Aquatic Life F – Contact	N/A
Stony Creek - William Lehr Ditch and other tributaries	05120201070060	F – Aquatic Life F – Contact	N/A
North Trib (Noblesville) Stony Creek	05120201070070	F – Aquatic Life F – Contact P – Aquatic Life N – Fish Consumption	N/A M – Biotic Community H – PCBs

Use Support: F=full support, P=partial support, N=non support
Cause (stressor) Rating: H=high, M=moderate, S=slight, T=need more information

According to the IDEM's monitoring and assessments data, the following subwatersheds are considered to be fully supporting of all designated uses, and

therefore not substantially impacted by stormwater discharges from Hamilton County's MS4 area:

- Stony Creek – William Lock Ditch (05120201070050)
- William Lehr Ditch and other tributaries (05120201070060)

Some stressors, however, such as impaired biotic communities, pathogens, and taste and odor, may be related to stormwater runoff. Based upon the IDEM's 305(b) assessments, the following subwatershed should be considered as a priority for Hamilton County's Stormwater Program. The subwatershed is highlighted in **Exhibit 7**.

- North Tributary to Stony Creek (Noblesville) (05120201070070)

6.2 IDEM 303(d) LIST OF IMPAIRED STREAMS

Section 303(d) of the Clean Water Act requires states to identify waters that do not or are not expected to meet applicable water quality standards with federal technology based standards alone. States are also required to develop a priority ranking for these waters, taking into account the severity of the pollution and the designated uses of the waters. Once this listing and ranking of waters is completed, the states are required to develop TMDLs for these waters in order to achieve compliance with the water quality standards. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources.

At the time of this writing, Applied Technologies and Management (ATM) of Gainesville, Florida is under contract with the federal Environmental Protection Agency (EPA) to develop an E. coli TMDL for Stony Creek. ATM is currently in the process of gathering and interpreting available E. coli data from a variety of sources including, but not limited to, the IDEM, Hamilton County Health Department and the Hamilton County Surveyor's Office. ATM will use this data to develop a load duration curve in order to determine maximum loads. Additionally, ATM will attempt to identify potential sources of E. coli within the Stony Creek watershed. To assist with the identification of potential sources and to educate the public about the TMDL process, ATM and IDEM will conduct a public meeting. ATM anticipates a final TMDL for Stony Creek by Spring of 2005

Table 16 identifies 303(d) listed impaired waterbodies within the County's MS4 area for the Stony Creek Watershed. In addition, the table identifies the water quality parameters of concern, priority rankings, the TMDL development schedule, and 14-digit hydrologic unit code for each impaired stream. Subwatersheds considered impaired by stormwater related stressors, as discussed in Section 6.1, are considered sensitive areas and are considered priorities for Hamilton County's Stormwater Program. **Exhibit 8** identifies the impaired streams within the County's MS4 area.

Table 16
2002 303(d) Listed Streams within Hamilton County's MS4 Area for the Stony Creek Watershed

Waterbody	HUC	Parameter(s) of Concern	TMDL Development Schedule
Stony Creek	05120201070050	E. Coli, Impaired Biotic Communities, PCBs	2001-2006
Stony Creek	05120201070050	Impaired Biotic Communities, PCBs	2011-2016

Based upon the impaired stream listings included in Table 16, the following subwatershed will be considered priorities for Hamilton County's Stormwater Program:

- Stony Creek – William Lock Ditch (05120201070050)

6.3 DR. CLAUDE BAKER'S FINDINGS AND CONCLUSIONS

CBBEL subcontracted water quality monitoring tasks to Dr. Claude Baker of Indiana University. Dr. Baker, of the New Albany campus, and his students conducted water quality tasks, including chemical monitoring, habitat assessments, and bio-monitoring at nine sites within the Stony Creek watershed during the months of May, June, and October of 2003.

6.3.1 Stony Creek Water Quality Monitoring

Water quality samples were collected at nine sites to characterize high flow, base flow, and low flow conditions. Monitoring sites are illustrated in **Exhibit 9** and described in **Table 17**. Water quality parameters evaluated during the study included: water and air temperature, dissolved oxygen, pH, alkalinity, turbidity, conductivity, total dissolved solids, nitrate, nitrite, ammonia-nitrogen, total nitrogen, ortho-phosphate, and fecal coliform bacteria. The results of the water quality monitoring for the nine stations are summarized in **Table 18**.

Table 17
Stony Creek Monitoring Sites

Site #	Site Description
1	Stony Creek at Atlantic Road near the Town of Fishersburg. Downstream from possible septic effluents, sewage disposal plant and a golf course.
2A	Stony Creek at Pilgrim Road between 191st and 196th Streets. Downstream of a cattle farm.
2	Wm. Lock Ditch portion of Stony Creek near 191st Street. Downstream of combined inputs from Wm. Lock Ditch and Stony Creeks
3	Wm. Lock Ditch above Stony Creek at 1976th Street and Mystic Road. Existing agricultural area with extensive drains.
4	Stony Creek on Highway 38 near existing IMI quarry. Downstream of the confluence of Stony Creek and Wm. Lock Ditch
5	William Lehr Ditch at 166th Street near Boden Road. Existing agricultural area undergoing development.
6	Stony Creek at Cumberland Road. Rapid development of strip malls north of creek.
7	Stony Creek at Greenfield Road. Urban landscape downstream of possible septic system inputs.
8	Stony Creek at Allisonville Road near confluence with the White River.

Table 18
Water Quality Results from 9 Stations on Stony Creek, Hamilton County, Indiana During High Discharges, Base Flow and Fall Flow Sampling Periods

STATION NO.		1	2A	2	3	4	5	6	8	7
Date	Flood	5/13	5/13	5/13	5/13	5/13	5/13	5/13	5/13	5/13
	Base Flow	6/27	6/27	6/27	6/27	6/27	6/27	6/27	6/27	6/27
	Fall Flow	10/3	10/3	10/3	10/3	10/3	10/3	10/3	10/3	10/3
Discharge (CFS)	Flood	High	High	High	High	High	High	High	High	High
	Base	6.05	Pond	27.7	13.8	56E	<10E	60E	59.0	65.0
	Fall	<1	Pond	82.86	27.66	112.8	24E	122.6	124.28	134.60
Air Temperature C	Flood	23.0	19.8	22.0	24.0	24.0	29.8	21.2	21.5	24.7
	Base	30.2	31.3	30.8	31.1	30.0	28.1	28.9	30.3	28.8
	Fall	9.5	8.6	9.4	9.8	11.0	9.2	9.0	10.8	9.3
Water Temperature C	F	13.0	14.0	13.8	15.6	15.2	18.3	17.6	16.5	17.3
	Base	20.4	22.3	20.3	20.2	23.6	23.9	25.8	25.0	24.1
	Fall	12.2	11.3	11.3	11.7	11.4	12.5	11.1	11.4	11.3
Dissolved Oxygen mg/L	F	97.5	9.72	9.45	8.97	7.07	6.03	7.52	7.54	6.48
	% Saturation F	91	92	90	88	69	63	77	76	66
	Base	7.8	10.57	10.70	11.83	11.40	12.60	11.4	11.1	8.4
	% Saturation Base	55.2	74.26	72.9	80.47	81.63	90.62	84.2	81.08	60.59
	Fall	11.62	12.27	12.2	12.72	13.12	13.8	13.8	12.8	11.0
pH (Units)	Flood	7.9	7.9	7.9	7.6	7.7	7.6	7.9	7.8	7.8
	Base	7.8	8.1	7.9	7.9	7.8	8.3	8.1	8.3	8.1
	Fall	8.2	8.3	8.3	8.2	8.3	8.2	8.2	8.3	8.2
Alkalinity mg/L	Flood	53.9	53.9	61.6	177.0	177.0	194.7	53.9	61.6	53.9
	Base	354	372	372	372	382	301	319	336	389
	Fall	194.7	300.9	300.9	336.3	265.5	301	319	336	389
Turbidity (NTU)	Flood	71.2	70.9	80.3	73.4	63.6	16.7	66.0	104.8	66.0
	Base	7	9	6	8	17	8	15	9	13
	Fall	3.2	4.0	1.8	3.4	1.7	3.5	3.8	23.9	13
Conductivity mmhos/cm										
	Flood	420	440	460	490	470	530	480	490	480
	Base	820	790	740	720	730	640	730	730	730
	Fall	660	600	660	660	690	660	660	690	680
Total Dissolved Solids Estimated mg/L	Flood	210	220	230	245	235	265	240	245	240
	Base	410	395	370	360	365	320	365	365	365
	Fall	330	300	330	330	345	330	330	345	340
Nitrate mg/ L	Flood	0.19	0.18	0.17	0.15	0.24	0.17	0.21	0.28	0.47
	Base	0.38	0.46	0.19	0.25	0.11	0.12	0.15	0.22	0.28
	Fall	1.10	0.30	0.90	1.40	1.50	0.39	0.49	1.60	1.20
Nitrite mg/ L	Flood	0.066	0.091	0.060	0.055	0.091	0.042	0.117	0.090	0.091
	Base	0.042	0.089	0.071	0.051	0.051	0.091	0.084	0.082	0.037
	Fall	0.015	0.014	0.015	0.029	0.010	0.019	0.014	0.013	0.018
Ammonia-Nitrogen mg/L										
	Flood	0.02	0.29	0.24	0.19	0.25	0.16	0.28	0.24	0.30
	Base	0.07	0.11	0.10	0.09	0.46	0.24	0.11	0.18	0.59
	Fall	0.01	0.01	0.01	0.01	0.12	0.00	0.05	0.04	0.06
Total Nitrogen mg/L	Flood	9	7	8	9	8	5	8	7	8
	Base	5.7	5.1	3.7	3.6	3.5	1.4	3.0	2.9	2.5
	Fall	3.2	2.7	3.4	3.4	2.7	1.9	3.2	3.4	3.1

Monitoring results identified several pollutants at concentrations of concern in the Stony Creek watershed. Fifteen of the thirty samples collected were above 200 fecal coliform colonies per each 100ml sample, which may pose threats to public health via

recreational contact. In addition, results identified elevated concentrations of phosphate and nitrate. These nutrients have been known to contribute to the growth of noxious algae and aquatic weeds in aquatic environments. Elevated turbidity values and visual observations also identified erosion and sedimentation problems at several locations in the watershed.

The Stony Creek Watershed Study suggests that pollutants of concern within the watershed may originate from the following:

- livestock with direct access to the stream
- overland flow (runoff) of manure and commercial fertilizers applied to agricultural fields
- failed on-site septic systems or illegal septic tank connections to tile drains
- agricultural tile drainage systems
- erosion and sedimentation from constructions sites
- erosion and scouring around bridges and streambanks
- runoff from impervious surfaces in urbanized areas
- lawn and garden fertilizers

6.3.2 Stony Creek Habitat Assessments

Habitat assessments conducted at each site were performed using two analyses methods: EPA's Habitat Assessment from the Rapid Bioassessment Protocols (RBP) and the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI).

6.3.2.1 RBP Results

The Upstream stations and the ditched tributaries (Sites 3 and 5) fell into the "poor" range due to pool and riffle being covered in silt and muck which do not provide favorable habitat for most aquatic organisms. In addition, the stream channel has been altered significantly through channelization leading to a loss of sinuosity.

Beginning at Station 4, the stream's habitat values improve into the "supporting" range. Riffles are larger and pools have depth and structure, however, much of the substrate is covered by silt and muck. Sites 7 and 8, along Greenfield Road and Allisonville Road provide the best habitat for macroinvertebrates due to the riffle areas which contain large numbers of rocks.

Despite the improvements noticed downstream, the RBP method of assessing habitat resulted in a conclusion that Stony Creek's habitat is "poor". Dredging, channelization, and the refilling of natural pools by sediments and muck have degraded the stream and riparian habitat of Stony Creek. The creek has a lack of exposed substrates that organisms use as habitat and water willow and aquatic emergent plants have choked existing riffle areas.

6.3.2.2 QHEI Results

The QHEI results were compatible with the RBP method. The only monitoring sites considered to be unimpaired were the most downstream sites at Greenfield Road and Allisonville Road (Sites 7 and 8). The other sites were determined to be "Modified Warm Water Habitat" and Wm. Lehr Ditch (Site 5) fell into the "Limited Resource Water" category.

6.3.3 Stony Creek Biomonitoring

Macroinvertebrates were collected at each of the nine sampling sites and evaluated by utilizing the EPA's Rapid Bioassessment Protocol (RBP). The RBP focuses on macroinvertebrates in riffle/run habitats. Samples were collected at each station utilizing a traveling kick net method.

Macroinvertebrate assessments completed for this project rated Stony Creek's biotic communities as "moderately" impaired. The study characterizes Stony Creek as having low numbers of individual species, low taxa richness, and an elevated population of organisms tolerant to pollution The report also states that in healthy streams, large numbers of schooling minnows (shiners, chubs, etc) are normally expected to be observed; however, not a single school of minnows was observed at any sampling site during this study. The study cites both poor water quality and poor habitat as the cause for the poor biotic community.

6.3.4 Recommendations

Dr. Baker's study provided a variety of recommendations for addressing the pollutants impacting water quality in the Stony Creek watershed. **Table 19** highlights recommendations from this study that are consistent with Hamilton County's NPDES Stormwater Phase II requirements as outlined in 327 IAC 15-13; however, additional recommendations are included in the study.

Table 19
Stony Creek Watershed Study Recommendations

Recommended BMPs	BMP Benefits
• Exclusionary fencing of cattle from streams and streambanks • Restoration of eroded streambanks and riparian areas through vegetative practices such as grass plantings and vegetative geogrids	• Exclusionary fencing minimizes bacteria and sediment loadings from livestock • Vegetative plantings minimize streambank erosion while serving as sediment and pollutant filters. Vegetation also slows the velocity of runoff from upland areas • Vegetative practices increase stream shading resulting in increased oxygen concentrations
• Implementation of manure management techniques	• Manure management minimizes bacteria and nutrient loading from manure-applied croplands and pasturelands
• Implementation of conservation tillage, nutrient management and conservation buffers upon croplands	• Conservation tillage minimizes the transport of sediment and sediment bound pollutants from croplands • Nutrient management minimizes the amount of nutrients applied reducing the risk of over application and subsequent runoff • Buffer strips serve as sediment and pollutant filters while slowing the velocity of runoff from croplands
• Utilization of erosion and sediment control (ESC) practices upon construction sites	• ESC practices minimize erosion and sedimentation that originates from developing and/or redeveloping areas

Recommended BMPs	BMP Benefits
• Utilization of post-construction BMPs such as retention and detention basins upon developing and re-developing areas	• Retention and detention ponds, as well as other post-construction BMPs, provide for the settling out of sediment and pollutants prior to discharge • Post-Construction BMPs also minimize runoff volumes and velocities minimizing upland and streambank erosion
• Maintenance of conveyances, especially around existing bridges	• Conveyance maintenance minimizes erosion and scouring of streambanks improving habitat
• Maintenance of stream channels by removing muck and some large woody debris (LWD)	• LWD provides beneficial fish habitat, however, much of the LWD is buried in silt and muck. The removal of these materials increases instream habitat.
• Promotion of Low Impact Development (LID)	• LID achieves stormwater management by altering site designs to create a functioning landscape that mimics a natural watershed.
• Conduct a study to determine the actual amount of imperviousness within the watershed.	• Studies suggest that watersheds that exceed 10% imperviousness experience accelerated water quality problems, bank erosion and scouring.

6.3.5 Conclusions

Implementation of the recommendations discussed in Table 18 will address multiple requirements of Hamilton County's NDPES Stormwater Phase II requirements. In addition, implementation of these recommendations would minimize the introduction of new or increased pollutant loads to streams, while also optimizing the ability of those streams to naturally process and decompose water quality pollutants. This approach would ultimately result in a healthier aquatic ecosystem for the Stony Creek watershed.

6.4 USFW SURVEY OF FISH COMMUNITIES AND HABITAT QUALITY IN TRIBUTARIES TO THE UPPER RIVER

In 2002, the United States Fish and Wildlife Service (USFW), at the direction of the Indiana Department of Natural Resources (IDNR), conducted a study of the West Fork White River from Muncie, Indiana to Indianapolis, Indiana. The study was conducted as

a result of the 1999 fish kill that resulted in the death of more than 180 tons of fish, aquatic organisms and riparian wildlife along a 50 mile stretch of the White River from the City of Anderson, Indiana through downtown Indianapolis, Indiana.

6.4.1 Study Design

The study included fish sampling, habitat assessments and water quality sampling. All primary tributary streams draining the West Fork White River within the fish kill zone were included in the study. In all, 77 sites were chosen for study, including several Hamilton County MS4 area receiving waters, such as Carmel Creek, Cicero Creek, Cool Creek, Crooked Creek, Little Cool Creek, Mud Creek, Stony Creek, and Williams Creek.

Fish community sampling occurred between July and September of 2002. The entire length and width of each site was electrofished with either a backpack unit or a single tow-barge unit. The Index of Biotic Integrity (IBI) was utilized to score each site based upon the number and species of fish collected. Habitat analyses were conducted the same day as fish sampling utilizing the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA. Water quality parameters were measured twice during the study utilizing a Hydrolab datasonde capable of measuring temperature, dissolved oxygen, specific conductivity, pH, oxidation-reduction potential, turbidity, salinity, nitrate and ammonia. Water quality parameters were measured in conjunction with the first fish sampling event and then again in October of 2002.

6.4.2 Study Results

A total of 51 fish species comprised of 15,404 individuals were collected during the study. IBI scores for the different sites resulted in the following classifications: 0% excellent, 6.6% good, 27.6% fair, 55.3% poor, and 10.5% very poor. The sites with the lowest IBI scores were primarily in the rural areas of northeast Hamilton County, Madison County and northwest Delaware County. Cicero Creek in Hamilton County had the highest IBI score of 50, just below the Sheridan Avenue bridge.

QHEI scores ranged from 30 to 90. Williams Creek, Cicero Creek, Carmel Creek, and Crooked Creek had the highest QHEI scores. Cool Creek, Lily Creek, Killbuck Creek, Little Killbuck Creek, Pipe Creek and Stony Creek had the poorest QHEI scores, all scoring less than 35. The study cites channelization, removal of riparian corridors, sedimentation, and the loss of instream cover as the primary reasons for the poor habitat conditions within these streams.

Stream segments influenced by pollutant loadings had increased values of salinity, specific conductance, and total dissolved solids. Bear Creek, Duck Creek, Little Cool Creek, Pipe Creek, and Stony Creek had specific conductance values greater than 1,000 uS/mL and total dissolved solids greater than 600.

Nutrient enrichment findings varied greatly between rural/agricultural areas and residential/urban areas. Nitrate levels ranged from .61 to 37.46 mg/L during October 2002 while ammonia levels ranged from 0.1 to 3.2 mg/L. Nitrate values greater than 10

mg/L and ammonia values greater than .2 mg/L are considered toxic to aquatic life. Therefore, baseline ammonia values collected during the study suggest that 80.3% of the stream reaches sampled were acutely toxic to aquatic life. The study concludes that, assuming October ammonia levels resemble baseline conditions and that ammonia levels escalate during the spring and summer, almost all stream segments would be chronically toxic to aquatic life.

6.4.3 Conclusions

The findings of this study indicate that sites with the lowest IBI scores were primarily in the rural areas of northeast of the Hamilton County MS4 area. However, some receiving waters within the MS4 area, including Cool Creek and Stony Creek, had the poorest QHEI scores due to channelization, removal of riparian corridors, sedimentation, and the loss of instream cover. In addition, Little Cool Creek and Stony Creek were documented to have elevated concentrations of stormwater related pollutants.

Based on the findings of this study, the following subwatersheds will be priorities for Hamilton County's Stormwater Program:

- Cool Creek – Grassy Branch/Little Cool Creek (05120201090030)
- Stony Creek – William Lock Ditch (05120201070050)
- Stony Creek-North Tributary (Noblesville) (05120201070070)
- Stony Creek-North Tributary (Noblesville) (05120201070070)

6.5 HEALTH DEPARTMENT STUDIES

After consultation with Mr. Barry McNulty, Administrator of the Hamilton County Health Department, no current Health Department studies were identified that were relevant to the County Stormwater Program. Other issues were discussed, as presented below:

6.5.1 On-Site Wastewater Treatment/Septic Systems

Due to the fact that Dr. Baker's water quality study indicated elevated levels of E. coli bacteria within Stony Creek, staff from Christopher B. Burke Engineering met with the Hamilton County Health Department (HCHD) to discuss the water quality impacts associated with septic systems and to determine the severity of the problem within the Stony Creek watershed. According to the HCHD, septic systems are a significant problem within the Stony Creek watershed for a variety of reasons. Such reasons include a typical homeowner's lack of knowledge of proper operation and maintenance, poor soil conditions, and small lot sizes which make necessary repairs difficult or impossible. In addition, the HCHD cited illicit connections and discharges as a major concern. The following information discusses each of these issues in more detail.

6.5.2 Lack of Septic System Understanding

Septic systems should be inspected on an annual basis to ensure they are working properly. Baffles, specially designed pipes which allow the sewage into and out of the tank, need to be inspected regularly to ensure they are not worn or damaged. Also, the level of sludge (the material that accumulates at the bottom of the tank) needs to be measured to determine when the system should be pumped. According to the HCHD, most residents do not understand septic systems and therefore do not properly maintain their septic systems. In fact, some residents are uncertain of the location of their septic system making maintenance impossible.

6.5.3 Poor Soil Conditions

According to Purdue University, 93% of the soils within Hamilton County have severe limitation for wastewater treatment (http://www.ces.purdue.edu/onsite/census.htm). The majority of the soils within the Stony Creek watershed are of either the Brookston, Miami or Crosby soil series which are cited in the Hamilton County Soil Survey as having severe limitations for on-site wastewater treatment due to the fact that they percolate slowly and are often wet due to the clay content of the soils. Hamilton County does require perimeter drains around most septic systems to aid in de-saturation of the soils, however, this is not always a successful approach due to the naturally wet condition of some soils. Also, many homes were constructed within the floodplains of the Stony Creek watershed. Due to the natural condition of floodplain soils, septic systems constructed within the floodplain pose an immediate threat to water quality.

6.5.4 Small Lot Sizes

The Towns of Durbin and Clarksville within Hamilton County and the Town of Fishersburg in Madison County are communities in which residents rely upon septic systems for wastewater treatment and private wells for drinking water. Many of the homes within these communities were built on small lots that do not provide adequate space for repairing or replacing drain fields nor do they provide adequate separation between wells and septic systems, 50 feet, as required by Indiana code. Such situations create a definite water quality concern and an immediate health concern. According to the HCHD, the Town of Fishersburg is currently working with the Town of Lapel to connect to their sanitary sewer system.

6.5.5 Illicit Connections and Discharges

Agriculture is the dominant land use within the Stony Creek watershed and as a result, tile drainage systems are common. Numerous residents have illegally connected their septic tank to these drainage tiles resulting in illicit discharges to Stony Creek and its tributaries. Because of the vastness of these agricultural tile systems and the rural nature of the watershed, identifying illicit connections is extremely difficult. Due to staff and budget constraints, the HCHD only conducts complaint driven investigations to identify illicit connections and discharges. According to the HCHD, they receive and investigate approximately thirty-five complaints a year.

6.5.6 Potential Solutions

Solving the septic system issue can be extremely difficult and a lengthy, and expensive process. However, the HCHD feels there are a numerous strategies that could be implemented to lessen the impacts of septic systems on water quality. Such strategies include connecting communities and neighborhoods within close proximity to sanitary sewer systems, developing septic system management districts, and providing county-wide septic system education.

According to the HCHD, sanitary sewers are often extended into areas of the county to facilitate new development. However, often times existing individual homes and subdivisions in close proximity are not connected to the system but are instead by-passed. The HCHD feels that many of the County's septic system problems could be solved if the County would require all homes and subdivisions on septic systems to connect to the newly available sanitary sewer systems.

Septic System Management Districts, according to the HCHD, would be a great benefit to residents that exist in areas not in close proximity to sanitary sewers. The goal of a management program is to ensure long-term performance of septic tank-soil absorption systems to protect the public health and the environment. Management Districts are involved in the planning and siting of new septic systems and annual inspections of existing septic systems. With annual inspections, the need for maintenance and repair is identified early, and can be taken care of at minimal or no cost. Most importantly, through annual inspections landscape changes that could damage or interfere with the septic system can be identified and corrected quickly. Through management of properly sited and designed septic tank-soil absorption systems, rural residents can obtain low-cost wastewater treatment and protect the public health and the environment.

Due to their current workload and staff limitations, the HCHD only provides septic system educational materials to owners of newly constructed homes that utilize septic systems. The HCHD feels that this information should be conveyed to all homeowners that utilize septic systems. The HCHD is optimistic that this will be accomplished through the County's Stormwater Phase II program and future watershed management plans.

6.6 NPDES PHASE 2 ISSUES

In May 2004, CBBEL prepared the NPDES Phase II Storm Water Quality Management Plan (SWQMP) Part B report for Hamilton County. The recommendations and conclusions that pertain to the Stony Creek Watershed should be implemented as part of this Master Plan, where appropriate.

7.0 PLAN FORMULATION/EVALUATION CRITERIA

This chapter presents a summary of the technical, environmental, institutional, and economical criteria that will be used to formulate and/or screen the proposed alternatives. Based on the nature and extent of stormwater issues in the area, as presented in Chapter 4, the following set of criteria was developed to aid in the formulation of recommended solutions, as well as in the screening of alternatives.

7. 1 TECHNICAL CRITERIA

- The recommended improvement plan should provide for the scheduled replacement of road crossings to meet the Hamilton County requirement of no road overtopping during the 100-year storm event. The improvement plan should not cause any additional road crossings to overtop during the 100-year storm event.

- Any recommended regional detention basins should be designed to ensure the future-condition 100-year and 10-year peak flow rates do not exceed the existing-condition 100-year and 10-year peak flow rates. For areas that are already developed, the additional option of reducing the future-condition 25-year flow rates to the pre-developed 2-year flow rates should be considered.

- The recommended improvement plan should not result in increased flood elevations in other portions of the watershed or other affected basins.

7.2 ENVIRONMENTAL CRITERIA

- The recommended improvement plan must not have any significant and /or permanent negative impacts on the environment, recreational opportunities, and/or fish and wildlife resources.

- The recommended improvement plan should be consistent with the local Stormwater Quality Management Plans.

- The recommended improvement plan should contribute to overall improved stormwater quality in the watershed.

7. 3 INSTITUTIONAL CRITERIA

- The recommended improvement plan must be socially and politically acceptable to residents and, to the extent practical, to other interest groups.

- The recommended improvement plan must be permittable under existing federal, state, and local permit programs.

7. 4 ECONOMIC CRITERIA

- The recommended improvement plan should be fundable and should significantly reduce the economic damages resulting from flooding events.

- The recommended improvement plan must be the most economically feasible solution among the alternatives that will provide an effective solution to the flooding issue problem areas.

8.0 INITIAL SCREENING OF POTENTIAL ALTERNATIVE SOLUTIONS

This chapter presents the preliminary screening of known suggested alternative solutions identified through information gathered during planning meetings, review of similar studies in other watersheds by CBBEL, and CBBEL's analysis.

DEFINITIONS OF VARIOUS TYPES OF PONDS

Several types of detention ponds/flood control facilities are referred to in this Watershed Master Plan. In order to clarify the purpose and function of each type of pond and terms used in this study, the definition for each type is included below.

ON-SITE DETENTION POND

On-site Detention Pond/Basin is referred to as a dry-bottom or wet-bottom pond that serves as a runoff control Best Management Practice (BMP) for a single development. The main purpose of on-site detention ponds is to control the peak rate of runoff and the runoff volume in accordance with the requirements of local ordinances so that the increase in peak runoff rates as a result of new development is offset. However, in recent years, they are increasingly designed in a manner to store the stormwater quality volume "first flush" and release it very slowly so that they can serve as a stormwater quality BMP as well. On-site detention basins are typically designed to control on-site runoff only with no detention of the off-site runoff. The off-site runoff from upstream sites (developed or undeveloped) is either bypassed around or through the pond. All off-site areas located upstream or downstream of the development site are required to include their own detention ponds. The costs associated with an on-site detention pond are borne exclusively by the site developer.

SUB-REGIONAL DETENTION POND

Sub-Regional Detention Pond/Basin is similar in the design and function to the On-site Detention Pond except that it typically serves two or more development sites in a manner that the entire runoff generated in areas upstream of the control structure, on-site and off-site, is detained by the pond. Since a sub-regional detention pond is designed to detain all on-site and off-site runoff, the off-site areas served by the pond are not required to provide their own detention ponds. The main advantages of sub-regional ponds compared to several individual on-site detention ponds are their enhanced effectiveness, enhanced reliability, and lower overall cost. Sub-regional detention ponds are typically financed by private-public partnership agreements that attempt to recover a portion of the cost of the sub-regional pond built as part of a particular development from other developments served by the pond.

REGIONAL DETENTION POND

A Regional Detention Pond/Basin is a larger version of a sub-regional detention pond, serving a much larger area than that typically controlled by a sub-regional pond. The regional ponds being considered for the Stony Creek Watershed would serve developments located in an area as large as 500 acres. Although they are typically designed to control the entire runoff upstream of the site where the control structure is located, regional detention ponds may also be sized to over-detain the runoff so that a

limited area downstream of the control structure may also be qualified for waiver of on-site detention requirements. The main advantages of regional detention ponds compared to several individual sub-regional and on-site detention ponds are superior functionality, reliability, and effectiveness; lower overall design and construction costs (due to the economy of scale); lower operation and maintenance costs; more reliable maintenance and upkeep; and a multitude of potential recreational benefits they can offer. Due to the magnitude of costs associated with design and construction of regional ponds, they are typically financed and operated/maintained mainly by public entities with plans to recoup a portion or all of the associated costs, including the operation and maintenance costs, from future developments that will benefit from these regional ponds.

FLOOD CONTROL FACILITY

A Flood Control Facility typically controls runoff from several square miles of watershed area. These facilities are usually planned, designed, constructed, operated, and maintained by federal, state, or local governmental entities to curb the existing or potential flooding problems in areas downstream of these facilities. These facilities are typically designed to serve a multitude of purposes above and beyond their main flood control function. However, unless explicitly included as part of the design, flood control facilities do not typically affect the requirement for providing on-site detention by individual developers upstream or downstream of the facility.

A listing of the known suggested alternatives and the preliminary screening results are presented in **Table 20**. The initial screening was completed based on the performance criteria presented in Chapter 7.

Table 20
Initial Screening of Potential Alternatives

I.D.	Potential Alternative	Remarks
A	Add the full reach of Stony Creek to the Hamilton County Surveyor Regulated Drain rolls for ongoing maintenance	This alternative would allow the County Surveyor's Office to collect funds to provide routine ditch maintenance on Stony Creek to ensure flow conveyance capacity is maintained which would prevent future flooding problems and reduce the expense of major ditch projects in the future. This alternative will be carried to the short-list for further evaluation.
B	Continue strict enforcement of drainage ordinance requirements for on-site detention with new development.	This alternative would allow future development according to the current ordinance requirements for the Stony Creek watershed, and would exclude additional projects or other alternatives. It would prevent increased peak flow rates and the associated potential flooding problems due to development and will be carried to the short-list for further evaluation.

I.D.	Potential Alternative	Remarks
C	Construct regional detention ponds in each approximately 500-acre subwatershed	This alternative would prevent increased peak flow rates and the associated potential flooding problems due to development and will be carried to the short-list for further evaluation.
D	Add Locke Ditch downstream of 211th Street to the Hamilton County Surveyor Regulated Drain rolls for ongoing maintenance.	This alternative would add the full reach of Locke Ditch to the maintenance rolls which would allow the County Surveyor to collect funds to provide routine ditch maintenance to ensure flow conveyance capacity is maintained which would prevent future flooding problems and reduce the expense of major ditch projects in the future. This alternative will be carried to the short-list for further evaluation.
E	Continue ongoing maintenance of regulated drains in the watershed.	This alternative would ensure flow conveyance capacity is maintained which would prevent future flooding problems and reduce the expense of major projects in the future. This alternative will be carried to the short-list for further evaluation.
F	Adopt the allowable 2-year and 10-year release rates calculated with this Master Plan for each subwatershed.	This alternative would provide the County Surveyor and City, and developers data they can use in regulating/designing proposed development projects and will be carried to the short-list for further evaluation.
G	Construct new ditches to drain the existing isolated low areas located throughout the watershed.	This alternative would provide a positive outlet for all areas throughout the watershed. However, this positive outlet would eliminate the natural storage provided under current conditions which would increase peak flow rates in Stony Creek and other streams in the watershed, potentially causing flooding problems. As areas develop, the depressional storage areas may be drained as part of the development process. However, the affect of the depressional storage will have to be incorporated into the on-site detention, or regional detention design, as applicable. Since this alternative would potentially cause downstream flooding problems, it will not be considered as part of this watershed plan.
H	Implement the recommended	This alternative would improve water quality in the

I.D.	Potential Alternative	Remarks
	water quality BMPs presented in Chapter 6.	watershed and will be carried to the short-list for further evaluation.
I	Maintain the current USGS stream gage, and add additional stream gages at key locations in the watershed.	This alternative would provide ongoing data regarding stream flow, and could provide water quality information, which could be used in the future to update stream hydrologic calculations as well as monitor the impact of various projects completed in the watershed. This alternative will be carried to the short-list for further evaluation.
J	Construct one major flood control basin in each of the large subwatersheds along Stony Creek.	This alternative has the potential of reducing the 100-year flow rates and lowering the 100-year flood elevations throughout the watershed and will be carried to the short-list for further evaluation.
K	Revise the hydraulic modeling of Stony Creek using updated hydrology and county contour mapping; extend the hydraulic model upstream to the county line.	This alternative would provide an accurate model of Stony Creek, based on the latest county contour mapping, and the detailed hydrologic analysis of the watershed. It would also provide floodplain and floodway information for the entire reach of Stony Creek in Hamilton County. It will be carried to the short-list for further evaluation.
L	Complete hydraulic analysis and floodplain/floodway mapping of the unstudied major streams in the Stony Creek watershed.	This alternative would provide accurate floodplain and floodway mapping along each major stream that would be used to help guide future development away from the floodplain areas and prevent flooding issues. It will be carried to the short-list for further evaluation.
M	Enlarge existing stream crossings to convey the full 100-year flow with no road overtopping	This alternative would improve the existing stream crossings that are overtopped during flood events or that cause a significant backwater. It has the potential of reducing upstream flood elevations and would bring the crossings into compliance with county ordinance requirements for stream crossings to convey the 100-year flow rate. It will be carried to the short-list for further evaluation.
N	Allow no development within the limits of the floodplain.	This alternative would ensure the natural floodplain storage is maintained and would prevent future flooding problems that are common with structures that are built within the floodplain limits. This alternative, when coupled with the county's stormwater detention

I.D.	Potential Alternative	Remarks
		requirements would help ensure no negative impacts due to future development within the watershed. Therefore, this alternative will be carried to the short-list for further evaluation.
O	Develop a project to maintain the existing storage at the abandoned Lapel quarry.	The quarry originally drained to Stony Creek and that continues to be the natural outlet. Since this area is in Madison County and outside the Hamilton County planning jurisdiction, it will not be evaluated further.
P	Develop a project to eliminate flooding at 191st Street and Prairie Baptist Rd, and also on the south side of 196th Street east of Prairie Baptist Rd.	Although alternatives that may be implemented as part of this master plan may benefit these areas, these localized flooding problems are beyond the scope of this master plan and will not be evaluated further as part of this watershed study.
Q	Develop a project to eliminate flooding of Allisonville Road at Stony Creek.	This flooding is caused by backwater from the White River. There may be alternatives such as raising Allisonville Road that would provide some benefit, but this is beyond the scope of this master plan and will not be evaluated further.
R	Develop projects to eliminate local flooding in the areas of 8th Street, 10th Street, and 13th Street in Noblesville.	Although alternatives that may be implemented as part of this master plan may benefit these areas, these localized flooding problems are beyond the scope of this master plan and will not be evaluated further as part of this watershed study.
S	Dredge and widen Stony Creek and the other major streams in the watershed to increase conveyance capacity to safely carry the ultimate development conditions flows, eliminating the need for detention basins.	Although this alternative may have technical merit in that sufficient increased conveyance capacity could be provided, it would not meet the environmental criteria. Stony Creek and the other major streams are valuable environmental resources. Extensive construction within the channel would cause significant negative impacts to the environment. This alternative does not meet the evaluation criteria and will not be evaluated further.

Based on the initial screening process, a short-list of promising alternatives for further consideration and possible inclusion in the recommended project was compiled. The short-list of possible master plan components that should be studied further is presented in **Table 21**. An in-depth discussion of each of the short-listed alternatives is provided in the next chapter of the report.

Table 21
Short List of Possible Master Plan Components

Component No.	Description
1	Continue strict enforcement of drainage ordinance requirements for on-site detention.
2	Adopt allowable unit discharge release rates based on existing conditions.
3	Construct regional detention ponds in each approximately 500-acre subwatershed.
4	Construct major flood control basins.
5	Add Stony Creek and William Locke Ditch to the Hamilton County Surveyor Regulated Drain rolls and implement ongoing maintenance.
6	Continue ongoing maintenance of regulated drains in the watershed.
7	Implement the recommended water quality BMPs to address Phase 2 requirements.
8	Maintain the current USGS stream gage on Stony Creek and add additional gages at key locations in the watershed.
9	Revise the hydraulic modeling of Stony Creek using updated hydrology and county contour mapping; extend the hydraulic model upstream to the county line.
10	Complete hydraulic analysis and floodplain/floodway mapping of unstudied major streams in the Stony Creek watershed.
11	Enlarge existing stream crossings to convey the full 100-year flow with no road overtopping.
12	Allow no development within the limits of the floodplain.

9.0 DETAILED EVALUATION OF POSSIBLE MASTER PLAN COMPONENTS

Each of the possible master plan components presented in Table 21 were subjected to a detailed evaluation of their technical effectiveness, economics, social and institutional impacts, and environmental feasibility. The results of these analyses are summarized in the following sections.

12 possible master plan components were included on the short-list. Each component would provide a possible solution to the problems identified in Chapter 3.0, or to help prevent future flooding issues.

9.1 CONTINUE STRICT ENFORCEMENT OF REQUIREMENTS FOR ON-SITE DETENTION

Candidate Plan Component 1 would continue the strict enforcement of the County drainage ordinance throughout the watershed. The primary objective of this plan would be to effectively prevent the increase of flooding and erosion damages within the watershed, and also ensure compliance with the State's Rule 13 requirements.

The current drainage ordinance limits the 100-year post-development peak flow rate to the 10-year pre-development peak flow rate, and the 10-year post-development peak flow rate to the 2-year pre-development peak flow rate. The primary objective is to prevent future development from being damaged or causing additional damages to existing development.

In order to determine the impact of on-site detention, as required with current drainage ordinances, future-condition modeling was first developed to calculate future flow rates assuming no detention. The objective of this future-condition modeling was to develop future-condition baseline modeling to use in analyzing the various detention alternatives.

To simulate the ultimate development of the watershed, the base-condition HEC-HMS model presented in Chapter 4.0 of this report was revised. The curve numbers for each subbasin were revised based on the assumed ultimate development shown on the zoning and land use maps provided by the Hamilton County Planning Department and the City of Noblesville (copies are provided in **Appendix 17**). This included removing the effect of the existing depressional storage in the assumed future-developed areas. Soil types of "C" and "D" were used in the areas that will develop to reflect soil compaction typical with development. The assumed future-condition and base-condition curve numbers are presented in **Table 22**. Copies of the future-condition curve number calculations are provided in Appendix 17. The assumed lag times were not changed in the future-condition model. The modeling shows that future development without detention storage would result in significantly increased flow rates, and associated increases in flood elevations, as would be expected. The HEC-HMS model output for the assumed future conditions with no detention storage is provided in **Appendix 18**.

Table 22
Future-Condition Hydrologic Parameters

BASIN ID	CN (Base-Condition)	CN (Future-Condition)
Stony Creek		
SC1	78	82
SC2	75	84
SC3	81	84
SC4	78	80
SC5	80	81
SC6	78	79
SC7	81	83
SC8	80	81
SC9	81	81
SC10	78	83
SC11	78	79
SC12	82	82
SC13	82	82
SC14	81	84
SC15	81	82
SC16	79	83
SC17	79	83
SC18	79	85
SC19	78	81
SC20	77	83
SC21	79	83
SC22	77	82
SC23	75	81
SC24	79	80
SC25	78	85
SC26	78	82
SC27	78	90
SC28	81	88
SC29	76	87
Stony Creek – Madison Co.		
MaCo1	81	81
MaCo2	81	81
MaCo3	81	81
MaCo4	78	78
MaCo5	79	79
MaCo5A	80	80
MaCo6	81	81

BASIN ID	CN (Base-Condition)	CN (Future-Condition)
MaCo7	81	81
MaCo8	80	80
MaCo9	80	80
MaCo10	80	80
MaCo11	84	84
MaCo12	80	80
MaCo13	80	80
Wheeler-Wheeler Drain		
WhWh1	80	88
WhWh2	80	83
WhWh3	76	82
William Lehr Ditch		
WmLe1	80	88
WmLe2	79	82
WmLe3	77	82
WmLe4	81	82
WmLe5	77	82
WmLe6	78	82
WmLe7	76	81
WmLe8	78	85
WmLe9	81	84
WmLe10	80	84
WmLe11	79	86
William Locke Ditch		
WmLo1	81	81
WmLo2	79	79
WmLo3	78	78
WmLo4	80	80
WmLo5	73	73
WmLo6	80	80
WmLo7	75	75
WmLo8	80	80
WmLo9	80	80
WmLo10	78	78
WmLo11	77	82
WmLo12	78	78
WmLo13	77	80
WmLo14	80	81
WmLo15	78	80
WmLo16	82	82

BASIN ID	CN (Base-Condition)	CN (Future-Condition)
WmLo17	82	82
WmLo18	78	80
WmLo19	79	79
Elwood-Wilson Drain		
ELW1	79	83
ELW2	74	83
ELW3	81	82
ELW4	79	85
ELW5	80	83
ELW6	84	93
ELW8	80	84
ELW9	75	86
ELW10	75	85

The effect of on-site detention storage as currently required by the Hamilton County ordinance was analyzed by modifying the future-condition hydrologic model to simulate this assumed storage condition.

In order to analyze this assumed storage condition, the unit discharge rate in cfs per acre (as it relates to storm event) for a typical developed subbasin was calculated. The unit discharge release rate for the 100-year event was calculated based on the 10-year base-condition (without depressional storage) discharge for the areas that are assumed would develop and drain through detention ponds, and the 100-year discharge for the areas that are assumed would not drain through detention ponds. The first step was to analyze a representative developed subbasin in the Stony Creek watershed. Subbasin 4 of the Elwood Wilson watershed was selected as a representative example. Based on aerial photographs of the area, approximately 70 percent of the watershed is developed and should drain through detention ponds, and 30 percent of the area has no detention. The peak 100-year discharge from the "detained" area was assumed to be the 10-year base-condition flow rate for that area, and the discharge from the "undetained" areas was assumed to be the base-condition 100-year flow rate.

A single-subbasin HEC-HMS hydrologic model was developed to calculate the 2, 10, 50, and 100-year discharges. The subbasin parameters were the same as those used for ELW 4 in the base-condition HEC-HMS model. Once the flow rates were calculated with this HEC-HMS model, they were divided by the drainage area to calculate the corresponding unit discharge release rates (discharge per acre). A representative 100-year unit discharge release rate for a typical developed subbasin was calculated by multiplying 70 percent of the area by the 10-year base condition unit discharge rate, 30 percent of the area by the 100-year base condition unit discharge rate, and then adding the results.

Similarly, a representative 10-year unit discharge release rate for a typical developed area was calculated by multiplying 70 percent of the area by the 2-year base condition unit discharge rate, multiplying 30 percent of the area by the 10-year base condition unit discharge rate, and adding the results.

The next step was to determine an equivalent storm frequency that would correspond with the two calculated unit discharge release rates. This was done by plotting the base-condition 2, 10, 50, and 100-year unit discharge release rates on logarithmic paper and drawing a best-fit line through the four points. Next, the two unit discharge release rates (10-year and 100-year) calculated based on 70 percent "detained" and 30 percent "undetained" were plotted to determine the equivalent storm frequency for each. Based on the results of this analysis, the 100-year unit discharge release rate was approximately equivalent to the unit discharge rate of the 25-year base-condition storm event, and the 10-year unit discharge release rate was approximately equivalent to the unit discharge rate of the 5-year base-condition storm event. A copy of these calculations is provided in **Appendix 19**.

To estimate the impacts of the on-site detention basins, i.e., assumed full development following the current Hamilton County Stormwater Ordinance requirements, the future-condition HEC-HMS model discussed earlier in this section was revised to include an on-site detention basin in each subbasin. The detention basins were modeled using the divert option in the HEC-HMS model to simulate the assumed on-site storage. The rating curve parameters required for the divert option were calculated using the assumption that the 10-year future-condition flow rate would be reduced to the 5-year base-condition flow rate, and the 100-year future-condition flow rate would be reduced to the 25-year base-condition flow rate. **Table 23** presents the existing-condition (with depressional storage) used for comparing the results, future-condition (no detention), and future-condition (on-site detention) flow rates. The HEC-HMS model output is included in Appendix 19.

Table 23
Comparison of Existing and Future 100-Year Flow Rates at Various Locations Assuming Current County Guidelines and Ignoring Depressional Storage

Location	Existing Condition (Depressional Storage) (cfs)	Future (No Detention and no Depressional Storage) (cfs)	Future (On-site Detention) (cfs)
Stony Creek			
County Line	1,210	2,200	1,735
Just Upstream of William Locke Ditch	1,390	2,350	1,850
Confluence of William Locke Ditch	2,120	3,480	2,700
186th Street	2,240	3,650	2,800
Just Upstream of William Lehr Ditch	2,460	4,020	3,070
Confluence of William Lehr Ditch	2,710	4,710	3,490
Just Upstream of Wheeler Drain	2,750	4,830	3,560
SR 37 (USGS Gage Location)	2,760	4,870	3,590
Mouth	2,850	5,060	3,720
William Locke Ditch			
East 211th Street	555	1,200	890
East 206th Street	625	1,420	1,090
Mouth	895	1,960	1,490
William Lehr Ditch			
Mouth	520	1,820	1,230
Wheeler-Wheeler Drain			
Mouth	105	400	250

Based on the results of this analysis, on-site detention in accordance with the current Hamilton County stormwater ordinance would result in increased peak flow rates over the existing condition (with depressional storage) along Stony Creek. The increased peak flow rates would result in increased flood elevations, and potentially increased flooding. Implementation of this component would result in no additional cost beyond the existing manpower costs required currently. However, each development would be required to provide on-site detention and ongoing maintenance of each detention facility. This analysis shows that additional detention, beyond what is currently required, should be considered to ensure existing flow rates would not be exceeded as the watershed continues to develop.

9.2 ADOPT UNIT DISCHARGE RELEASE RATES BASED ON EXISTING CONDITIONS

Candidate Plan Component 2 would provide regulatory unit discharge release rates that local regulators would use in reviewing proposed development plans, and that engineers would use in designing required on-site stormwater detention ponds. The current County development rules require all new development that increases runoff rates provide stormwater detention that releases post-developed 10-year and more frequent storm events at the pre-developed 2-year flow rate, and post-developed storm frequencies between the 10-year and 100-year at the pre-developed 10-year flow rate. Instead of the pre-developed 2-year and 10-year base condition flow rates being calculated by each applicant for each project, this component would provide allowable unit discharge release rates for geographic areas in the watershed. The unit discharge release rates were calculated using detailed hydrologic modeling based on the existing conditions (with depressional storage) in the entire watershed. The goal of this requirement is to ensure that existing peak flows would not increase with development. This component would apply to developments that would not drain to a regional stormwater detention pond.

Chapter 4 of this report presents the methodology and results of the hydrologic analysis of existing conditions. Table 10 presents the calculated existing-condition 2-year, 10-year, and 100-year unit discharge rates (cfs/acre) for each of the 83 subbasins that were delineated for the detailed analysis. Those proposed unit discharge rates were used to develop a revised hydrologic model of proposed conditions assuming the post-developed 100-year flow rate would be released at the existing-condition 10-year rate and the post-developed 10-year flow rate would be released at the existing-condition 2-year rate. That model shows major reductions in flow rates along Stony Creek would result with those proposed release rates. Since the goal of this alternative is to prevent increases in peak flow rates, and not to significantly reduce peak flow rates, the analysis was revised to calculate the impact of using higher allowable release rates assuming the post-developed condition 100-year is released at the existing-condition 100-year rate, and the post-developed condition 10-year is released at the existing-condition 10-year rate. The results of the original unit discharge rates (10-year and 2-year) along with this revised analysis and the existing-condition flow rates are presented in **Table 24**. A copy of the hydrologic model data and output from the HEC-HMS model is provided in **Appendix 20**.

Table 24
Comparison of Existing and Future 100-Year Flow Rates at Various Locations Assuming Allowable Unit Discharge Release Rates and Depressional Storage

Location	Existing Condition (cfs)	Future (reduce post 100 and 10-yr to existing 10 and 2-yr) (cfs)	Future (reduce post 100 and 10-yr to existing 100 and 10-yr) (cfs)
Stony Creek			
County Line	1,210	795	1,020
Just Upstream of William Locke Ditch	1,390	900	1,160
Confluence of William Locke Ditch	2,120	1,325	1,710
186th Street	2,240	1,370	1,770
Just Upstream of William Lehr Ditch	2,460	1,440	1,860
Confluence of William Lehr Ditch	2,710	1,570	1,940
Just Upstream of Wheeler Drain	2,750	1,570	1,940
SR 37 (USGS Gage Location)	2,760	1,580	1,940
Mouth	2,850	1,670	1,950
William Locke Ditch			
East 211th Street	555	400	530
East 206th Street	625	455	610
Mouth	895	620	810
William Lehr Ditch			
Mouth	520	560	560
Wheeler-Wheeler Drain			
Mouth	105	250	250

Based on the results of this analysis, on-site detention in accordance with the proposed allowable unit discharge release rates would result in somewhat decreased peak flow rates along Stony Creek. This component would provide consistent data to use for proposed development in areas not served by regional detention basins. It does not violate any of the criteria presented in Chapter 8 and would involve no additional costs to the County or City; it would save the cost of calculating (and reviewing) site-specific allowable release rates on a project-by-project basis. However, each development would be required to provide on-site detention and ongoing maintenance of each detention facility.

The recommended allowable unit discharge release rates for the areas in the watershed are shown on **Exhibit 10**. Some subbasins were combined to establish reasonable allowable unit discharge release rates for specific geographic areas in Hamilton County.

This analysis assumes that Madison County will also adopt the recommended allowable release rates for their portion of the watershed. Note that some subwatersheds are drained by existing tiles. Unit discharge release rates may be reduced from what is shown on Exhibit 10 in these areas, depending on the capacity of the existing tile. Additionally, several subwatersheds have issues due to limited cover over existing tiles, meaning the tile sizes would be limited to what is existing unless the area is filled sufficiently to provide room for a larger tile. These potentially reduced unit discharge release rates will be established on a case-by-case basis when the areas are proposed for development.

9.3 CONSTRUCT REGIONAL DETENTION PONDS IN EACH APPROXIMATELY 500-ACRE SUBWATERSHED

Candidate Plan Component 3 would provide regional detention ponds placed in most of the Hamilton County subwatersheds defined for the detailed hydrologic analysis. The main goal of this component would be to prevent significant increases in peak flow rates along Stony Creek with development of the watershed. The objective here would be to provide regional stormwater detention in lieu of requiring on-site detention ponds with each development. Developers would direct-release to a regional pond, or to a major flow conveyance that would carry stormwater to a regional pond.

The future-condition HEC-HMS model described in Section 9.1 was revised to simulate a single regional detention storage basin in appropriate subbasins. This was done by using the divert option for each of the proposed detention basins to reduce the future-condition 10-year flow rate to the existing-condition 10-year flow rate, and the future-condition 100-year flow rate to the existing-condition 100-year flow rate. A comparison of the existing-condition and regional pond condition 2, 10, and 100-year flow rates is presented in **Table 25**. A copy of the HEC-HMS output table is provided in **Appendix 21**.

Table 25
Comparison of Existing-Condition (With Depressional Storage) and Regional Pond Conditions

Location	Existing Condition			Regional Ponds		
	2-yr	10-yr	100-yr	2-yr	10-yr	100-yr
Stony Creek						
County Line	375	735	1,210	395	745	1,220
Just Upstream of William Locke Ditch	430	845	1,390	445	835	1,360
Confluence of William Locke Ditch	645	1,280	2,120	810	1,330	2,000
186th Street	675	1,350	2,240	880	1,420	2,110
Just Upstream of William Lehr Ditch	730	1,470	2,460	1,020	1,570	2,450
Confluence of William Lehr Ditch	790	1,610	2,710	1,230	1,830	2,760
Just Upstream of Wheeler Drain	800	1,630	2,750	1,270	1,930	2,950
SR 37 (USGS Gage Location)	800	1,640	2,760	1,270	1,960	2,990
Mouth	820	1,680	2,850	1,320	2,080	3,210
William Locke Ditch						
East 211th Street	160	325	555	310	415	590
East 206th Street	175	365	625	310	415	625
Mouth	250	520	895	485	785	1,210
William Lehr Ditch						
Mouth	115	280	520	275	340	565
Wheeler-Wheeler Drain						
Mouth	20	55	105	90	160	245

Based on this analysis, the regional pond alternative would ensure that future-condition flow rates would not significantly exceed existing-condition flow rates along Stony Creek. Additionally, developers would not have to build on-site detention ponds with each development, and the city and county would have control over each detention pond to ensure they are properly maintained so they function properly. Note that as currently modeled, the flow rates would increase in the William Locke Ditch and Wheeler-Wheeler Drain watersheds. Additional detention could be provided in the Locke watershed to further lower flow rates, but the main goal here was to maintain existing peak flow rates in Stony Creek, which would be achieved with this scenario. The Wheeler Drain watershed is assumed to be fully developed, and there are no good locations for upstream detention to lower flow rates along the ditch. The impact on Stony Creek is minimal.

This component would provide a total of 31 regional detention basins throughout the watershed. These basins would be constructed in lieu of on-site detention.

Developments would have to provide conveyance to the appropriate regional detention basin. It was assumed that no regional ponds would be built in the Wheeler-Wheeler and Elwood Wilson subbasins due to existing and imminent development in those areas.

The results of this analysis along with the estimated cost (assuming $40,000 per acre-foot of storage) are presented below for each major sub-watershed:

1. William Lehr Watershed – Seven basins ranging in size from about 45 acre-feet to 215 acre-feet. A total of about 625 acre-feet of storage would be provided. The estimated cost for each basin would range from about $1,800,000 to $8,600,000, with a total estimated cost of about $25,000,000.

2. William Locke Watershed – 13 basins ranging in size from about 19 acre-feet to 90 acre-feet, with one basin that would be about 260 acre-feet. A total of about 900 acre-feet of storage would be provided. The estimated cost for each basin would range from about $760,000 up to $10,400,000 for the largest basin. The total estimated cost for the Locke watershed is about $36,000,000.

3. Other Stony Creek Watersheds – 11 basins ranging in size from about 16 acre-feet to 108 acre-feet would be provided in the Ethel Ogle Michaels Shed, the Weaver and Hooke Shed, and two small unnamed sheds. A total of about 590 acre-feet of storage would be provided. The estimated cost for each basin would range from about $640,000 up to $4,320,000, with a total estimated cost of about $23,600,000.

The general location of each proposed regional pond is shown on **Exhibit 11**.

9.4 CONSTRUCT MAJOR FLOOD CONTROL BASINS

Candidate Plan Component 4 would provide large flood control basins in major subwatersheds. The main goal of this component would be to prevent significant increases in peak flow rates along Stony Creek with development of the watershed. Although flood control basins are typically designed to serve a multitude of purposes above and beyond their main flood control function and they do not typically affect the requirement for providing on-site detention by individual developers upstream or downstream of the facility, for this study it was assumed that no on-site detention would be required.

The future-condition HEC-HMS model described in Section 9.1 was revised to simulate a single flood control basin in the William Locke, Weaver and Hooke, and William Lehr subwatersheds. This was done by using the divert option for each of the proposed basins to reduce the future-condition 10-year flow rate to the existing-condition 10-year flow rate, and the future-condition 100-year flow rate to the existing-condition 100-year flow rate. A comparison of the existing-condition and flood control basin condition 2, 10, and 100-year flow rates is presented in **Table 26**. A copy of the HEC-HMS output table is provided in **Appendix 22**.

Table 26
Comparison of Existing-Condition (With Depressional Storage) and Major Flood Control Basin Conditions

Location	Existing Condition			Flood Control Basins		
	2-yr	10-yr	100-yr	2-yr	10-yr	100-yr
Stony Creek						
County Line	375	735	1,210	395	745	1,220
Just Upstream of William Locke Ditch	430	845	1,390	445	835	1,360
Confluence of William Locke Ditch	645	1,280	2,120	790	1,290	1,960
186th Street	675	1,350	2,240	860	1,390	2,150
Just Upstream of William Lehr Ditch	730	1,470	2,460	960	1,520	2,500
Confluence of William Lehr Ditch	790	1,610	2,710	1,090	1,680	2,720
Just Upstream of Wheeler Drain	800	1,630	2,750	1,120	1,730	2,810
SR 37 (USGS Gage Location)	800	1,640	2,760	1,130	1,760	2,830
Mouth	820	1,680	2,850	1,180	1,950	2,980
William Locke Ditch						
East 211th Street	160	325	555	360	705	1,160
East 206th Street	175	365	625	450	875	1,420
Mouth	250	520	895	620	1,190	1,950
William Lehr Ditch						
Mouth	115	280	520	540	985	1,550
Wheeler-Wheeler Drain						
Mouth	20	55	105	90	160	245

Based on this analysis, the flood control basin alternative would ensure that future-condition flow rates would not significantly exceed existing-condition flow rates along Stony Creek. Additionally, developers would not have to build on-site detention ponds with each development, and the city and county would have control over each flood control basin to ensure they are properly maintained so they function properly. Note that for this scenario, the flow rates would significantly increase along the streams in each subwatershed since the flood control basins would be built at the mouth of each stream. The main goal here was to maintain existing peak flow rates in Stony Creek, which would be achieved with this scenario. However, runoff for individual subbasins would increase, requiring stream modifications and/or additional intermittent ponds in some areas.

This component would provide a total of three flood control basins. These basins would be constructed in lieu of on-site detention, saving developers that cost. Developments

or the County/City would have to provide conveyance to the appropriate flood control basin which would result in significant additional construction and ongoing maintenance costs beyond the cost of the flood control basins. It was assumed that no flood control basins would be built in the Wheeler-Wheeler and Elwood Wilson subbasins due to existing and imminent development in those areas.
The results of this analysis along with the estimated cost (assuming $40,000 per acre-foot of storage) are presented below for each flood control basin:

1. William Lehr Watershed – Approximately 710 acre-feet of storage would be provided. The estimated cost for this basin would be about $28,400,000.

2. William Locke Watershed – Approximately 1010 acre-feet of storage would be provided. The estimated cost for this basin would be about $40,400,000.

3. Weaver and Hooke Watershed – Approximately 360 acre-feet of storage would be provided. The estimated cost for this basin would be about $14,400,000.

The general location of each proposed flood control basin is shown on **Exhibit 12**.

9.5 ADD STONY CREEK AND WILLIAM LOCKE DITCH TO HAMILTON COUNTY REGULATED DRAIN ROLLS AND IMPLEMENT AN ONGOING MAINTENANCE PROGRAM

Candidate Plan Component 5 would add the full reach of Stony Creek and the William Locke Ditch to the county regulated drain rolls to implement an ongoing stream maintenance and debris removal (e.g., logjams, felled trees, trash, etc.) program for each stream. Stony Creek is not currently a regulated drain; William Locke Ditch is a regulated drain, but no maintenance fees are being collected. **Exhibit 13** shows the limits of each stream.

Stony Creek is the ultimate outlet of every part of the Stony Creek watershed. Although most of the creek is in relatively good shape, there are some sandbars, logjams, and locations of channel bank erosion that will likely get worse without channel maintenance. If Stony Creek does not flow properly, none of the other streams and laterals in the watershed will flow properly. Officials from Hamilton County and the City of Noblesville, as well as several residents, suggested adding Stony Creek as a regulated drain to allow the County Surveyor to fix the existing problems and perform ongoing maintenance to prevent future problems as the watershed continues to develop.

William Locke Ditch drains the northeast portion of the watershed and is the outlet for several other regulated drains. Since no maintenance fees are being collected, there is no ongoing maintenance program. Residents requested that maintenance be completed on the ditch downstream of 211th Street to remove existing logjams, sandbars, and other areas of sediment accumulation and vegetation. Without ongoing

maintenance, the stream will continue to degrade exacerbating flooding problems along the stream and in storm drain systems that outlet into the ditch.

Ongoing maintenance of the streams by the Hamilton County Surveyor's Office on an annual basis would be an effective way of preventing logjams and other obstructions to flood flows. Such obstructions often cause higher flood stages (especially during smaller, more frequent floods), result in increased sedimentation, and promote additional stream bank erosion. By removing the logjams, felled trees, and general garbage (such as tires and other debris that typically ends up in major ditches) from the streams annually, the need for extensive stream restoration work can be significantly reduced.

Annual stream cleanup and maintenance activities would reduce the potential impacts from existing and future logjams. Logjams can aggravate bank erosion and also induce higher future flood stages than the unobstructed waterway. According to results of a hydraulic analysis performed by CBBEL for a pilot stream reach in another part of the state, removal of larger logjams from the channel can often be just as effective as a large-scale river restoration project in reducing future increases in potential flood damages. Such maintenance activities cost much less than large-scale river restoration projects, have less negative impacts on the environment, and usually do not involve a long and drawn out permit process. Adding Stony Creek and William Locke Ditch to the county regulated drain rolls and ongoing maintenance of the streams is therefore recommended as a master plan component.

The first "maintenance" project(s) on these streams would likely be extensive since no maintenance work has been done in many years. However, once the initial work is completed, ongoing annual maintenance would be effective in maintaining proper flow carrying capacity. The initial work on the streams should focus on those areas identified during a detailed study of the streams as causing the greatest flooding problems. One specific problem noted along Stony Creek is a large sandbar located at the Greenfield Avenue crossing. After completion of the initial maintenance, the annual maintenance would focus on specific sites identified during inspections of the streams. The estimated cost associated with the first "maintenance" project(s) is approximately $50,000 for Stony Creek and approximately $25,000 for William Locke Ditch. These costs were based on similar ditch maintenance completed on other regulated drains in Hamilton County. In addition to these costs, the annual cost of ongoing maintenance is estimated to be in the range of $20,000 for Stony Creek and $10,000 for William Locke Ditch, also based on annual costs associated with similar streams in Hamilton County.

9.6 CONTINUE ONGOING MAINTENANCE OF REGULATED DRAINS IN THE WATERSHED

Candidate Plan Component 6 would provide for the continuation and improvement of ongoing ditch maintenance (e.g., bottom dipping, weed control, etc.) and debris removal (e.g., logjams, felled trees, trash, etc.) programs for all regulated drains within the Stony Creek Watershed. The objective of this plan would be to relieve localized drainage

backups and prevent future reductions in the conveyance capacity of drainage ditches by maintaining the original cross sectional area and roughness characteristics of these ditches.

Although ongoing maintenance activities would not normally alleviate serious overbank flooding problems, they can enhance the functioning of local drainage networks. Such periodic maintenance activities also prevent logjams and other obstructions to flow. Each stream should be inspected annually, and maintenance work completed on an as-needed basis to prevent relatively minor problems, i.e., small logjams, trash, and other debris, from causing major problems requiring extensive and expensive reconstruction efforts.

As indicated in Chapter 2 of this report, the Hamilton County Surveyor's Office already has a maintenance program and expends a significant sum of money on maintenance work every year. The inclusion of this activity as an essential component of the Stony Creek Watershed Master Plan is therefore intended to stress the need for continuation of the existing program.

The cost associated with this recommendation would vary based on the type of maintenance required but should be in the range of several thousand dollars per year, per drain. However, ongoing maintenance would reduce the need for large-scale ditch reconstruction, saving money in the long run.

9.7 IMPLEMENT THE RECOMMENDED WATER QUALITY BMPs TO ADDRESS PHASE 2 REQUIREMENTS

Candidate Plan Component 7 would implement the recommended water quality BMPs that were presented in Chapter 6. The objective of the recommended BMPs was to improve water quality, which is required under the NPDES Phase II program.

The recommended water quality BMPs will address multiple requirements of the Hamilton County's NDPES Stormwater Phase II requirements. There are ten recommended BMPs for this study that are consistent with the Phase II requirements. The ten recommended BMPs are as follows:

A. Exclusionary fencing of cattle from streams and streambanks,

B. Restoration of eroded streambanks and riparian areas,

C. Implementation of manure management techniques,

D. Implementation of conservation tillage, nutrient management and conservation buffers upon croplands

E. Utilization of erosion and sediment control (ESC) practices upon construction sites,

F. Utilization of post-construction BMPs such as retention and detention basins upon developing and re-developing areas,

G. Maintenance of conveyances, especially around existing bridges,

H. Maintenance of stream channels by removing muck and some large woody debris,

I. Promotion of Low Impact Development, and

J. Conduct a study to determine the actual amount of imperviousness within the watershed.

The "strategies" will be implemented as part of the upcoming Rule 13 requirements for designated MS4 communities to develop a Stormwater Quality Management Plan (SWQMP). Sediment control basins, streambank stabilization, and stream maintenance are all part of the overall Hamilton County Stormwater Master Plan. Public education and outreach are already being done and this will continue as the Hamilton County Surveyor's Office develops the Rule 13 SWQMP for the unincorporated areas of Hamilton County. The Hamilton County Surveyor's Office has already initiated communication with the various municipalities in the County regarding the SWQMP and is currently pursuing a cooperative effort with regard to public education and outreach; this should continue.

9.8 MAINTAIN THE CURRENT USGS STREAM GAGE ON STONY CREEK AND ADD ADDITIONAL GAGES AT KEY LOCATIONS IN THE WATERSHED

Candidate Plan Component 8 would have the County coordinate with the USGS to ensure the existing stream gage located at the SR 37 crossing of Stony Creek is maintained, and that additional gages be added in the watershed.

Based on the review of the watershed, it is recommended that additional stream gages be installed at the Fishersburg Avenue and Atlantic Road crossings of Stony Creek, and also at the 196th Street crossing of the William Locke Ditch. These stream gages would provide ongoing data regarding stream flow that can be used in the future to update hydrologic analyses of the watershed, and also to evaluate impacts of various projects in the watershed.

The cost to the County for each gage would be approximately $10,000 for the initial installation and an additional $5,000 per year for maintenance. The total cost of this component would be approximately $30,000 with ongoing annual maintenance costs of about $15,000.

9.9 REVISE THE HYDRAULIC MODELING OF STONY CREEK USING UPDATED HYDROLOGY AND COUNTY CONTOUR MAPPING; EXTEND THE HYDRAULIC MODEL UPSTREAM TO THE COUNTY LINE

Candidate Plan Component 9 would update and correct the existing hydraulic modeling for Stony Creek. The objective of this plan is to provide a more accurate hydraulic model that reflects the actual existing conditions along the stream and to extend the hydraulic model upstream to the county line.

Currently, the flow rates used in the FIS modeling are based on the IDNR Coordinated Discharge Curves for Stony Creek, as discussed in Chapter 4. However, the stream gage analysis for the Stony Creek gage, also discussed in Chapter 4, shows a significantly lower 100-year peak discharge may be appropriate.

In addition to the questionable flow rates, several permits have been issued along Stony Creek and should be included in the updated regulatory modeling. The effective Stony Creek model extends from the confluence with the White River to the downstream face of 186th Street, which is approximately 6.3 miles. The model should be extended approximately 4 stream miles upstream to the county line in order to calculate the 100-year flood elevations and delineate the floodplain and floodway limits for the entire reach of Stony Creek within Hamilton County. The Hamilton County 2-foot contour interval topographic mapping should be used for this updated analysis.

The cost associated with this recommendation would include the engineering required to develop the hydraulic model, survey cost, and any cost associated with the map revisions. Based on average cost estimates for this type of work, the cost per mile of detailed study of stream ranges from about $10,000 to $15,000 per stream mile. Based on this cost estimate and noting that there are about 10 stream miles, the cost may be as much as $100,000 to $150,000. This work would be appropriate for completion as part of the County's Cooperative Technical Partner (CTP) agreement currently being pursued with FEMA so that the associated costs may be shared between the County and FEMA.

9.10 COMPLETE HYDRAULIC ANLAYSIS AND FLOODPLAIN/FLOODWAY MAPPING OF UNSTUDIED MAJOR STREAMS IN THE STONY CREEK WATERSHED

Candidate Plan Component 10 would include developing detailed hydraulic modeling for unstudied major streams in the Stony Creek watershed, specifically William Locke Ditch, Weaver and Hooke Ditch, Ethel Ogle Michaels Ditch, Harvey Gwinn Ditch, and James I. Teter Ditch. The objective of this plan is to provide 100-year flood elevations and floodplain and floodway limits for the major streams in the watershed. The approximate limits of the streams proposed for detailed study are shown on **Exhibit 15**.

The flood elevations and floodway limits would be used to regulate development within the current flood prone areas and reduce the impact the development would have on any existing flooding problems. It would also help eliminate future flooding problems.

The modeling and mapping would need to be approved by IDNR and FEMA in order to add the floodplain maps. The cost associated with this recommendation would include the engineering required to develop the hydraulic model, survey cost, and any cost associated with the map revisions. Based on average cost estimates for this type of work, the cost per mile of detailed study of stream ranges from about $10,000 to $15,000 per stream mile. Based on this cost estimate and noting that there are about 15 stream miles, the cost may be as much as $150,000 to $225,000. This work would be appropriate for completion as part of the County's Cooperative Technical Partner (CTP) agreement currently being pursued with FEMA so that the associated costs may be shared between the County and FEMA.

9.11 ENLARGE EXISTING STREAM CROSSINGS TO CONVEY THE FULL 100-YEAR FLOW WITH NO ROAD OVERTOPPING

Candidate Plan Component 11 would include raising the public roadway elevations and enlarging each stream crossing that the hydraulic modeling shows would be overtopped during the 100-year flood event. The purpose of this alternative is to bring the crossings into compliance with the County requirements.

Based on preliminary CBBEL modifications to the IDNR FIS model for Stony Creek that added permitted work in the floodway, the following bridge would be overtopped during a 100-year flood event:

- Chapel Road

Based on the IDNR FIS model for the Elwood Wilson Drain, the following bridges or roadways would be overtopped during a 100-year flood event:

- South Street
- Pleasant Street
- 16th Street
- Firestone Street
- 19th Street

In addition, the new hydraulic analysis for William Lehr Ditch and Wheeler-Wheeler Drain, as presented in Chapter 5, shows the following bridges or roadways would be overtopped during a 100-year flood event:

For William Lehr Ditch:

- State Road 238

- 156th Street
- 166th Street
- private crossing at the stone quarry

For Wheeler-Wheeler Drain:

- Fox Drive
- Cumberland Avenue north of Greenfield Avenue (low area in road, not a crossing)
- Two private drives
- Eight pedestrian bridges

Additional stream crossings and low areas would likely be identified during the detailed study of the streams recommended with component 10. The Hamilton County requirements apply to public roadways and crossings but not private drives and pedestrian bridges. Therefore, the private drives and pedestrian bridges would not need to be revised to convey the 100-year flood event. The other crossings should be modified to comply with County requirements.

9.12 ALLOW NO DEVELOPMENT WITHIN THE LIMITS OF THE FLOODPLAIN

Candidate Plan Component 12 would prevent future development from taking place within the limits of the floodplain. The objective of this component would be to maintain the current natural floodplain storage and associated natural peak flow rate reduction, and also reduce the flooding problems that can occur with structures built within the floodplain limits. Additionally, natural riparian corridors along the streams would be maintained, enhancing environmental benefits. This component would require the floodplain limits be established for each stream in the watershed that is not currently mapped. This could be done on a county wide basis through county-funded mapping projects, or case-by-case by developers as they propose developing property within the watershed. In some cases where this "no-disturb" alternative would not be practical, a form of "no net loss of floodplain storage" policy could be adopted where any fill placed in the floodplain would be compensated with an equivalent or larger amount of excavation within the project area.

Although a "no-disturb" floodplain policy would ensure the integrity of the floodplain and its habitat, this component would result in many acres of land that could be developed under current guidelines being declared undevelopable. Consequently, property values for affected parcels would be reduced. Property owners/developers would undoubtedly be opposed to such a requirement.

10.0 FINAL SCREENING OF PROMISING SOLUTIONS

Based on the detailed evaluation of the 12 short-listed alternatives discussed in the previous chapter, several alternatives are recommended as components of the Stony Creek Watershed Master Plan. **Table 27** provides a summary for the final screening of the short-listed alternatives and whether they were recommended as components of the Master Plan.

Table 27
Comparison of the Short-listed Alternatives

ID	DESCRIPTION	ADVANTAGES	DISADVANTAGES	RECOMMEND?
1	Continue strict enforcement of current requirements for on-site detention	• No additional cost county for implementation. • Provides a uniform approach to control of development in the floodplain. • Can be implemented immediately.	• Would result in increased peak flow rates along Stony Creek, resulting in potentially increased flooding. • Each development required to provide on-site detention and ongoing maintenance.	Yes*
2	Adopt the allowable unit discharge release rates based on existing conditions	• Ensures existing-condition flow rates do not increase. • Provides consistent data to use for proposed development. • Reduces the cost of calculating allowable release rates on a project by project basis.	• Each development required to provide on-site detention and ongoing maintenance.	Yes
3	Construct regional detention ponds in each approximately 500-acre subwatershed	• Future-condition flow rates would not significantly exceed existing conditions. • Developers would not have to provide on-site detention and ongoing maintenance. • City and County would have control over each pond to ensure ongoing proper maintenance and function. • Potential water quality and recreational opportunities. •	• Overall cost is very high. • Projects would likely have to be funded (at least initially) by City or County. • Developers would have to provide conveyance facilities to the appropriate pond(s).	Yes
4	Construct major flood control basins	• Future-condition flow rates would not significantly exceed existing conditions. • Developers would not have to provide on-site detention and ongoing maintenance. • City and County would have control over each pond to ensure ongoing proper maintenance and function. • Potential water quality and recreational opportunities.	• Cost of each basin is very high (ranging from $7.2 to $20.2 million) • Projects would have to be funded by City or County. • Major infrastructure improvements would be required to convey stormwater to the basins. • Flow rates along streams would significantly increase, requiring additional stream modifications or intermediate ponds.	No

ID	DESCRIPTION	ADVANTAGES	DISADVANTAGES	RECOMMEND?
5	Add Stony Creek and William Locke Ditch to the Hamilton County Surveyor Regulated Drain rolls	• Removes obstructions to flow that increase flood elevations and potential damages. • Provides fund source and access rights for maintaining conveyance along the streams • Improves outdoor recreation possibilities and aesthetics. • Prevents need for extensive restoration work.	• Initial work could be costly. • Increases workload on County Surveyor staff.	Yes
6	Continue ongoing maintenance of regulated drains in the watershed	• Removes obstructions to maintain proper flow conveyance in main channels. • Helps ensure proper function of local drainage systems outletting into regulated drains. • Prevents need for future extensive ditch reconstruction projects.	• Costs up to several thousand dollars per year, per drain.	Yes
7	Implement the recommended water quality BMPs presented in Chapter 6	• Addresses multiple requirements of the NPDES Stormwater Phase II requirements. • Provides a healthier aquatic ecosystem for the watershed. • Minimizes the introduction of new or increased pollutant loads to the streams.	• Some strategies could be expensive and time consuming. • Requires on-going maintenance.	Yes
8	Maintain the current USGS stream gage on Stony Creek and add additional gages at key locations in the watershed	• Provide ongoing data regarding stream flow that can be used in the future to update hydrologic analyses. • Data would be used to evaluate impacts of various projects in the watershed. • USGS shares cost of the gages and the ongoing maintenance costs.	• Local share of initial cost of about $10,000 per gage plus ongoing maintenance costs of about $5,000.	Yes
9	Revise the hydraulic modeling of Stony Creek using updated hydrology and county contour mapping; extend the hydraulic model upstream to the county line	• Model would be based on more accurate (lower) flow rates. • Model would include the construction that has taken place in the floodway. • Model would be based on latest contour data from county mapping. • Would provide accurate floodplain and floodway mapping for entire stream reach. • Analysis and mapping could be at least partially funded from CTP program.	• Detailed study/restudy could cost $10,000 to $15,000 per mile of studied stream.	Yes

ID	DESCRIPTION	ADVANTAGES	DISADVANTAGES	RECOMMEND?
10	Complete hydraulic analysis and floodplain/ floodway mapping of unstudied major streams in the Stony Creek watershed	• Would provide accurate floodplain and floodway mapping for each stream. • Mapping would be used to regulate development within current flood-prone areas and reduce the impact of development on any existing flood problems. • Analysis and mapping could be at least partially funded from CTP program.	• Detailed study/restudy could cost $10,000 to $15,000 per mile of studied stream.	Yes
11	Enlarge existing stream crossings to convey the full 100-year flow with no road overtopping	• Would eliminate road overflow at the undersized stream crossings, bringing crossings into compliance with county requirements. • Could lower flood elevations immediately upstream of the crossings. • This could be done as bridges are replaced in the future.	• Very expensive depending on the location and amount of work required. • Although flood elevations would be slightly lower with larger crossings, the extent of lowering would typically be limited and the benefit would not be commensurate with the cost.	No**
12	Allow no development within the limits of the floodplain	• Maintain the current natural floodplain storage. • Reduce the flooding problems that occur with structures built in the floodplain limits. • Would not increase the Base Flood Elevations for the streams.	• Restricts the amount of land that could be developed. • Could reduce the amount of economical growth within the watershed. • Would require additional enforcement of the ordinances.	Yes

* This alternative is recommended, but under current guidelines, there is the potential of increased flow rates with development. Therefore, it is recommended that the county adopt unit discharge release rates for areas throughout the watershed, as recommended with component #2.

** This alternative is not recommended for the County Drainage Board and Surveyor's office to undertake. However, assistance could and should be provided to the County Highway Department in setting priorities for bridge replacements. A list of bridges and portions of road that would be inundated during a flood event should be provided to the highway department.

11.0 FUNDING CONSIDERATIONS

This master plan presents several proposed components. The components include modifying ordinances, implementing water quality BMPs, performing ongoing maintenance of existing and potentially additional regulated drains, constructing regional ponds, adding stream gages, and preparing floodplain and floodway maps. Funding considerations for each are presented below:

- Modifying ordinances to include the recommended unit discharge release rates would likely be completed using existing City/County resources for staff time required to complete the modifications.

- Implementing water quality BMPs would be funded along with the City's and County's NPDES Phase 2 program. There are also a variety of grants that could be pursued, including the 319 grant that the Surveyor is currently pursuing through the IDEM. The EPA also funds a grant program called "The Watershed Initiative" that has a goal of protection and restoration of the country's water resources. Components of this master plan may qualify for this type of grant.

- Ongoing maintenance of County regulated drains will continue to be funded with the maintenance assessments collected in each regulated drain watershed.

- The construction of regional ponds could be funded by the County of City, but more likely by developers in the watersheds that would be tributary to each pond. The project could be initially funded by the City or County, then paid off with assessments as the tributary watershed develops. Alternatively, a developer could fund the initial construction then be partially reimbursed with assessments with additional development of the watershed.

- Stream gages would be partially funded by the USGS with the County required to pay half the initial installation cost and ongoing annual maintenance. Funds for the stream gages would likely not be eligible for any grant funding.

- Floodplain and floodway maps may be partially funded through development of cooperative agreements between FEMA, IDNR, and the County through FEMA's Cooperating Technical Partner (CTP) program. The County Surveyor is currently pursuing a CTP agreement with FEMA and the IDNR.

12.0 CONCLUSIONS AND THE PROPOSED IMPLEMENTATION PLAN

This chapter presents a summary of conclusions and recommendations of the study and a prioritized list of recommended actions for implementing the recommended plan components.

12.1 CONCLUSIONS

The overall conclusion of this study is that the extent of existing flooding problems in the Stony Creek watershed is relatively small. Some streambank erosion and sediment build up were identified along with some local flooding problems. But overall, the watershed has relatively minimal flooding problems. However, based on an assessment completed as part of this study, there are existing water quality problems and also concerns regarding potential future problems that may result from development if no mitigating actions are taken.

Hamilton County is growing rapidly and there are recognized potential impacts of flooding and further reduced stormwater quality that can be caused by continued, improperly regulated development within the watershed. This master plan focused on alternatives to minimize existing flooding and stormwater quality concerns, as well as addressing potential stormwater problems that could accompany future development.

An array of suggestions and promising alternatives was identified through information gathered during public meetings held in the early project stages and during ongoing meetings with local officials, and also based on experience with similar studies developed by CBBEL for other watersheds in Hamilton County and in other parts of Indiana. These suggested alternatives were evaluated against the study criteria and constraints. Based on the preliminary screening process, a short-list of 12 possible master plan components was developed. The short-listed Candidate Plan Components were subjected to a more detailed evaluation of hydraulic effectiveness, economic advantage, institutional impacts, and environmental feasibility. Based on the results of this detailed screening process, 10 are recommended for adoption as recommended plan components. They are presented below in the Proposed Implementation Plan.

With respect to runoff quantity control, it is the recommendation of this study for the City of Noblesville and Hamilton County to assist and encourage potential developers seeking development within the Stony Creek Watershed to design and construct multi-purpose regional ponds within sub-watersheds shown in Exhibit 11 through forming private-public partnerships. When construction of such a large-scale project is not feasible for an area, the developers should be required to construct sub-regional detention ponds that would control all on-site and off-site runoff upstream of the site. In the latter case, the County and the City of Noblesville should assist these developers with arrangements that would make it possible for these developers to recoup a part of their expenses from the upstream developers, who would no longer be required to provide on-site detention. When it is not feasible or practical to construct regional or sub-regional ponds for an area, on-site detention ponds should be required. The noted

regional ponds, sub-regional ponds, and on-site detention ponds should all be sized according to unit discharge release rates provided in Exhibit 10. When two or more sub-watersheds are affected, an area-weighted average unit discharge release rate should be calculated.

As in most planning processes, stormwater Master Planning is a dynamic process. Successful implementation of this plan will be contingent upon its accuracy and validity at the time of implementation. The Stony Creek Watershed Stormwater Master Plan will need to be regularly updated to reflect the changed circumstances occasioned by additional data, new regulations, funding considerations, new policy directions, and experience gained in the initial stages of plan implementation.

12.2 PROPOSED IMPLEMENTATION PLAN

The following Master Plan components are recommended for adoption. They are presented for implementation generally in the order of highest priority to lowest priority:

1. **Adopt the allowable 100-year and 10-year unit discharge release rates calculated with this Master Plan for each subwatershed:**

   - Formally adopt the unit discharge release rates shown on Exhibit 10 and strictly enforce their use for future development projects.

   - Update County and City ordinances to include the appropriate unit discharge release rates.

   - The allowable release rate for proposed developments in each subwatershed should be calculated by multiplying the natural drainage area of the watershed within the proposed development area that is tributary to the stream by the appropriate unit discharge release rate. The entire development proposed to drain to a stream should be designed to release at that calculated allowable release rate. For example, if an 80-acre subdivision is proposed for development, and the entire 80 acres will drain to the stream, but the pre-development area that drains naturally to the stream is only 65 acres and the unit discharge release rate for that subwatershed area is 0.24 cfs per acre, then the allowable release rate for the 80-acre subdivision should be calculated as:

65 acres x 0.24 cfs per acre = 15.6 cfs

The additional 15 acres being diverted into the watershed should not result in an increased allowable discharge. In this same example, if the entire 80-acre area does drain to the stream in the pre-developed condition, but the 15 acre portion has a unit discharge release rate of 0.15 cfs per acre, then the allowable release rate for the entire 80-acre subdivision would be calculated as:

(65 acres x 0.24 cfs/acre) + (15 acres x 0.15 cfs/acre) = 17.9 cfs

2. **Continue strict enforcement of drainage ordinance requirements for on-site detention with new development:**

   - Coordinate City and County ordinance requirements regarding on-site detentions for new developments to ensure consistency in the watershed.
   - Add the appropriate unit discharge release rates, as explained in Component 1.

3. **Implement the recommended water quality BMPs presented in Chapter 6:**

   - Continue pursuing a cooperative effort with regard to public education and outreach.
   - Continue analyses of water quality issues through 319 grant funding and other ongoing grant funding that may be available.
   - Develop programs and guidelines to fund the water quality BMPs.
   - Develop specific priorities based on the need and required permits (if any).
   - Continue monitoring water quality and compliance with requirements in the watershed.

4. **Allow no development within the floodplain limits:**

   - Strictly enforce this existing requirement of the Hamilton County Surveyor's office.
   - Use existing regulatory floodplain maps (FEMA or IDNR-approved) if they exist. If no regulatory floodplain maps exist, require developers to prepare and submit floodplain maps based on modeling completed in accordance with IDNR Hydraulic Modeling Guidelines. Note that IDNR will require this anyway

for development along streams that are in their jurisdiction (with drainage areas greater than one square mile.)

5. **Continue ongoing maintenance of regulated drains in the watershed:**

   - Develop priorities based on the need, severity of logjam, obstruction, or other problem, easement requirements, and required permits (if any).
   - Continue with ongoing maintenance activities according to the developed priorities, as funds allow.

6. **Add the full reach of Stony Creek, and Locke Ditch downstream of 211th Street to the Hamilton County Surveyor Regulated Drain rolls for ongoing maintenance:**

   - Develop programs and guidelines to fund the maintenance and debris removal activities.
   - Develop priorities based on the need, severity of logjams and debris, and required permits (if any).
   - Apply and receive any necessary permits.
   - Continue ongoing maintenance and debris removal activities according to the developed priorities, as funds allow.

7. **Construct regional detention ponds:**

   - Regional ponds should be considered as shown on Exhibit 11 in areas where a regional approach is desired either by the County/City, or by developers.
   - In areas that would be served by a regional pond, the unit discharge release rates would not apply. All parts of the area tributary to the pond would discharge directly to the pond. The developer would be required to provide proper stormwater conveyance (storm drains) sized to have capacity for the 100-year discharge.
   - Regional ponds should be sized in accordance with the hydrologic modeling and methodology developed for this master plan. The ponds should be designed to ensure existing-condition flow rates for the watershed tributary to the pond are not exceeded for the 2-year, 10-year, and 100-year events.

8. **Maintain the current USGS stream gage and add additional gages at key locations in the watershed:**

   - Contact the USGS to coordinate the addition of the recommended additional gages.
   - Construct new gages at Atlantic Road crossing of Stony Creek, and also at the 196th Street crossing of William Locke Ditch.

9. **Revise hydraulic modeling of Stony Creek using updated hydrology and county contour mapping; extend the hydraulic model upstream to the county line:**

   - Collect and review existing hydrologic and hydraulic modeling for the streams.
   - Perform detailed survey for required road crossing and other needed cross section locations.
   - Develop a new hydraulic model for the entire stream in Hamilton County, in accordance with the IDNR Hydraulic Modeling Guidelines and FEMA criteria.
   - Prepare the revised flood hazard mapping.
   - Submit to IDNR and FEMA for approval.

10. **Complete the hydraulic analysis and floodplain/floodway mapping of unstudied major streams in the Stony Creek watershed:**

    - Develop mapping for William Locke Ditch, Weaver and Hooke Ditch, Ethel Ogle Michaels Ditch, Harvey Gwinn Ditch, and James I. Teter Ditch.
    - Perform detailed survey for required road crossing and other needed cross section locations.
    - Develop required hydraulic modeling for each stream.
    - Prepare the flood hazard mapping.
    - Submit to IDNR and FEMA for approval.

13.0 REFERENCES

1. Camiros, LTD., Comprehensive Master Plan for the City of Noblesville, Indiana, November 1995.

2. DLZ Indiana, LLC, Elwood Wilson Drainage Basin Study, Revised December 12, 2002.

3. Federal Emergency Management Agency, Flood Insurance Study, Hamilton County and Incorporated Areas, February 19, 2003.

4. Office of Hamilton County Surveyor, Regulated Drain Map (Preliminary), April 1, 2003.

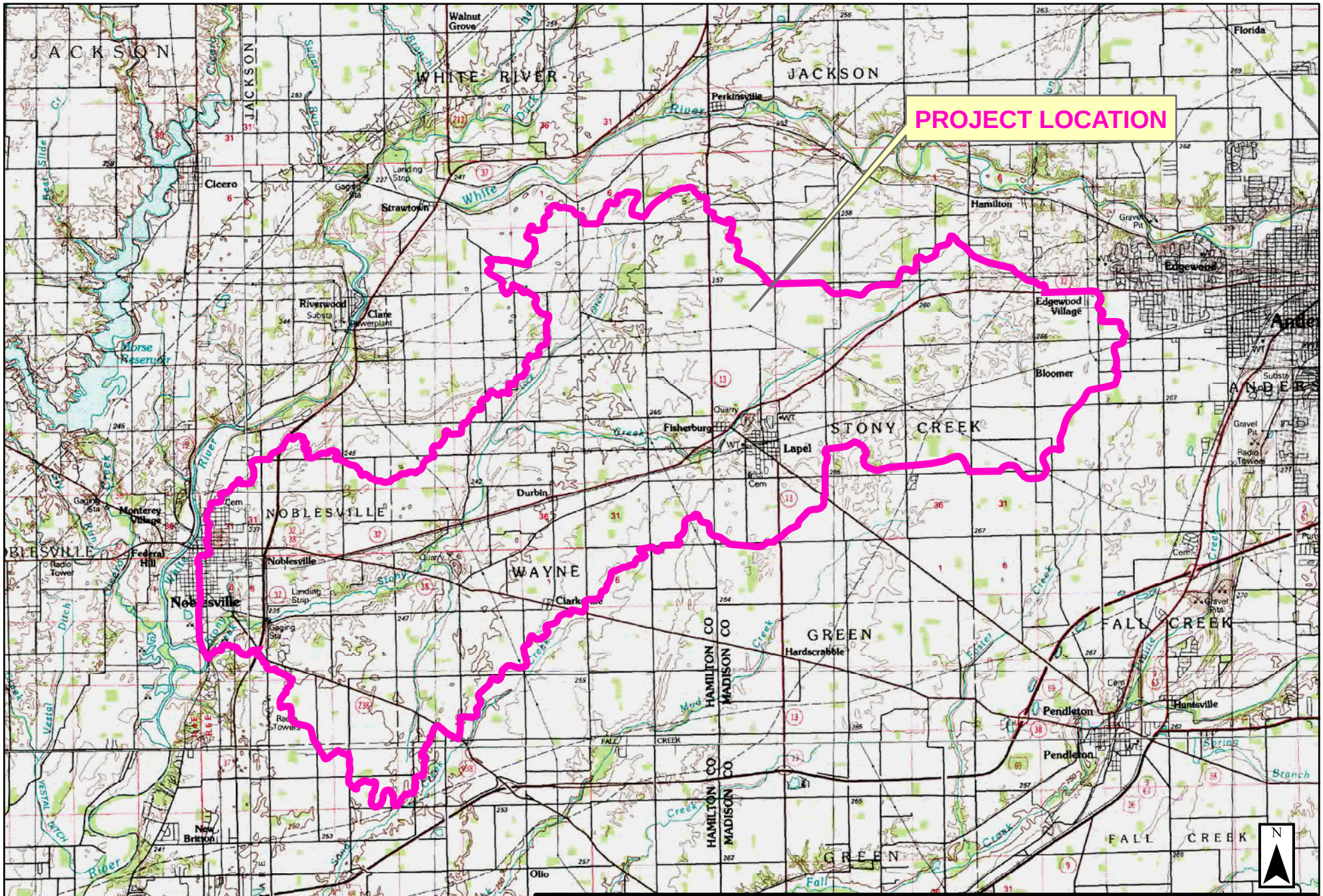
5. Office of Hamilton County Surveyor, Wayne Township Zoning, Revised May 12, 1998.

6. Office of Hamilton County Surveyor, White River Township Zoning, Revised September 9, 2002.

7. Office of Madison County, Official 2002 Madison County Zoning Map, Effective July 15, 2002.

8. U.S. Department of Agriculture, Soil Conservation Service, Soil Survey of Hamilton County, Indiana, 1978.

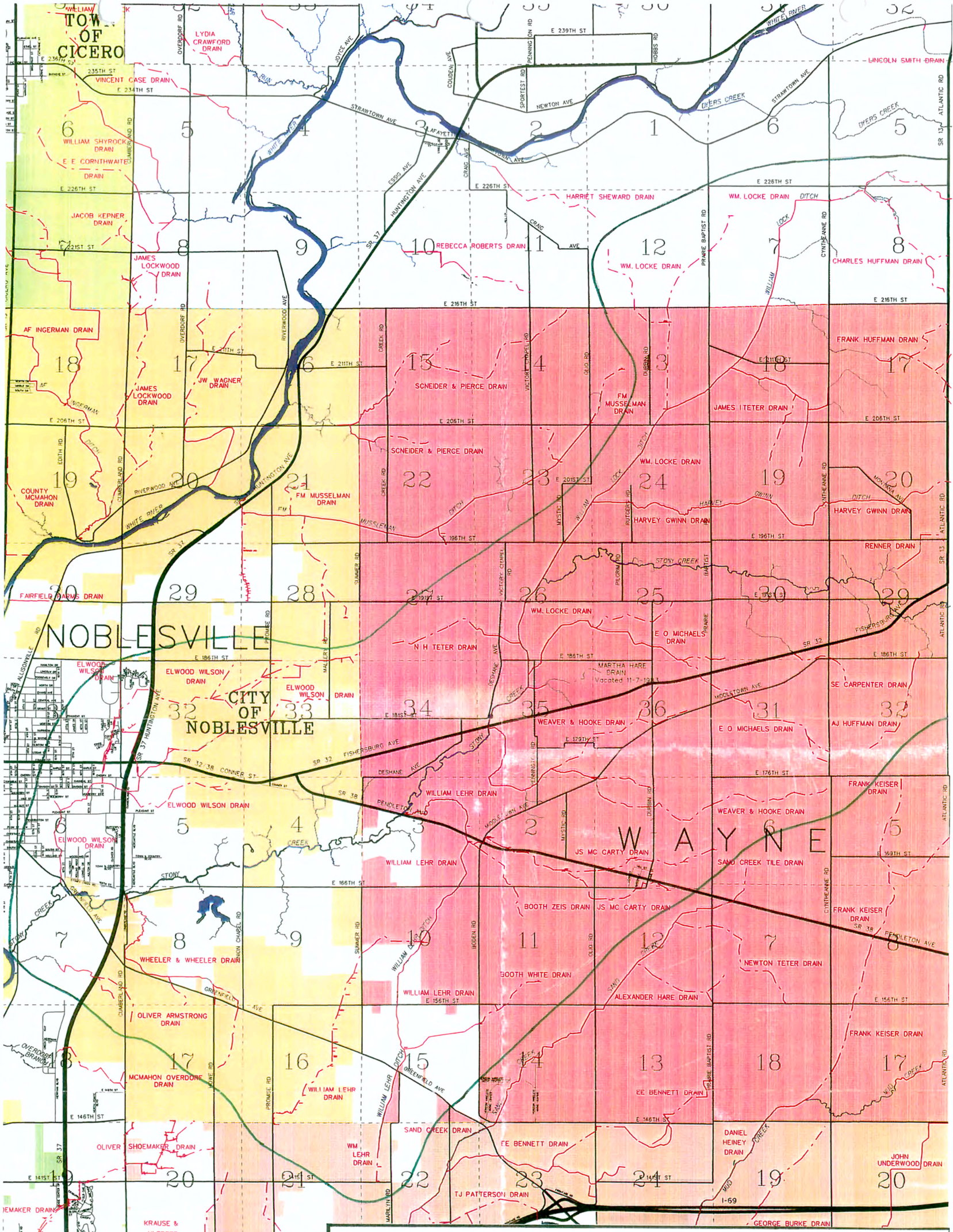
9. U.S. Geological Survey, 1:24,000 Quadrangle Maps (several).



Base Map Source: USGS 1:100,000 Quadrangle Maps: Greensburg, Indianapolis, Lafayette, Muncie

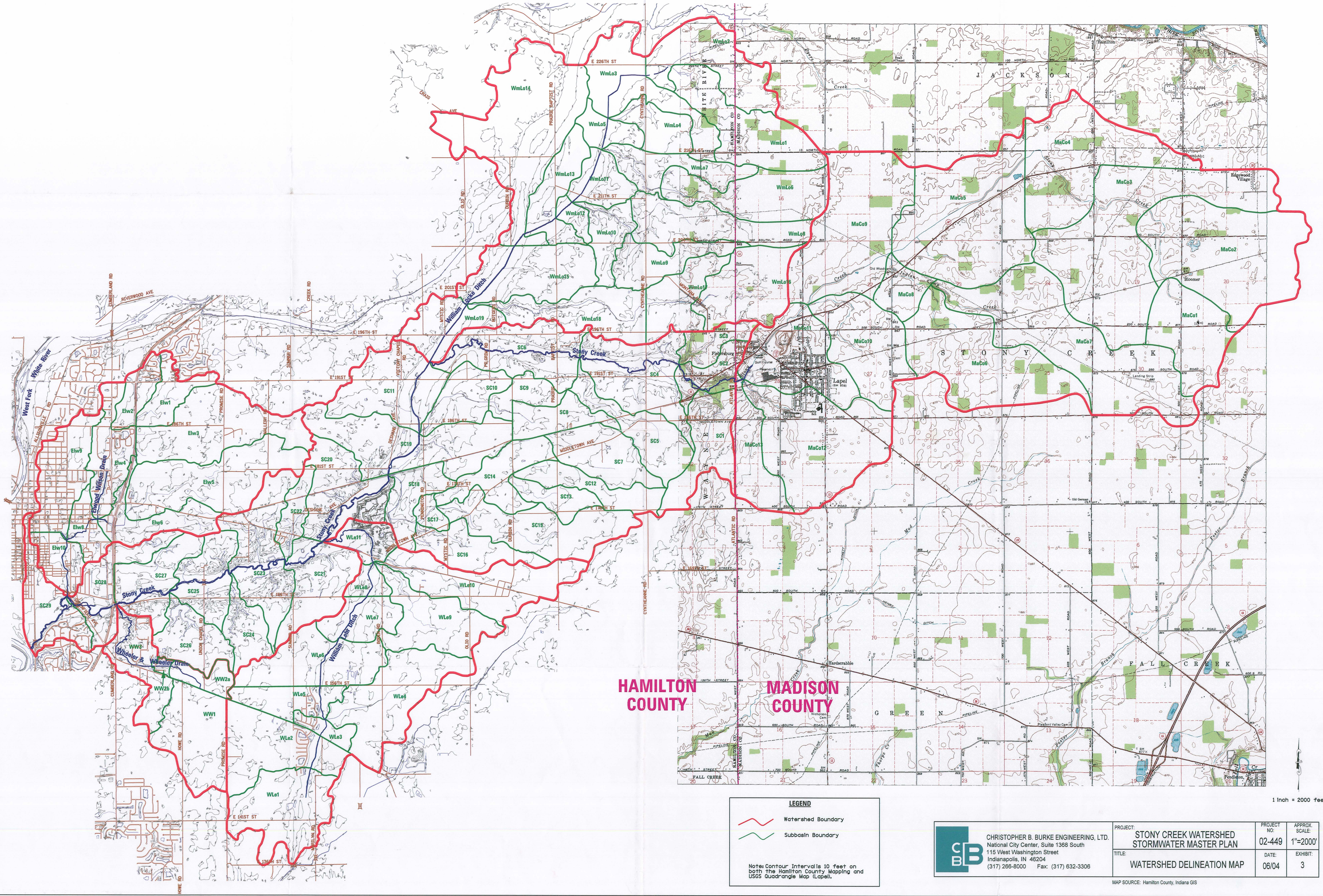
Christopher B. Burke Engineering, Ltd.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, Indiana 46204
(t) 317.266.8000 (f) 317.632.3306

PROJECT: STONY CREEK WATERSHED STORMWATER MASTER PLAN	PROJECT NO. 02-449	APPROX. SCALE 1"=2 miles	
TITLE: LOCATION MAP		DATE: 06/04	
		EXHIBIT 1	



CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, Indiana 46204
TEL (317)266-8000 FAX (317)632-3306

PROJECT:	PROJECT NO:	APPROX. SCALE:
Stony Creek Watershed Stormwater Master Plan	02-449	As Shown
TITLE: Regulated Drains Source: Hamilton County, Indiana, Mapping		DATE: 06-04
		Exhibit 2



1 Inch = 2000 feet

LEGEND

Watershed Boundary

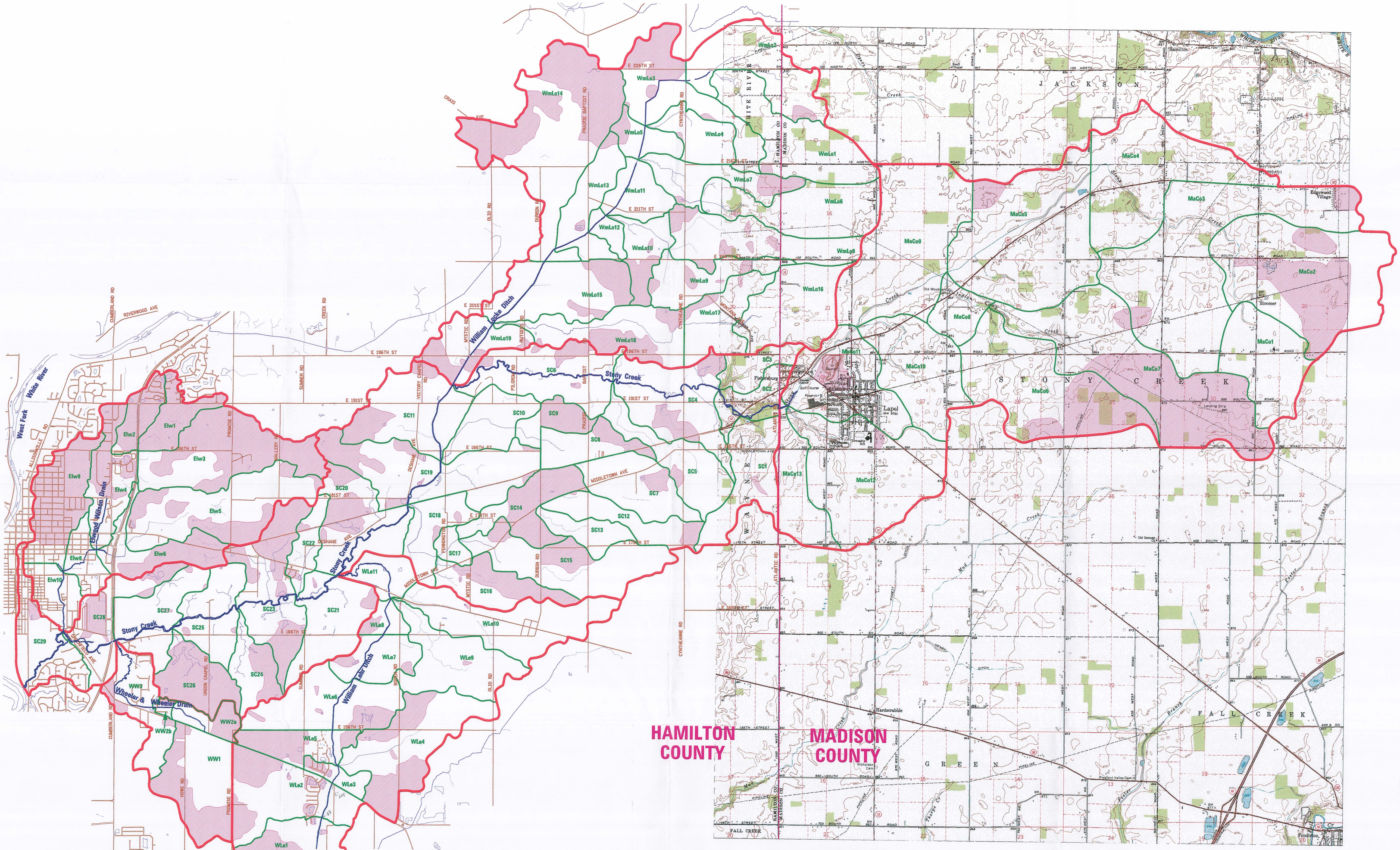
Subbasin Boundary

Note: Contour Intervalls 10 feet on both the Hamilton County Mapping and USGS Quadrangle Map (Lapel).

CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

PROJECT:	PROJECT NO:	APPROX. SCALE:
STONY CREEK WATERSHED STORMWATER MASTER PLAN	02-449	1"=2000'
TITLE: WATERSHED DELINEATION MAP	DATE: 06/04	EXHIBIT: 3

MAP SOURCE: Hamilton County, Indiana GIS



LEGEND

- Watershed Boundary
- Subbasin Boundary
- Depressional Areas

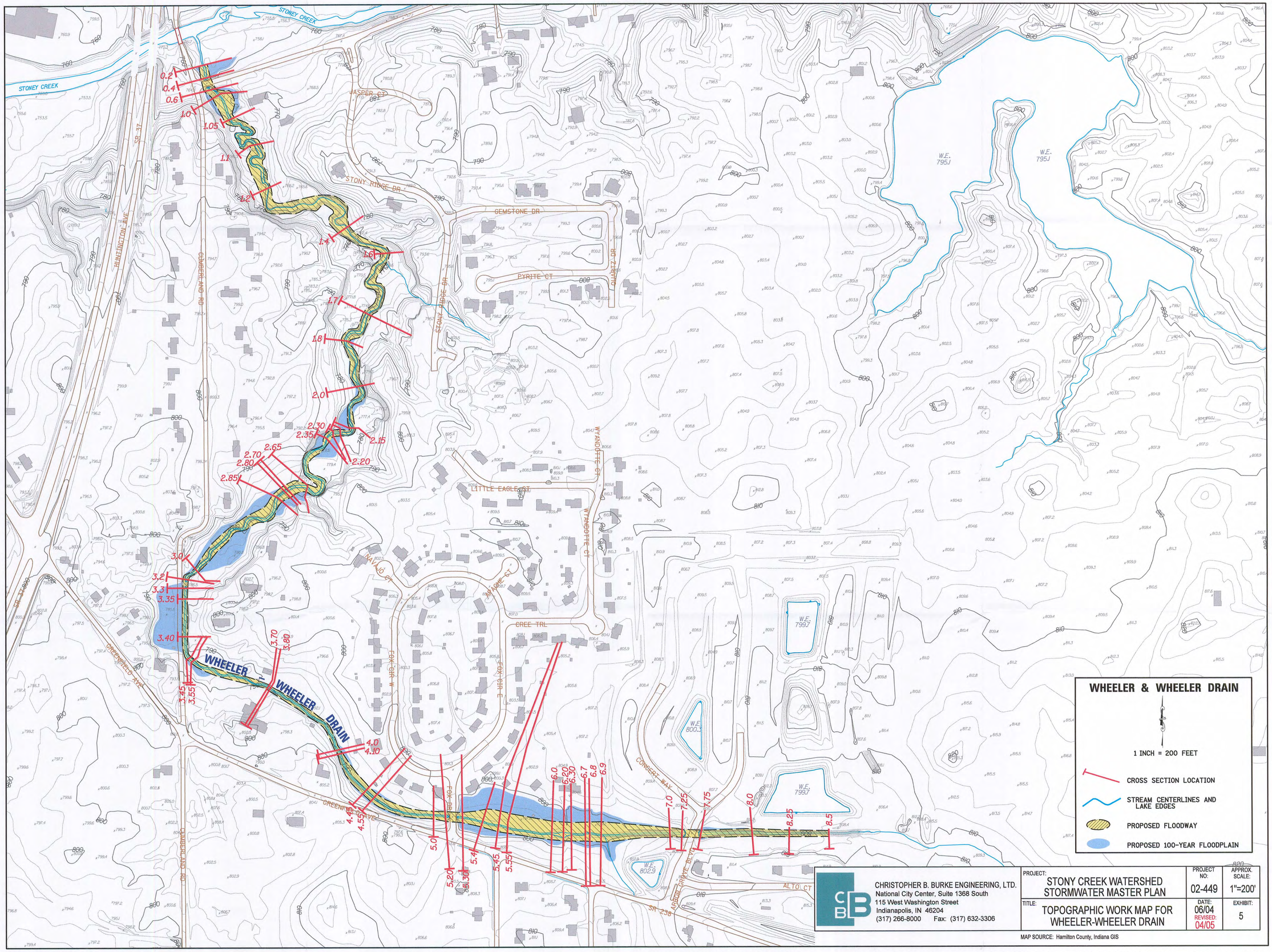
Note: Contour Intervals 10 feet on both the Hamilton County Mapping and USGS Quadrangle Map (Lapel).

1 inch = 2000 feet

CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

PROJECT: STONY CREEK WATERSHED STORMWATER MASTER PLAN		PROJECT NO: 02-449	APPROX. SCALE: 1"=2000'
TITLE: WATERSHED DELINEATION MAP WITH DEPRESSIONAL AREA DELINEATIONS		DATE: 06/04 REVISED: 11/04	EXHIBIT: 4

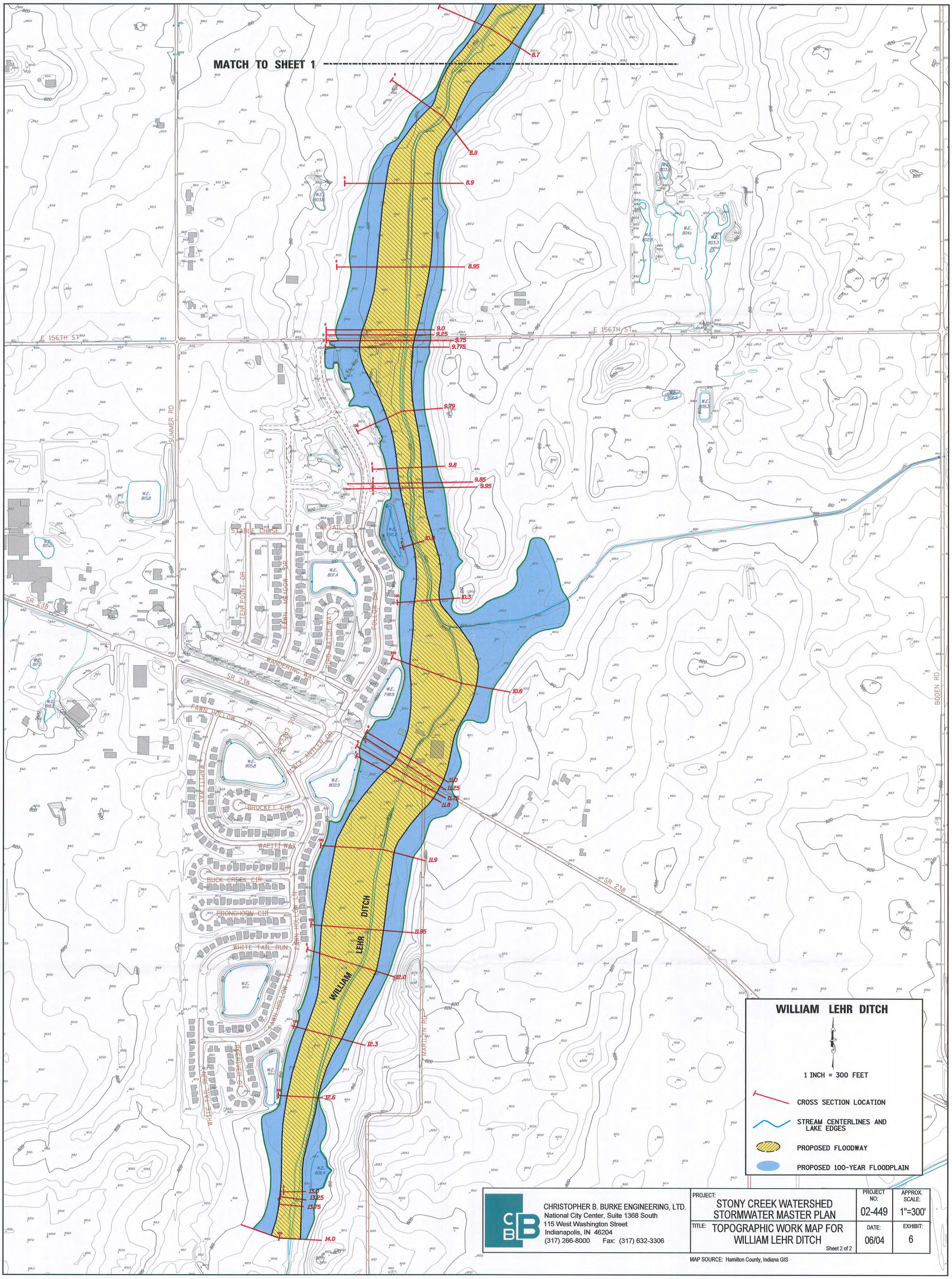
MAP SOURCE: Hamilton County, Indiana GIS



CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

PROJECT: STONY CREEK WATERSHED STORMWATER MASTER PLAN	PROJECT NO: 02-449	APPROX. SCALE: 1"=200'
TITLE: TOPOGRAPHIC WORK MAP FOR WHEELER-WHEELER DRAIN	DATE: 06/04 REVISED: 04/05	EXHIBIT: 5

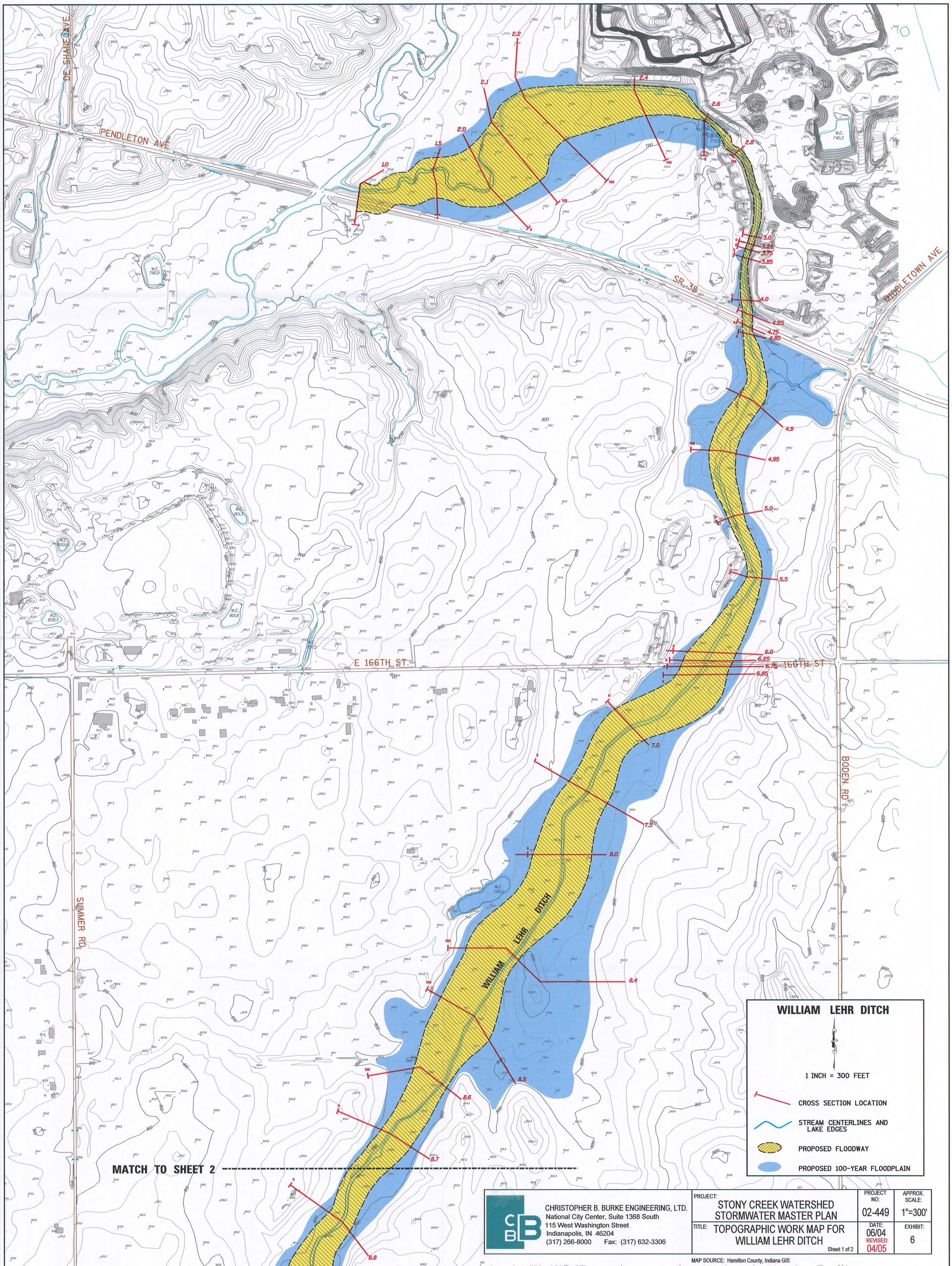
MAP SOURCE: Hamilton County, Indiana GIS



CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

PROJECT:	PROJECT NO:	APPROX. SCALE:
STONY CREEK WATERSHED STORMWATER MASTER PLAN	02-449	1"=300'
TITLE: TOPOGRAPHIC WORK MAP FOR WILLIAM LEHR DITCH Sheet 2 of 2	DATE: 06/04	EXHIBIT: 6

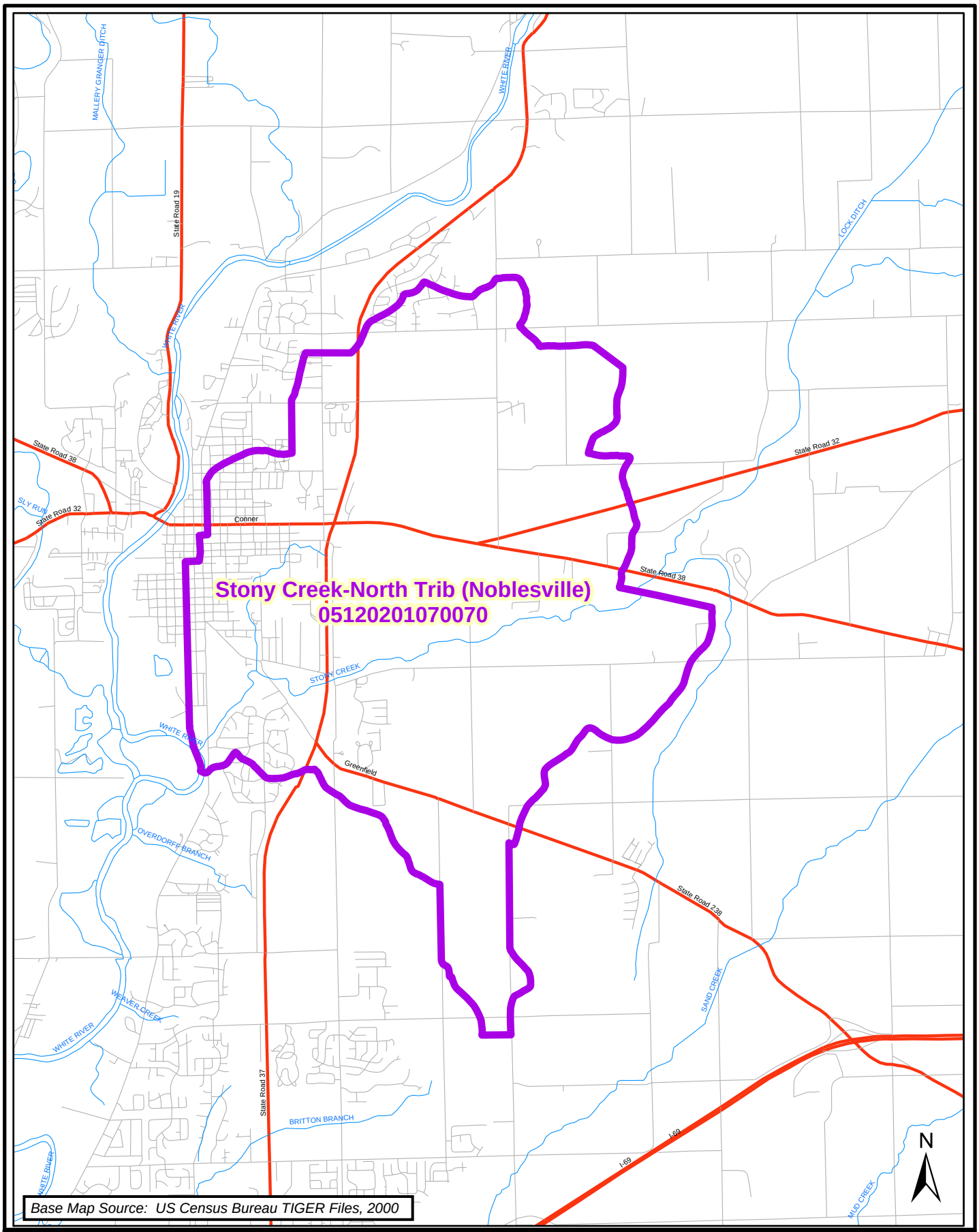
MAP SOURCE: Hamilton County, Indiana GIS



CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

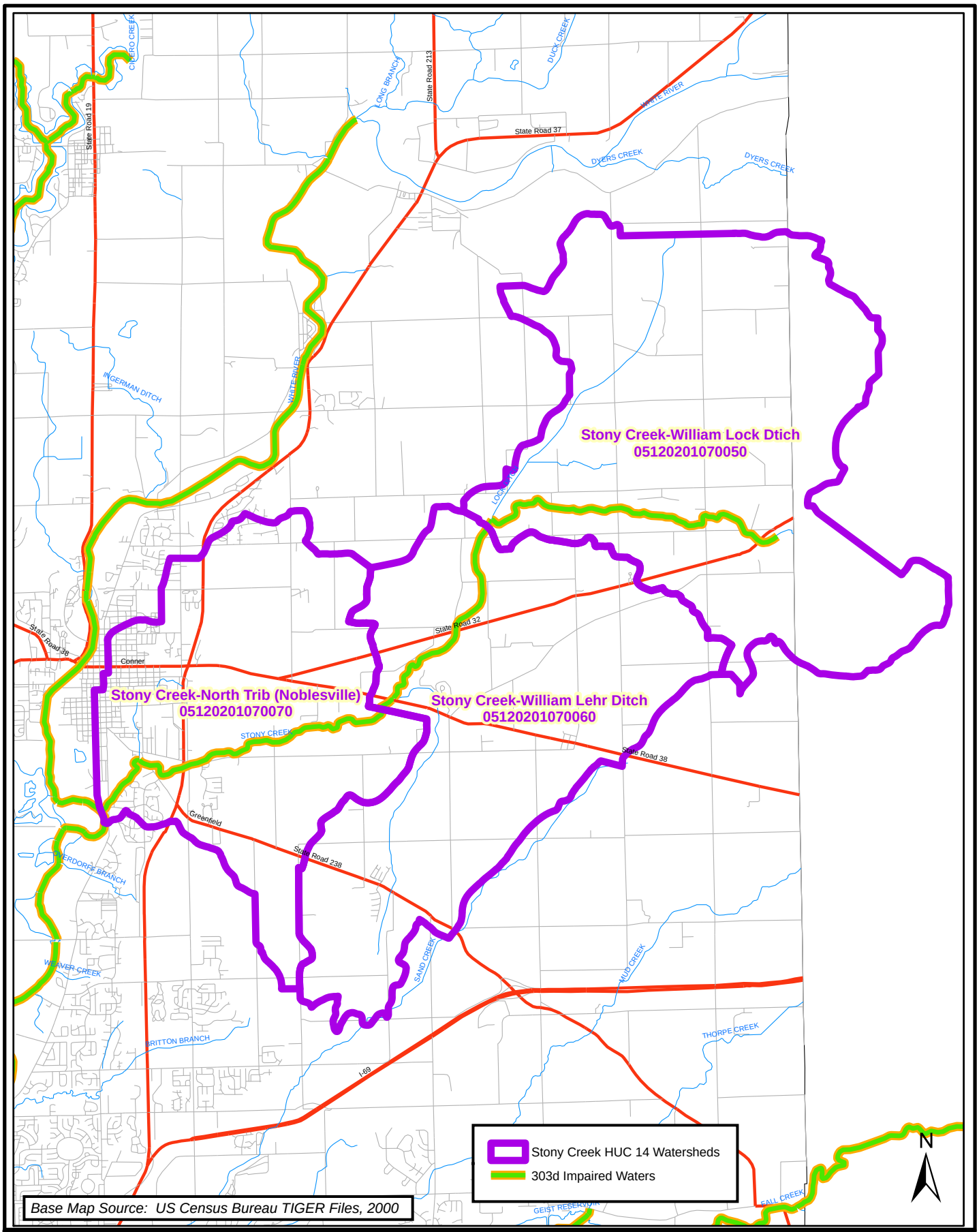
PROJECT: STONY CREEK WATERSHED STORMWATER MASTER PLAN	PROJECT NO: 02-449	APPROX. SCALE: 1"=300'
TITLE: TOPOGRAPHIC WORK MAP FOR WILLIAM LEHR DITCH (Sheet 1 of 2)	DATE: 06/04 REVISED: 04/05	EXHIBIT: 6

MAP SOURCE: Hamilton County, Indiana GIS



Christopher B. Burke Engineering, Ltd.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, Indiana 46204
(t) 317.266.8000 (f) 317.632.3306

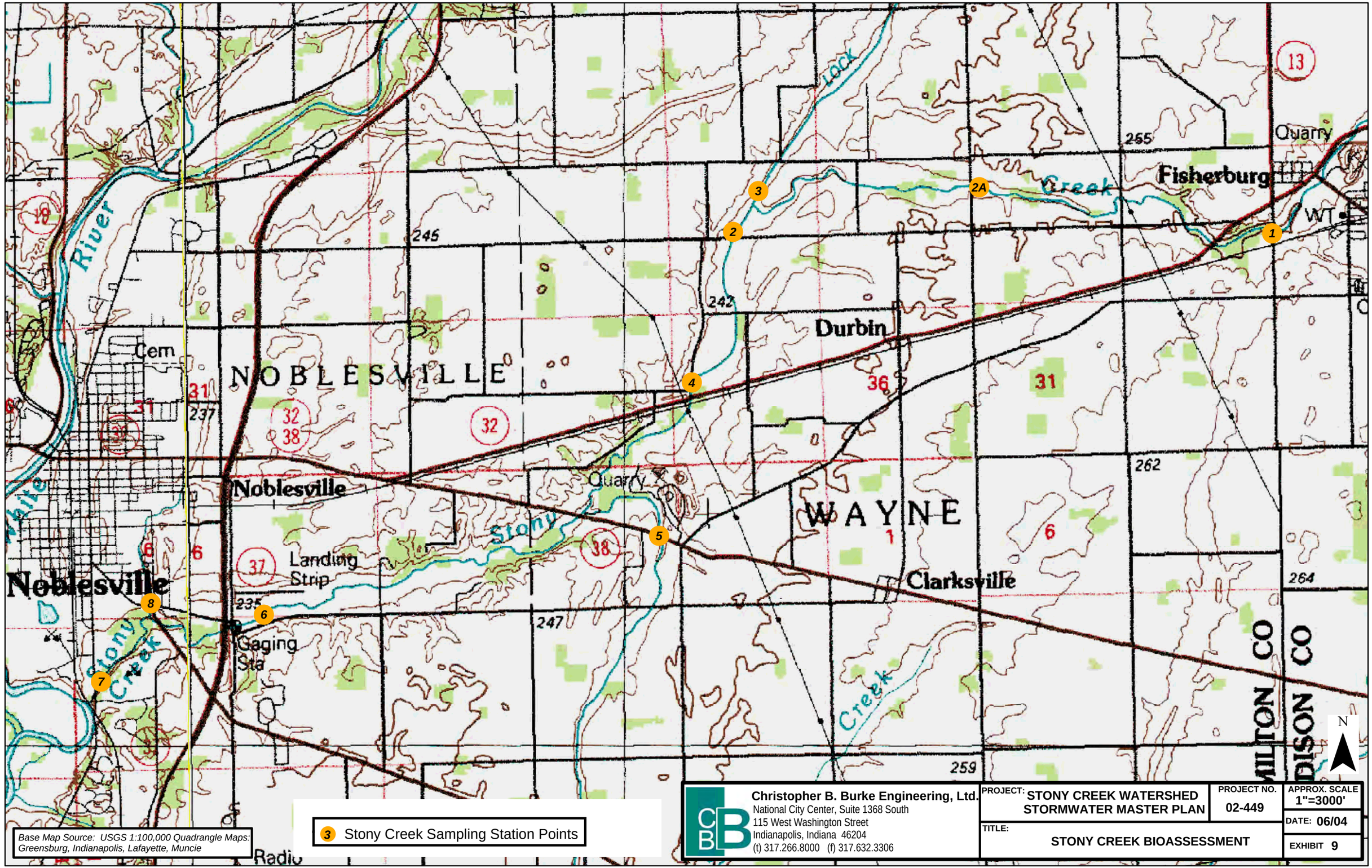
PROJECT: STONY CREEK WATERSHED STORMWATER MASTER PLAN	PROJECT NO. 02-449	APPROX. SCALE 1"=5000'	
TITLE: STONY CREEK WATERSHED 305b PRIORITY WATERSHEDS		DATE: 06/04	
		EXHIBIT 7	



Base Map Source: US Census Bureau TIGER Files, 2000

Christopher B. Burke Engineering, Ltd.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, Indiana 46204
(t) 317.266.8000 (f) 317.632.3306

PROJECT: STONY CREEK WATERSHED STORMWATER MASTER PLAN	PROJECT NO. 02-449	APPROX. SCALE 1"=1.5 miles	
TITLE: STONY CREEK WATERSHED 303d IMPAIRED WATERS		DATE: 06/04	
		EXHIBIT 8	

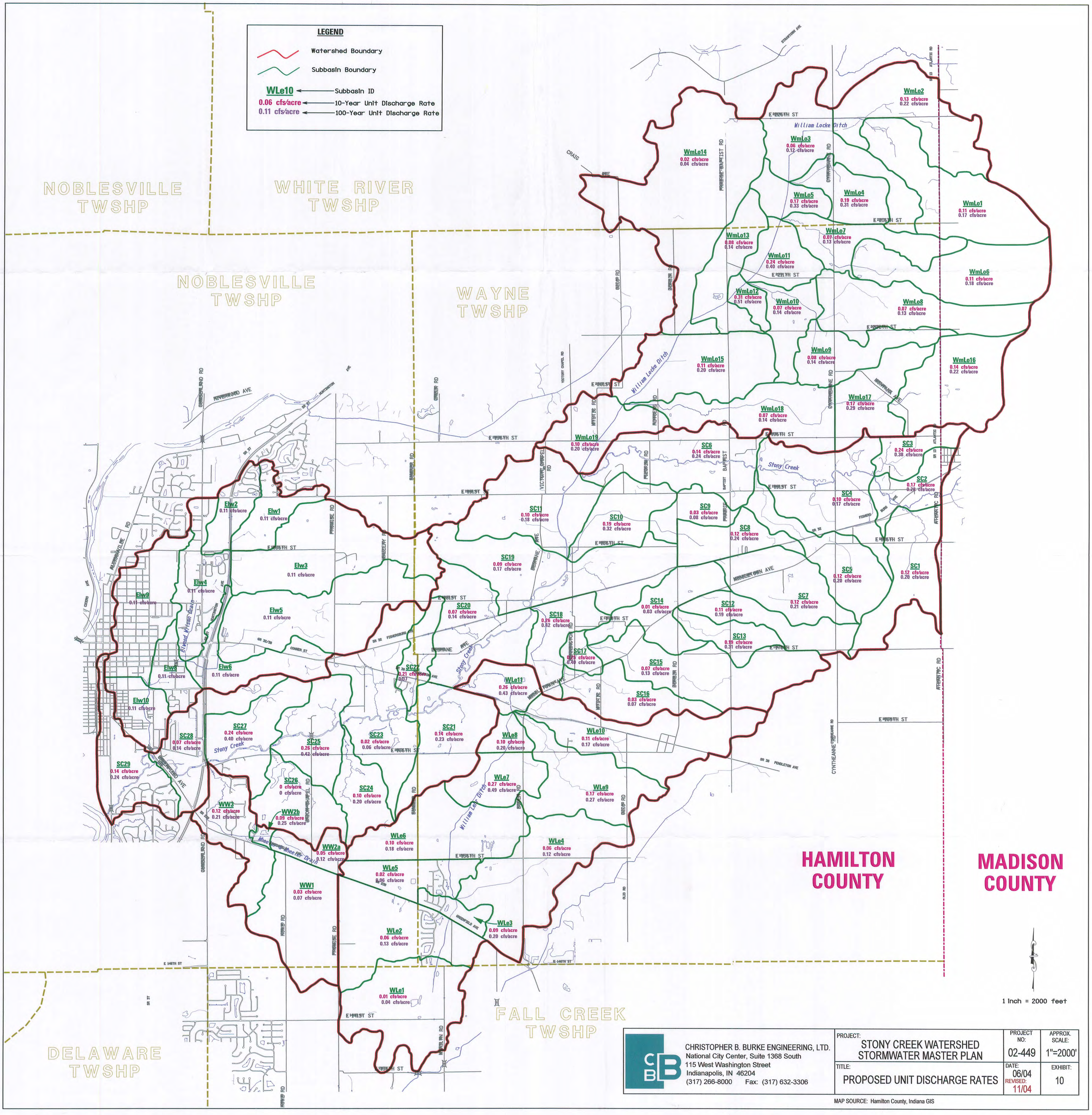


Base Map Source: USGS 1:100,000 Quadrangle Maps: Greensburg, Indianapolis, Lafayette, Muncie

3 Stony Creek Sampling Station Points

Christopher B. Burke Engineering, Ltd.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, Indiana 46204
(t) 317.266.8000 (f) 317.632.3306

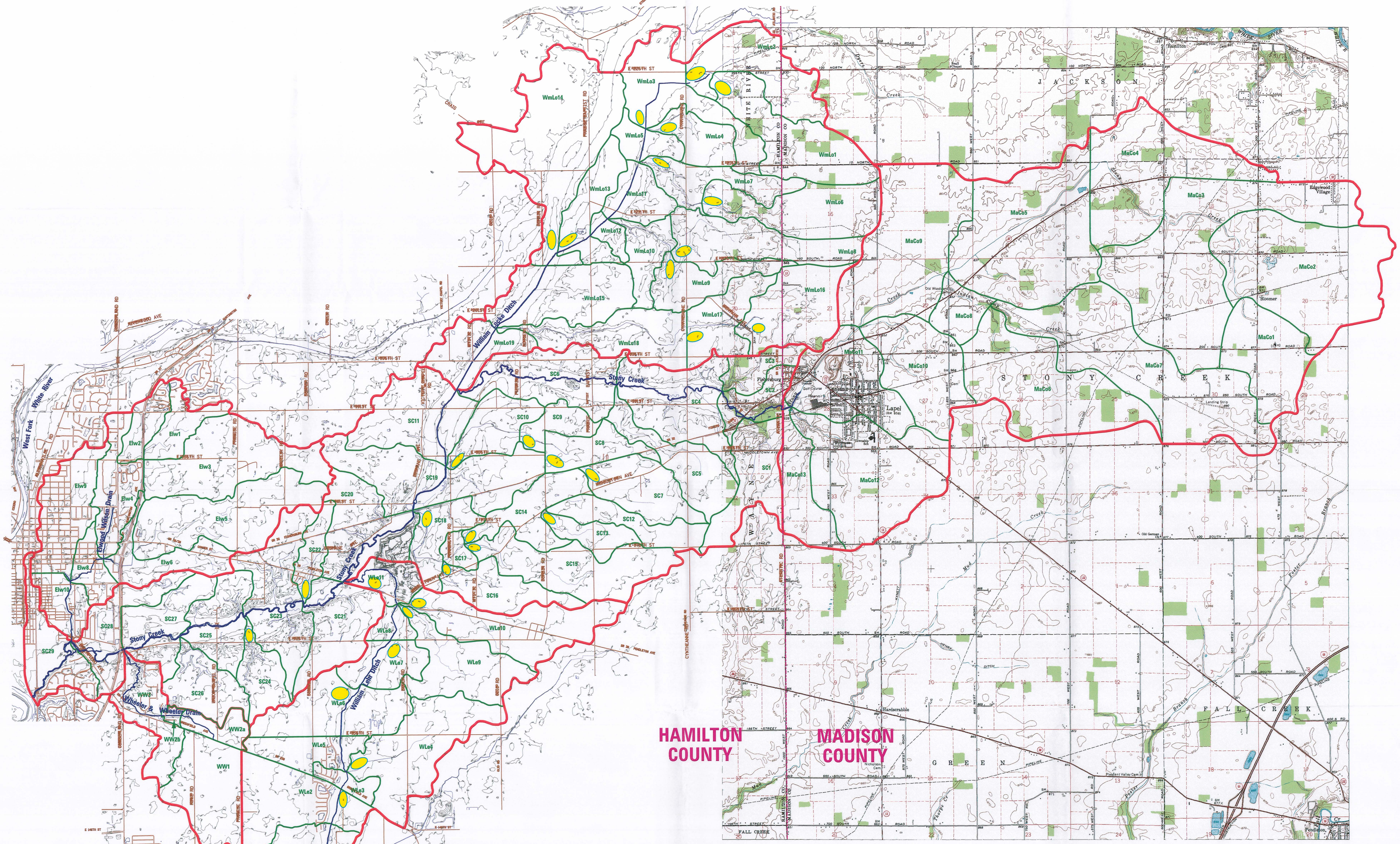
PROJECT: STONY CREEK WATERSHED STORMWATER MASTER PLAN	PROJECT NO. 02-449	APPROX. SCALE 1"=3000'
TITLE: STONY CREEK BIOASSESSMENT		DATE: 06/04
		EXHIBIT 9



CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

PROJECT: STONY CREEK WATERSHED STORMWATER MASTER PLAN	PROJECT NO: 02-449	APPROX. SCALE: 1"=2000'
TITLE: PROPOSED UNIT DISCHARGE RATES	DATE: 06/04 REVISED: 11/04	EXHIBIT: 10

MAP SOURCE: Hamilton County, Indiana GIS



LEGEND

- Watershed Boundary
- Subbasin Boundary
- Proposed Regional Pond

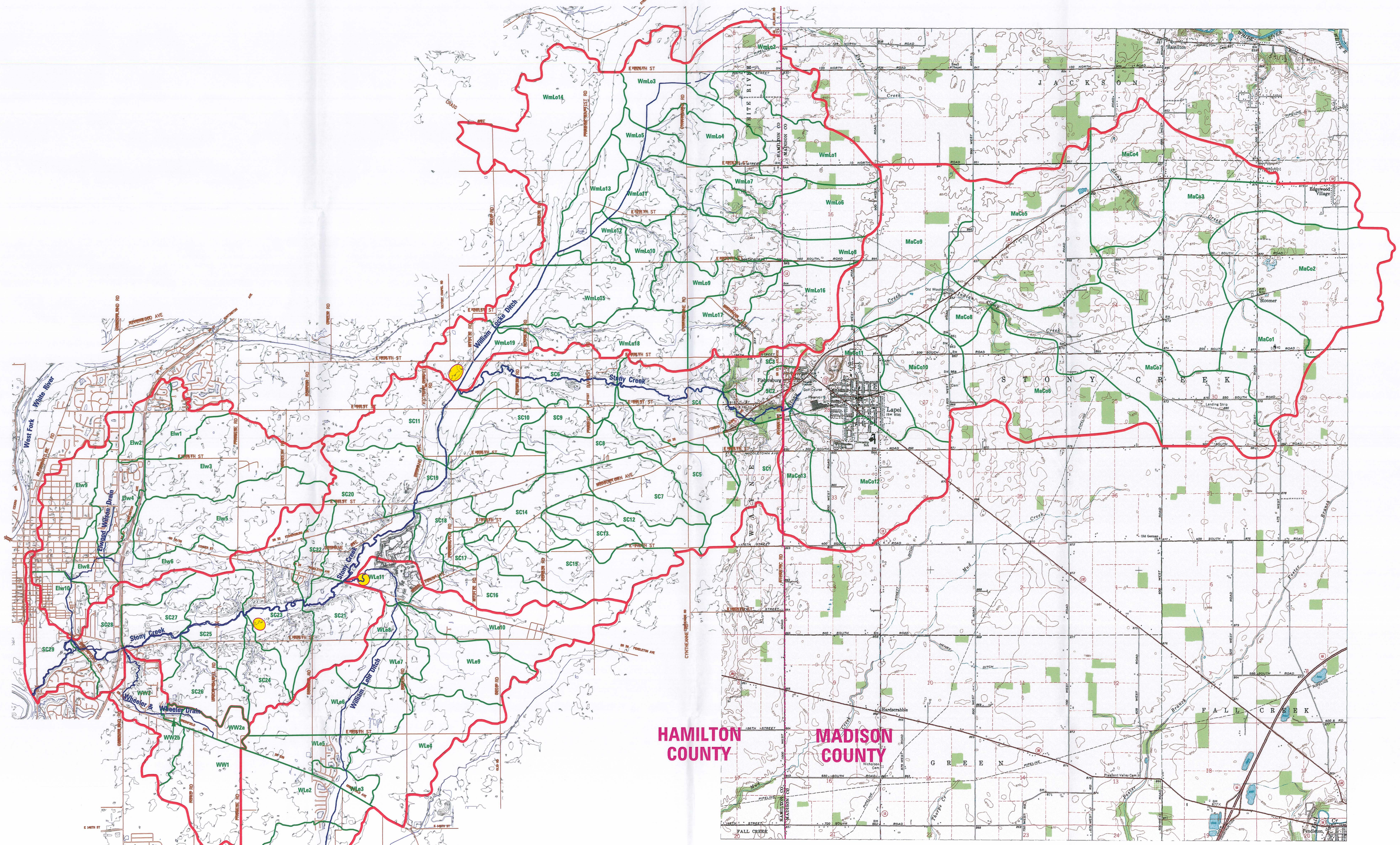
Note: Contour Intervals 10 feet on both the Hamilton County Mapping and USGS Quadrangle Map (Lapel).

1 Inch = 2000 feet

CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

PROJECT:	PROJECT NO:	APPROX. SCALE:
STONY CREEK WATERSHED STORMWATER MASTER PLAN	02-449	1"=2000'
TITLE: CANDIDATE PLAN COMPONENT 3 LOCATION OF PROPOSED REGIONAL PONDS	DATE: 06/04	EXHIBIT: 11

MAP SOURCE: Hamilton County, Indiana GIS



LEGEND

- Watershed Boundary
- Subbasin Boundary
- Proposed Flood Control Basin

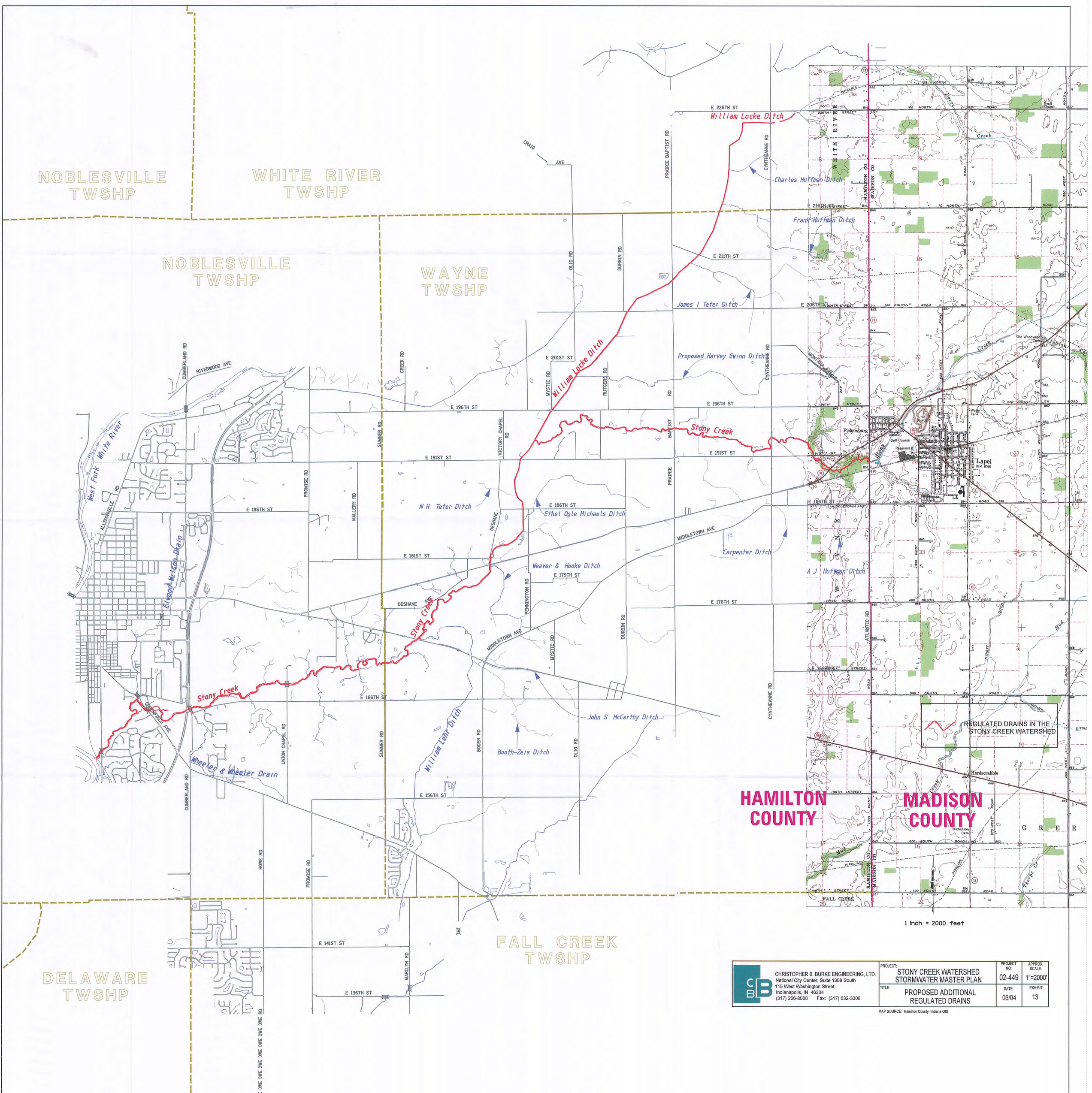
Note: Contour Intervals 10 feet on both the Hamilton County Mapping and USGS Quadrangle Map (Lapel).

1 Inch = 2000 feet

CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1398 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

PROJECT:	PROJECT NO:	APPROX. SCALE:
STONY CREEK WATERSHED STORMWATER MASTER PLAN	02-449	1"=2000'
TITLE: CANDIDATE PLAN COMPONENT 4 LOCATION OF PROPOSED FLOOD CONTROL BASINS	DATE: 06/04	EXHIBIT: 12

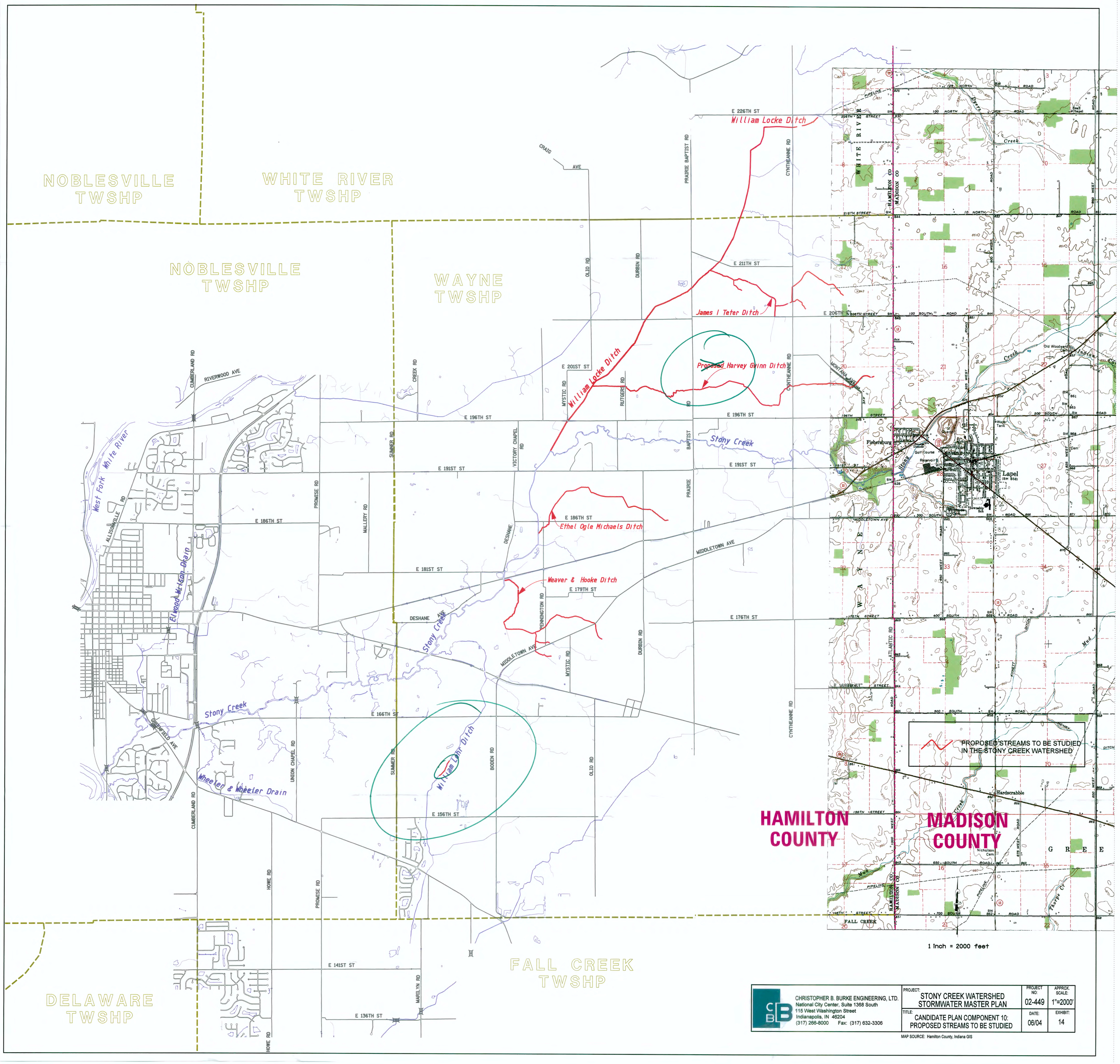
MAP SOURCE: Hamilton County, Indiana GIS



CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

PROJECT: STONY CREEK WATERSHED STORMWATER MASTER PLAN	PROJECT NO: 02-449	APPROX. SCALE: 1"=2000'
TITLE: PROPOSED ADDITIONAL REGULATED DRAINS	DATE: 06/04	EXHIBIT: 13

MAP SOURCE: Hamilton County, Indiana GIS



CHRISTOPHER B. BURKE ENGINEERING, LTD.
National City Center, Suite 1368 South
115 West Washington Street
Indianapolis, IN 46204
(317) 266-8000 Fax: (317) 632-3306

PROJECT:	PROJECT NO:	APPROX. SCALE:
STONY CREEK WATERSHED STORMWATER MASTER PLAN	02-449	1"=2000'
TITLE: CANDIDATE PLAN COMPONENT 10: PROPOSED STREAMS TO BE STUDIED	DATE: 06/04	EXHIBIT: 14

MAP SOURCE: Hamilton County, Indiana GIS