CITY OF JEFFERSONVILLE
STORMWATER MASTER PLAN

Clark County, Indiana

Prepared for

City of Jeffersonville Drainage Board
City Hall 500 Quartermaster Court
Jeffersonville, IN 47130

December 2012

Prepared by

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CBBEL Project No. 11-0021

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EXECUTIVE SUMMARY

In July 2011, the City of Jeffersonville hired Christopher B. Burke Engineering, LLC and Jacobi, Toombs, and Lanz, Inc to prepare a Stormwater Master Plan that addresses the new flooding, drainage, and water quality priorities within the City. These include the recent annexation of a substantial land area previously under the jurisdiction of Clark County; addressing existing and anticipated future problems related to stormwater runoff and localized flooding; responsibilities as a Municipal Separate Storm Sewer System community; and stormwater related issues of a consent decree from the US EPA to address the Combined Sewer Overflow problems through a Long Term Control Plan.

A 2-phased approach was used to develop this Stormwater Master Plan. Phase 1 is a screening-level analysis of flooding, drainage, and water quality issues in the entire City. The outcome, a list of promising solutions, is further evaluated in Phase 2 to identify recommended Master Plan components and a prioritized list for implementation. The following lists, in priority for implementation, the recommended structural and non-structural recommended Master Plan components to address existing and anticipated future flooding, drainage, and water quality problems in the City of Jeffersonville.

Recommended Structural Master Plan Components:

1. Constructed Wetland in Woodland Court
2. Green Infrastructure in the Downtown Area
3. Green Infrastructure in Oak Park Conservancy District
4. Construction of New or Upgrade Storm Sewers throughout Oak Park Conservancy District
5. Stream Restoration of Lancassange Creek in Oak Park Conservancy District, Lentzier Creek, Woodland Court, and Mill Creek
6. Bypass Channel of Lancassange Creek in Oak Park Conservancy District
7. Upstream Offline Detention Basins OPCD Flood Control Project
8. Voluntary Acquisition and/or Floodproofing Program in the Downtown Area, Oak Park Conservancy District, Waverly, Woodland Court, and Lick Run

Recommended Non-Structural Master Plan Components

1. Citywide Stormwater Ordinance & Technical Standards Update
2. Citywide Floodplain Management Ordinance Update
3. Citywide Green Infrastructure Policy
4. Citywide Operations & Maintenance Manual Update
5. Updating Stream Hydraulic Studies of Lancassange Creek, Lentzier Creek, Woodland Court, Mill Creek and other selected streams
6. Citywide Development of Codes & Design Standards Update
7. City's Participation in the Community Rating System
8. Flood Depth Mapping in Oak Park Conservancy District, Woodland Court, and Lick Run
9. Citywide Flood Response Plan
10. Fluvial Erosion Mapping in Oak Park Conservancy District and other selected streams
11. Prioritization Plan for Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the Special Flood Hazard Area

The total estimated cost for recommended structural and non-structural recommended Master Plan components is up to $32,825,000 and $315,500, respectively. Implementation should focus on a balance of structural and non-structural projects and dependent on multiple years of funding from a variety of sources.

This Master Plan provides a roadmap for the City of Jeffersonville to address existing and anticipated future flooding, drainage, and water quality problems and concerns in a comprehensive, regional, multi-year approach. In addition to the recommended Master Plan components listed above, this Plan identified 70 local drainage, flooding or water quality problems. These problems are smaller in scale and should be addressed using relatively simple design or maintenance solutions. These do not require the same level of detailed evaluation as the larger neighborhood or regional problems that are addressed in this Stormwater Mater Plan. As solutions to these problems are identified, they should also be subjected to the Triple Bottom Line evaluation procedure identified in this study and prioritized. As of the time of writing of this Master Plan, the following three projects have already been identified and recommended to be pursued as early implementation projects:

1. 8th Street & Hopkins Lane Storm Improvements (estimated cost = $430,000)
2. Magnolia Avenue & Roselawn Court Drainage Improvements (estimated cost = $592,680)
3. 8th & Ohio/7th & Indiana Detention Basin (estimated cost = $380,000)

This 18-month planning process was led by a Project Team of City and consultant project management staff. Project updates were provided monthly to the Drainage Board and guidance on major project milestones was provided by an Advisory Committee. The public and key City departments were engaged in the planning process.

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1.1 INTRODUCTION

The City of Jeffersonville has recently become one of the largest cities in southern Indiana. In February 2008 and January 2010, the City officially annexed a substantial land area (7,800 acres) previously under the jurisdiction of Clark County. The 2010 US Census figures show the City's population at 44,953 which is a 64% increase from 2000. While many of the city services were already supporting this annexed area, stormwater management was handled by the County.

This Stormwater Master Plan (SWMP) reflects updated priorities for stormwater management in the City of Jeffersonville. These include the annexation of a substantial land area previously under the jurisdiction of Clark County; addressing existing and anticipated future problems related to stormwater runoff and localized flooding; responsibilities as a Municipal Separate Storm Sewer System (MS4) community; and stormwater related issues of a consent decree from the US EPA to address the Combined Sewer Overflow (CSO) problems through a Long Term Control Plan (LTCP).

To effectively address these priorities, the City of Jeffersonville Drainage Board retained Christopher B. Burke Engineering, LLC (CBBEL) and Jacobi, Toombs, and Lanz, Inc. (JTL) to develop a SWMP.

1.2 PURPOSE & SCOPE

The purpose of this SWMP is to present findings and observations, and provide recommended alternatives based on the results of detailed analysis that will:

- Solve or reduce existing flood/drainage problems,
- Prevent an increase in existing flood/drainage problems as growth occurs,
- Prevent or minimize future damages,
- Help preserve the natural and beneficial function of the drainage system, and
- Help preserve and enhance stormwater quality.

The scope included identifying the stormwater management issues throughout the City of Jeffersonville, both existing and anticipated, that could arise with continued growth and development. These issues include flooding, drainage, and stormwater quality issues.

1.3 APPROACH

The City of Jeffersonville SWMP has been prepared using the following 2-phase approach.

Problem Identification and Prioritization
Phase 1 is a screening-level analysis of flooding, drainage and stormwater quality issues in the entire City. This includes a characterization of the base conditions, identification of existing and anticipated problems and/or concerns, a grouping of problem areas into target study areas, and a list of promising solutions.

Detailed Evaluation & Development of Report
Phase 2 is a detailed evaluation of the promising solutions identified in Phase 1. An implementation plan, complete with a conceptual layout and cost estimate for each recommended plan component, will be the end result of Phase 2.

The outcome of this phased approach is an overall understanding of the problems and a detailed analysis of targeted study areas, resulting in plan components that would effectively address stormwater quality and quantity problems/concerns in a prioritized approach.

1.4 PARTICIPATION

Participation from staff, decision-makers, and the public is essential to understanding the flooding and drainage issues and to craft solutions to effectively address these problems. The following outlines the layers of public and private participants engaged throughout the development of the City of Jeffersonville SWMP. **Appendix 1** includes the Work Plan for this SWMP and provides more details on specific project tasks, roles and responsibilities, and timeline.

Project Team
The Project Team consisted of Jeffersonville, CBBEL, and JTL project management staff. The primary role of the Project Team was to ensure the development of the SWMP stayed on schedule, budget, and met the contracted needs of the Drainage Board.

Advisory Committee
The Advisory Committee is representative of the private and public sectors of the City of Jeffersonville. Each member was specifically selected based on their knowledge of stormwater issues, access to the tools necessary to mitigate stormwater problems, and/or represent stakeholders for successful implementation of stormwater practices.

The Advisory Committee met 6 times to provide input and guidance throughout the development of the SWMP. **Table 1-1** lists the Advisory Committee members and the organization they represented.

Table 1-1 Members of the Advisory Committee

Representing	Name	Email
Mayor's Office	Mike Moore	mmoore@cityofjeff.net
Drainage Board	Steve Gill	car10chief@aol.com
Planning Department	Dan Matson	dmatson@cityofjeff.net
Emergency Management	Leslie Kavanaugh	clark.ema@insightbb.com
Building Commissioner/ Floodplain Manager	Russ Segraves	rsegraves@cityofjeff.net
Oak Park Conservancy District	Bryan Wallace	bryanw@oakparkcd.us
Flood Control District	Mike Lanham/ Don Teterick	mikelanham@insightbb.com donttrck@insightbb.com
City Council	Lisa Gill	lgill@cityofjeff.net
Clark County SWCD	Matt Bell	Matt.bell@nacdnet.net
Community	Wayne Carter	waycart@insightbb.com
Community	Veronica Conlin	vcr1501@yahoo.com
Community	Sandy Knott	sandyknott64@gmail.com
Community	Bruce Burns	b1taxht@att.net
Community	Antia Fields	ronaldantia@sbcglobal.net

Implementation of recommendations from this SWMP will require coordination with the policies, programs, and projects from other city departments. **Table 1-2** lists representatives from those departments that were involved, as needed, throughout the planning process:

Table 1-2 City Staff Participation

Representing	Name	Email
Economic Development	Rob Waiz	rwaiz@cityofjeff.net
Parks & Recreation	Robert Manor	bmanor@cityofjeff.net
Streets & Sanitation	David Hosea	dhosea@cityofjeff.net
Communications	Leah Farris	lfarris@cityofjeff.net
Mayor's office (City Growth Coordinator)	Rick Lovan	rlovan@cityofjeff.net

Drainage Board

Monthly Progress Memos were provided to the City of Jeffersonville Drainage Board to keep them engaged in the development of the SWMP. At major project milestones, the Project Team made a formal presentation to the Drainage Board to ensure the SWMP would meet their needs for implementation. Monthly project updates to the Drainage Board are included in **Appendix 2**.

Public

Public participation is essential to the successful implementation of any plan. To better understand the local flooding and drainage issues, the Project Team conducted 5 open house style meetings throughout the City. These included:

1. First Christian Church (7/12/11)
2. City Hall (8/23/11)
3. Firehouse #2 (9/21/11)
4. Firehouse #4 (9/21/11)
5. Oak Park Baptist Church (10/28/11)

At these meetings, participants were encouraged to divide into small groups to mark up large paper maps and discuss their stormwater problem, issue or concern in detail with a member of the Project Team.

Comment Forms were distributed at the public open houses and attendees were encouraged to document their water quality and quantity concern. Blank forms were posted on the City webpage and made available at the City Utility Office. Problem areas marked on the paper maps and Comment Forms were recorded and catalogued using GIS.

1.5 ORGANIZATION OF DOCUMENT

The City of Jeffersonville SWMP is divided into several chapters with appendices of backup data. A brief summary of the contents of each chapter is presented below:

Chapter 1: Project Overview – presents the project purpose and scope, the approach, and participation.

Chapter 2: Existing Conditions, Problems/Concerns – describes the current condition of the citywide programs, policies, and projects as well as each watershed. It also summarizes the extent and severity of surface water quantity and quality concerns based on information gathered from local staff, decision-makers, and public input, review of previous studies, data collection, and screening-level analysis.

Chapter 3: Future Conditions and Associated Concerns – describes the anticipated future land uses and regulations or projects. It also identifies the severity and extent of problems that could arise as a result.

Chapter 4: Master Plan Goals and Performance Criteria – describes the goals for the SWMP in terms of water quality improvement, flood reduction or prevention, etc. Also discusses the criteria used to evaluate potential solutions in order to meet these goals.

Chapter 5: Prioritization of Problems/Concerns and Initial Screening of Potential Solutions – explains the process to catalogue identified problems into target study areas and the screening of potential solutions based on the performance criteria discussed in Chapter 4.

Chapter 6: Detailed Evaluation of Promising Solutions – a detailed analysis of solutions filtered through the screening process in Chapter 5 to determine their feasibility as a promising solution for the SWMP.

Chapter 7: Final Screening of Promising Solutions and Selection of Recommended Master Plan Components – provides a final screening of the promising solutions that were evaluated in Chapter 6 using a triple bottom line assessment.

Chapter 8: Funding Considerations of Recommended Master Plan Components – an evaluation of local, state, and federal funding possibilities for the implementation of recommended Master Plan components.

Chapter 9: Summary and Conclusions – provides a summary of the planning process, prioritized list of recommended Master Plan components and concluding thoughts.

Chapter 10: Proposed Implementation Plan – lists implementation steps for the recommended Master Plan components.

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CHAPTER 2 EXISTING CONDITIONS, PROBLEMS / CONCERNS

2.1 INTRODUCTION

Identifying effective solutions to stormwater problems depends on a thorough understanding of the existing stormwater conditions and concerns. The intent of this Chapter is two-fold:

1. Describe the current citywide programs, policies, and projects as they relate to floodplain and stormwater management, and
2. Understand the current condition (including the nature and extent of problems and concerns) for each of the major watersheds in the City.

The extent and nature of known existing stormwater conditions and concerns in the City of Jeffersonville were identified through various means including: discussions with Drainage Board, City staff, County staff, OPCD staff, public meetings and comment forms; review of applicable City plans, codes, GIS data, projects, studies, construction documents; and review of relevant data and studies from the Indiana Department of Natural Resources (IDNR), the United States Geological Survey (USGS), the United States Army Corps of Engineers (USACE), etc.

With the exception of new water quality sampling, hydrologic analysis, and hydraulic analysis for a few unstudied stream reaches, which were performed as part of this SWMP study, the data presented and recommendations made in this SWMP were based on best available data.

2.2 CITYWIDE PROGRAMS, POLICIES & PROJECTS

There are a number of entities and regulations that govern floodplain and stormwater management in the City of Jeffersonville. These entities include: the City of Jeffersonville Department of Engineering, the (IDEM), IDNR, and USACE, which have been given authority through local, state, and federal regulations.

2.2.1 Stormwater Management

In the City of Jeffersonville, stormwater issues are handled by the Engineering Department under the authority granted by Indiana Code 36-9-27 and governed by local ordinances for Drainage (2006-OR-20), Qualified Professional Certification (2010-OR-012), Post-Construction Storm Water Management (2005-OR-65), Stormwater Illicit Discharge Control (2004-OR-055), and Construction Site Runoff Control (2004-OR-56).

The purpose of these Ordinances is to provide authority and title for stormwater management granted to the Jeffersonville City Council under "Home Rule" and required based on Phase II of the National Pollution Discharge Elimination System (NPDES) program (FR Doc. 99–29181). The latter was authorized by the 1972 amendments to the Clean Water Act, IDEM Rule 13 (327 IAC 15-13), and IDEM Rule 5 (327 IAC 15-5). The Ordinances covers all stormwater management related projects or properties located within the jurisdiction of the City of Jeffersonville. These Ordinances regulate:

- Discharges of prohibited non-stormwater flows into the stormwater drainage system.
- Stormwater drainage improvements related to development of lands.
- Drainage control systems installed during new construction and grading of lots and other parcels of land.
- Erosion and sediment control systems installed during new construction and grading of lots and other parcels of land.
- The design, construction, and maintenance of stormwater drainage facilities and systems.
- The design, construction, and maintenance of stormwater quality facilities and systems.
- Land-disturbing activities affecting wetlands.

As a requirement of the NPDES Phase II program, the City of Jeffersonville has prepared a Stormwater Quality Management Plan (SWQMP) to improve the water quality that enters streams and the Ohio River from the City of Jeffersonville. This Plan addresses the 6 minimum control measures identified by EPA and IDEM. These include:

- Public education and outreach
- Public involvement and participation
- Illicit discharge detection and elimination (IDDE)
- Construction site stormwater runoff control
- Post-construction stormwater management in development and redevelopment
- Pollution prevention and good housekeeping for municipal operations

Prior to being annexed into the City of Jeffersonville, the Oak Park Conservancy District (OPCD) was designated as an NPDES Phase II community and responsible for managing stormwater within the jurisdiction. The OPCD and the City have been working cooperatively to solve drainage problems. At the end of 2011, an Interlocal Agreement was signed by the OPCD Board of Directors and the City of Jeffersonville City Council. The Agreement states that the City has drainage jurisdiction over Lancassange Creek and the road right-of-ways; OPCD handles drainage issues in the easements.

To help meet these requirements, the City of Jeffersonville and the OPCD are members of the Southern Indiana Stormwater Advisory Committee (SWAC). Eight MS4s in Southern Indiana have partnered together to guide the development of each community's SWQMP, provide a regional consistent message, and minimize duplication of effort among neighboring stormwater jurisdictions.

In 1997 the City of Jeffersonville prepared a SWMP that identified priority projects for the improvement of stormwater collection and conveyance. To date, the Drainage Board has completed the majority of projects in this Plan.

2.2.2 **Floodplain Management**

Floodplain management is governed locally through the City of Jeffersonville Planning and Zoning Department under the authority granted by Indiana Code 3476 and governed through the local Floodplain Management Ordinance 94-OR-40.

The purpose of this ordinance is to guide development in the flood hazard areas in order to reduce the potential for loss of life and property, reduce the potential for health and safety hazards, and to reduce the potential for extraordinary public expenditures for flood protection and relief. The intent of this ordinance is to:

- To prevent unwise developments from increasing flood or drainage hazards to others.
- To protect new buildings and major improvements to buildings from flood damage.
- To protect human life and health from the hazards of flooding.
- To lessen the burden on the taxpayer for flood control projects repairs to flood-damaged public facilities and utilities, and flood rescue and relief operations.
- To maintain property values and a stable tax base by minimizing the potential for creating flood blighted areas.
- To make federally subsidized flood insurance available for structures and their contents in the City of Jeffersonville by fulfilling the requirements of the National Flood Insurance Program.

The City's Building Commissioner administers the Floodplain Ordinance based on the regulatory floodplains delineated on FEMA's 2004 Flood Insurance Rate Maps (FIRMs). New FIRMs were completed in 2011 and are expected to be effective in 2013. Through a special request from the City to the IDNR, the analysis of the floodplains in this SWMP was based on the new Preliminary FIRMs.

2.2.3 **Long-Term Control Plan**

To eliminate and/or minimize Combined Sewer Overflows (CSO) from the City of Jeffersonville, the EPA and IDEM require the City to prepare a Long-Term Control Plan (LTCP). A consent decree issued from EPA in 2009 obligates the City to prepare a LTCP and implement the recommended improvements to the system by 2025. This 2010 LTCP was prepared to meet the requirements of the Consent Decree and fulfill the City's obligation under the Clean Water Act (CWA).

The ultimate goal of the LTCP is to satisfy the requirements of the CWA by providing for the attainment of water quality standards as prescribed by the designated use of each CSO receiving water. The Ohio River and all Indiana waters are designated warm water aquatic habitat and full body contact recreation (fishable and swimmable).

Communities throughout the US have illustrated that CSO events can be successfully reduced through stormwater management practices. The Waste Water Department is responsible for implementing the City's LTCP.

2.2.4 **Waters of the State**

In Indiana, the USACE, IDEM and IDNR have jurisdiction over the Waters of the State. These entities administer a variety of federal and state regulations for wetlands, lakes, rivers, ponds, streams, creeks, and other regulated waterbodies. IDEM has prepared a Waterways Permitting Handbook to guide local decision-makers, developers, and citizens through the regulatory process.

The USACE has jurisdiction over all navigable Waters of the United States under the Rivers and Harbors Act of 1899. The USACE also regulated the placement of dredge or fill materials into the Waters of the United States under Section 404 of the Clean Water Act. As a result, no person may deposit or fill materials into the wetlands or Waters of the United States without a permit from the USACE.

IDEM is responsible for maintaining, protecting, and improving the physical, chemical, and biological integrity of Indiana's waters. IDEM administers the Section 401 Water Quality Certification Program, and draws its authority from the federal Clean Water Act and from Indiana's Water Quality Standards. Any person who wishes to place fill materials, excavate or dredge, or mechanically clear (use of heavy equipment) within a wetland, lake, river, stream, or other Water of the State must first apply to the USACE for a Clean Waters Act Section 404 permit. If the USACE determines that a permit is necessary, then the person must also apply for, and obtain, a Section 401 Water Quality Certification from IDEM. A Section 404 permit cannot be granted without a Section 401 permit.

IDNR is charged by the State of Indiana to serve as stewards of Indiana's surface and ground water resources by overseeing construction of activities within, over and/or under the State's waterways. These statutes were enacted to allow the State's water related resources to be utilized in a prudent manner while simultaneously minimizing induced flood related damages and protecting Indiana's environmental and cultural resources. IDNR regulatory programs include: Lakes Preservation Act, Lowering of Ten Acre Lakes Act, Flood Control Act, Navigable Waterways Act, Sand and Gravel Permits Act, and Construction of Channels Act. Construction in the floodway of a water body or navigable water, channel, or public freshwater lake must receive a permit from IDNR.

2.2.5 **Land Use Planning**

Stormwater quality and quantity is impacted by land development practices. Areas with greater impervious cover (roads, rooftops, parking, etc.) have greater volumes of runoff and pollutant loading to receiving streams. Integrating stormwater management into planning and zoning decision-making can minimize stormwater problems once the project is built.

Growth and development in the City of Jeffersonville is guided by the Planning and Zoning Department using the City's Comprehensive Plan (Ordinance 07-OR-68). This Plan identifies specific stormwater-related goals including:

- Protect life and property from stormwater-related danger and damage, by facilitating orderly growth, development and redevelopment (Goal PU-2)
- Provide consistency and efficiency in the review of drainage features of plans and designs prepared by developers (Objective PU-2.1)
- Storage facilities should be sized to store the specified recurrence interval runoff for future, as opposed to current land use (Policy Recommendation)

- As a means of controlling cost and minimizing erosion and sedimentation, the stormwater system for areas undergoing development should be planned and designed to generally conform to the natural drainage system (Policy Recommendation)

2.3 EXISTING CONDITIONS BY WATERSHED

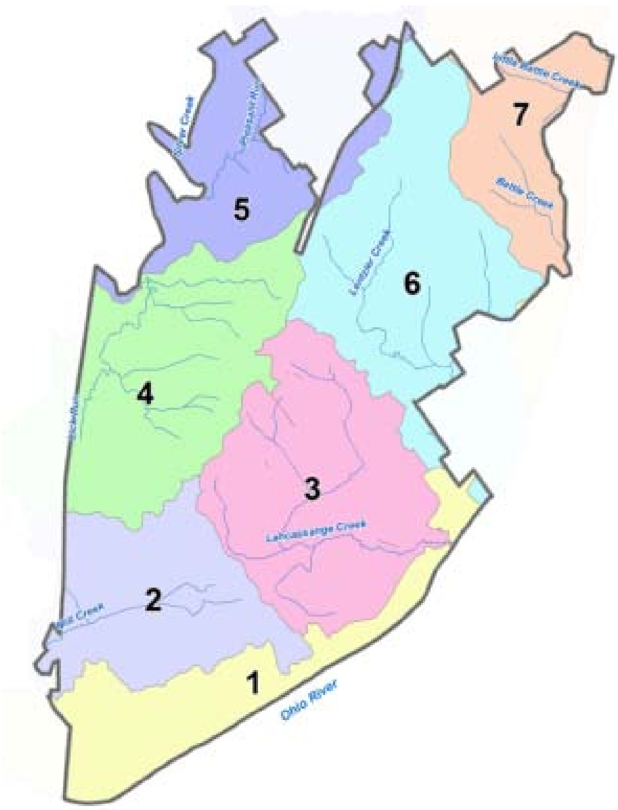

Figure 2-1 Major Watersheds

There are 7 major watersheds in the City of Jeffersonville (**Figure 2-1**). These are:

1. Ohio River/Cane Run Watershed
2. Mill Creek Watershed
3. Lancassange Creek Watershed
4. Lick Run Watershed
5. Silver Creek/Pleasant Run Watershed
6. Lentzier Creek Watershed
7. Battle Creek Watershed

The discussion on existing conditions is by these major watersheds. However, to better understand the unique flooding and drainage issues in the City of Jeffersonville, these 7 major watersheds were further divided into 26 subwatersheds.

This Chapter includes a general overview, a summary of existing water quantity and water quality conditions, and a list of flooding and drainage issues for each of the 7 major watersheds.

General Overview – this section includes a description of the general location and reference map of the watershed, discussion on the drainage area inside/outside the City, waterbodies, and land use.

Water Quantity – this section includes a determination of unit peak flows for each subwatershed, a description of the flood risk areas, an assessment of the floodplain area, identification of structures in the special flood hazard area (SFHA), and flood-related studies and projects.

As part of this SWMP, hydrologic modeling using HEC-HMS was conducted for each subwatershed to determine the unit peak flows (cfs per acre) for 2-, 10-, and 100-year events. The values determined through this analysis represent the baseline conditions for future analysis of the watershed's peak flow production trends. **Exhibit 2-1** shows the unit peak flows for each of the 26 subwatersheds.

A preliminary analysis of flood risk areas was also completed using HEC-RAS (using approximate methods) to complete or extend existing studies up to the 1 square mile drainage area as determined by IDNR. Streams studied by approximate methods as part of this SWMP include: Jenny Lind Run, Battle Creek, Lick Run, Lick Run tributaries, Lentzier Creek (extended), and Lancassange Creek (extended a very short distance).
Figure 2-2 shows the location of the extended stream hydraulic studies.

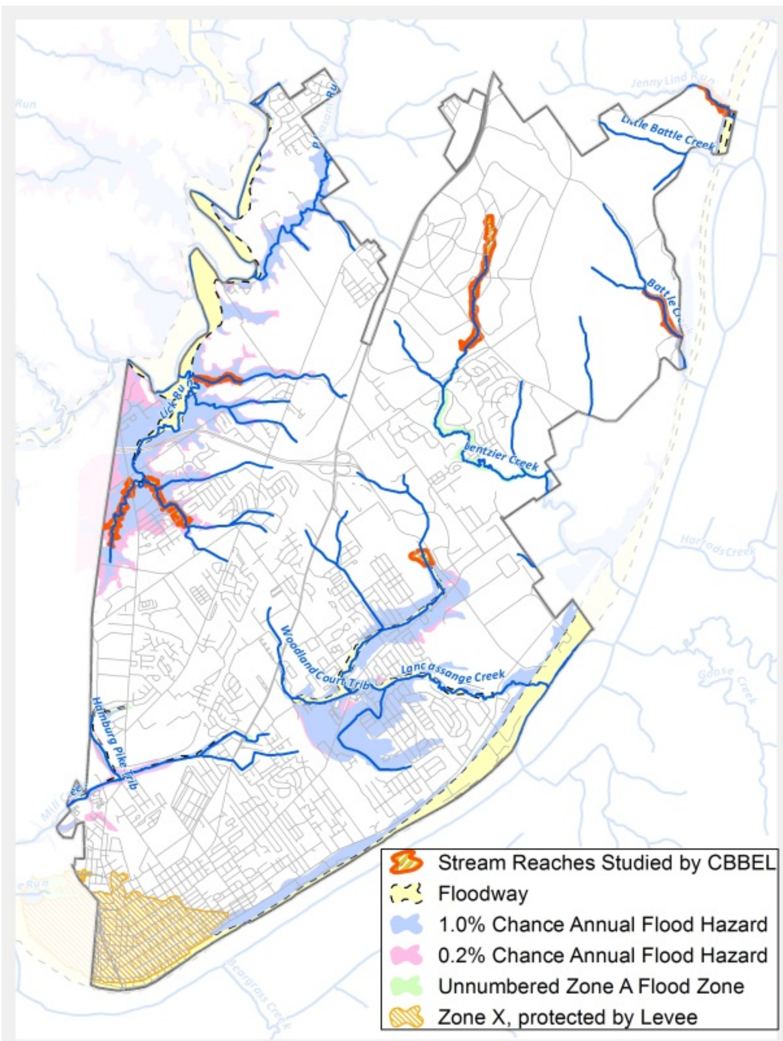

Figure 2-2 Stream Hydraulic Studies (extended as part of this SWMP)

To evaluate the floodplain delineations as shown on the effective and preliminary FIRMs, a comparison was completed between the 2011 preliminary FIRM floodways and Base Flood Elevations (BFE) (which for some streams is based on modeling done in the 1970s) and more recent aerial photography and City of Jeffersonville (2005) contour data. The comparison was done to determine if:

- Delineated floodplain included ground above the BFE or if ground below the BFE was missed by the floodplain limits.
- The channel was contained within the delineated floodway.

These factors can be good indicators of whether or not the modeling and floodplain delineations provide a good representation of the flood risk. If the comparison of BFE and topography shows areas where the floodplain limits are incorrectly noted, that indicates that at least a redelineation of the floodplain limits would be appropriate. If the channel is not contained within the floodway, it can be an indication that the modeling does not accurately reflect the topography.

The flood profiles were also reviewed to identify locations where BFEs would change if bridges had been replaced since survey data that was used in the Flood Insurance Study (FIS) was obtained. Based on this data, the potential for only minor changes due to bridge replacements was found.

To determine the number of structures in each floodplain area, a desktop GIS analysis was used to compare the preliminary FIRMs and the building footprint shapefile provided by the City.

Supporting information for the analysis in this section is included in **Appendix 3**.

Water Quality – this section includes a discussion on water quality data and known impairments, estimated pollutant loadings from land use and impact of impervious cover.

As part of this SWMP, water quality data was gathered and analyzed by a research team from Indiana University School of Public and Environmental Affairs (SPEA). The research team collected 3 chemical samples, 1 physical habitat evaluation, and 1 biological sample from 10 sites throughout the City of Jeffersonville. The following chemical parameters were measured: temperature, dissolved oxygen, percent dissolved oxygen saturation, conductivity, pH, alkalinity, soluble reactive phosphorus, total phosphorus, nitrate-nitrogen, ammonia-nitrogen, total organic nitrogen, total suspended solids (TSS), and *E. coli* bacteria.

While each individual parameter is an important view of the water quality, for the purposes of this SWMP, the sampling site average TSS and *E. coli* values will be utilized to provide a very general assessment of the overall water quality at each sampling location.

Rankings for average TSS values are defined as:

- Excellent – 0-10.0 mg/L
- Good – 10.1 – 28.0 mg/L
- Fair – 28.1 – 133.0 mg/L
- Poor – 133.1 mg/L and above

Rankings for average *E. coli* values are defined as:

- Excellent – 0-50 colonies/100 mL
- Good – 51-200 colonies/100 mL
- Fair – 201-1,000 colonies/100 mL
- Poor – 1,001 colonies/100 mL and above

It is important to note that chemical sampling results provide a "snapshot" of the water quality at the precise time of sample collection. Chemical composition of the water column or water body can change quickly with changes in temperature, precipitation, adjacent land disturbances, and changes in velocities and flow within the stream. These results, however, are an integral component in better understanding sources and impacts of pollution within the watershed.

Benthic macroinvertebrates were gathered to assess stream habitat and biotic integrity utilizing the macroinvertebrate Index of Biotic Integrity (mIBI). These communities are indicative of the overall health of an aquatic system, and provide a long term view of the water quality in a particular watershed or stream. As the streams become more polluted, various high quality organisms will be less prevalent and lower quality organisms will dominate the community.

Rankings for mIBI scores are defined as:

- Non-impaired – Scores of 6-8
- Slightly-impaired – Scores of 4-6
- Moderately-impaired – Scores of 2-4
- Severely-impaired – Scores of 0-2

Physical characteristics of the stream segments were also assessed utilizing the Qualitative Habitat Evaluation Index (QHEI). The QHEI provides an overall quantitative metric that can generally correspond to the ability of a stream to support fish or other invertebrate communities. It is important to note that QHEI scores are indicative of the 200 foot stream reach segment that was assessed. Significant changes in any of the individual metrics (substrate, in-stream cover, channel morphology, riparian and bank condition, pool and riffle quality, and gradient) could be observed upstream or downstream of these areas.

Rankings for QHEI scores are defined as:

- Excellent – Scores of 60 or more
- Good – Scores of 45-60
- Fair – Scores of 32-45
- Poor – Scores of 0-32

The full report prepared by the Indiana University is included in **Appendix 4**.

In 2004 and 2008, the OPCD collected water quality samples as part of their NPDES Phase II permit. Similarly, the City of Jeffersonville conducted a Stream Visual Assessment Protocol (SVAP) at multiple locations in 2006, 2009 and 2010. **Figure 2-3** shows the locations of the water quality data available for analysis.

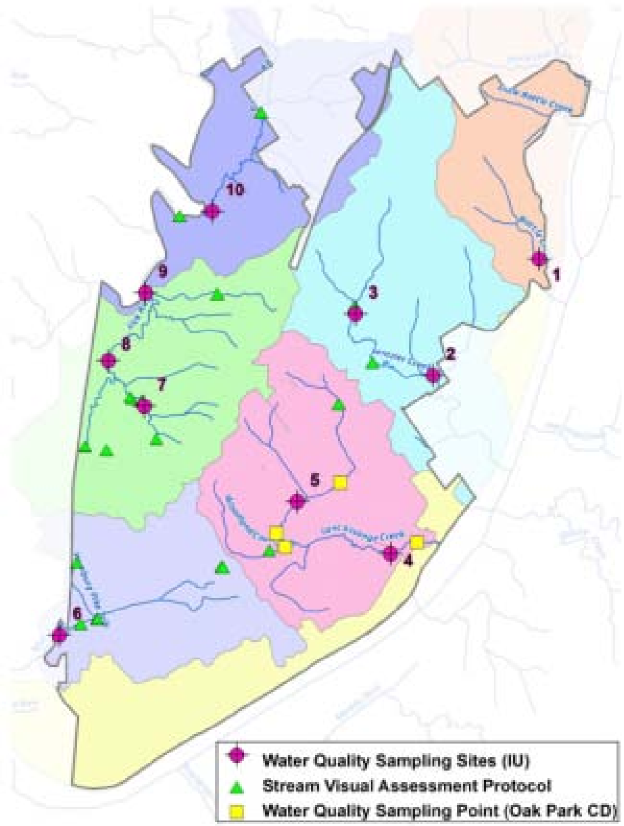

Figure 2-3 Water Quality Sampling Sites (IU, OPCD, SWMP)

Current water quality pollutant loadings were estimated for each of the 26 subwatersheds using the Long-Term Hydrologic Impact Analysis (L-THIA) tool. L-THIA is a desktop analysis that estimates change in recharge, runoff, and nonpoint source pollution (nitrogen, phosphorus, TSS, Biological Oxygen Demand (BOD), and *E.coli)* using local land use, soil, and climate data. **Figure 2-4** illustrates the rankings for each pollutant.

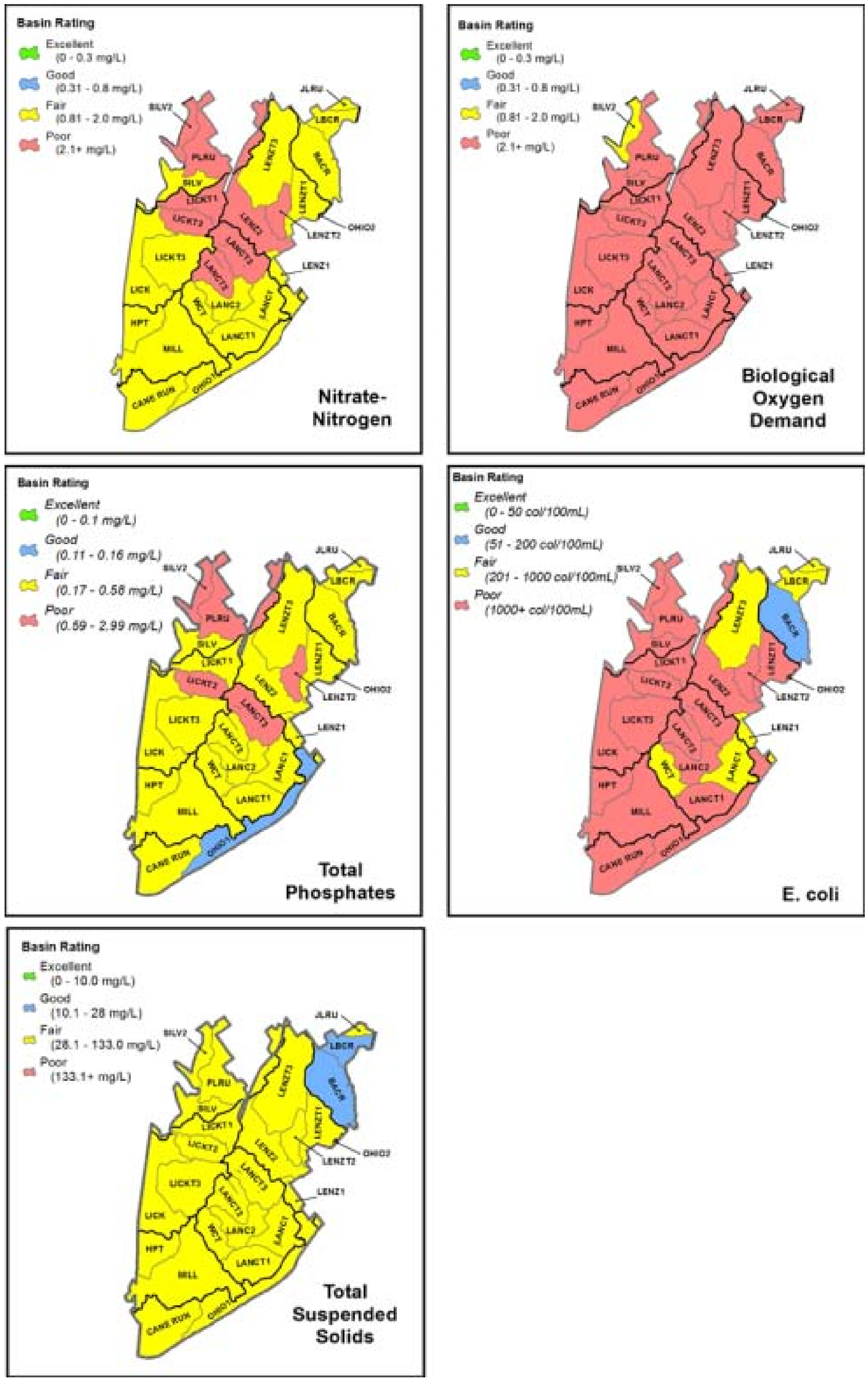

Figure 2-4 L-THIA Existing (N, P, TSS, BOD, E. coli) Citywide

Rankings for each pollutant loading are defined as:

- Excellent – pollutant levels are not impacting aquatic organisms
- Good – pollutant levels may begin to impact highly sensitive aquatic organisms
- Fair – pollutant levels may begin to impact moderately sensitive aquatic organisms
- Poor – pollutant levels may impact all aquatic organisms and the overall health of the stream ecosystem.

Impervious cover was estimated for each land use code based on the maximum percent impervious allowed for each zoning classification (**Figure 2-5**). Percent impervious is a common indicator of stream health and defined as:

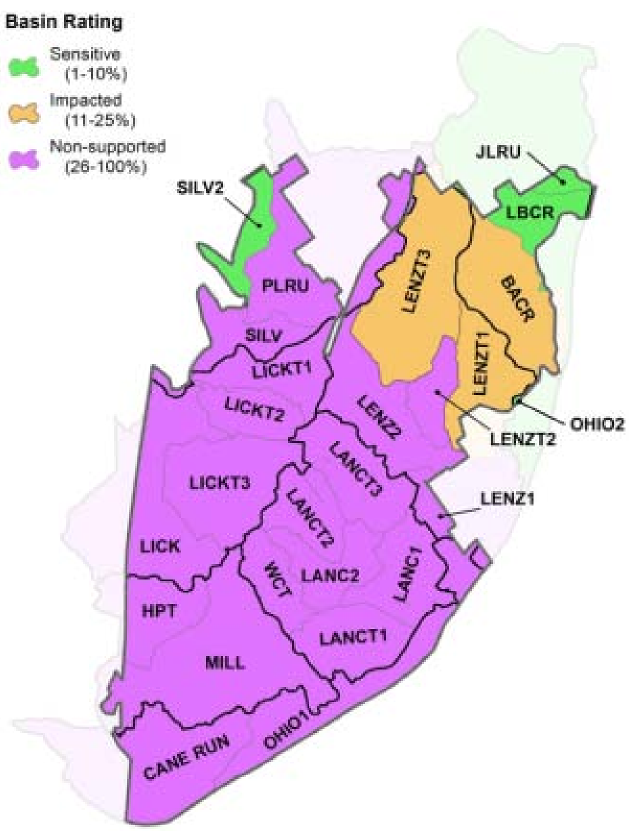

Figure 2-5 Impervious Cover (existing conditions) Citywide

- Sensitive Stream (1-10% impervious cover) – water may be warmer and slightly polluted, erosion may be evident, most rare and endangered species absent, few insect species
- Impacted Stream (11-25% impervious cover) – warmer water, erosion usually obvious, rare species absent, pollution tolerant insects only
- Non-supporting Stream (26-100% impervious cover) - warm water and pollution evident, unstable habitat, non-native species dominate, only pollutant tolerant fish and insects
- Supporting water quality data is included in Appendix 4.

Known Problems – the section includes a list of the flooding and drainage problems that were identified through meetings with the Drainage Board, City, County, and OPCD staff, and public. Although this SWMP included an extensive outreach effort to identify problems and concerns, only those areas identified by participants have been included. It is possible that other problems may exist that are not documented. Problems were grouped into 7 categories. These are defined as:

1. Building Flooding – documented water inside buildings
2. Drainage Issues – low lying areas where water collects and is slow to drain, outside of a floodplain

3. Maintenance – debris, sediment, or dense vegetation that restricts flow and causes water to back up
4. Restrictive Structure – undersized or insufficient culverts or bridges that restrict flow and causes water to back up
5. Riverine Flooding – area adjacent to the waterway that floods
6. Streambank Erosion – unstable streambanks depositing sediment or woody debris into the waterway and/or potential to affect neighboring land use
7. Street Flooding – standing water in the street; deep enough that it is impassible or unsafe for vehicles to travel through

These problem areas are discussed in more detail in Chapter 5 of this SWMP. The following discussion of each major watershed includes a detailed description and map of the problems.

2.3.1 Ohio River/Cane Run Watershed

Figure 2-6 Ohio/Cane Run Watershed

General Overview:
The Ohio River/Cane Run Watershed is located in the southern-most portion of the City of Jeffersonville and extends along the Ohio River (**Figure 2-6**). This area was first developed in 1786 for Fort Finney. The City of Jeffersonville grew around the Fort and the area remains heavily urbanized today. The predominant land use is commercial, high density residential and heavy industrial. Numerous historic landmarks dating back to the Civil War are located in this watershed as well as Jeffersonville Boat and Machine Company (Jeffboat), the largest inland shipbuilder in the United States (**Figure 2-7**).

Figure 2-7 Picture of Jeffboat (source: unreferenced web search)

Interstate 65 travels through a small portion of this watershed and connects Indiana to Kentucky via the Kennedy Bridge. It is estimated that 130,000 vehicles use this route daily.

The total watershed area is 3,606 acres. For the purpose of the water quantity and water quality analyses, the Ohio River/Cane Run Watershed was further divided into 3 subwatersheds: CANE RUN, OHIO1, and OHIO2. **Table 2-1** lists the subwatersheds, drainage area and the percent of the drainage area that is within the City of Jeffersonville.

Table 2-1 Ohio River/Cane Run Subwatersheds

Subwatershed Name	Drainage Area (acres)	Within City Limits
CANE RUN	1,950	64%
OHIO1	1,226	97%
OHIO2	430	3%
TOTAL	**3,606**	**68%**

Both the OHIO1 and OHIO2 subwatershed drain directly into the Ohio River, however, the CANE RUN subwatershed drains into the Town of Clarksville before discharging into the Ohio River.

Water Quantity:
Based on the hydrologic analysis performed as part of this SWMP, the 2-year, 10-year, and 100-year existing-condition unit peak flow rates have been determined and shown on **Exhibit 2-1** and **Table 2-2**. This data can be used as a baseline for setting maximum allowable release rates for proposed new development/ redevelopment in the watershed and for future evaluations of peak flow production trends within the City.

Table 2-2 Ohio River/Cane Run Peak Flow Rates

Subwatershed Name	100-year (cfs/acre)	10-year (cfs/acre)	2-year (cfs/acre)
CANE RUN	0.93	0.46	0.39
OHIO1	0.99	0.39	0.14
OHIO2	1.85	0.83	0.35

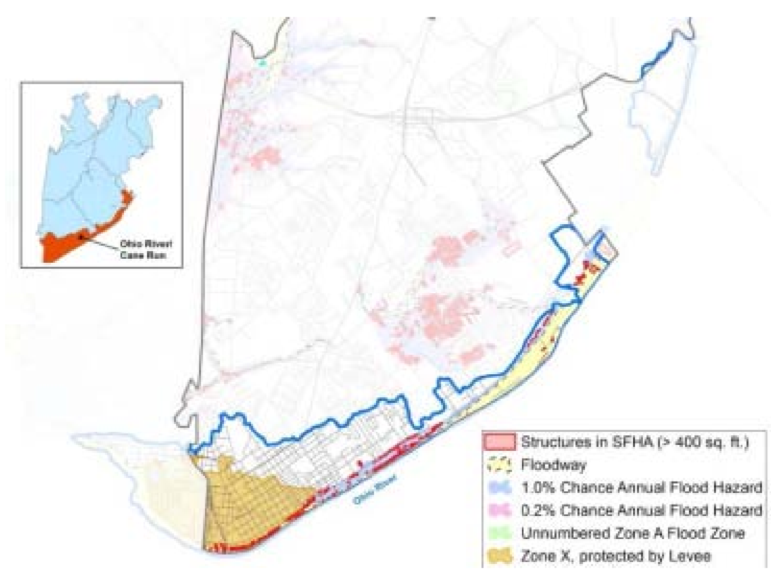

Figure 2-8 Ohio/Cane Run Watershed - Buildings in the SFHA and Zone X

Much of the Ohio River/Cane Run Watershed is protected from flooding by a network of levees and floodwalls along the Ohio River. Approximately 1,584 buildings (greater than 400 square feet) are located behind the levees and floodwall. The operation and maintenance of this flood protection system is under the authority of the Jeffersonville-Clarksville Flood Control Board.

The Jeffersonville-Clarksville Flood Control District operates and maintains the flood pumping stations that serve both the City of Jeffersonville and the Town of Clarksville. The Cane Run pumping station, located within Clarksville, is currently more than 70 years old and is in need of rehabilitation. The Flood Control District is currently in the process of designing a replacement for this pumping station that will increase the pumping capacity and lower the point at which the pumps will begin pumping and reduce flooding associated with this drainage area.

Outside of the flood protection area there are 318 buildings in the SFHA of Ohio River. Of these, 171 are located in the floodway. **Figure 2-8** and **Table 2-3** show the distribution of buildings in the floodplain in the Ohio River/Cane Run Watershed.

Table 2-3 Buildings in the SFHA in the Ohio River/Cane Run Watershed

Floodway	100-year Floodplain	Zone A	500-year Floodplain	Zone X (behind levee)
171	318	0	318	1,582

Figure 2-9 Street flooding downtown Jeffersonville (August 2009)

An analysis of the proposed preliminary floodplain delineation for the Ohio River and the most recent 2' topographic data indicates that some areas with higher ground (above the base flood elevation) are erroneously included in the regulatory floodplain and some areas with lower ground are erroneously shown as excluded.

Drainage in the interior of this CANE RUN subwatershed is poor and flooding is prevalent. Recent floods in August 2009, February 2010, and April 2011 resulted in multiple street closures and flood-related damage to buildings (**Figure 2-9**). Stormwater is currently conveyed toward the 10th Street Pump Station. During wet weather conditions, the pump station is capable of discharging 36 million gallons of water per day (MGD) to the Jeffersonville Wastewater Treatment Plant. As the flow to the pump station approaches 36 MGD, excess runoff is diverted through a pipe to the low area near Indiana Avenue and 8th Street. The remainder of the excess flow is diverted to Cane Run by way of an overflow weir at the pump station.

Estimated flooding extents and depths for the 100-year flood were taken from the Jeffersonville Canal Feasibility Study prepared by Strand Associates, Inc. in February 2010 (**Figure 2-10**). The greatest depth of flooding occurs in the area bound by 10th Street on the north, Broadway on the west, 7th Street on the south, and Wall Street on the east. There are approximately 80 commercial and 225 residential buildings in the area. Flooding in the City also impacts the downstream Town of Clarksville.

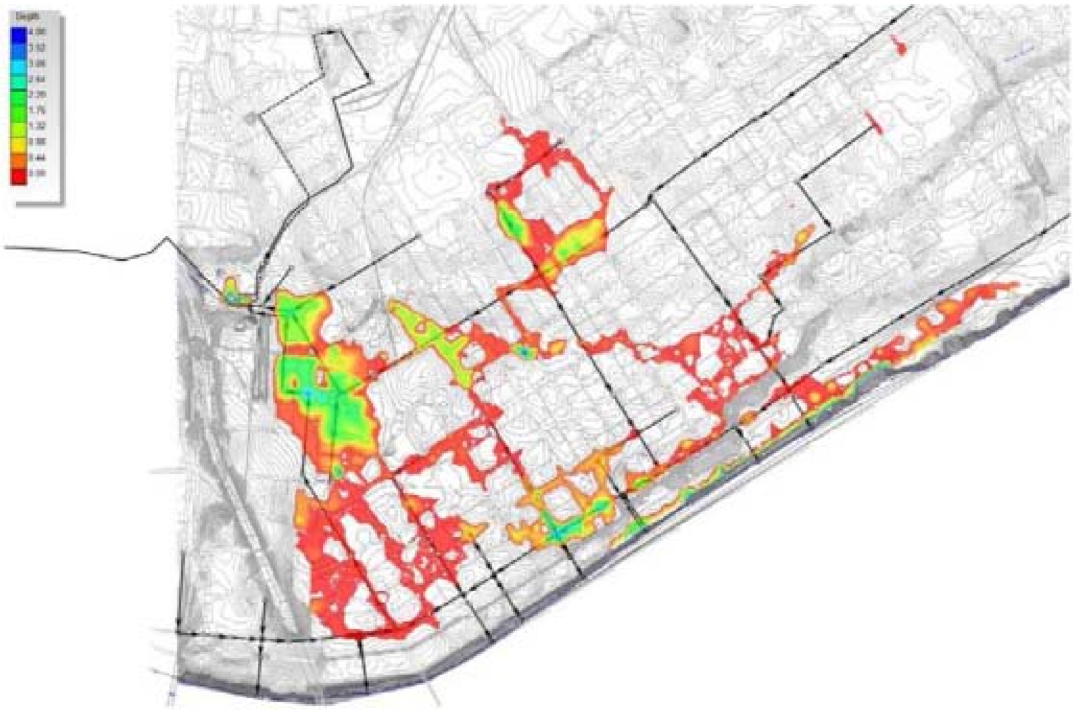

Figure 2-10 Estimated Downtown 100-Year Flooding and Depths

According to reports from the local media, portable flood gates were installed into the floodwall along the Ohio River during the April 2011 flood to protect the downtown area. This was the first flood in 14 years where the flood gates have been installed. Large pumps were brought in from surrounding Cities to remove the flood water in the downtown area.

Throughout the past 5 years, the City of Jeffersonville has taken on several projects in the CANE RUN subwatershed to help reduce localized flooding. The area near the intersection of 8th Street and Ohio Avenue has been identified as one of the lowest elevations in the watershed and has been the point of attention for multiple projects. In 2010, the City completed a project along 7th Street and Indiana Avenue to collect stormwater from 2 blocks of impervious area and convey that water first to a bioswale to allow for a reduction of stormwater entering the pipe conveyance system through infiltration. Similarly, in 2011, the City completed a project along 8th Street between Indiana Avenue and Watt Street that provided for a partial combined sewer separation that collected and conveyed stormwater away from the overloaded combined sewer interceptor. Portions of this project were routed through a large bioswale to help reduce the amount of stormwater entering the pipe conveyance system.

The City of Jeffersonville is currently in the process of constructing a new WWTP effluent line to remove their current WWTP effluent discharge from the Cane Run Watershed. The removal of this discharge should provide a benefit to the overall watershed.

Despite the above-noted projects, a major portion of downtown Jeffersonville remains vulnerable to interior drainage flooding during major rainfall events. To alleviate this problem, the City's elected officials proposed a significant flood control project in the form of a two-stage, dual purpose canal. The canal as planned was to serve both as a flood control project to address the interior drainage flooding and as a recreational/economic development corridor. The plans for construction of the canal were put on hold in early 2012 due to concerns regarding its cost and the City is looking for less expensive alternatives to address the flooding issues. A detailed evaluation of various alternatives is provided in Chapter 6 of this SWMP.

Water Quality:
The Ohio River is listed on IDEM's 303(d) Impaired Streams List for E.coli and PCBs in fish tissue. As a CSO area, EPA requires compliance with the technology-based and water quality-based requirements of the Clean Water Act as part of the City's LTCP. Also, the Ohio River Valley Sanitation Commission (ORSANCO) sets pollution control standards for industrial and municipal waste water discharges to the Ohio River, and tracks certain dischargers whose effluent can seriously impact water quality. Based on these ongoing water quality monitoring efforts, additional water quality samples were not gathered as part of this SWMP.

The Ohio River/Cane Run Watershed is heavily urbanized and has an estimated impervious cover of 67% (Figure 2-5). Based on this analysis, the runoff from this watershed is non-supporting of a healthy aquatic habitat. The L-THIA analysis (Figure 2-4 and **Table 2-4**) indicated that pollutant levels from stormwater runoff would impact aquatic organisms and the overall health of the stream. It is expected that only pollutant-tolerant species would be found in the waterbodies. A complete summary of the L-THIA data and exhibits is in Appendix 4.

Table 2-4 L-THIA Results for Ohio River/Cane Run Watershed

Nonpoint Source Pollutant	L-THIA Results
Nitrogen	Fair
Phosphorus	Fair to Good
TSS	Fair
BOD	Poor
E.coli	Poor

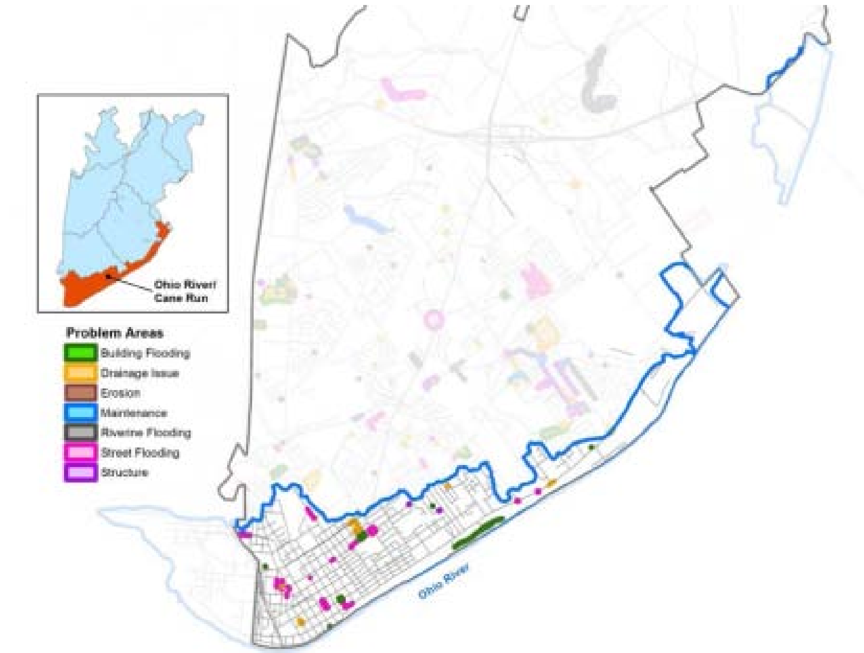

Figure 2-11 Ohio River/Cane Run Problem Areas

The City of Jeffersonville entered into a Consent Decree in November of 2009 with the U.S. Department of Justice, the U.S. EPA and IDEM to avoid a lawsuit in Federal Court for the City's violations of the CWA as a result of CSO discharges to the Ohio River. The Consent Decree contains a number of improvement projects that must be completed by 2025 in order to avoid fines and penalties, as well as further litigation. The importance of this is that the combined sewer service area makes up the majority of the CANE RUN subwatershed, an area which will see a series of projects to collect both sanitary and storm flow and provide storage until the combined flow can be conveyed to the wastewater treatment plant. The goal of these projects will be to reduce the number of combined sewer overflow events to both the Ohio River and Cane Run

Known Problems:

Discussions with City and County staff and the public during the development of this SWMP identified 36 flooding and drainage problems in the Ohio River/Cane Run Watershed. These are illustrated on (**Figure 2-11**) and summarized below:

- Building Flooding (8)
- Drainage Issues (6)
- Restrictive Structures (2)
- Street Flooding (20)

The description, source, and other comments regarding each identified problem are included in **Appendix 5**.

2.3.2 Mill Creek Watershed

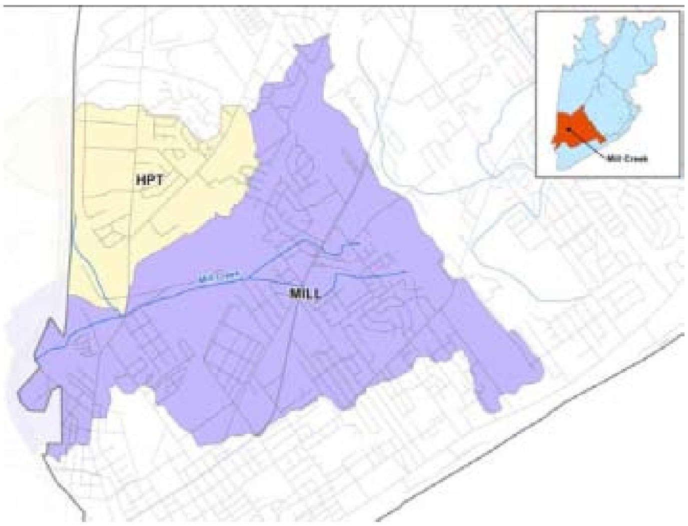

Figure 2-12 Mill Creek Watershed

General Overview:

The Mill Creek Watershed drains 3,162 acres of commercial, single/multi-family residential and light/heavy industrial development in the south western portion of the City of Jeffersonville. Much of this area (91% or 2,862 acres) is within Jeffersonville and drained by Mill Creek and Hamburg Pike Tributary into the neighboring Town of Clarksville (**Figure 2-12**).

For the purpose of the water quantity and water quality analyses, the Mill Creek Watershed was divided into 2 subwatersheds: 1 representing the main stem of Mill Creek (MILL) and the other Hamburg Pike tributary (HPT). **Table 2-5** lists the subwatersheds, drainage area and the percent of the drainage area that is within the City of Jeffersonville.

Table 2-5 Mill Creek Subwatersheds

Subwatershed Name	Drainage Area (acres)	Within City Limits
MILL	2,371	94%
HPT	791	80%
TOTAL	**3,162**	**91%**

Hamburg Pike tributary (HPT) drains into Mill Creek (MILL) and then flows through the Town of Clarksville before discharging into the Ohio River.

Water Quantity:

Based on the hydrologic analysis performed as part of this SWMP, the 2-year, 10-year, and 100-year existing-condition unit peak flow rates have been determined and shown on **Exhibit 2-1** and **Table 2-6**. This data can be used as a baseline for setting maximum allowable release rates for proposed new development/redevelopment in the watershed and for future evaluations of peak flow production trends within the City.

Table 2-6 Mill Creek Peak Flow Rates

Subwatershed Name	100-year (cfs/acre)	10-year (cfs/acre)	2-year (cfs/acre)
MILL	1.65	0.81	0.39
HPT	2.19	1.00	0.43

A detailed floodplain study appears to have been completed for the FIS in the late 1970s or early 1980s for Mill Creek and Hamburg Pike Tributary. This detailed study took into account the attenuation of stream flow downstream of two railroad bridges on Mill Creek due to the storage that was available upstream of the railroads and the limited outflow capacity through the railroads. Flows will be increased downstream if the storage area upstream of the railroads is reduced or if the capacity of the opening through the railroads is increased. An analysis of the proposed preliminary FEMA maps and most recent 2' topography reveals several locations where the channel of both streams is shown outside the floodway. There are also locations where high ground is erroneously included in the floodplain and places where low ground is erroneously excluded. The hydraulic models for Mill Creek and Hamburg Pike Tributary are old enough that they include minimal cross sections and may have missed topography that impacts the water surface elevations.

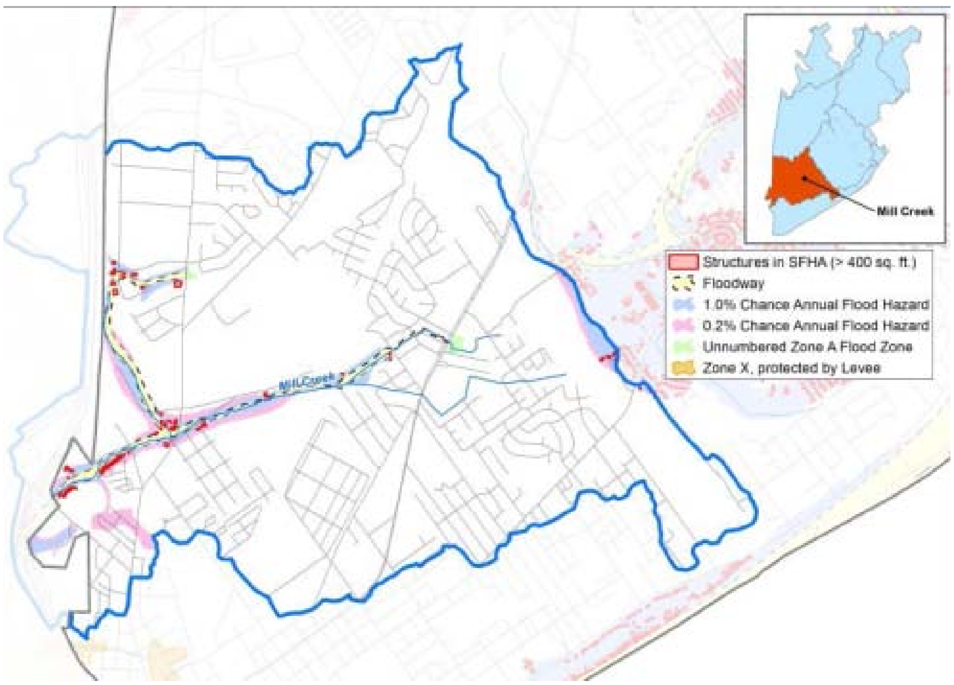

Figure 2-13 Mill Creek Watershed Buildings in SFHA

The GIS analysis of the building layer and the preliminary FIRM identified 82 buildings in the SFHA. **Figure 2-13** and **Table 2-7** show the number of structures in the floodway, 100- and 500-year Mill Creek floodplain.

Table 2-7 Buildings in the SFHA in the Mill Creek Watershed

Floodway	100-year Floodplain	Zone A	500-year Floodplain	Zone X (behind levee)
19	65	17	148	NA

Similar to the CANE RUN subwatershed (in the Ohio River/Cane Run Watershed), the Jeffersonville-Clarksville Flood Control District operates and maintains the flood pumping station that serves Mill Creek for both

Jeffersonville and Clarksville. The Mill Creek pumping station, located in Clarksville, is currently more than 70 years old and is in need of rehabilitation. The Flood Control District is currently in the process of designing a replacement for this pumping station that will increase the pumping capacity and reduce flooding associated with this drainage area.

The City of Jeffersonville has recently completed several projects in this area to reduce flooding along the upper reaches of Mill Creek. The Nachand Lane/Clarview Drainage Improvement project has reduced flooding near the Youngstown Shopping Center, Nachand Lane, Plank Road and Clarview Drive area by providing a collection and conveyance mechanism to move the stormwater runoff out of these areas. This project was completed in 2011. In 2010, the City constructed and improved drainage conveyance on the upper most reach of Mill Creek near the Rolling Fields subdivision, reducing flooding. Other miscellaneous drainage improvement projects have been completed in this drainage area since the last stormwater management plan was prepared in 1997 that have reduced flooding and provided stormwater conveyance.

Water Quality:

The City conducted SVAP assessments on Mill Creek downstream of the confluence with Hamburg Pike Tributary in 2006, 2009 and 2010 and identified an area of severe streambank erosion. In the headwaters of the Mill Creek Watershed a 2009 and 2010 SVAP also noted streambank erosion. A field investigation was completed during the development of this SWMP to confirm the severity of the problem (**Figure 2-14**).

Figure 2-14 Streambank Erosion along Mill Creek

Water quality samples were collected as part of this SWMP at Mill Creek and Eastern Blvd (Figure 2-3). The following summarized the results from the samples gathered. **Table 2-8** provides the general water quality summary and Appendix 4 includes the full water quality report:

- **Chemical** – For all sampling events, nitrate concentrations were well below the IDEM drinking water standard of 10.0 mg/L. Further, total phosphorus concentrations were below the IDEM TMDL draft target of 0.3 mg/L. Only the September sample resulted in *E. coli* concentrations higher than the IDEM single sample standard of 235 CFU/100 mL. Ammonia concentrations at this location were among the highest for all locations and for all individual events.
- **Biological** – The resulting mIBI score for this location was the lowest score of the 9 sampling sites with a score of 2.0

(of a possible 8.0) indicating moderately to severely impaired macroinvertebrate communities. Similarly, the HBI score for this location was the worst of the sampling sites with an index score of 7.68 of 10.0.

- **Physical** – The predominant land use at this site was noted as mowed lawn/field and the riparian zone was very narrow with less than 5 meters on both banks. With a QHEI score of 47 (of a possible 100), this location is categorized as Fair. Individual metric scores associated with the quality and amount of instream cover, as well as the channel morphology were problematic for this site. Instream conditions were poor with unstable substrate, moderate embeddedness, and poor pool/riffle development.

Table 2-8 Water Quality Summary for Mill Creek Watershed

Sampling Parameter	Sampling Results
Chemical (TSS)	Excellent
Chemical *(E. coli)*	Fair
Biological	Severely Impacted
Physical	Good

The impervious cover for the Mill Creek Watershed is estimated to be 65% and non-supporting of a healthy stream ecosystem (Figure 2-5). The L-THIA analysis (Figure 2-4 and **Table 2-9**) indicated that pollutant levels from stormwater runoff would impact aquatic organisms and the overall health of the stream. It is expected that only pollutant tolerant species would be found in the waterbodies. A summary of the L-THIA data and exhibits is in Appendix 4.

Table 2-9 L-THIA Results for the Mill Creek Watershed

Nonpoint Source Pollutant	L-THIA Results
Nitrogen	Fair
Phosphorus	Fair
TSS	Fair
BOD	Poor
E.coli	Poor

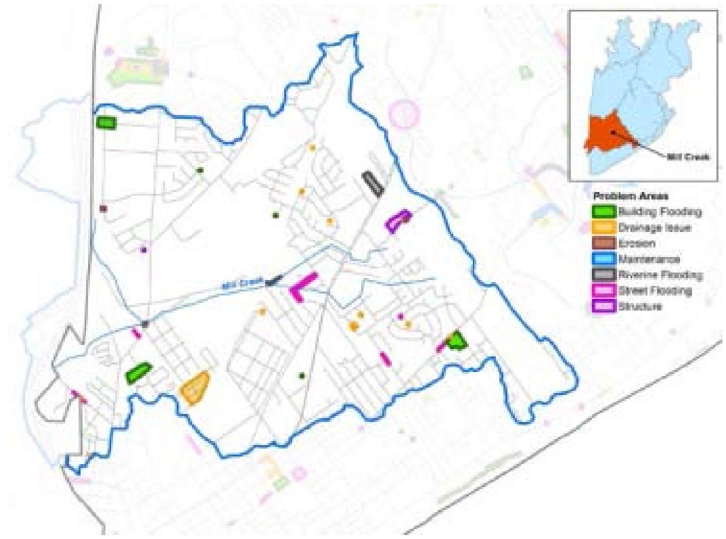

Figure 2-15 Mill Creek Problem Areas

Known Problems:
Discussions with City and County staff and the public during the development of this SWMP identified 34 flooding and drainage problems in the Mill Creek Watershed. These are illustrated on **Figure 2-15** and summarized below:

- Building Flooding (6)
- Drainage Issue (13)
- Restrictive Structure (3)
- Riverine Flooding (3)
- Streambank Erosion (3)
- Street Flooding (8)

The description, source, and other comments regarding each identified problem are included in Appendix 5.

2.3.3 Lancassange Creek Watershed

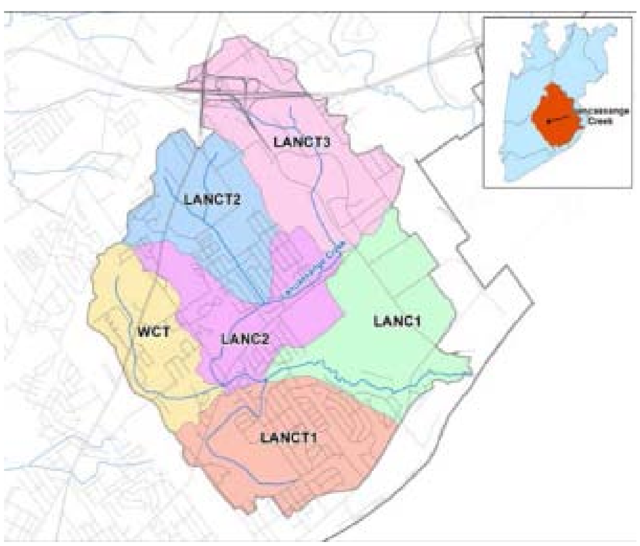

Figure 2-16 Lancassange Creek Watershed

General Overview:
Lancassange Creek Watershed is centrally located in the City of Jeffersonville and includes the recently annexed OPCD. The watershed is 4,255 acres and entirely within the new City limits (**Figure 2-16**). Land use in the Lancassange Creek Watershed is compact single family residential (predominantly in the OPCD) and some multi-family, large areas of commercial and light industrial use, and undeveloped agricultural areas.

For the purpose of the water quantity and water quality analyses, the Lancassange Creek Watershed was divided into 6 subwatersheds: Lancassange Creek (LANC1 and LANC2), Woodland Court Tributary (WCT), and an Unnamed Tributary (LANCT1, LANCT2 and LANCT3) all drain the watershed into the Ohio River. **Table 2-10** lists the subwatersheds, drainage area and the percent of the drainage area that is within the City of Jeffersonville.

Table 2-10 Lancassange Creek Subwatersheds

Subwatershed Name	Drainage Area (acres)	Within City Limits
LANC1	809	100%
LANC2	637	100%
LANCT1	786	100%
LANCT2	607	100%
LANCT3	915	100%
WCT	501	100%
TOTAL	**4,255**	**100%**

Water Quantity:
Based on the hydrologic analysis performed as part of this SWMP, the 2-year, 10-year, and 100-year existing-condition unit peak flow rates have been determined and shown on **Exhibit 2-1** and **Table 2-11**. This data can be used as a baseline for setting maximum allowable release rates for proposed new development/redevelopment in the watershed and for future evaluations of peak flow production trends within the City.

Table 2-11 Lancassange Creek Peak Flow Rates

Subwatershed Name	100-year (cfs/acre)	10-year (cfs/acre)	2-year (cfs/acre)
LANC1	1.85	0.83	0.35
LANC2	1.89	0.81	0.32
LANCT1	0.99	0.39	0.14
LANCT2	1.64	0.67	0.24
LANCT3	1.40	0.62	0.26
WCT	1.66	0.71	0.28

A detailed floodplain study was completed for the 1980 Clark County FIS and may have had some updates since that time for all but the upper reaches of Lancassange Creek and Woodland Court Tributary. An analysis of the proposed preliminary FEMA maps and the Jeffersonville 2-foot contour interval topography indicated several locations, for both streams, where the floodway does not include the channel and an area upstream on Lancassange Creek where significant flow would leave the stream based on existing base flood elevations. The hydraulic model for Lancassange Creek and Woodland Court Tributary are old enough that they include minimal cross sections and may have missed topography that impacts the water surface elevations. As part of this SWMP, an analysis of the upper reach of Lancassange Creek was completed to determine approximate base flood elevations for stream reaches with a 1 square mile or more drainage area.

The GIS analysis of the building layer and preliminary DFRIM identified 1,111 buildings in the SFHA. **Figure 2-17** and **Table 2-12** shows the number of structures in the Lancassange Creek floodplain.

Table 2-12 Buildings in the SFHA in the Lancassange Creek Watershed

Floodway	100-year Floodplain	Zone A	500-year Floodplain	Zone X (behind levee)
95	1,111	0	1,147	NA

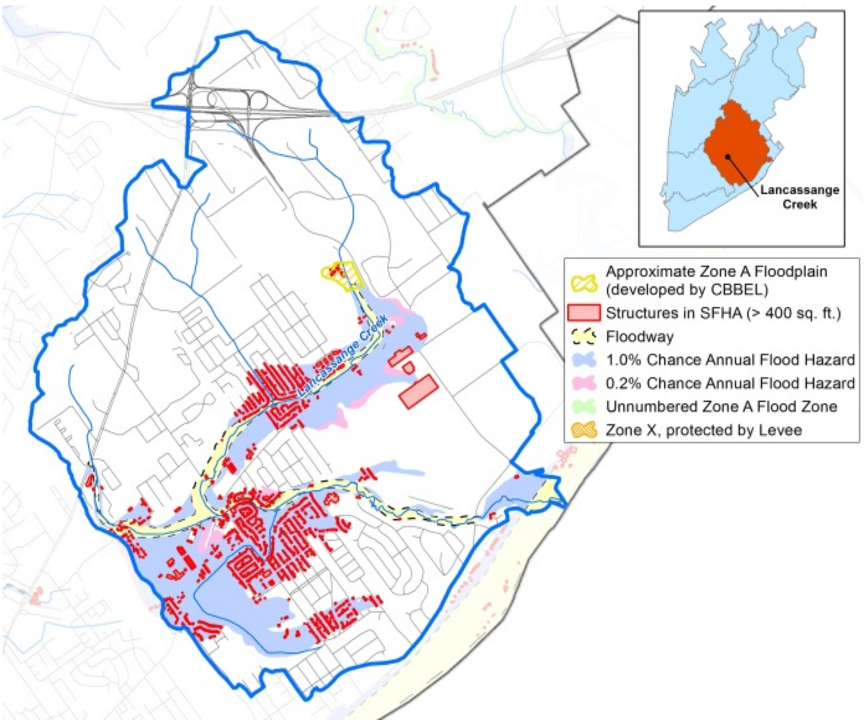

Figure 2-17 Lancassange Creek Watershed Buildings in SFHA

As previously mentioned, the City of Jeffersonville recently annexed the majority of the Lancassange Creek watershed into its jurisdiction. This watershed was previously under control by Clark County and the OPCD, and remains in the OPCD. The City of Jeffersonville has made stormwater improvements in the Mellwood Subdivision, to help convey flow. The OPCD has made numerous improvements throughout their district to help localized flooding and ponding.

Water Quality:

Water quality samples were collected as part of this SWMP at Lancassange Creek at Utica Pike and at President's Place (Figure 2-3). The following summarized the results from the samples gathered. **Table 2-13** provides the general water quality summary and Appendix 4 includes the full water quality report:

- **Chemical** – Both sampling locations indicated moderate levels of Nitrate concentrations (ranging from 0.575 mg/L – 1.28 mg/L) while all individual sampling results for total phosphorus were well below the IDEM draft target of 0.3 mg/L (ranging from 0.036 mg/L – 0.058 mg/L). *E. coli* concentrations were above the state standard for 2 sampling events at Site #4 and 1 sampling event at Site #5.
- **Biological** – Site #5 received the most ideal mIBI score of all sampling locations with a 4.00 (of 8.0). However, this score is still indicative of slight to moderate impairments.

Lancassange Creek at Utica Pike resulted in an mIBI score of 3.11 indicating moderate impairments. Regarding the HBI scores, both sites received scores indicating an elevated level of organic pollution; Site #4-6.12 and Ste #5-5.47.

- **Physical** – Site #4 was noted as having a predominant land use of forested area on both streambanks, while Site #5 was manicured lawns with little riparian zone. QHEI scores at these locations were moderate compared to other sites; Site #4-48.0 and Site #5-37.0, the 3rd and 5th highest scores respectively. While Site #5 had a more ideal individual metric score regarding substrate, the individual metric scores for channel morphology, riparian zone, and pool/glide quality were significantly lower than those scores for Site #4.

Table 2-13 Water Quality Summary for Lancassange Creek Watershed

Sampling Parameter	Sampling Results
Chemical (TSS)	Excellent
Chemical (*E. coli)*	Fair
Biological	Moderately Impacted
Physical	Good - Fair

In 2004 and 2008, the OPCD completed water chemistry monitoring at 4 locations in this subwatershed (Figure 2-3). Sampling included heavy metals such as Copper, Lead, and Nickel and many of the samples analyzed resulted in concentrations lower than the detection limits set for each parameter. In addition, similar to the sampling results noted above, the nitrate concentrations for these locations were fair to poor ranging from 0.704 mg/L to 3.25 mg/L for individual samples. All individual phosphorus concentrations were below the Indiana target of 0.3 mg/L (ranging from below detection limits to 0.283 mg/L). E coli samples collected in October of 2004 were much higher than those collected during the sampling events of 2011. Individual concentrations ranged from 4,200 CFU/100 mL to 8,800 CFU/100 mL.

The City of Jeffersonville conducted a SVAP on 2 sites in 2006, 2009 and 2010. This assessment indicated a narrow riparian corridor in the headwaters of Lancassange Creek but did not indicated issues with streambank erosion.

The impervious cover analysis completed for the Lancassange Creek Watershed indicated that the impervious cover was 59% and as a result, non-supporting of a healthy stream ecosystem (**Figure 2-5**). The L-THIA analysis (Figure 2-4 and **Table 2-14**) indicated that pollutant levels from stormwater runoff would impact aquatic organisms and the overall health of the stream. It is expected that only pollutant tolerant species would be found in the waterbodies. A summary of the L-THIA data and exhibits is in Appendix 4.

Table 2-14 L-THIA Results for the Lancassange Creek Watershed

Nonpoint Source Pollutant	L-THIA Results
Nitrogen	Fair to Poor
Phosphorus	Fair to Poor
TSS	Fair
BOD	Poor
E.coli	Fair to Poor

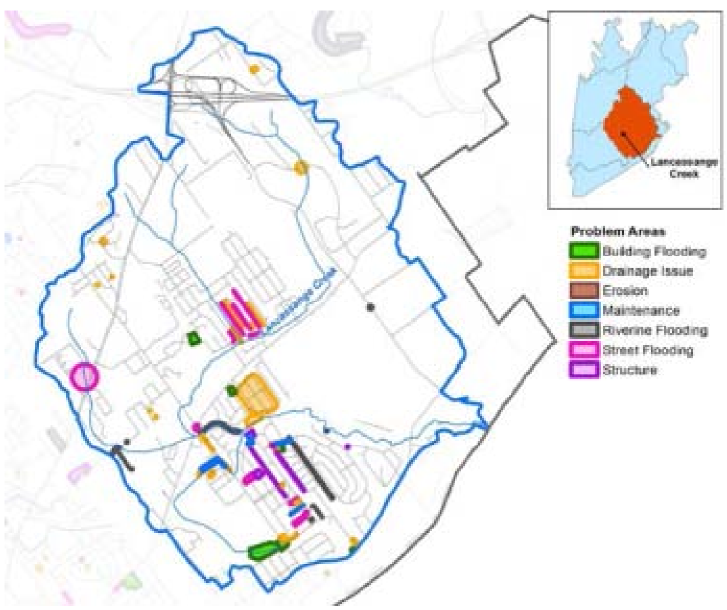

Figure 2-18 Lancassange Creek Problem Areas

Known Problems:
Discussions with City, County, and OPCD staff and the public during the development of this SWMP identified 73 flooding and drainage problems in the Lancassange Creek Watershed. These are illustrated in **Figure 2-18** and summarized below:

- Building Flooding (6)
- Drainage Issue (27)
- Maintenance (4)
- Restrictive Structure (5)
- Riverine Flooding (15)
- Street Flooding (14)

The description, source, and other comments regarding each identified problem are included in Appendix 5.

2.3.4 Lick Run Watershed

General Overview:
The Lick Run Watershed is located along the western border of the City of Jeffersonville and drains 4,618 acres. Approximately 83% (3,839 acres) of this watershed is within Jeffersonville (**Figure 2-19**). The watershed is predominantly single family residential with some pockets of multi-family development, commercial, and undeveloped land.

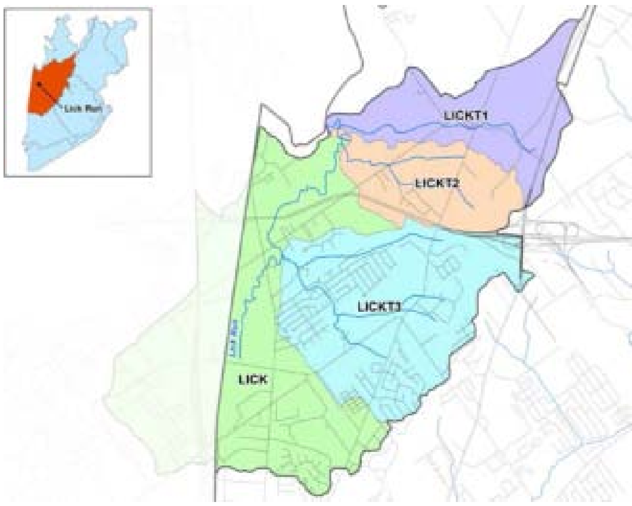

Figure 2-19 Lick Run Watershed

For the purpose of the water quantity and water quality analyses, the Lick Run Watershed was divided into 4 subwatersheds: Lick Run main stem (LICK) and 3 unnamed tributaries (LICKT1, LICKT2 and LICKT3). **Table 2-15** lists the subwatersheds, drainage area and the percent of the drainage area that is within the City of Jeffersonville.

Table 2-15 Lick Run Subwatersheds

Subwatershed Name	Drainage Area (acres)	Within City Limits
LICK	2,073	63%
LICKT1	708	98%
LICKT2	527	100%
LICKT3	1,310	100%
TOTAL	**4,618**	**83%**

Lick Run and the unnamed tributaries drain into Silver Creek inside the City limits.

Water Quantity:

Based on the hydrologic analysis performed as part of this SWMP, the 2-year, 10-year, and 100-year existing-condition unit peak flow rates have been determined and shown on Exhibit 2-1 and **Table 2-16**. This data can be used as a baseline for setting maximum allowable release rates for proposed new development/redevelopment in the watershed and for future evaluations of peak flow production trends within the City.

Table 2-16 Lick Run Peak Flow Rates

Subwatershed Name	100-year (cfs/acre)	10-year (cfs/acre)	2-year (cfs/acre)
LICK	1.38	0.70	0.35
LICKT1	1.20	0.52	0.52
LICKT2	1.76	0.84	0.39
LICKT3	1.62	0.71	0.29

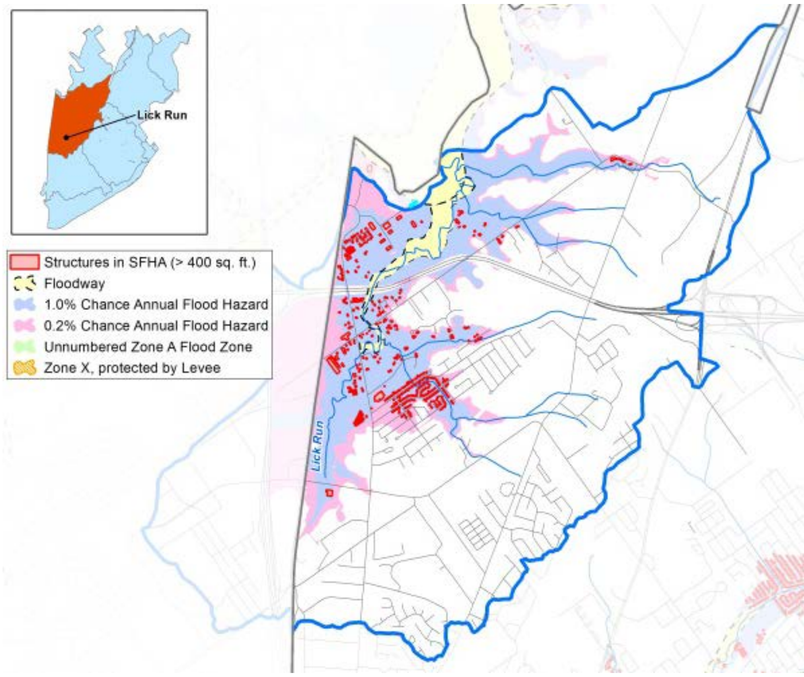

Figure 2-20 Lick Run Watershed Buildings in SFHA

A detailed floodplain study of Lick Run was completed in about 2006 for use in the 2011 preliminary Clark County FIS. The floodplain delineation for Lick Run is controlled by Silver Creek. The Silver Creek floodplain elevations were originally determined for the 1980 Clark County FIS. A redelineation was done for the 2011 preliminary FIS based on the previous BFE and the Jeffersonville 2-foot topographic data. The channel and floodplain for Lick Run appear to be in agreement with the current topography. As part of this SWMP, an analysis of two tributaries to Lick Run and the upper reach of Lick Run was completed to determine approximate base flood elevations and floodplain limits for stream reaches with 1 square mile or more drainage area.

The GIS analysis of the building layer and preliminary DFRIM identified 374 structures in the SFHA. **Figure 2-20** and **Table 2-17** shows the number of structures in the Lick Run floodplain.

Table 2-17 Buildings in the SFHA in the Lick Run Watershed

Floodway	100-year Floodplain	Zone A	500-year Floodplain	Zone X (behind levee)
0	374	0	589	NA

In 2006, the City of Jeffersonville constructed a large regional detention basin along with various stormwater infrastructure conveyance components to provide relief to the Meadows Subdivision. This project was identified in the 1997 Stormwater Management Plan, and has provided substantial flooding relief to a large residential area. In 2007, the City widened and straightened a portion of Lick Run near Charlestown-New Albany Road to assist with capacity and conveyance. Upstream areas associated with this project, Waverly Road area, continue to observe flooding due to pipe restrictions.

Water Quality:

Water quality samples were collected as part of this SWMP on Lick Run (Middle Fork) at Bishop Road and another on Lick Run at Potter Road (Figure 2-3). The following summarized the results from the samples gathered. **Table 2-18** provides the general water quality summary and Appendix 4 includes the full water quality report:

- **Chemical** – All individual sampling events resulted in low concentrations of nitrates with 4 of the 6 samples below 0.30 mg/L. The remaining 2 samples, both during the September event, were just slightly higher: Site #7-0.311 mg/L and Site #8-0.324 mg/L. Similarly, all total phosphorus individual results were well below the IDEM target of 0.3 mg/L, with the highest concentration at Site #8 of 0.084 mg/L. The September sampling event at Site #8 was the only individual *E. coli* concentration above the Indiana State standard.
- **Biological** – Site #7 scored the 3rd best overall mIBI (3.33 of 8.0) while Site #8 received a 2.44 (the 2nd lowest score). Both scores indicate these sampling locations as moderately impaired. The HBI scores indicate that Site #7 (score of 6.25; the 2nd worst of all locations) is Fair and that Site #8 (score of 5.20; 3rd best score) is Good in relation to organic pollution impacts to macroinvertebrate communities.
- **Physical** – Both locations in this watershed received low overall QHEI scores; Site #7-17 of 100 and Site #8-29.5 of 100. At each location, individual metric scores were lower than half of the potential scores. Site #7 is located in a residential subdivision with no riparian zone established and the stream was completely channelized with concrete walls. The stability, even with concrete walls, is still only moderate as areas of undermining and erosion are present. Instream conditions, as can be expected in a concrete channel, were extremely lacking. Site #8 was only slightly more ideal as the substrate was primarily muck, areas of erosion were visible, and no riffle development was evident.

Table 2-18 Water Quality Summary for Lick Run Watershed

Sampling Parameter	Sampling Results
Chemical (TSS)	Excellent
Chemical (*E. coli)*	Good
Biological	Moderately Impacted
Physical	Poor

Figure 2-21 Modifications to Lick Run

The City conducted SVAPs at multiple sites in the Lick Run Watershed in 2006, 2009 and 2010. The assessment found the stream had been straightened, very limited riparian cover, streambank erosion, and encroachment from neighboring land uses. A field investigation was completed during the development of this SWMP to confirm the severity of the problem (**Figure 2-21**)

The impervious cover for the Lick Run Watershed is estimated at 57% and as a result non-supporting of a healthy aquatic habitat (Figure 2-5). The L-THIA analysis (Figure 2-4 and **Table 2-19**) indicated that pollutant levels from stormwater runoff would impact aquatic organisms and the overall health of the stream. It is expected that only pollutant tolerant species would be found in the waterbodies. A summary of the L-THIA data and exhibits is in Appendix 4.

Table 2-19 L-THIA Results for the Lick Run Watershed

Nonpoint Source Pollutant	L-THIA Results
Nitrogen	Fair to Poor
Phosphorus	Fair to Poor
TSS	Fair
BOD	Poor
E.coli	Poor

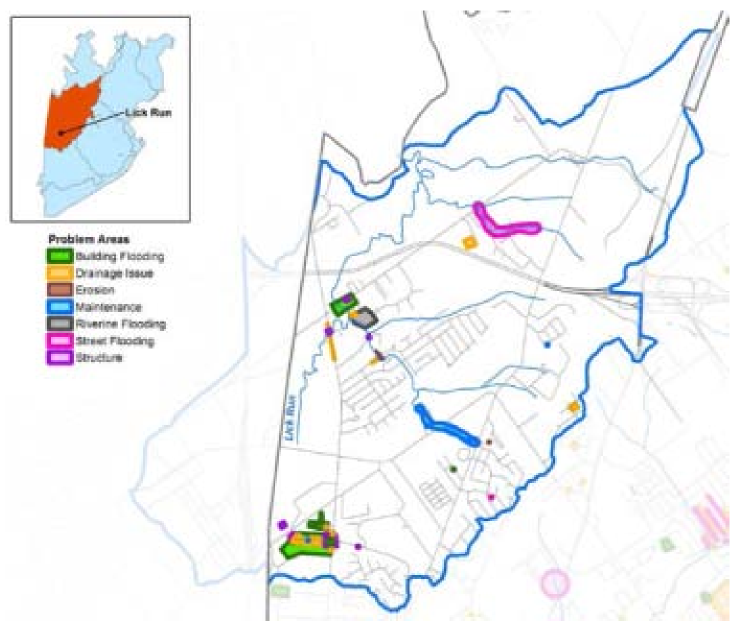

Figure 2-22 Lick Run Problem Areas

Known Problems:
Discussions with City and County staff as well as the public during the development of this SWMP identified 41 flooding and drainage problems in the Lick Run Watershed. These are illustrated **Figure 2-22** and summarized below:

- Building Flooding (12)
- Drainage Issue (10)
- Maintenance (5)
- Restrictive Structure (8)
- Riverine Flooding (1)
- Streambank Erosion (2)
- Street Flooding (3)

The description, source, and other comments regarding each identified problem are included in Appendix 5.

2.3.5 Silver Creek/Pleasant Run Watershed

General Overview:

The Silver Creek/Pleasant Run Watershed is a 3,967 acre drainage area in the north western part of the City of Jeffersonville. A little over half the watershed is located in the City (57% or 2,277 acres) and drains into Pleasant Run and Silver Creek (**Figure 2-23**). Land use in the Silver Creek/Pleasant Run Watershed is agriculture and low density residential.

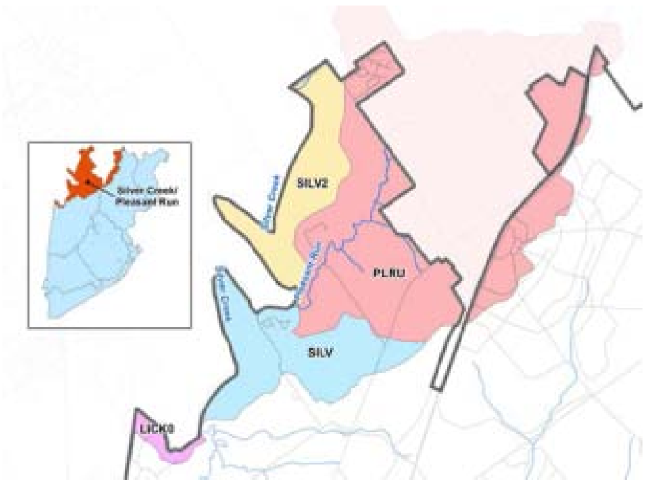

Figure 2-23 Silver Creek/Pleasant Run Watershed

For the purpose of the water quantity and water quality analyses, the watershed was subdivided into 3 subwatersheds, one representing the Pleasant Run tributary (PLRU), one representing areas directly discharging to Silver Creek south of Pleasant Run mouth (SILV), and one representing areas directly discharging to Silver Creek north of Pleasant Run mouth (SILV2). **Table 2-20** lists the subwatersheds, drainage area and the percent of the drainage area that is within the City of Jeffersonville.

Table 2-20 Silver Creek/Pleasant Run Subwatersheds

Subwatershed Name	Drainage Area (acres)	Within City Limits
PLRU	2,960	45%
SILV	585	95%
SILV2	422	95%
TOTAL	**3,967**	**57%**

Water Quantity:

Based on the hydrologic analysis performed as part of this SWMP, the 2-year, 10-year, and 100-year existing-condition unit peak flow rates have been determined and shown on Exhibit 2-1 and **Table 2-21**. This data can be used as a baseline for setting maximum allowable release rates for proposed new development/redevelopment in the watershed and for future evaluations of peak flow production trends within the City.

Table 2-21 Silver Creek/Pleasant Run Peak Flow Rates

Subwatershed Name	100-year (cfs/acre)	10-year (cfs/acre)	2-year (cfs/acre)
PLRU	1.17	0.47	0.17
SILV	1.82	0.85	0.37
SILV2	3.12	1.26	0.44

A detailed floodplain study was completed for Silver Creek for the 1980 Clark County FIS. The floodplain was redelineated for the preliminary 2011 FIS using the Jeffersonville 2-foot topographic data and Silver Creek topographic mapping. The channel location and floodplain delineation for Silver Creek therefore appears to be in agreement with the current topography.

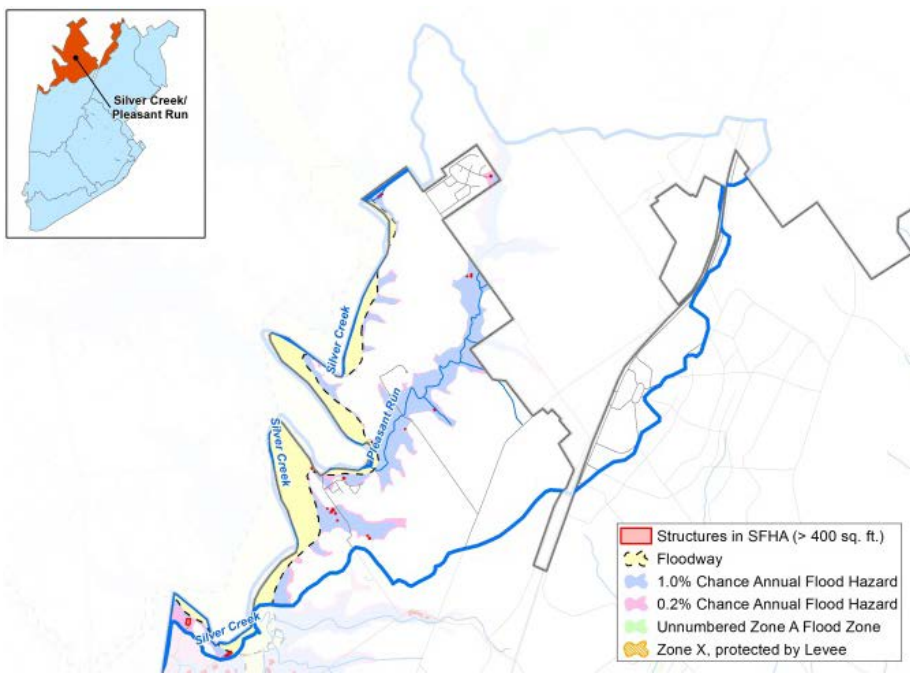

Figure 2-24 Silver Creek/Pleasant Run Watershed - Buildings in SFHA

Pleasant Run appears to have been studied for the 2011 preliminary FIS and was delineated based on 5-foot interval contours. The floodplain appears to generally coincide with these contours. The floodway has not been delineated. Based on the most recent aerial photography it appears the channel is outside of the floodplain in a few places and the floodplain, as drawn, includes a swale that appears to have been filled for a house which may not actually be below the base flood elevation.

The GIS analysis of the building layer and the preliminary DFRIM identified 20 buildings in the SFHA. **Figure 2-24** and **Table 2-22** show the number of structures in the Lick Run SFHA.

Table 2-22 Buildings in the SFHA in the Silver Creek/Pleasant Run Watershed

Floodway	100-year Floodplain	Zone A	500-year Floodplain	Zone X (behind levee)
2	20	0	28	NA

The City of Jeffersonville recently annexed the majority of this watershed into their jurisdiction, and as such, has made limited improvements to date.

Water Quality:

Silver Creek is listed on IDEM's 303(d) Impaired Streams List for E.coli and Impaired Biotic Communities. Water quality samples were collected as part of this SWMP on Silver Creek at Watson Sellersburg Road and on Pleasant Run at Prather Road (Figure 2-3). Summarized below are the results from the samples gathered.

Table 2-23 provides the water quality summary and Appendix 4 includes the full water quality report:

- **Chemical** – Sites #9 and #10 *E. coli* results were above the Indiana State standard 4 of 6 times with the highest score of 1,119.9 CFU/100 mL at Site #10 during the September sampling event. All but 1 individual total phosphorus concentration was above 0.1 mg/L (Site #10, August event: 0.142 mg/L) and all were well below the Indiana target of 0.3 mg/L. Nitrate concentrations were also minimal with only 1 sample above 1.0 mg/L (Site #10, November event: 1.044 mg/L).
- **Biological** – mIBI scores for the locations in this subwatershed were indicative of moderately impaired macroinvertebrate communities with scores of 3.11 and 3.56. HBI scores for these locations resulted in the top 2 scores overall; Site #10 – the best score of 4.89 and Site #9 – the 2nd best score of 4.92. While these scores still indicate potential problems with organic pollution, these scores were the most ideal throughout the study area.
- **Physical** – QHEI scores for Site #9 and Site #10 were the top scores of this monitoring effort; 66.0 and 56.0 respectively; indicating a good-excellent potential to support in-stream flora and fauna. High scores were noted for substrate and riparian zones. For Site #9, instream conditions were good with a moderately stable substrate, moderate embeddedness, and a fair pool/riffle development. Likewise, the substrate at Site #10 was in good condition. However, the embeddedness was noted as extensive and there was little to no pool/riffle development.

Table 2-23 Water Quality Summary for the Silver Creek/Pleasant Run Watershed

Sampling Parameter	Sampling Results
Chemical (TSS)	Excellent
Chemical (*E. coli)*	Fair
Biological	Moderately Impacted
Physical	Excellent - Good

The City conducted SVAPs at several sites in the Silver Creek/Pleasant Run Watershed in 2009 and 2010 (Figure 2-3). The assessment found a narrow riparian corridor, encroachment from agricultural practices but no evidence of streambank erosion.

The impervious cover in the Silver Creek/Pleasant Run Watershed varies. In a small undeveloped portion the impervious cover is 3% and should support sensitive aquatic species (Figure 2-5). The remaining area is estimated to have 46% impervious cover and as a result non-supporting of healthy aquatic habitat. The L-THIA analysis (Figure 2-4 and **Table 2-24**) indicated that pollutant levels from stormwater runoff would impact aquatic organisms and the overall health of the stream. It is expected that only pollutant tolerant species would be found in the waterbodies. A summary of the L-THIA data and exhibits is in Appendix 4.

Table 2-24 L-THIA Results for the Silver Creek/Pleasant Run Watershed

Nonpoint Source Pollutant	L-THIA Results
Nitrogen	Fair to Poor
Phosphorus	Fair to Poor
TSS	Fair
BOD	Fair to Poor
E.coli	Poor

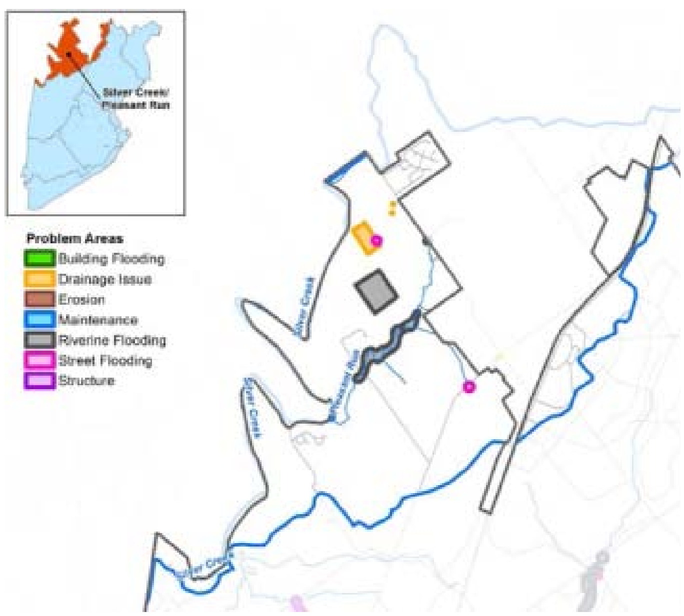

Figure 2-25 Silver Creek/Pleasant Run Problem Areas

Known Problems:

Discussions with City and County staff as well as the public during the development of this SWMP identified 10 flooding and drainage problems in the Silver Creek/Pleasant Run Watershed. These are illustrated on **Figure 2-25** and summarized below:

- Drainage Issue (4)
- Riverine Flooding (4)
- Street Flooding (2)

The description, source, and other comments regarding each identified problem are included in Appendix 5.

2.3.6 Lentzier Creek Watershed

General Overview:

The Lentzier Creek Watershed is a 5,363 acre area located in the north central part of the City of Jeffersonville. Lentzier Creek and several tributaries drain this area into the Ohio River. Much of the watershed (79% or 4,235 acres) is located in Jeffersonville including the recently annexed and significantly large undeveloped River Ridge (**Figure 2-26**). Other land use in the watershed includes a mixture of medium to high density residential, commercial, and heavy industrial development.

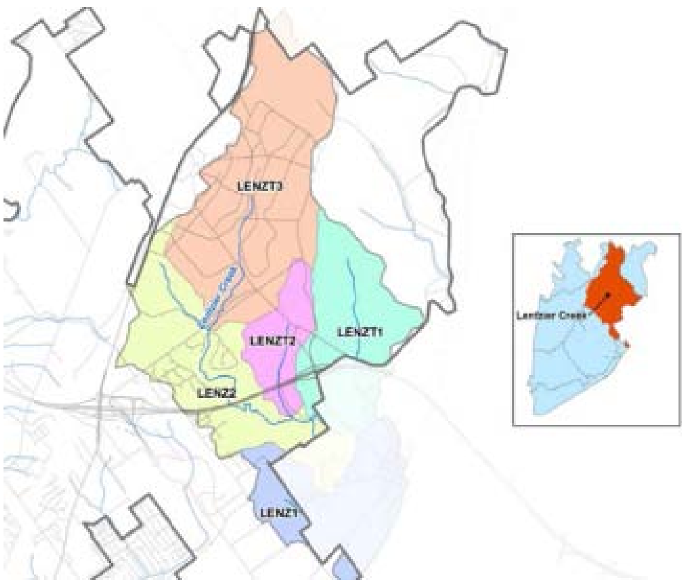

Figure 2-26 Lentzier Creek Watershed

For the purpose of the water quantity and water quality analyses, the watershed was subdivided into 5 subwatersheds: 2 on the main stem of Lentzier Creek (LENZ1 and LENZ2) and 3 tributaries (LENZT1, LENZT2 and LENZT3). **Table 2-25** lists the subwatersheds, drainage area and the percent of the drainage area that is within the City of Jeffersonville.

Table 2-25 Lentzier Creek Subwatersheds

Subwatershed Name	Drainage Area (acres)	Within City Limits
LENZ1	889	27%
LENZ2	1,287	86%
LENZT1	987	75%
LENZT2	393	100%
LENZT3	1,808	97%
TOTAL	**5,363**	**79%**

Water Quantity:

Based on the hydrologic analysis performed as part of this SWMP, the 2-year, 10-year, and 100-year existing-condition unit peak flow rates have been determined and shown on **Exhibit 2-1** and in

Table 2-26. This data can be used as a baseline for setting maximum allowable release rates for proposed new development/redevelopment in the watershed and for future evaluations of peak flow production trends within the City.

Table 2-26 Lentzier Creek Peak Flow Rates

Subwatershed Name	100-year (cfs/acre)	10-year (cfs/acre)	2-year (cfs/acre)
LENZ1	2.06	0.99	0.46
LENZ2	0.93	0.38	0.26
LENZT1	1.45	0.56	0.19
LENZT2	1.74	0.73	0.27
LENZT3	1.01	0.40	0.14

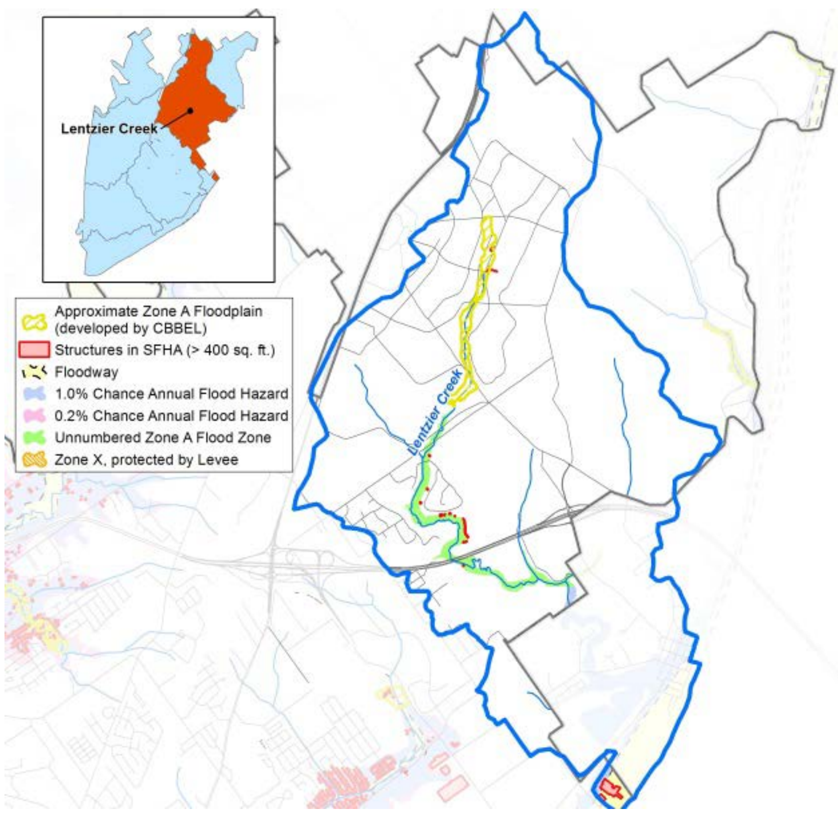

Figure 2-27 Lentzier Creek Watershed - Buildings in SFHA

An approximate level study was done for most of Lentzier Creek for the 2011 preliminary FIS. Because only a portion of the studied reach has 2-foot topography, the floodplain delineation for the remaining portion of the stream (which was done on 5-foot contour interval mapping) excludes the channel in several locations. The Lentzier Creek floodplain is not as steep as the floodplain valley of other streams. As a result, the floodplain extent would be more sensitive to changes in the BFE. As part of this SWMP, an analysis of the upper reach of Lentzier Creek was completed to determine approximate base flood elevations and delineate the floodplain so that all of the stream reaches for the creek with 1 square mile or more drainage area have the floodplain determined.

The GIS analysis of the building layer and preliminary DFRIM identified 20 structures in the SFHA. **Figure 2-27** and **Table 2-27** show the number of structures in the Lentzier Creek floodplain.

Table 2-27 Buildings in the SFHA in the Lentzier Creek Watershed

Floodway	100-year Floodplain	Zone A	500-year Floodplain	Zone X (behind levee)
1	1	19	1	NA

The City of Jeffersonville recently annexed the majority of this watershed into their jurisdiction, and as such, has made limited improvements to date. The River Ridge Development Authority owns and operates a large portion of the upstream end of Lentzier Creek. They are currently working with the City to evaluate possible detention/retention improvements to provide relief to Lentzier Creek.

Water Quality:

Water quality samples were collected as part of this SWMP on Lentzier Creek at Lentzier Trace (Figure 2-4). **Table 2-28** provides the overall water quality summary and Appendix 4 includes the full water quality report. The results from this sampling indicate:

- **Chemical** – The Nitrate concentrations at this location were the greatest 3 individual sampling results for the entire study, ranging from 2.4 mg/L-3.1 mg/L where other locations typically ranged from 0.01 mg/L-1.3 mg/L. Conversely, total phosphorus concentrations ranged from 0.035 mg/L – 0.079 mg/L, much lower than the IDEM target of 0.3 mg/L. This location also produced the 2 highest concentrations of total suspended solids and the highest concentration of *E. coli*.
- **Biological** – The mIBI score for this location is 2.89 (of 8.0) and is near the lowest of all locations indicating the site is moderately impaired. Higher mIBI scores indicate lower levels of overall impacts to macroinvertebrate communities. In regard to the HBI, Site #3 received a moderate score, 5.81 of a possible 10.0. For the HBI index, a higher score indicates higher levels of organic pollution.
- **Physical** – For both streambanks, manicured residential lawn with no riparian zone was the predominant land use for this sampling location. This location received the lowest QHEI score of the 9 sampled sites with an overall score of 10 (of a possible 100) and is categorized as Very Poor. Individual metrics for riparian zone, pool/glide quality, and riffle/run quality all received scores of 0 points. It is noted that the substrate was dominated by muck and silt and there was little to zero overall instream structure.

Table 2-28 Water Quality Summary for Lentzier Creek Watershed

Sampling Parameter	Sampling Results
Chemical (TSS)	Good
Chemical (*E. coli)*	Fair
Biological	Moderately Impacted
Physical	Poor

Figure 2-28 Streambank Erosion along Lentzier Creek

The City conducted SVAPs at 2 sites in the Lentzier Creek Watershed in 2009 and 2010. The assessment found encroachment of neighboring residential land use and evidence of streambank erosion. A field investigation was completed during the development of this SWMP to confirm the severity of the problem (**Figure 2-28**).

The impervious cover analysis completed for the Lentzier Creek Watershed indicated approximately half the watershed is 20% impervious and the streams would expect to show signs of being impacted by runoff. The rest of the watershed is estimated to be 44% impervious and non-supporting of a healthy stream ecosystem (Figure 2-5). The L-THIA analysis (Figure 2-4 and **Table 2-29**) indicated that pollutant levels from stormwater runoff would impact aquatic organisms and the overall health of the stream. It is expected that only pollutant tolerant species would be found in the waterbodies. A summary of the L-THIA data and exhibits is in Appendix 4.

Table 2-29 L-THIA Results for the Lentzier Creek Watershed

Nonpoint Source Pollutant	L-THIA Results
Nitrogen	Fair to Poor
Phosphorus	Fair to Poor
TSS	Fair
BOD	Poor
E.coli	Poor

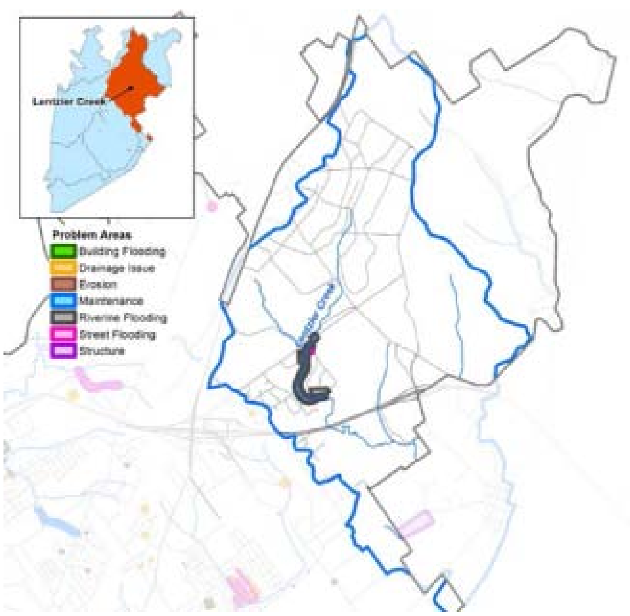

Figure 2-29 Lentzier Creek Watershed Problem Areas

Known Problems:

Discussions with City and County staff as well as the public during the development of this SWMP identified 11 flooding and drainage problems in the Lentzier Creek Watershed. These are illustrated on **Figure 2-29** and summarized below:

- Restrictive Structure (1)
- Riverine Flooding (9)
- Street Flooding (1)

The description, source, and other comments regarding each identified problem are included in Appendix 5.

2.3.7 Battle Creek Watershed

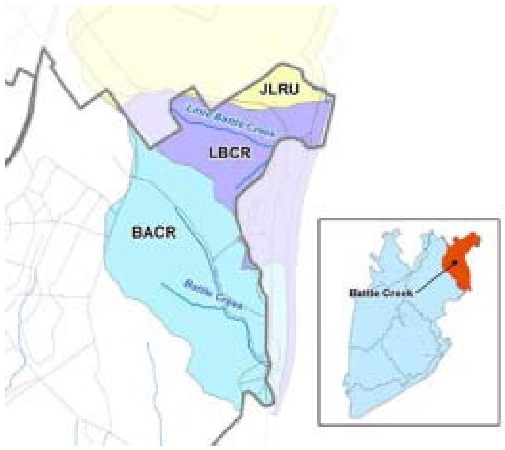

Figure 2-30 Battle Creek Watershed

General Overview:
The Battle Creek Watershed is located along the Ohio River in the north east portion of the City of Jeffersonville. The total drainage area is 4,612 acres of which only 38% or 1,757 acres is in the City (**Figure 2-30**). Battle Creek, Little Battle Creek and Jenny Lind Run drain runoff from the predominantly grassland and forested land of the River Ridge property into the Ohio River.

For the purpose of the water quantity and water quality analyses, the watershed was subdivided into 3 subwatersheds: Battle Creek (BACR), Jenny Lind Run (JLRU), and Little Battle Creek (LBCR). **Table 2-30** lists the subwatersheds, drainage area and the percent of the drainage area that is within the City of Jeffersonville.

Table 2-30 Battle Creek Subwatersheds

Subwatershed Name	Drainage Area (acres)	Within City Limits
BACR	1,286	90%
JLRU	2,431	5%
LBCR	894	52%
TOTAL	**4,612**	**38%**

Water Quantity:
Based on the hydrologic analysis performed as part of this SWMP, the 2-year, 10-year, and 100-year existing-condition unit peak flow rates have been determined and shown on **Exhibit 2-1** and **Table 2-31**. This data can be used as a baseline for setting maximum allowable release rates for proposed new development/redevelopment in the watershed and for future evaluations of peak flow production trends within the City.

Table 2-31 Lentzier Creek Peak Flow Rates

Subwatershed Name	100-year (cfs/acre)	10-year (cfs/acre)	2-year (cfs/acre)
BACR	1.21	0.46	0.15
JLRU	0.72	0.25	0.07
LBCR	1.63	0.61	0.19

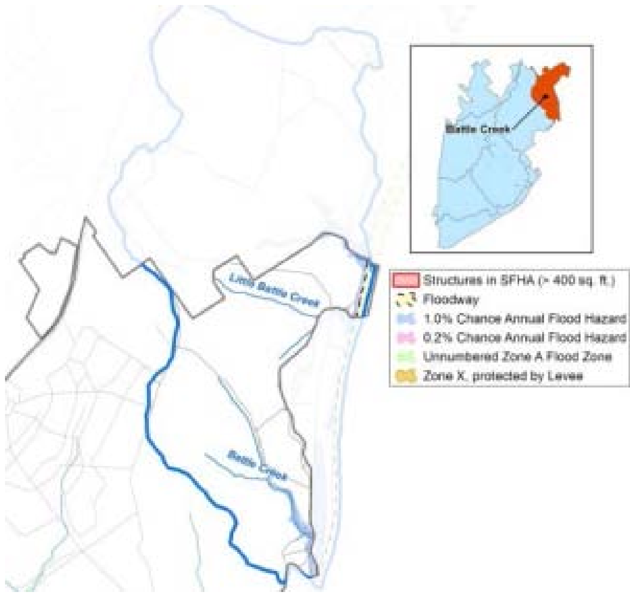

Figure 2-31 Battle Creek Watershed - Buildings in SFHA

The floodplain shown for Little Battle Creek is based on the Ohio River backwater which controls the BFE for the indicated reach of Little Battle Creek. Based on comparison with the aerial photography, this delineation includes the channel.

As part of this SWMP, an approximate level analysis of Jenny Lind Run and Battle Creek were completed to determine base flood elevations and floodplain limits for the reaches with 1 square mile or more drainage area.

The GIS analysis of the building layer and preliminary DFRIM identified 3 structures in the SFHA. **Figure 2-31** and **Table 2-32** shows the number of structures in the Battle Creek floodplain.

Table 2-32 Buildings in the SFHA in the Battle Creek Watershed

Floodway	100-year Floodplain	Zone A	500-year Floodplain	Zone X (behind levee)
1	3	0	3	NA

The City of Jeffersonville recently annexed the majority of this watershed into their jurisdiction, and as such, has made limited improvements to date.

Water Quality:
Water quality samples were collected as part of this SWMP on Battle Creek at Patrol Road (Figure 2-3) however the creek was dry during each scheduled sampling event and no data was collected.

The impervious cover analysis completed for the Battle Creek Watershed indicated that the current land use is 12% impervious and will support sensitive aquatic species (Figure 2-5). The L-THIA analysis (Figure 2-4 and **Table 2-33**) indicated that pollutant levels from stormwater runoff would impact aquatic organisms and the overall health of the stream. Conditions remain favorable for some sensitive (pollution intolerant) aquatic species however habitat may become affected by increased land use runoff. A summary of the L-THIA data and exhibits is in Appendix 4.

Table 2-33 L-THIA Results for the Battle Creek Watershed

Nonpoint Source Pollutant	L-THIA Results
Nitrogen	Fair
Phosphorus	Fair
TSS	Good to Fair
BOD	Poor
E.coli	Good to Fair

Known Problems:
No problems were identified from discussions with City and County staff or the public during the development of this SWMP.

2.4 SUMMARY OF KNOWN PROBLEMS/CONCERNS

The discussion in this Chapter provided an overview of the current citywide policies, programs and projects as well as the existing stormwater conditions and concerns within each watershed. Known flooding and drainage problems/concerns were identified through various means including discussions with Drainage Board, City staff, County staff, OPCD staff, public meetings and comment forms; review of applicable City plans, codes, GIS data, projects, studies, construction documents; and review of relevant data and studies from IDNR, USGS, etc. **Table 2-34** summarizes the known drainage problems for each of the watersheds in the City of Jeffersonville

The most prevalent problem/concern is the number of buildings in the SFHA. The GIS desktop analysis conducted as part of this SWMP identified 1,928 buildings (greater than 400 square feet) in the SFHA. More than half of these buildings (1,111) are in the Lancassange Creek Watershed. Both the Lick Run Watershed (374 buildings) and Ohio River/Cane Run Watershed (318 buildings) have large numbers of buildings in the SFHA as well. In the Lick Run Watershed, there were 12 reports of water being inside buildings. Input from the public during the development of this SWMP included 32 reports of building flooding problems citywide.

Thirty-two problems of riverine flooding (areas adjacent to waterways) were reported. Of these, 15 were in the Lancassange Creek Watershed and 9 in the Lentzier Creek Watershed. Restrictive structures such as undersized culverts or bridges that restrict flow and cause water to back up were most reported at 20 sites. Eight were reported in the Lick Run Watershed and 6 in Lancassange Creek. Similarly maintenance issues where debris, sediment, or dense vegetation restricts flow and causes water to back up was reported in the Lancassange Creek Watershed (5) and Lick Run Watershed (5).

Table 2-34 Known Problems and Concerns

WATERSHED	KNOWN PROBLEMS[1]								STRUCTURES IN FLOOD ZONES[2]						WATER QUALITY SAMPLING[3]				WATER QUALITY INDICATORS[4]					
	Building Flooding	Drainage Issue	Erosion	Maintenance	Restrictive Structure	Riverine Flooding	Street Flooding	TOTAL	Floodway	100-year Floodplain	Zone A	TOTAL (SFHA)	500-year Floodplain	Zone X (behind levee)	Chemical (TSS)	Chemical (*E.coli*)	Biological	Physical	Impervious	Nitrogen	Phosphorus	TSS	BOD	*E.coli*
Ohio River/Cane Run	8	6	0	0	2	0	20	**36**	171	318	0	**318**	318	1,582	NA	NA	NA	NA	Non-supporting	Fair	Good to Fair	Fair	Poor	Poor
Mill Creek	6	13	3	0	3	3	6	**34**	19	65	17	**82**	148	0	Excellent	Fair	Severely Impacted	Good	Non-supporting	Fair	Fair	Fair	Poor	Poor
Lancassange Creek	6	27	0	5	6	15	14	**73**	95	1,111	0	**1,111**	1,147	0	Excellent	Fair	Moderately Impacted	Good to Fair	Non-supporting	Fair to Poor	Fair to Poor	Fair	Poor	Fair to Poor
Lick Run	12	10	2	5	8	1	3	**41**	0	374	0	**374**	589	0	Excellent	Good	Moderately Impacted	Poor	Non-supporting	Fair to Poor	Fair to Poor	Fair	Poor	Poor
Silver Creek/Pleasant Run	0	4	0	0	0	4	2	**10**	2	20	0	**20**	28	0	Excellent	Fair	Moderately Impacted	Excellent to Good	Impacted to Non-supporting	Fair to Poor	Fair to Poor	Fair	Fair to Poor	Poor
Lentzier Creek	0	0	0	0	1	9	1	**11**	1	1	19	**20**	1	0	Good	Fair	Moderately Impacted	Poor	Impacted	Fair to Poor	Fair to Poor	Fair	Poor	Poor
Battle Creek	0	0	0	0	0	0	0	**0**	1	3	0	**3**	3	0	NA	NA	NA	NA	Supporting	Fair	Fair	Good to Fair	Poor	Good to Fair
TOTAL	**32**	**60**	**5**	**10**	**20**	**32**	**46**	**205**	**289**	**1,892**	**36**	**1,928**	**2,234**	**1,582**										

[1] Based on discussions with City, County, and OPCD staff and the public
[2] Results from GIS analysis of building layer, 2012 Preliminary FIRM
[3] Summary of water quality data collected by Indiana University as part of this SWMP
[4] Percent impervious based on land use and ranking of non-point source pollutants from L-THIA analysis

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Drainage Issues were reported in all watersheds except the Battle Creek Watershed. The greatest number of low lying areas outside the floodplain where water collects and is slow to drain were reported in the Lancassange Creek Watershed (27) followed by the Mill Creek Watershed (13). Street flooding was defined as standing water that is deep enough to be impassible or unsafe for vehicles to travel through and was most reported as a problem in the Ohio River/Cane Run Watershed (20).

Five problem areas with streambank erosion including unstable sites that deposit sediment or woody debris into the waterway and/or threaten neighboring land uses were reported in Mill Creek Watershed (3) and the Lick Run Watershed (2). Water quality sampling in both the Mill Creek and Lick Run indicated severely and moderately impacted biological stream health.

The water quality sampling and analysis completed by IU suggests that Chemical (TSS) levels obtained during sampling events may not be indicative of the anticipated sediment concentrations and loadings due to the flashy nature of the streams in Jeffersonville. Due to this, correlations between the other water quality indicators will be further detailed.

While the average *E. coli* concentrations fell within the “good” and “fair” ranges, every site (except Site 7) had concentrations violating the Indiana standards for recreational waterbodies. It is anticipated that these elevated *E. coli* concentrations are due to nearby pasture fields and/or poorly functioning septic systems. The biological and physical samplings are closely correlated as the lack of a functional habitat (physical evaluation) will reduce the ability for a quality biological component. Many sampling locations lacked the necessary riffle development and suffered from substrate embeddedness, both which reduces the amount of suitable habitat to support aquatic organisms.

Further correlations can be made between these water quality sampling results and the water quality indicators (imperviousness and pollutant loadings). For example, with the exception of Battle Creek watershed, all of the watersheds in Jeffersonville are impacted or non-supporting in terms of the amount of impervious land uses. The “impacted” and “non-supporting” categories lead to expected overview of unstable habitats and primarily pollutant tolerant aquatic organisms. This expectation is strengthened by the results of the biological and physical site evaluations indicating poor habitat and few high quality aquatic organisms.

Further, it is anticipated through watershed based estimations that the *E. coli* concentrations will be “fair” to “poor” and this is proven as the water quality sampling resulted in numerous violations of the Indiana Water Quality Standards.

Additionally, the flashy stream conditions observed during the water quality sampling (and anticipated through the watershed based estimations) may be cause of some of the known problems (such as erosion and flooding) and may have an exacerbated effect to any structures located within the SFHA during times of increased rainfall.

Understanding the existing conditions and concerns, especially the known flooding and drainage problems, is important since it becomes the foundation for the goals and performance criteria, the recommendations to address these problems, and the implementation of this SWMP.

CHAPTER 3 FUTURE CONDITIONS & ASSOCIATED CONCERNS

3.1 INTRODUCTION

Understanding future conditions and the associated stormwater concerns is critical to the successful development and ultimate implementation of this SWMP. This Chapter describes the anticipated future land uses and regulations or projects. It also identifies the severity and extent of problems that could arise as a result.

3.2 ANTICIPATED FUTURE CONDITIONS BY WATERSHED

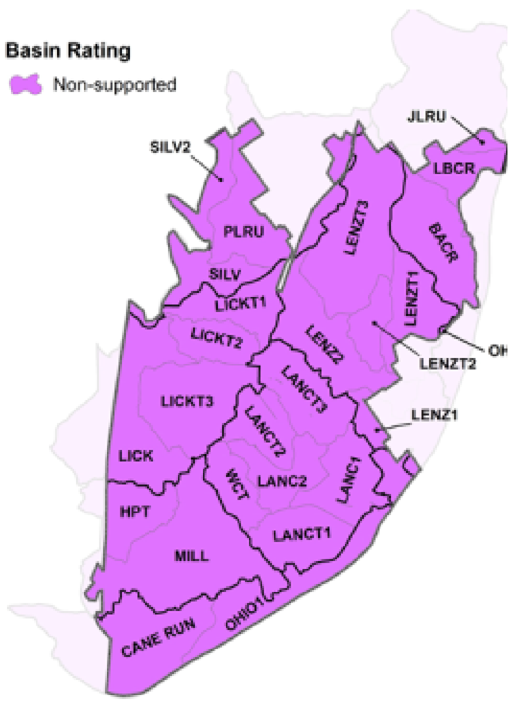

Figure 3-1 Impervious Cover (Future Conditions) Citywide

A list of anticipated future concerns was developed from information gathered from staff, decision-makers and public input as well as review of previous studies, data collection, and CBBEL experience with concerns throughout the state. This includes:

- Increased runoff from new development
- Increased flooding and drainage problems
- Need for additional and/or replacement infrastructure as well as maintenance of infrastructure
- Changes in land use and imperviousness
- Anticipated pollutant loadings and stormwater pollutant removal requirements
- Loss of habitat and species diversity
- Impact to quality of life

Future land use and maximum percent impervious cover were derived from the City's Zoning Ordinance (**Figure 3-1**). The L-THIA desktop analysis was used to understand the impact future land use would have on water quality. This analysis was based on the land use categories identified in the Zoning Ordinance and assume built out conditions (**Figure 3-2**).

Each watershed description includes a summary of the extent and severity of anticipated future surface water quantity and quality concerns.

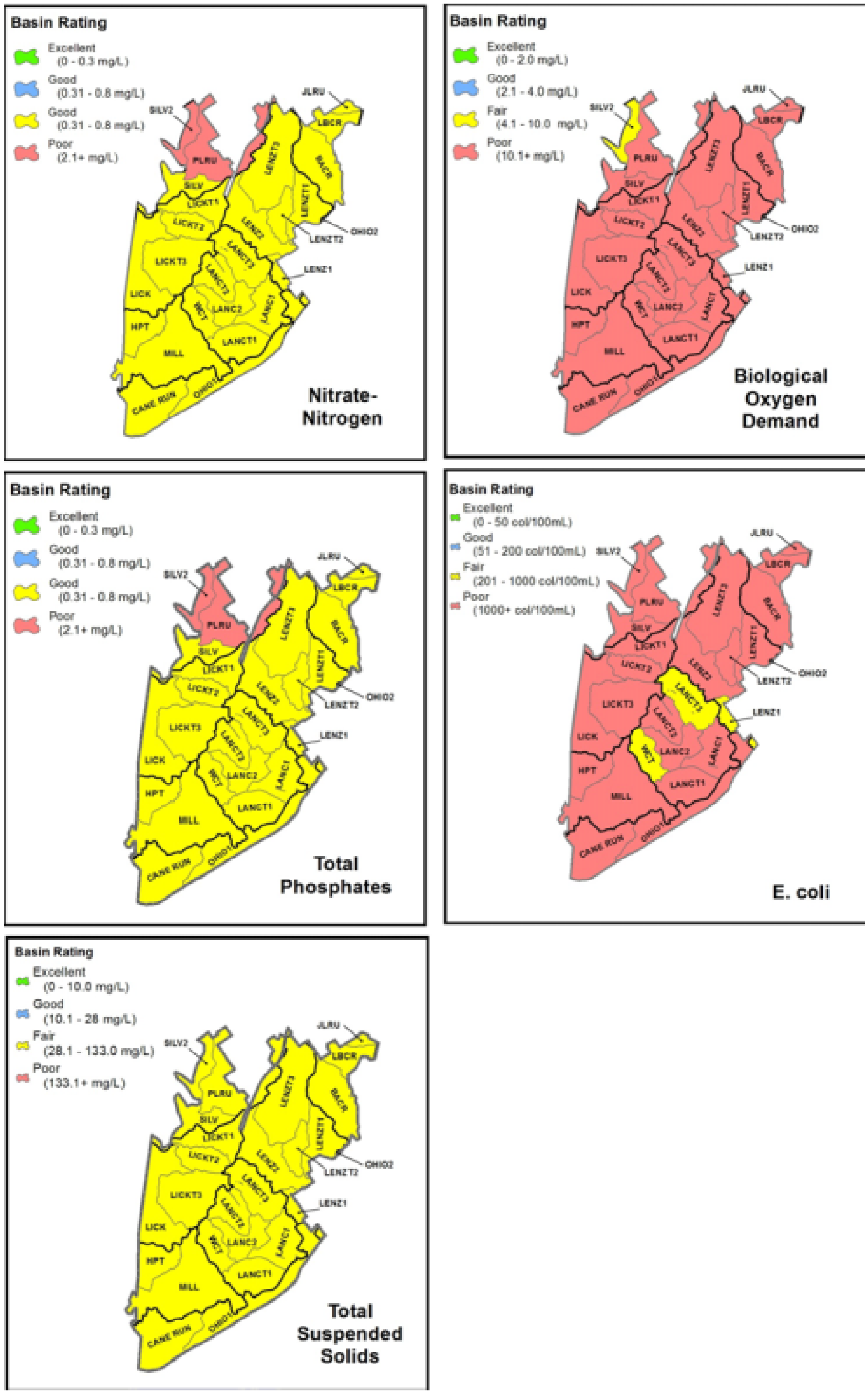

Figure 3-2 L-THIA Future (N, P, TSS, BOD, E. coli) Citywide

3.2.1 Ohio River/Cane Run Watershed

Future land use in the Ohio River/Cane Run Watershed is expected to increase in industrial use along the Ohio River. The conversion of commercial to industrial land use and the loss of some undeveloped land does not affect the overall percent impervious in the watershed (66%) and its relationship to water quality (Figure 3-1). Based on the L-THIA analysis, it is expected that additional industrial development will result in higher phosphorus loadings. As this area develops, BMPs to capture and treat phosphorus should be used to prevent further degradation of water quality (Figure 3-2 and **Table 3-1).**

Table 3-1 L-THIA Results for the Ohio River/Cane Run Watershed

Nonpoint Source Pollutant	L-THIA Results (existing)	L-THIA Results (future)
Nitrogen	Fair	Fair
Phosphorus	Good to Fair	Fair
TSS	Fair	Fair
BOD	Poor	Poor
E.coli	Poor	Poor

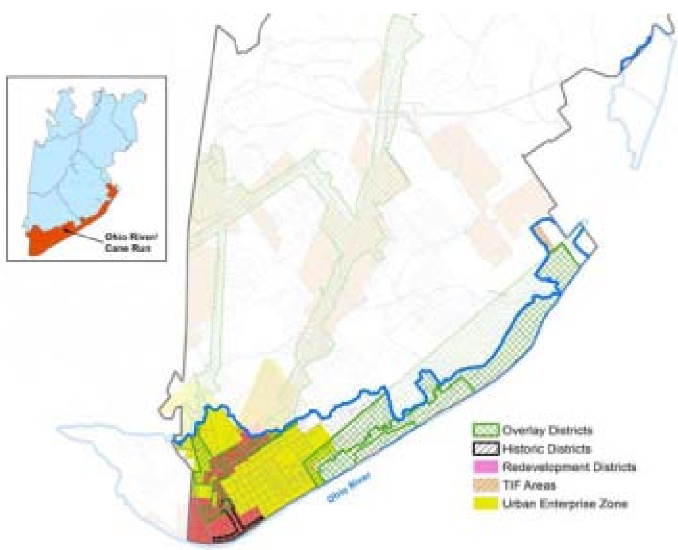

Figure 3-3 Ohio River/Cane Run Special Districts

Increased impervious cover can be correlated to increased loadings of pollutants as well as increased volumes and velocities of water which may increase erosion of streambanks and streambeds, leading to higher sediment loadings. The increased loadings will also have an impact on the physical condition of the stream, the quality of in-stream habitat, and the success of macroinvertebrate communities within this area.

There are numerous special districts in this watershed which will guide or restrict growth and development. These include: Utica Pike, Commercial Corridor (10th Street and Hamburg Pike), and Wellhead Protection Area (WHPA) Overlay Zones; Historic District; Tax Incremental Financing (TIF) District; Redevelopment District; and Urban Enterprise Zone. Floodplain and stormwater management should become integrated into the requirements of these districts especially where problems have been documented (**Figure 3-3**).

Figure 3-4 Rendering of Proposed Falls Landing Park

Figure 3-5 Buy-Outs in Downtown Jeffersonville

To reduce CSO events as mandated by the EPA, the City is installing a large diameter interceptor along Market Street and Mulberry Street and constructing a 2-acre retention pond in the proposed Falls Landing Park (**Figure 3-4**). Ongoing and proposed flood control and drainage improvements should alleviate flooding problems in this watershed.

The City, as a part of multiple projects in the downtown area, has purchased a large number of properties, shown in **Figure 3-5**, that have been affected by flooding. The purchase of these properties will lessen the impact that potential flooding may have on these areas.

Unless appropriate controls are added to the current floodplain and stormwater management ordinances, new development or redevelopment within the Ohio River/Cane Run watershed may result in increased flood stages, increased flood velocities, increased runoff peaks, increased runoff volumes, longer bankfull inundations, and increased streambank erosion. Because the basin is already mostly developed, the increases are likely to be minimal unless future land uses add large areas of imperviousness. Measures such as prohibition of encroaching in the regulatory floodway, requiring compensatory floodplain storage, requiring over-compensatory on-site detention and requiring permanent retention of channel protection volume should be considered to ensure the existing problems and concerns are not exacerbated as new development or redevelopment occurs in the watershed.

Additional green infrastructure projects like the pilot bioretention projects at Bale's Automotive (7th Street and Ohio Street) and on Market Street between Clark Street and Fort Street (**Figure 3-6** and **Figure 3-7**) could be effective to reduce nuisance flooding/drainage issues, improve water quality and aesthetics, and add much needed green space to a very impervious area.

Figure 3-6 Market Street Bioretention

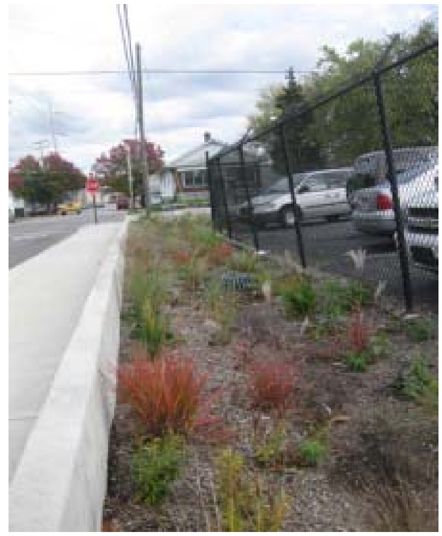

Figure 3-7 Bales Auto Bioretention

3.2.2 Mill Creek Watershed

Although the estimated overall impervious cover is anticipated to remain roughly the same (65% to 62%) in the Mill Creek Watershed, the type of land use is projected to dramatically change (Figure 3-1). It is anticipated that there will be a reduction in commercial land uses and a substantial increase of single family residential. According to the L-THIA analysis, the pollutant loadings are expected to reduce but not enough to affect the ranking. As a result, estimated water quality impacts from land use will remain the same (Figure 3-2 and **Table 3-2**)

Table 3-2 L-THIA Results for the Mill Creek Watershed

Nonpoint Source Pollutant	L-THIA Results (existing)	L-THIA Results (future)
Nitrogen	Fair	Fair
Phosphorus	Fair	Fair
TSS	Fair	Fair
BOD	Poor	Poor
E.coli	Poor	Poor

A change from commercial land use to residential land use may allow for increasing the width and functionality of riparian zones. While this may not affect the overall pollutant loadings from the watershed, larger and more functional riparian zones may lead to enhanced filtration and uptake of excess nutrients as well as a higher quality in-stream habitat. This may allow for an improvement in the physical condition of the stream as well as an improvement in the macroinvertebrate assemblages in the watershed.

Unless appropriate controls are added to the current floodplain and stormwater management ordinances, new development or redevelopment within the Mill Creek watershed may result in increased flood stages, increased flood velocities, increased runoff peaks, increased runoff volumes, longer bankfull inundations, and increased streambank erosion. With the exception of the outer edges of the basin, the basin is already mostly developed. Therefore, some of the noted increases could occur due to loss of pervious area in these locations, especially if the tree cover is removed. However, the increases are likely to be localized unless future land uses add large areas of imperviousness. Measures such as prohibition of encroaching in regulatory floodway, requiring compensatory floodplain storage, requiring over-compensatory on-site detention and requiring permanent retention of channel protection volume should be considered to ensure the existing problems and concerns are not exacerbated as new development or redevelopment occurs in the watershed. Changes in development may also result in the need for additional or changed existing infrastructure which will need repairs and maintenance in order to not adversely impact drainage in the watershed.

The projects identified in the Mill Creek watershed will require structural improvements to road crossings and culverts to increase stormwater conveyance and possibly elevate roadways. The projects will evaluate possible alternatives to reduce or retain water.

Similar to the neighboring Ohio River/Cane Run Watershed, there are several special districts in this watershed which will guide or restrict growth and development. These include: Commercial Corridor Overlay Districts along 10th Street and Hamburg Pike; Historic District; TIF District; Redevelopment District; and Urban Enterprise Zone. Floodplain and stormwater management should become integrated into the requirements of these districts especially where problems have been documented (**Figure 3-8**).

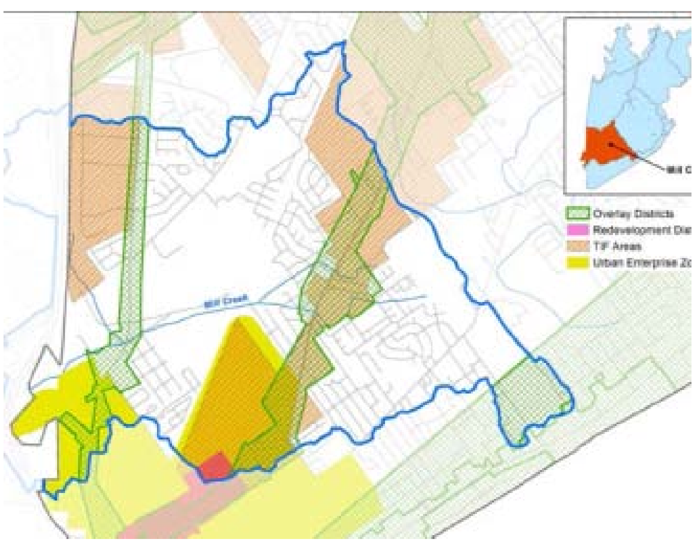

Figure 3-8 Mill Creek Special Districts

3.2.3 **Lancassange Creek Watershed**

Land use in the Lancassange Creek Watershed is expected to change dramatically. All existing undeveloped agricultural areas are expected to be converted to single family residential use, especially in the central/northern portion of watershed. Industrial uses are expected in the eastern portion of the watershed. However, impervious cover is expected to only increase slightly from 61% to 65% (Figure 3-1).

Water quality conditions are expected to remain the same with the exception of nitrogen, phosphorus, and E.coli. For both nitrogen and phosphorus, water quality in the northern portion of the watershed (conversion of agriculture to residential) is expected to improve from poor to fair. In the southeast portion of the watershed (agriculture to industrial) E.coli is expected to change from fair to poor. As the southeast portion develops, BMPs that are effective at treating E.coli should be incorporated to prevent further degradation of water quality (Figure 3-2 and **Table 3-3**)

Table 3-3 L-THIA Results for the Lancassange Creek Watershed

Nonpoint Source Pollutant	L-THIA Results (existing)	L-THIA Results (future)
Nitrogen	Poor to Fair	Fair
Phosphorus	Poor to Fair	Fair
TSS	Fair	Fair
BOD	Poor	Poor
E.coli	Poor	Poor to Fair

As land is converted, it would be beneficial to incorporate riparian zone development practices to allow the waterways to increase functionality regarding the physical condition of the stream and the riparian areas. These actions may also improve overall chemical water quality conditions.

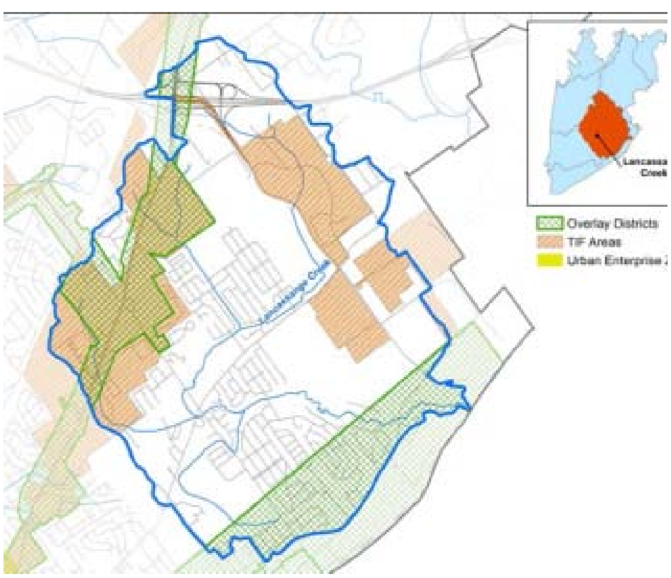

Figure 3-9 Lancassange Creek Watershed Special Districts

Because a large percentage of the basin could be developed into more impervious land uses, appropriate controls should be added to the current floodplain and stormwater management ordinances so that new development or redevelopment within the Lancassange Creek watershed does not result in increased flood stages, increased flood velocities, increased runoff peaks, increased runoff volumes, longer bankfull inundations, and increased streambank erosion. Measures such as prohibition of encroaching in regulatory floodway, requiring compensatory floodplain storage, requiring over-compensatory on-site detention and requiring permanent retention of channel protection volume should be considered to ensure the existing problems and concerns are not exacerbated as new development or redevelopment occurs in the watershed. This is especially important in the Lancassange Creek Watershed since it appears that the CBBEL hydrologic modeling indicates that the coordinated discharges used in the FIS may be too low. A stream gage should be placed on Lancassange Creek to evaluate expected discharges. Changes in development may also result in the need for additional or changed existing infrastructure which will need repairs and maintenance in order to not adversely impact drainage in the watershed.

A detailed study by the U.S. Army Corps of Engineers and various other studies have identified that improvements to Lancassange Creek need to be made. One idea is to construct a flood protection berm or levee in conjunction with an outlet control system to prevent backwater from the Ohio River from flowing up Lancassange Creek and a flood pumping station. In conjunction with various other projects, such a flood control project may be able to collect, convey, and reduce the overall quantity of stormwater impacting the Oak Park area.

There are several special districts in the Lancassange Creek Watershed which will guide or restrict growth and development. These include: Commercial Corridor Overlay Districts along 10th Street and Holman Lane; WFPA Overlay District; TIF District; Redevelopment District; and Urban Enterprise Zone. Floodplain and stormwater management should become integrated into the requirements of these districts especially where problems have been documented (**Figure 3-9**).

3.2.4 Lick Run Watershed

Impervious cover in the Lick Creek Watershed is expected to remain about the same at 60% (Figure 3-1). It is anticipated that undeveloped agricultural land will be converted to single family residential as well as some increase in commercial and industrial land uses. These changes in land use are expected to have little impact on pollutant loading except for nutrients. Anticipated changes in phosphorus and nitrogen pollutant loadings are expected to improve from poor to fair in the north portion of the watershed where agriculture is converted to residential (Figure 3-2 and **Table 3-4**)

Table 3-4 L-THIA Results for the Lick Run Watershed

Nonpoint Source Pollutant	L-THIA Results (existing)	L-THIA Results (future)
Nitrogen	Poor to Fair	Fair
Phosphorus	Poor to Fair	Fair
TSS	Fair	Fair
BOD	Poor	Poor
E.coli	Poor	Poor

Future water quality conditions may not significantly improve without the conversion to more natural stream conditions. Sampling areas were highly artificial leading to undesirable scores related to habitat and macroinvertebrate communities. If more natural conditions are allowed, it is anticipated that these stream function would improve.

Unless appropriate controls are added to the current floodplain and stormwater management ordinances, new development or redevelopment that changes the expected land uses and associated runoff potential within the Lick Run watershed will likely result in increased flood stages, increased flood velocities, increased runoff peaks, increased runoff volumes, longer bankfull inundations, and increased streambank erosion. Measures such as prohibition of encroaching in regulatory floodway, requiring compensatory floodplain storage, requiring over-compensatory on-site detention and requiring permanent retention of channel protection volume should be considered to ensure the existing problems and concerns are not exacerbated as new development or redevelopment occurs in the watershed. Changes in development may also result in the need for additional or changed existing infrastructure which will need repairs and maintenance in order to not adversely impact drainage in the watershed.

Infrastructure projects associated with the Lick Run Watershed will include culvert replacement to allow for additional conveyance capacity and green infrastructure improvements to help reduce the overall quantity of water entering the stormwater system.

The Lick Creek Watershed includes a couple special districts which will guide or restrict growth and development. These include: Commercial Corridor Overlay

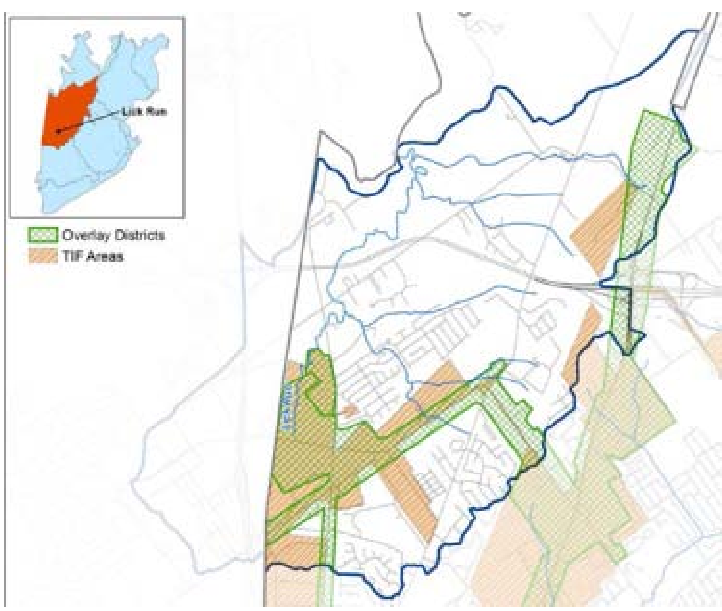

Figure 3-10 Lick Run Watershed Special Districts

Districts (10th Street, Holman Lane, Charleston New Albany Pike, Veterans Parkway, and Hamburg Pike) and TIF District. Floodplain and stormwater management should become integrated into the requirements of these districts especially where problems have been documented (**Figure 3-10**).

3.2.5 **Silver Creek/Pleasant Run Watershed**

Impervious cover in the Silver Creek/Pleasant Run Watershed is expected to increase from 31% to 48%. Overall, approximately half of the undeveloped agriculture and forest land cover is expected to be converted to low density residential and industrial land uses. The analysis for impervious cover indicates that the furthest west portion of the watershed along Silver Creek is expected to have the most significant change in water quality as a result of development. It is expected that conditions will change from being able to support a sensitive aquatic system to non-supporting. Development of this area should use low impact development and green infrastructure to minimize this dramatic shift in water quality (Figure 3-1).

According to L-THIA, non-point source pollutant loadings are expected to change but not significant enough to affect the ranking in the existing conditions (Figure 3-2 and **Table 3-5**)

Table 3-5 L-THIA Results for the Silver Creek Watershed

Nonpoint Source Pollutant	L-THIA Results (existing)	L-THIA Results (future)
Nitrogen	Poor to Fair	Poor to Fair
Phosphorus	Poor to Fair	Poor to Fair
TSS	Fair	Fair
BOD	Poor to Fair	Poor to Fair
E.coli	Poor	Poor

In regard to stream function and macroinvertebrate communities, it is imperative that forested areas and riparian zones are protected and/or enhanced. The sampling conducted within this watershed indicated the highest quality habitat as well as some of the most ideal macroinvertebrate assemblages throughout the study area. Any future negative impacts or increased pollutant loadings may quickly impact these aspects of the stream quality.

Unless appropriate controls are added to the current floodplain and stormwater management ordinances, new development or redevelopment within the Silver Creek/Pleasant Run watershed will likely result in increased flood stages, increased flood velocities, increased runoff peaks, increased runoff volumes, longer bankfull inundations, and increased streambank erosion. A comparison of existing condition flow rates in this watershed with those in the more developed watersheds to the south (with the exception of the flatter Ohio River/Cane Run basin) provides an indication of the impact that development and increased imperviousness can have on the amount of water that runs off the land and flows along downstream properties. Runoff rates in the Pleasant Run basins is 1.17 cfs per acre while those in Lick Run and Lancassange Creek basins to the south are at or above 1.5 cfs per acre.

Measures such as prohibition of encroaching in regulatory floodway, requiring compensatory floodplain storage, requiring over-compensatory on-site detention and requiring permanent retention of channel protection volume should be considered to ensure the existing problems and concerns are not exacerbated as new development or redevelopment occurs in the watershed. Changes in development may also result in the need for additional or changed existing infrastructure which will need repairs and maintenance in order to not adversely impact drainage in the watershed.

The current plan does not include any specific infrastructure improvement projects at this time.

3.2.6 **Lentzier Creek Watershed**

Figure 3-11 River Ridge Development

Land use in the Lentzier Creek Watershed is expected to change dramatically especially in the northern most portion where the River Ridge Development is planned. River Ridge is a 6,000 acre proposed modern business park on the former Indiana Army Ammunition Plant (**Figure 3-11**). The development will consist of a mixture of commercial office, retail, wholesale and moderate to heavy industrial uses. Impervious cover in this watershed is expected to almost double to 60% and result in waterways unable to support a healthy stream ecosystem (Figure 3-1).

The LTHIA results showed similar results with the exception of the lower portion of this watershed. Land use change from undeveloped agricultural uses to low density residential and industrial uses will reduce nutrient loading. However, the estimated pollutant loading will remain high enough to support only pollutant tolerant aquatic species. Incorporating low impact development and green infrastructure into the proposed developments should reduce the water quality impacts (Figure 3-2 and **Table 3-6**).

Table 3-6 L-THIA Results for the Lentzier Creek Watershed

Nonpoint Source Pollutant	L-THIA Results (existing)	L-THIA Results (future)
Nitrogen	Poor to Fair	Fair
Phosphorus	Poor to Fair	Fair
TSS	Fair	Fair
BOD	Poor	Poor
E.coli	Fair to Poor	Poor

Incorporating more natural stream characteristics, such as natural streambanks and/or riparian zones as the land use changes will be beneficial to this subwatershed. The sampling location in this area was extensively armored and channelized with little riparian development. Future improvements to instream habitat and the riparian zones should increase the overall scores associated with the QHEI and the macroinvertebrate communities.

Figure 3-12 Proposed Bridge, East End Indiana Approach
(source: INDOT webpage)

In addition to the planned River Ridge Development, the proposed extension of IN 265 and 6-lane bridge over the Ohio River (East End Indiana Approach) will travel through the lower portion of this watershed and may cross over Lentzier Creek (**Figure 3-12**).

Unless appropriate controls are added to the current floodplain and stormwater management ordinances, new development or redevelopment within the Lentzier Creek watershed will likely result in increased flood stages, increased flood velocities, increased runoff peaks, increased runoff volumes, longer bankfull inundations, and increased streambank erosion. A comparison of existing condition flow rates in this watershed with those in the more developed watersheds to the south (with the exception of the flatter Ohio River/Cane Run basin) provides an indication of the impact that development and increased imperviousness can have on the amount of water that runs off the land and flows along downstream properties. Runoff rates in the Lentzier Creek basins are close to 1.0 cfs per acre while those in the more developed Lick Run and Lancassange Creek basins to the south are at or above 1.5 cfs per acre.

Measures such as prohibition of encroaching in regulatory floodway, requiring compensatory floodplain storage, requiring over-compensatory on-site detention and requiring permanent retention of channel protection volume should be considered to ensure the existing problems and concerns are not exacerbated as new development or redevelopment occurs in the watershed. This is especially important in the Lentzier Creek Watershed since it appears that the CBBEL hydrologic modeling indicates that the coordinated discharges used in the FIS may be too low. A stream gage should be placed on Lentzier Creek to evaluate expected discharges. Changes in development may also result in the need for additional or changed existing infrastructure which will need repairs and maintenance in order to not adversely impact drainage in the watershed.

The current plan does not include any specific infrastructure improvement projects at this time.

3.2.7 Battle Creek Watershed

The planned River Ridge Development discussed above (Lentzier Creek Watershed) will extend into the Battle Creek Watershed as well. Impervious cover in the Battle Creek Watershed is expected to increase from 14% to 70% (Figure 3-1). With the exception of nutrient loadings and BOD, water quality is expected to be impacted significantly and not support a healthy stream ecosystem. Incorporating low impact development and green infrastructure into the proposed developments should reduce the water quality impacts (Figure 3-2 and **Table 3-7**).

Table 3-7 L-THIA Results for the Battle Creek Watershed

Nonpoint Source Pollutant	L-THIA Results (existing)	L-THIA Results (future)
Nitrogen	Fair	Fair
Phosphorus	Fair	Fair
TSS	Good to Fair	Fair
BOD	Poor	Poor
E.coli	Good to Fair	Poor

Increased impervious cover can be correlated to increased loadings of pollutants as well as increased volumes and velocities of water which may increase erosion of streambanks and streambeds, leading to higher sediment loadings. The increased loadings will also have an impact on the physical condition of the stream, the quality of in-stream habitat, and the success of macroinvertebrate communities within this area.

Unless appropriate controls are added to the current floodplain and stormwater management ordinances, new development or redevelopment within the watershed will likely result in increased flood stages, increased flood velocities, increased runoff peaks, increased runoff volumes, longer bankfull inundations, and increased streambank erosion. A comparison of existing condition flow rates in this watershed with those in the more developed watersheds to the south (with the exception of the Ohio River/Cane Run basin) provides an indication of the impact that development and increased imperviousness can have on the amount of water that runs off the land and flows along downstream properties. Runoff rates in the Battle Creek basins are 0.7 to 1.2 cfs/ Acre while those in Lick Run and Lancassange Creek basins to the south are at or above 1.5 cfs per acre. If the Battle Creek watershed portion of the basin were not as steep, it would have a runoff rate closer to the Jenny Lind Run portion of the basin.

Measures such as prohibition of encroaching into the regulatory floodway, requiring compensatory floodplain storage, requiring over-compensatory on-site detention and requiring permanent retention of channel protection volume should be considered to ensure the existing problems and concerns are not exacerbated as new development or redevelopment occurs in the watershed. Changes in development may also result in the need for additional or changed existing infrastructure which will need repairs and maintenance in order to not adversely impact drainage in the watershed.

The current plan does not include any specific infrastructure improvement projects at this time.

3.3 SUMMARY OF FUTURE CONDTIONS, ANTICIPATED PROBLEMS/CONCERNS

It is anticipated that future land use development as it is currently planned will result in an overall percent impervious cover that will result in water quality, drainage and flooding problems. The greatest change of impervious cover is in the proposed River Ridge development site in the upper portion of the Lentzier Creek Watershed and Battle Creek Watershed. In the most extreme case, in the JLRU subwatershed of Battle Creek Watershed, impervious cover is expected to increase ten-fold from 7% to 70%.

Future development and redevelopment efforts citywide should incorporate water quality and quantity practices to protect, prevent, and mitigate future problems and concerns including:

- Increased runoff from new development
- Increased flooding and drainage problems
- Need for additional and/or replacement infrastructure as well as maintenance of infrastructure
- Changes in land use and imperviousness
- Anticipated pollutant loadings and stormwater pollutant removal requirements
- Loss of habitat and species diversity

- Impact to quality of life

Similar to understanding the existing conditions (Chapter 2), the future conditions and associated concerns are as important since they too become the foundation for the goals and performance criteria (Chapter 4) and the detailed evaluations of promising solutions (Chapter 6).

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CHAPTER 4 MASTER PLAN GOALS & PERFORMANCE CRITERIA

4.1 INTRODUCTION

Setting realistic and measurable goals is essential to the successful implementation of this SWMP. Goals are the desired change or outcome as a result of this planning effort. Depending on the magnitude of the problem, goals may be general, specific, long-term, or short-term. Performance Criteria are measures that will be used to formulate and/or screen the proposed alternatives to address stormwater concerns to meet the goals. This Chapter defines the goals and performance criteria for the City of Jeffersonville SWMP.

4.2 MASTER PLAN GOALS

1. Reduce flooding and drainage problems
2. Improve water quality of stormwater runoff
3. Protect, enhance, and restore natural systems for stormwater conveyance and storage
4. Integrate SWMP recommendations into current and future policies, programs, projects

4.3 PERFORMANCE CRITERIA

Based on the nature and extent of existing and future stormwater conditions and concerns, the following set of economic, environmental, and social Performance Criteria were developed to aid in the formulation of recommended solutions, as well as screening of alternatives.

Economic Criteria

- Proposed solutions should address neighborhood or regional scale problems and provide the greatest total value to the community by benefiting a relatively large percentage of people (localized problems that can be resolved by localized solutions will be catalogued and expected to be addressed by the City in a separate parallel track to this SWMP).
- Proposed solutions should be economically feasible and cost effective.

Environmental Criteria

- Proposed solutions should not have any significant and/or permanent negative impacts on the environment, recreational opportunities, and/or fish and wildlife resources.
- Proposed solutions should be consistent with the City's Stormwater Quality Management Plan and address water quality impairments identified in the Plan and those anticipated from existing and future land use.

Social Criteria

- Proposed solutions should improve public health, well-being, and community livability.
- Proposed solutions should maintain flood-free roads to at least the 10% annual chance of flooding elevation with no overflow from riverine sources and reduce flooding of homes to the 1% annual chance of flooding plus 2-foot freeboard when feasible.
- Proposed solutions should address public safety and allow for flood-free emergency access.
- Proposed solutions should be socially and politically acceptable to residents and, to the extent practical, to other interest groups and be permittable under existing federal, state, and local permit programs.

CHAPTER 5 PRIORITIZATION OF PROBLEMS/CONCERNS & INITIAL SCREENING OF POTENTIAL SOLUTIONS

5.1 INTRODUCTION

This Chapter discusses how the problems/concerns were catalogued and the screening of potential solutions for further evaluation in Phase 2 of this SWMP.

5.2 CATALOGUED PROBLEM

In total, 205 known flooding and drainage problems/concerns were identified and ranged in scale from isolated maintenance issues to thousands of buildings in the SFHA. In an effort to address as many problems as possible and use the resources of this SWMP to find solutions to the major issues, problems were catalogued geographically into local, neighborhood, and regional scale problem categories. These are defined as:

- Local Scale Problems (80 problems) – isolated problem typically maintenance and/or restrictive structure problems that restrict flow and cause water to back up in a small area or for a short period of time.
- Neighborhood Scale Problems (49 problems) – small number of various problems that are in proximity to each other and may be solved with one or more regional solutions.
- Regional Scale Problems (76 problems) – major flooding or drainage issues that affect a large area and will require further detailed study and potentially a major project to resolve the issue.

According to the Performance Criteria discussed in Chapter 4 and based on a consensus by Project Team members and Advisory Committee, proposed solutions as part of this SWMP will focus on addressing neighborhood or regional scale problems and provide the greatest total value to the community by benefiting a relatively large percentage of people. Localized problems that can be resolved by localized solutions will be addressed by the City in a separate parallel track to this SWMP.

Table 5-1, Table 5-2, Table 5-3,

Table 5-4, Table 5-5, and **Table 5-6** summarize the problems identified. These tables include the problem number (location shown on **Exhibit 5-1**), the type of problem, the source that identified the problem, if the problem was grouped with other problems, the probable cause, and how the problem was catalogued. Appendix 5 includes additional details for each problem area including early potential solutions. The promising solutions to neighborhood and regional scale problems were further evaluated as discussed in Chapter 6 of this SWMP.

Table 5-1 Ohio River/Cane Run Watershed Problem Areas

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
30	Street Flooding	City Staff	30, 82, 83, 115, 116	*low lying area*	Neighborhood
82	Drainage Issue	Public Meeting (8/23/2011)			
83	Drainage Issue	Public Meeting (8/23/2011)			
115	Street Flooding	9/7/2011 Email			
116	Building Flooding	9/7/2011 Email			
31	Street Flooding	City Staff	31,125	*unknown*	Neighborhood
125	Street Flooding	Field Visit, April 2011			
7	Street Flooding	EMA Director	7,8,11,25,26,27	*unknown*	Neighborhood
8	Street Flooding	EMA Director			
11	Street Flooding	EMA Director			
25	Street Flooding	City Staff			
26	Street Flooding	City Staff			
27	Street Flooding	City Staff			
9	Street Flooding	EMA Director	9,28,29,117	*unknown*	Neighborhood
28	Street Flooding	City Staff			
29	Street Flooding	City Staff			
117	Building Flooding	9/1/2011 Email			
12	Street Flooding	EMA Director/ City Staff		*unknown*	Neighborhood
13	Street Flooding	EMA Director		*unknown*	Neighborhood
15	Street Flooding	EMA Director		*unknown*	Neighborhood
24	Street Flooding	City Staff		*unknown*	Neighborhood
35	Drainage Issue	City Staff		*low lying area*	Neighborhood
80	Drainage Issue	Public Meeting (8/23/2011)		*poor street repair*	Neighborhood
81	Street Flooding	Public Meeting (8/23/2011)		*undersized infrastructure*	Neighborhood
126	Street Flooding	Field Visit, April 2011		*low lying area*	Neighborhood
127	Street Flooding	Field Visit, April 2011		*low lying area*	Neighborhood
128	Building Flooding	Field Visit, April 2011		*unknown*	Neighborhood
140	Building Flooding	City Google Mapping Project		*undersized infrastructure*	Neighborhood

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
155	Structure	City Google Mapping Project		*undersized infrastructure*	Neighborhood
159	Structure	City Google Mapping Project		*undersized infrastructure*	Neighborhood
161	Drainage Issue	City Google Mapping Project		*low lying area*	Neighborhood
164	Building Flooding	City Google Mapping Project		*infrastructure failure*	Neighborhood
166	Drainage Issue	City Google Mapping Project		*low lying area*	Neighborhood
168	Building Flooding	City Google Mapping Project		*low lying area*	Neighborhood
87	Building Flooding	Public Meeting (8/23/2011)		*Ohio River floodplain*	Neighborhood
131	Building Flooding	Field Visit, April 2011		*Ohio River floodplain*	Neighborhood

Table 5-2 Mill Creek Watershed Problem Areas

ID	PROBLEM	SOURCE	GROUPED PROBLEM	PROBABLE CAUSE	CATALOGUED PROBLEM
10	Street Flooding	EMA Director	10, 86, 145	*undersized structure*	Local
86	Building Flooding	Public Meeting (8/23/2011)			
145	Drainage Issue	City Google Mapping Project			
121	Drainage Issue	Public Comment Form	121, 122	*low lying area*	Local
122	Drainage Issue	Public Comment Form			
14	Street Flooding	EMA Director/ City Staff	14, 154	*low lying area*	Local
154	Drainage Issue	City Google Mapping Project			
146	Drainage Issue	City Google Mapping Project	146, 165	*lack of storm drain*	Local
165	Street Flooding	City Google Mapping Project			
16	Riverine Flooding	EMA Director	16, 17	*Mill Creek floodplain*	Local
17	Riverine Flooding	EMA Director			

ID	PROBLEM	SOURCE	GROUPED PROBLEM	PROBABLE CAUSE	CATALOGUED PROBLEM
84	Structure	Public Meeting (8/23/2011)	84, 91, 92, 147, 192	*undersized structure; low road*	Neighborhood
91	Structure	Public Meeting (8/23/2011)			
147	Drainage Issue	City Google Mapping Project			
192	Erosion	City Stream Visual Assessment Protocol			
92	Riverine Flooding	Public Meeting (8/23/2011)			
32	Street Flooding	City Staff		*unknown*	Local
33	Street Flooding	City Staff		*low lying area*	Local
34	Street Flooding	City Staff		*low lying area*	Local
97	Building Flooding	Public Meeting (9/21/2011)		*undersized structure*	Local
143	Building Flooding	City Google Mapping Project		*failing structure*	Local
144	Building Flooding	City Google Mapping Project		*unknown*	Local
158	Drainage Issue	City Google Mapping Project		*low lying area*	Local
160	Drainage Issue	City Google Mapping Project		*low lying area*	Local
167	Building Flooding	City Google Mapping Project		*low lying area*	Local
169	Drainage Issue	City Google Mapping Project		*low lying area*	Local
170	Drainage Issue	City Google Mapping Project		*low lying area*	Local
171	Drainage Issue	City Google Mapping Project		*low lying area*	Local
173	Structure	City Google Mapping Project		*undersized structure (Edgewood Dr)*	Local
187	Drainage Issue	City Google Mapping Project		*low lying area*	Local
188	Drainage Issue	10/5/11 Email		*low lying area*	Local
189	Building Flooding	10/5/11 Email		*unknown*	Local
190	Erosion	City Stream Visual Assessment Protocol		*undersized structure; water; upstream development*	Local
191	Erosion	City Stream Visual Assessment Protocol		*encroachment surrounding use*	Local
43	DELETE	City Staff			

Table 5-3 Lancassange Creek Watershed Problem Areas

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
1	Street Flooding	EMA Director	1, 2, 6, 20, 21, 22, 23, 44, 45, 46, 47	*lack of infrastructure; lack of maintenance*	Regional
2	Street Flooding	EMA Director			
6	Street Flooding	EMA Director			
20	Drainage Issue	OPCD Staff			
22	Drainage Issue	OPCD Staff			
23	Drainage Issue	OPCD Staff			
44	Street Flooding	City Staff			
45	Street Flooding	City Staff			
46	Street Flooding	City Staff			
47	Street Flooding	City Staff			
21	Drainage Issue	OPCD			
128	Building Flooding	Field Visit, April 2011	128, 205	*unknown*	Local
205	Drainage Issue	Public Meeting (10/27/11)			
149	Drainage Issue	City Google Mapping Project – City Pilot	149, 150	*low lying area*	Local
150	Drainage Issue	City Google Mapping Project – City Pilot			
18	Drainage Issue	OPCD	18, 68, 74	*low lying area*	Local
68	Drainage Issue	Public Meeting (7/12/2011)			
74	Building Flooding	Public Meeting (8/23/2011)			
3	Riverine Flooding	EMA Director	3, 4, 5, 43, 85, 172, 175, 185	*Woodland Creek floodplain; ponding water on street; low area; culverts appear undersized; stream enlarged with erosion*	Regional
4	Riverine Flooding	EMA Director			
5	Riverine Flooding	EMA Director			
43	Riverine Flooding	City Staff			
85	Riverine Flooding	Public Meeting (8/23/2011)			
172	Riverine Flooding	City Google Mapping Project – City Pilot			
175	Riverine Flooding	City Google Mapping Project – City Pilot			

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
185	Riverine Flooding	City Google Mapping Project – City Pilot			
197	Street Flooding	Public Meeting (10/27/11)	36, 37, 38, 39, 61, 62, 66, 72, 136, 197, 198, 199, 200, 203	*no infrastructure; high seepage (2hrs gone); no culverts under some drives, shallow ditches; nowhere for water to drain from low areas*	Regional
200	Street Flooding	Public Meeting (10/27/11)			
36	Drainage Issue	City Staff			
37	Drainage Issue	City Staff			
38	Drainage Issue	City Staff			
39	Riverine Flooding	City Staff			
61	Building Flooding	JTL			
62	Riverine Flooding	Public Meeting (7/12/2011)			
66	Building Flooding	Public Meeting (7/12/2011)			
72	Drainage Issue	Public Meeting (7/12/2011)			
136	Riverine Flooding	City Google Mapping Project – City Pilot			
198	Street Flooding	Public Meeting (10/27/11)			
199	Maintenance	Public Meeting (10/27/11)			
203	Drainage Issue	Public Meeting (10/27/11)			
40	Drainage Issue	City Staff	40, 64, 65, 69, 70, 71, 95, 119, 138, 139, 163, 178, 195, 196	*infrastructure questionable*	Regional
64	Building Flooding	Public Meeting (7/12/2011)			
65	Drainage Issue	Public Meeting (7/12/2011)			
70	Street Flooding	Public Meeting (7/12/2011)			
71	Structure	Public Meeting (7/12/2011)			
95	Structure	Public Meeting (7/12/2011)			
119	Structure	9/19/2011 Email			
138	Riverine Flooding	City Google Mapping Project – City Pilot			
139	Maintenance	City Google Mapping Project – City Pilot			

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
163	Drainage Issue	City Google Mapping Project – City Pilot			
178	Structure	City Google Mapping Project – City Pilot			
69	Structure	Public Meeting (7/12/2011)			
195	Maintenance	Public Meeting (10/27/11)			
196	Maintenance	Public Meeting (10/27/11)			
41	Drainage Issue	City Staff	41, 137, 177, 202	*maintenance; lack infrastructure*	Neighborhood
137	Maintenance	City Google Mapping Project – City Pilot			
177	Drainage Issue	City Google Mapping Project – City Pilot			
202	Drainage Issue	Public Meeting (10/27/11)			
63	Drainage Issue	Public Meeting (7/12/2011)	63, 75, 201	*infrastructure*	Local
75	Street Flooding	Public Meeting (8/23/2011)			
201	Street Flooding	Public Meeting (10/27/11)			
78	Drainage Issue	Public Meeting (8/23/2011)	78, 186	*low lying area*	Local
186	Drainage Issue	City Google Mapping Project – City Pilot			
67	Building Flooding	Public Meeting (7/12/2011)		*low lying area*	Local
130	Riverine Flooding	Field Visit, April 2011		*undersized detention*	Local
148	Drainage Issue	City Google Mapping Project		*low lying area*	Local
176	Drainage Issue	City Google Mapping Project		*low lying area*	Local
179	Structure	City Google Mapping Project		*undersized culvert*	Local
204	Drainage Issue	10/28/11 Email		*low lying area*	Local
42	Riverine Flooding	City Staff		*Lancassange Creek floodplain*	Local
48	Street Flooding	City Staff		*Woodland Court Tributary floodplain*	Local
129	Drainage Issue	Field Visit, April 2011		*back up from Lancassange Creek*	Local
180	Riverine Flooding	City Google Mapping Project – City Pilot		*Lancassange Creek floodplain*	Local

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
19	DELETE	OPCD			

Table 5-4 Lick Run Watershed Problem Areas

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
51	Maintenance	City Staff	51, 153, 157	*Lick Run UNT floodplain*	Local
153	Maintenance	City Google Mapping Project			
157	Maintenance	City Google Mapping Project			
54	Drainage Issue	City Staff	54, 88	*culvert size*	Local
88	Structure	Public Meeting (8/23/2011)			
73	Building Flooding	Public Meeting (8/23/2011)	73, 90, 94, 120	*Lick Run floodplain*	Neighborhood
90	Riverine Flooding	Public Meeting (8/23/2011)			
94	Structure	Public Meeting (8/23/2011)			
120	Drainage Issue	Public Comment Form			
96	Building Flooding	Public Meeting (9/21/2011)	96, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 142, 183	*RR structure size and maintenance*	Regional
98	Street Flooding	Public Meeting (9/21/2011)			
99	Obstruction	Public Meeting (9/21/2011)			
100	Building Flooding	Public Meeting (9/21/2011)			
101	Building Flooding	Public Meeting (9/21/2011)			
102	Building Flooding	Public Meeting (9/21/2011)			
103	Drainage Issue	Public Meeting (9/21/2011)			
104	Building Flooding	Public Meeting (9/21/2011)			
105	Obstruction	Public Meeting (9/21/2011)			
106	Building Flooding	Public Meeting (9/21/2011)			
106	Drainage Issue	Public Meeting (9/21/2011)			
107	Building Flooding	Public Meeting (9/21/2011)			
108	Obstruction	Public Meeting (9/21/2011)			
109	Drainage Issue	Public Meeting (9/21/2011)			

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
110	Building Flooding	Public Meeting (9/21/2011)			
111	Building Flooding	Public Meeting (9/21/2011)			
112	Drainage Issue	Public Meeting (9/21/2011)			
113	Building Flooding	Public Meeting (9/21/2011)			
142	Obstruction	City Google Mapping Project			
183	Drainage Issue	City Google Mapping Project			
49	Street Flooding	City Staff		*unknown*	Local
52	Drainage Issue	City Staff		*Lick Run UNT floodplain*	Local
60	Structure	JTL		*Pedestrian Bridge*	Local
89	Structure	Public Meeting (8/23/2011)		*Lick Run floodplain*	Local
114	Drainage Issue	9/7/2011 Email		*low lying area*	Local
151	Erosion	City Google Mapping Project		*underground detention*	Local
152	Building Flooding	City Google Mapping Project		*unknown*	Local
156	Structure	City Google Mapping Project		*structure failing, needs replace*	Local
174	Street Flooding	City Google Mapping Project		*unknown*	Local
184	Maintenance	City Google Mapping Project		*maintenance*	Local
194	Drainage Issue	10/28/11 Email		*low-lying area*	Local
193	Erosion	City Stream Visual Assessment Protocol		*upstream development; water*	Neighborhood

Table 5-5 Silver Creek/Pleasant Run Watershed Problem Areas

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
181	Drainage Issue	City Google Mapping Project – City Pilot	181, 182	*unknown*	Local
182	Drainage Issue	City Google Mapping Project – City Pilot			
58	Riverine Flooding	City Staff	58, 141	*Pleasant Run floodplain*	Local
141	Riverine Flooding	City Google Mapping Project –			

		City Pilot			
55	Street Flooding	City Staff		*infrastructure/ undersized detention*	Local
56	Riverine Flooding	City Staff		*Pleasant Run floodplain*	Local
59	Drainage Issue	City Staff		*unknown*	Local
124	Drainage Issue	Field Visit, April 2011		*low lying area*	Local
132	Street Flooding	Field Visit, April 2011		*unknown*	Local
133	Riverine Flooding	Field Visit, April 2011		*Pleasant Run floodplain*	Local

Table 5-6 Lentzier Creek Watershed Problem Areas

ID	PROBLEM	SOURCE	GROUPED PROBLEMS	PROBABLE CAUSE	CATALOGUED PROBLEM
50	Riverine Flooding	City Staff	50, 76, 77, 79, 92, 118, 123, 134, 135, 162	*Lentzier Creek floodplain; County development*	Regional
76	Riverine Flooding	Public Meeting (8/23/2011)			
79	Riverine Flooding	Public Meeting (8/23/2011)			
92	Riverine Flooding	Public Meeting (8/23/2011)			
118	Riverine Flooding	8/23/2011 Letter			
123	Riverine Flooding	Public Comment Form			
134	Riverine Flooding	Field Visit, April 2011			
135	Riverine Flooding	Field Visit, April 2011			
162	Riverine Flooding	City Google Mapping Project – City Pilot			
77	Street Flooding	Public Meeting (8/23/2011)			
93	Structure	Public Meeting (8/23/2011)			Local

Note: There were no problems identified in the Battle Creek Watershed.

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5.3 IDENTIFICATION OF TARGET STUDY AREAS

Target Study Areas were created out of the grouped neighborhood and regional scale problems as well as the buildings in the SFHA (**Figure 5-1**).

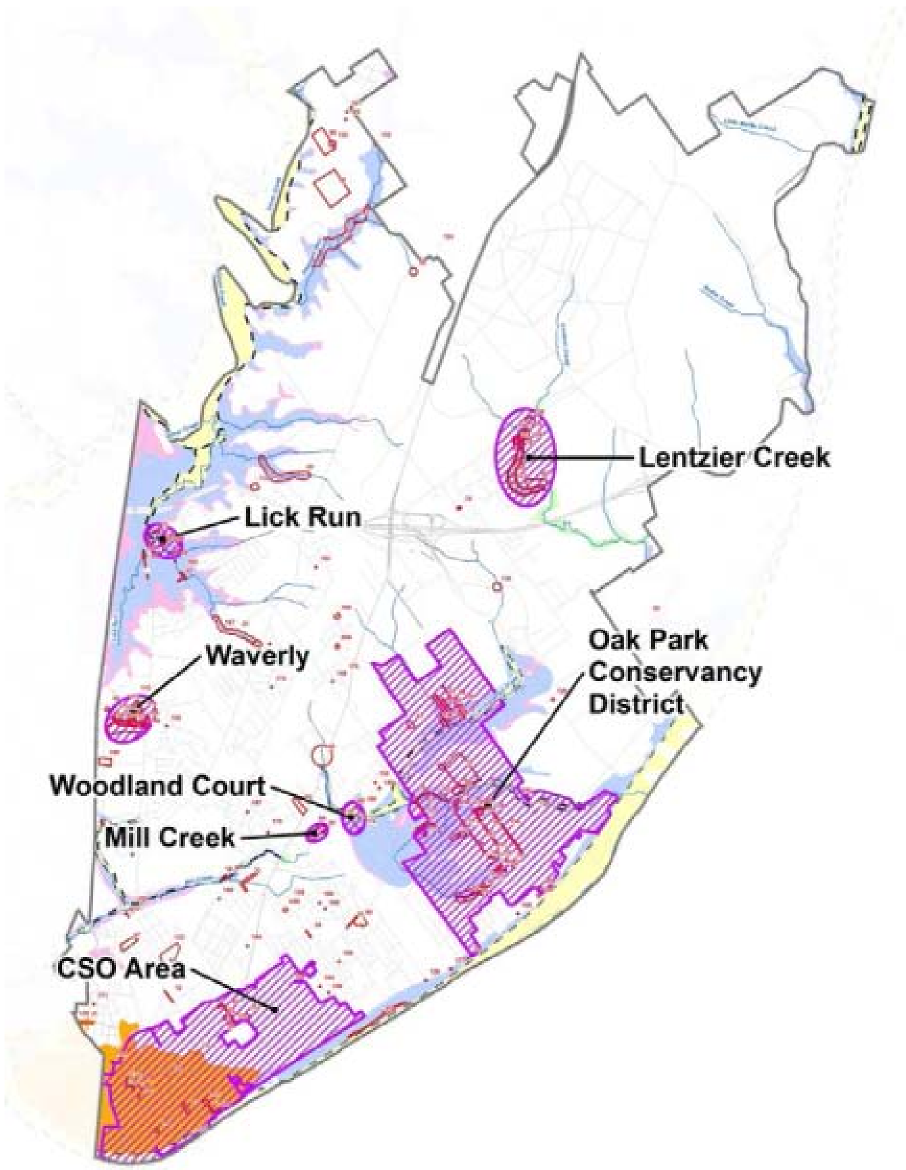

Figure 5-1 Target Study Areas

These include:

1. Existing Buildings in the SFHA (**Figure 5-2**)

- Description – 1,928 buildings identified through a GIS desktop analysis and another 1,584 protected by a levee. Although not all buildings have flooded, this Target Study Area is included in this SWMP due to the potential for building flooding and restricted vehicular access.
- Problem Type(s) – buildings in the SFHA
- Watershed(s) – all
- Council District(s) – all

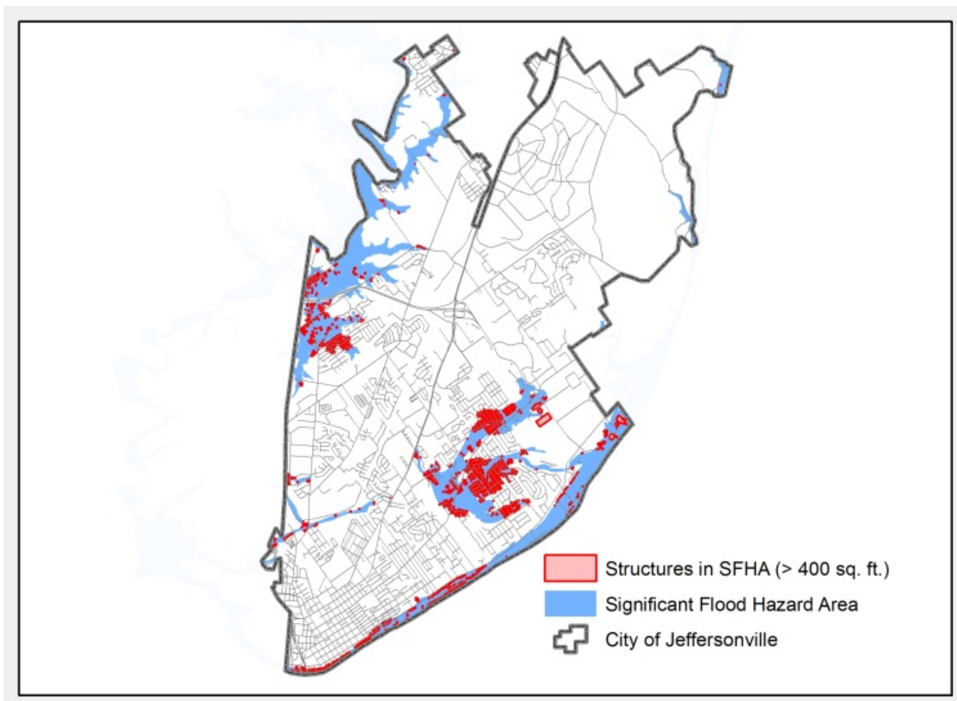

Figure 5-2 Existing Buildings in the SFHA Target Area

2. CSO/Downtown Area (**Figure 5-3**)

- Description – heavily urbanized old downtown area that generates more runoff than current infrastructure can handle resulting in CSO events, flooded buildings and standing water in streets.
- Problem Type(s) – all
- Watershed(s) – Ohio River/Cane Run
- Council District(s) – #1, #2

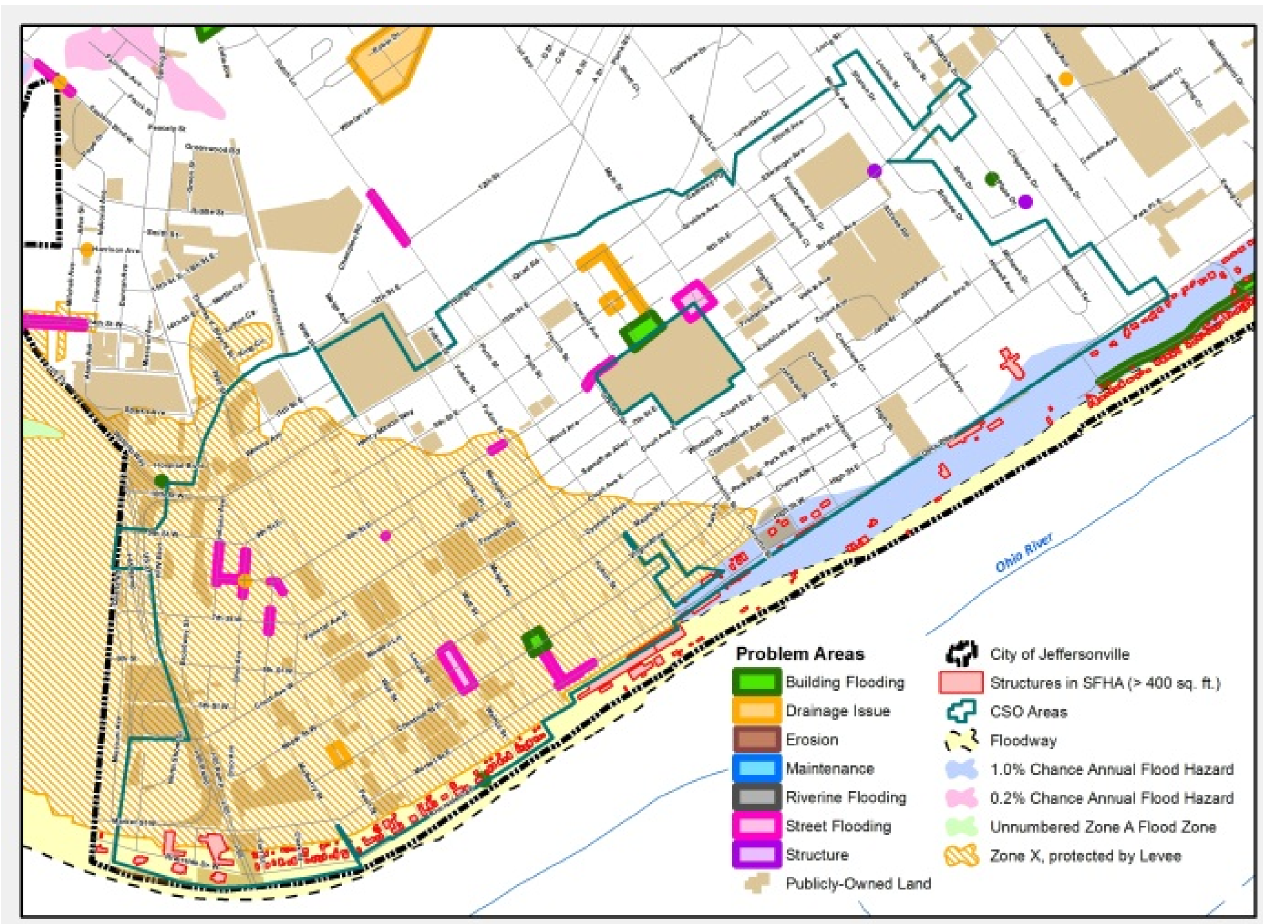

Figure 5-3 CSO/Downtown Jeffersonville Areas TSA

3. OPCD (**Figure 5-4**)

- Description – area is within Lancassange Creek floodplain and without stormwater infrastructure or the infrastructure in place is undersized, needs maintained, or replaced to function properly
- Problem Type(s) – (6 of 7) building flooding, drainage issue, maintenance, restrictive structure, riverine flooding, street flooding
- Watershed(s) – Lancassange Creek
- Council District(s) – #3, #6

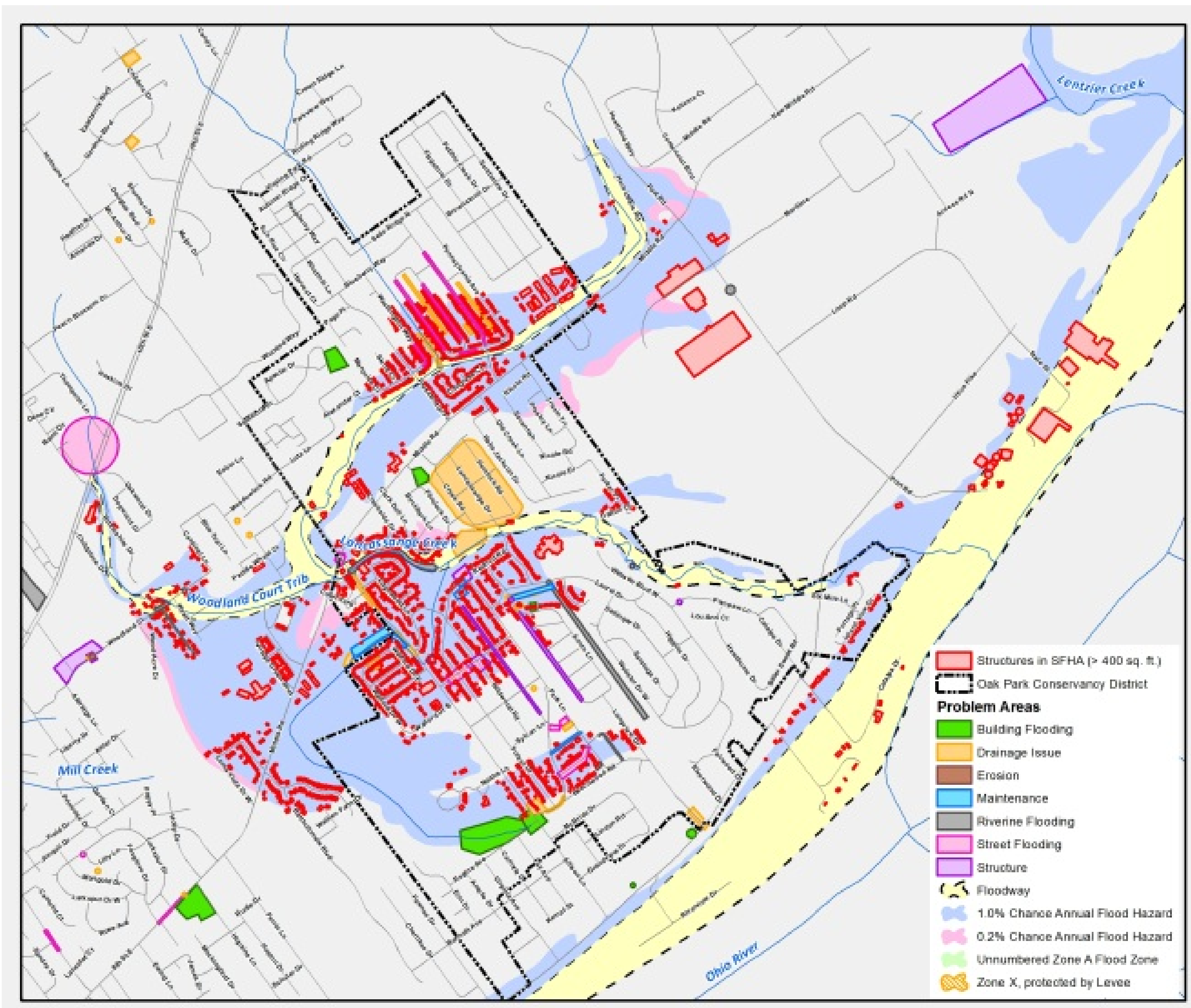

Figure 5-4 Oak Park Conservancy District TSA

4. Lentzier Creek (**Figure 5-5**)

- Description – area is within the Lentzier Creek floodplain and experiences flash flooding, standing water in yards and driveways, and flooding in streets
- Problem Type(s) – (2 of 7) riverine flooding, street flooding
- Watershed(s) – Lentzier Creek
- Council District(s) – #6

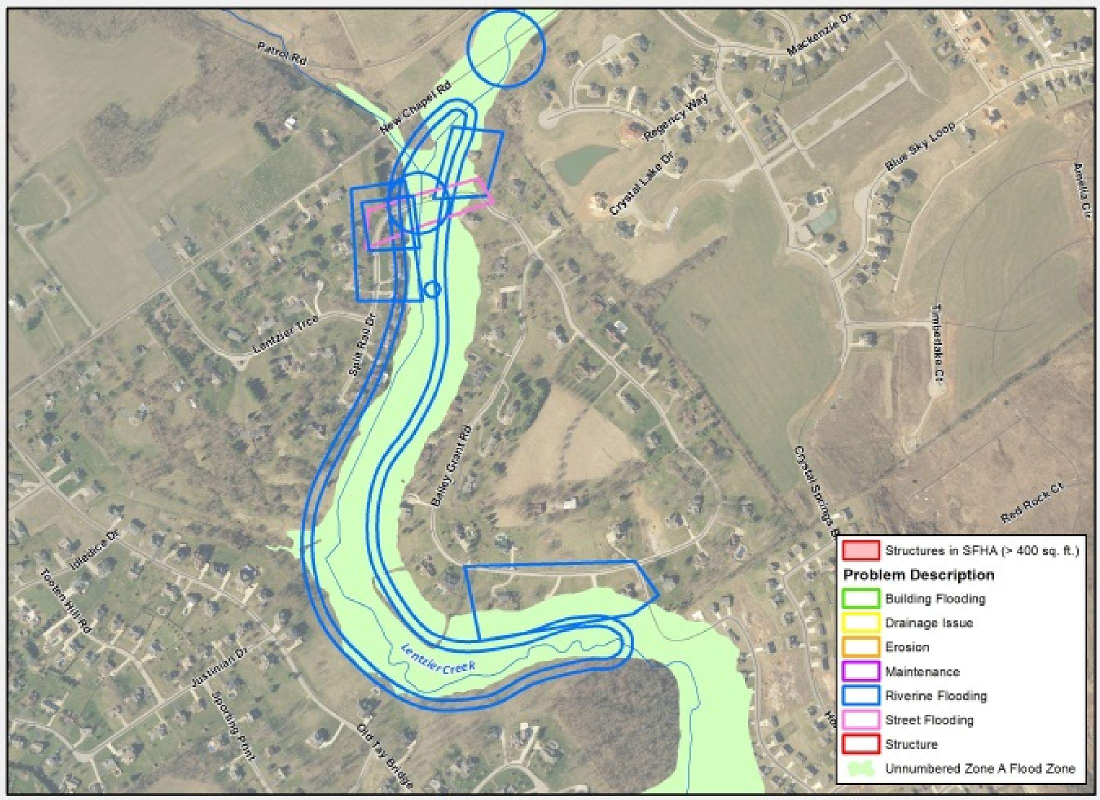

Figure 5-5 Lentzier Creek TSA

5. Waverly (**Figure 5-6**)

- Description – low-lying area where homes, streets and yards frequently flood. Water unable to drain due to undersized and unmaintained culverts under railroad
- Problem Type(s) – (6 of 7) building flooding, drainage issue, maintenance, restrictive structure, riverine flooding, street flooding
- Watershed(s) – Lick Run
- Council District(s) – #2

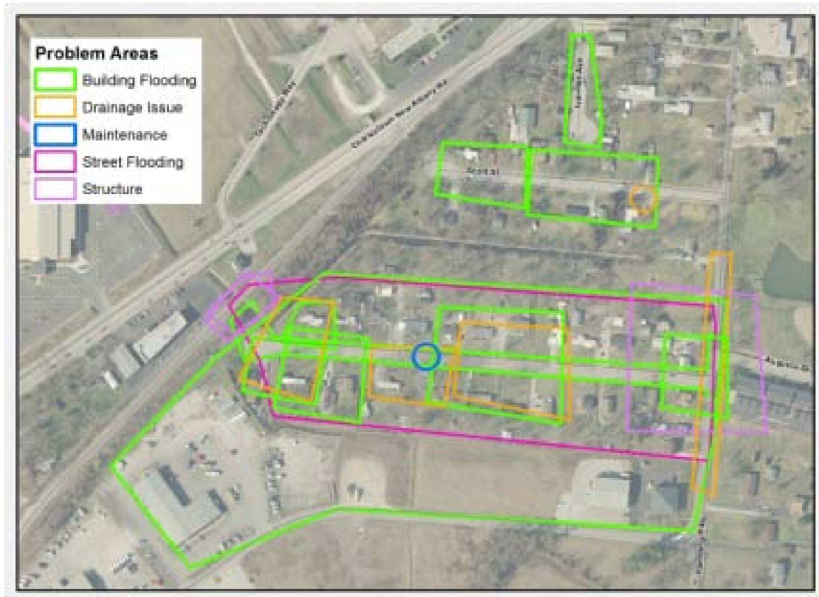

Figure 5-6 Waverly TSA

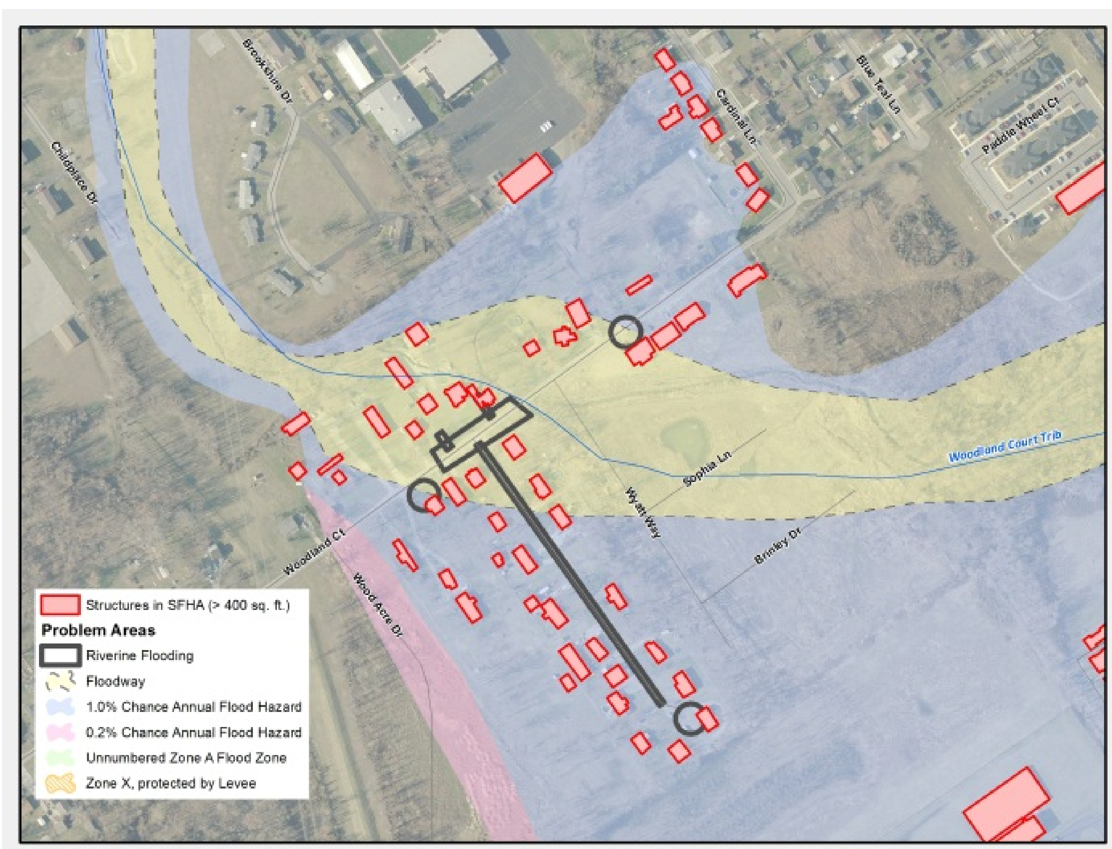

Figure 5-7 Woodland Court TSA

6. Woodland Court (**Figure 5-7**)

- Description – low-lying area in the Woodland Court Tributary; standing water in yards and street
- Problem Type(s) – (2 of 7) riverine flooding, street flooding
- Watershed(s) – Lancassange Creek
- Council District(s) – #5

7. Lick Run (**Figure 5-8**)

- Description – area located in the Lick Run floodplain and experiences building flooding and drainage issues. Undersized culverts may be contributing to the problem
- Problem Type(s) – (5 of 7) building flooding, drainage issue, erosion, restrictive structure, riverine flooding
- Watershed(s) – Lick Run
- Council District(s) – #4

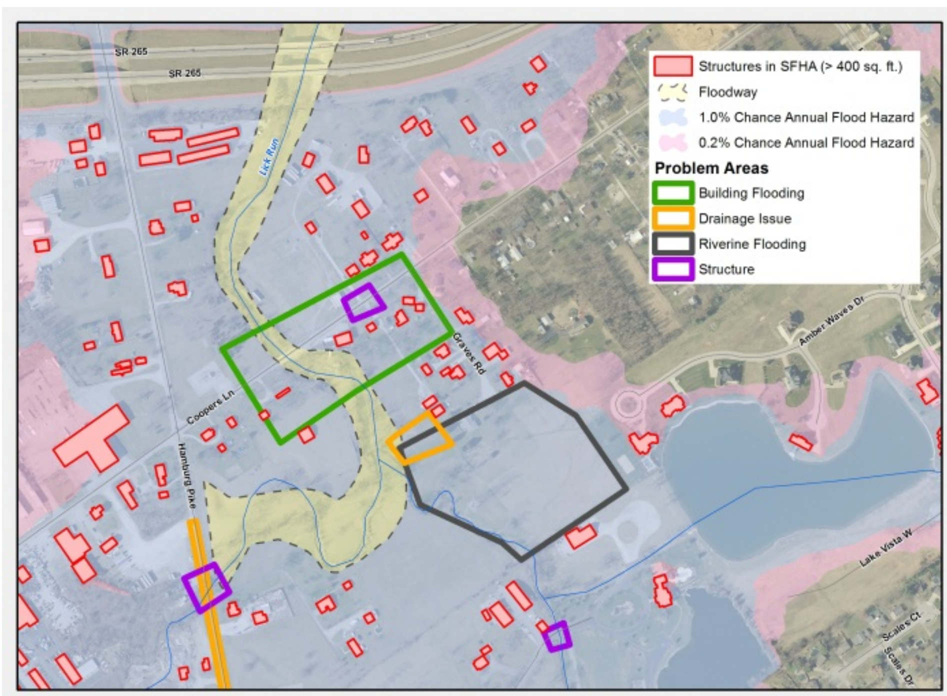

Figure 5-8 Lick Run TSA

8. Mill Creek (**Figure 5-9**)

- Description – area has streambank erosion and drainage issues which may be the result of an undersized culvert
- Problem Type(s) – (4 of 7) drainage issue, erosion, restrictive structure, riverine flooding
- Watershed(s) – Mill Creek
- Council District(s) – #5

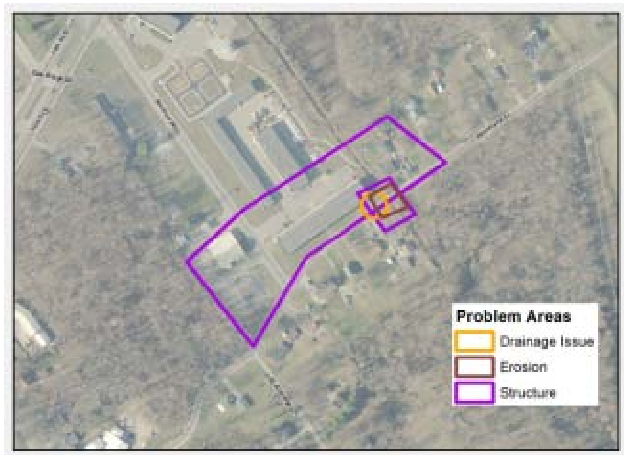

Figure 5-9 Mill Creek TSA

S
A Target Study Area was created to include the citywide programs and policies that would address existing and anticipated future flooding and drainage problems:

8. Citywide Programs

- Description – emphasis on policies and programs to address existing and anticipated future problems
- Problem Type(s) – all
- Watershed(s) – all
- Council District(s) – all

Appendix 6 includes a summary worksheet for each Target Study Area.

5.4 IDENTIFICATION & INITIAL SCREENING OF POTENTIAL SOLUTIONS

To the greatest extent possible, both structural and non-structural solutions were considered to address the existing and anticipated future stormwater and flooding problems. The following define the different types of structural and non-structural solutions:

Structural Solutions (Figure 5-10)

Figure 5-10 Bioinfiltration is an example of a source control structural solution

- Source Control Solutions – physical measures that are located at the source or beginning of the drainage system on public or private property that promote ground infiltration and address stormwater runoff (rain gardens, rain barrels, porous pavement, tree boxes, inlet filters, etc.)
- Conveyance Control Solutions – stormwater transport systems that are typically located in the right of way or along the waterway to control flow and/or promote infiltration, reduce pollutant loadings, lower the temperature of runoff to discharging streams (pipes, swales, floodwalls, levees, etc.)
- End-of-Pipe Control Solutions – stormwater storage or treatment structures that occur at the end of the stormwater conveyance system (wet or dry stormwater ponds, wetlands, etc.)
- Restoration – methods used to restore degraded or impaired streams, wetlands or other aquatic habitats (streambank stabilization, weirs, riparian restoration, retrofit stormwater ponds, etc.)

Non-structural Solutions (Figure 5-11)

Figure 5-11 Flood depth mapping is an example of a non-structural solution

- Policy – related to the revision, update or amendment of local planning, code enforcement and/or ordinances that guide or regulate development (zoning, stormwater, floodplain ordinances, etc.)
- Program – related to education and outreach efforts, building private/public partnerships, and collaboration among entities and agencies to address stormwater and flooding issues
- Project – related to new or revised stream hydraulic studies, stream gages placement and data, GIS database management, and flood control structure inventory to better forecast, track, and mitigate stormwater and flooding issues (GIS database flooding complaints, prioritization and management aspects of acquisition of structures in SFHA, flood depth mapping, flood response plan, evacuation plan, etc.)

Potential structural and non-structural solutions were identified to address the problems in each Target Study Area. The Performance Criteria discussed in Chapter 4 was used to screen these potential solutions and identify promising solutions. Appendix 6 includes the worksheets used to screen potential solutions for each Target Summary Area. Those potential solutions found to meet the performance criteria were identified as part of the initial evaluations summarized in these worksheets and added to a short list of promising solutions as discussed in Section 5.5.

5.5 SUMMARY OF SHORT LISTED PROMISING SOLUTIONS

A summary of short-listed promising solutions to address existing flooding problems and concerns and those addressing concerns regarding potential worsening of flooding problems in the future is provided in **Table 5-7**. These promising solutions will be further evaluated in detail in Chapter 6.

Table 5-7 Short-listed Promising Solutions

ID #	PROMISING SOLUTION	TARGET STUDY AREA
PS-1	City's Participation in Community Rating System	Buildings in the SFHA
PS-2	Prioritization Plan for Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA	
PS-3	Citywide Fluvial Erosion Mapping	Citywide
PS-4	Citywide Flood Response Plan	
PS-5	Citywide Update of Stream Hydraulic Studies	
PS-6	Citywide Green Infrastructure Policy	
PS-7	Citywide Floodplain Management Ordinance Update	
PS-8	Citywide Stormwater Ordinance & Technical Standards Update	
PS-9	Citywide Development Codes & Design Standards Update	
PS-10	Citywide Operations & Maintenance Manuals Update	
PS-11	Canal as Planned Alternative Downtown Flood Control Project	CSO/Downtown Area
PS-12	Reverse Canal Alternative Downtown Flood Control Project	
PS-13	Storm Sewer Interceptor Alternative Downtown Flood Control Project	
PS-14	Near-Surface Tunnel Alternative Downtown Flood Control Project	
PS-15	Voluntary Acquisition and/or Floodproofing Program in the CSO/Downtown Area	
PS-16	Green Infrastructure in the CSO/Downtown Area	

ID #	PROMISING SOLUTION	TARGET STUDY AREA
PS-17	Flood Depth Mapping in OPCD	OPCD
PS-18	Fluvial Erosion Mapping in OPCD	
PS-19	Updating Stream Study of Lancassange Creek	
PS-20	Green Infrastructure in OPCD	
PS-21	Construction of New or Upgraded Storm Sewers throughout OPCD (McBride Dr., Laurel Ave. & Capitol Hills Dr.)	
PS-22	Bypass Channel of Lancassange Creek OPCD Flood Control Project	
PS-23	Upstream Offline Detention Basins OPCD Flood Control Project	
PS-24	Combination of Bypass Channel and Upstream Offline Detention Basins OPCD Flood Control Project	
PS-25	Levee and Pump Station near Lancassange Creek Mouth OPCD Flood Control Project	
PS-26	Voluntary Acquisition and/or Floodproofing Program in OPCD	
PS-27	Stream Restoration of Lancassange Creek in OPCD	
PS-28	Updating Stream Study of Lentzier Creek	Lentzier Creek
PS-29	Stream Restoration of Lentzier Creek	
PS-30	Voluntary Acquisition and/or Floodproofing Program in Waverly	Waverly
PS-31	Increasing the capacity of Upper Lick Run openings under Abandoned Railroad and Charleston New Albany Road in Waverly	
PS-32	Stream Restoration of Upper Lick Run in Waverly	
PS-33	Upstream Stormwater Pond at Golf Course in Waverly	
PS-34	Voluntary Acquisition and/or Floodproofing Program in Woodland Court	Woodland Court
PS-35	Flood Depth Mapping in Woodland Court	
PS-36	Updating Stream Study of Woodland Court Tributary	
PS-37	Enlarging Culvert Under Woodland Court Tributary	
PS-38	Stream Restoration of Woodland Court	
PS-39	Constructed Wetland in Woodland Court	
PS-40	Voluntary Acquisition and/or Floodproofing Program in Lick Run	Lick Run
PS-41	Flood Depth Mapping of Lick Run	
PS-42	Increasing the Conveyance Capacity of Hamburg Pike and Cooper Lane Crossings of Lick Run	
PS-43	Updating Stream Study of Mill Creek	Mill Creek
PS-44	Increasing the Culvert Capacity of Mill Creek at Woodland Court Crossing	
PS-45	Stream Restoration of Mill Creek	

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CHAPTER 6 DETAILED EVALUATION OF PROMISING SOLUTIONS

This Chapter includes a detailed evaluation of the promising solutions identified in Chapter 5 to determine their feasibility to address flooding, drainage, and stormwater quality problems. The discussion is grouped by Target Study Areas and includes a brief description of the area and types of problems as well as a discussion, conceptual layout, analysis, and estimated cost for each promising solution (for future reference, these potential solutions are numbered sequentially and coded with a prefix “PS”).

6.1 PROMISING SOLUTIONS TO ADDRESS EXISTING BUILDINGS IN THE SFHA

A GIS-based desktop analysis of the preliminary FIRMs and the City’s building footprint layer identified 1,928 structures that are greater than 400 square feet in the SFHA (289 in the floodway and 36 in Zone A) and an additional 1,584 structures in Zone X (protected by a levee) in the downtown area. Although not all of these buildings have experienced flooding, due to their location, there is potential for flood-related losses to buildings and property as well as restricted vehicular access on flooded streets. There is also a concern that some of the underlying FIS hydraulic studies may have incorrectly shown some of these structures within the high risk flooding area. So, there may also be an inappropriate flood zone designation issue that will need to be addressed.

Two promising solutions were identified to address the problem of existing buildings in the SFHA. These include Community Rating System (PS-1) and Voluntary Acquisition and/or Floodproofing Program (PS-2).

PS-1: City’s Participation in Community Rating System

The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions that meet the 3 goals of the CRS: (1) reduce flood losses; (2) facilitate accurate insurance rating; and (3) promote education and awareness of flood insurance.

Savings in flood insurance premiums are proportional to the points assigned to various activities. There are 10 CRS classes: Class 1 requires the most credit points (4,500+) and gives the largest premium reduction (45%); Class 10 has the lowest credit points (less than 499) and receives no premium reduction. A minimum of 500 points are necessary to enter the CRS program and receive the minimum 5% flood insurance premium discount.

As of October 2011, there are nearly 900 communities nationwide participating in the CRS program. The following lists the 18 communities in Indiana that participate and their current class: Allen County (8), City of Anderson (8), Bartholomew County (8), City of Columbus (8), City of Decatur (8), City of Evansville (8), City of Fort Wayne (8), Hamilton County (7), Hancock County (8), City of Indianapolis (8), City of Kokomo (8), Kosciusko County (9), City of Milford Junction (8), City of Noblesville (8), City of North Webster (8), City of Syracuse (8), Vanderburgh County (8), and Vigo County (10).

The CRS assigns credits based on the following 4 activities:

1. Activity 300 Public Information – credits programs that advise people about the flood hazard, flood insurance, and ways to reduce flood damage. Credit is based on whether a community maintains elevation certificates; provides map information service; conducts outreach projects to flood-prone residents; requires flood-related disclosure from real estate agents to potential buyers; provides flood protection information in the library and/or community webpage; and provides flood protection assistance. It also provides data that insurance agents need for accurate flood insurance rating. A maximum of 939 points is available for this activity. However, according to the CRS Coordinator's Manual, an average of 393 points is awarded.
2. Activity 400 Mapping and Regulations – credits programs that provide increased protection to new development. Credit is based on whether the community maintains additional flood data; has an open space preservation program; enforces higher regulatory standards; maintains historic flood data; and regulates stormwater runoff from new development. For this activity, a maximum of 5,895 points is available but the average points awarded is 620.
3. Activity 500 Flood Damage Reduction – credits programs that reduce flood risk to existing development. Credit is based on whether a community has a flood hazard mitigation plan; a program to acquire and relocate flood-prone buildings out of the floodplain; a flood protection program for floodproofing or elevating flood-prone buildings; and inspects and maintains the drainage system.

A total of 6,689 points is available for this activity. However, according to the CRS Coordinator's Manual, an average of 653 points is awarded.

4. Activity 600 Flood Preparedness – credits programs that provide flood preparedness and response as well as maintenance of flood hazards structures. Credit is based on whether a community has a flood warning program that provides early warning to the public; maintains existing levees not otherwise credited but providing flood protection; and has a state approved dam safety program. The maximum points for this activity are 1,330 but the average points awarded is 357.

The average points awarded for the above 4 activities is 2,023 of 14,850 possible points. In many cases, current floodplain management programs, policies, and projects will get the community into the program as a Class 8 and result in a 10% discount in flood insurance premiums. Obtaining a lower class rating and higher premium discounts is achievable with a more advanced floodplain management effort.

The City of Jeffersonville has been a member of the NFIP since June 1974. According to the May 25, 2012 Community Assistance Visit issued by IDNR, there are 436 flood insurance policies in effect within Jeffersonville providing $78,317,400 worth of flood loss related protection.

There are several repetitive loss structures in the City of Jeffersonville. FEMA defines a repetitive loss structure as a structure covered by a contract of flood insurance issued under the NFIP, which has suffered flood loss damage on two occasions during a 10-year period that ends on the date of the second loss, in which the cost to repair the flood damage is 25% of the market value of the structure at the time of each flood loss.

There are 2 major advantages of participating in the CRS program. First is the long-term benefit for the City of Jeffersonville in reducing future flood losses. Second is the annual financial benefit to residents and businesses in lower insurance premium rates which may result in investments in property improvements and/or otherwise reinvested in the community.

Table 6-1 illustrates the potential discount in flood insurance premiums based on the City of Jeffersonville's level of participation in the CRS program.

Table 6-1 CRS Flood Insurance Premium Discounts

Rate Class	Credit Points	Total Premium Discount	
1	4,500+	45%	$ 105,690
2	4,000-4,499	40%	$ 93,947
3	3,500-3,999	35%	$ 82,203
4	3,000-3,499	30%	$ 70,460
5	2,500-2,999	25%	$ 58,717
6	2,000-2,499	20%	$ 46,973
7	1,500-1,999	15%	$ 35,230
8	1,000-1,499	10%	$ 23,487
9	500-999	5%	$ 11,743
10	0-499	0%	$ -

The initial cost to gather and review materials and complete the CRS application is estimated at $10,000. Annual program maintenance and recertification is estimated at $2,500 and $4,000 to prepare for and participate in the 5-year Cycle Visit. Throughout participation in the CRS program, the City may wish to add or modify activities from the original application. The fee to complete program modification worksheets and assemble documentation may range between $2,000 to $5,000 depending on the activity being added or modified.

PS-2: Prioritization Plan for Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA

Removing or modifying buildings subject to flooding reduces the risk of future flood-related losses. In a property acquisition or buyout project, the community identifies and purchases private property, acquires the title to it, and then removes the structure(s). By law, that property, which is now public property, must forever remain as open space. The community can use it to create public parks, wildlife refuges, etc. but it cannot sell it to private individuals nor develop it. The acquired properties will also serve as floodplain storage. Therefore no fill is to be placed on any acquired property located in the floodplain. Property acquisitions work the same way as any other real estate transaction. Land and buildings are appraised at their pre-flood fair market value. Buyouts are strictly voluntary and no homeowners are ever forced to relinquish their property. The following lists some of the advantages and disadvantages of the voluntary acquisition (buyout) program:

Advantages of Voluntary Acquisition (Buyout):

- Saves money in long-term since it breaks the disaster-response-recovery cycle

- Provides permanent protection to flood-prone structures
- Serves multiple objectives for community planning
- Enhances natural flood protection
- Respects private property rights

Disadvantages of Voluntary Acquisition (Buyout):

- High upfront cost of purchasing properties
- Loss of local tax base of purchased properties
- Disrupts established neighborhoods
- Higher housing costs for those relocating
- Incomplete participation limits effectiveness

Individuals who decide not to participate in the voluntary acquisition (buyout) program should retrofit their structure to reduce potential flood-related losses. Floodproofing may be designed to reduce the number of times the building is flooded or to limit the potential damage to the building and its contents when it's flooded. General approaches to floodproofing range from low cost solutions such as moving or elevating valuables from the area subject to flooding to more expensive solutions including:

1. Implementing measures that prevent basement flooding and sewer backups;
2. Wet floodproofing – modifying the building and relocating the contents to allow floodwaters inside the structure with little or no damage;
3. Dry floodproofing – preventing water from entering the structure by making the building floor and walls watertight;
4. Floodwalls – preventing floodwaters to come near the building by constructing barriers around the building or at the lower elevations on the property; and
5. Elevation – preventing the floodwaters to enter the building by raising the building in place.

Selecting the appropriate floodproofing measure for a structure will depend on the nature of the flood hazard, the physical condition of the site, the function and use of the building, and its structural characteristics.

Funds for both acquisition and floodproofing may come directly from the community or through FEMA's Hazard Mitigation Grant Program (HMGP) or Flood Mitigation Assistance Program (FMAP). Both HMGP and FMAP funds are available to states and local communities that participate in the National Flood Insurance Program (NFIP) to implement long-term flood mitigation measures including elevating, floodproofing or acquisition of flood-prone structures. HMGP grants are unique in that they are only available after a major disaster. Federal grant programs will provide 75% of the funds and require 25% match by state, local, or individual funds.

Acquisition costs are typically the assessed value of the property plus 20% for demolition, closing cost fees, etc. For the purpose of this study the total acquisition costs for each residential building is assumed to be $132,000. However, 75% of this cost is typically paid by a Federal grant.

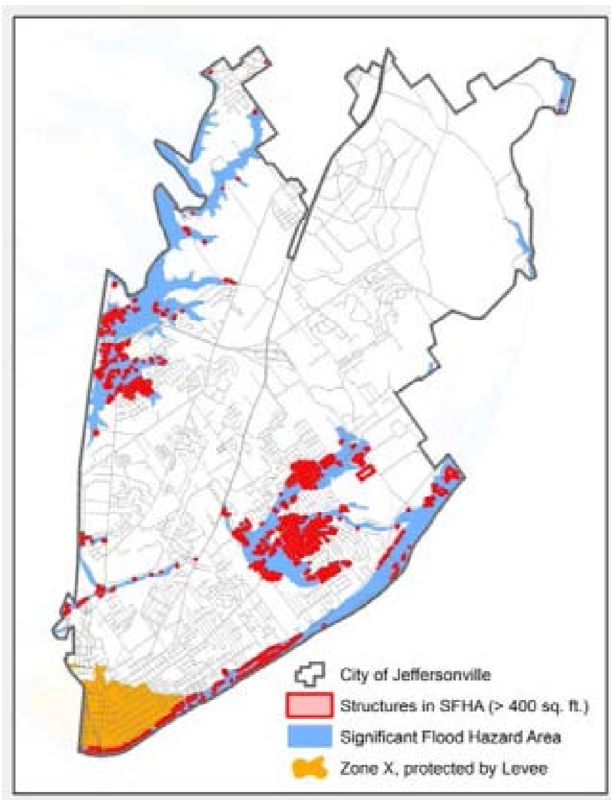

Figure 6-1 Distribution of Structures in the SFHA

Depending on the structure and mitigation needs, floodproofing or retrofitting structures for flood protection may range from $20,000 to $70,000 per structure. However, to ensure that the property owner has a significant stake in the retrofitting project, it was assumed that the City's contribution to each property owner will be only 50% of the total actual project costs, with the City's share not to exceed $20,000 for each commercial building and $10,000 for each residential building.

In the City of Jeffersonville there are 1,928 structures greater than 400 square feet in the SFHA and an additional 1,584 protected by a levee in the downtown area. **Figure 6-1** illustrates the distribution of structures in the SFHA. Outside of the SFHA, the Waverly area (Lick Run Watershed) frequently report drainage and building flooding issues.

Table 6-2 breaks down the number of structures within the SFHA (floodway 1% annual chance, and approximate Zone A), within 0.2% annual chance (500-year), and those protected by a levee for each of the 7 major watersheds in the City.

Table 6-2 also includes the number of reports of building flooding by the public during the development of this SWMP. In the Lick Run Watershed, 11 of the 12 building flooding complaints were from the Waverly area.

Table 6-2 Structures in the SFHA Classified by Flood Zone

WATERSHED	STRUCTURE IN[1]					BUILDING FLOODING[2]
	FW	1% (100-year)	ZONE A	0.2% (500-year)	ZONE X (levee)	
Battle Creek	1	3	0	3	0	0
Lancassange Creek	95	1,111	0	1,147	0	6
Lentzier Creek	1	1	19	1	0	0
Lick Run	0	374	0	589	0	12
Mill Creek	19	65	17	148	0	6
Ohio River/Cane Run	171	318	0	318	1,582	8
Silver Creek/Pleasant Run	2	20	0	28	0	0
TOTAL	289	1,892	36	2,234	1,582	32

[1] *from GIS analysis*
[2] *from public input*

Of the 1,584 structures in Zone X (protected by the levee), the City has purchased 43 parcels and has plans to purchase another 10 parcels as part of the previously proposed stormwater/combined sewer conveyance system (**Figure 6-2**). Although the canal project is being reconsidered by the new City Administration, it is the Project Team's understanding that the intent of the City Redevelopment Commission is to complete the land acquisition effort to utilize the space for another beneficial use.

Figure 6-2 Parcels to be Acquired for Proposed Canal Project

As a first step to identifying target areas for acquisition, voluntary retrofitting, or no action, the 1,928 structures in the SFHA should be categorized. This type of screening process will help the City identify what type of mitigation would be most effective and set priorities for implementation.

Structures could be grouped into categories based on the estimated depth of flooding and the FIS flood zone in which they were located. In some cases (Lancassange Creek, Lentzier Creek, Lick Run, and Mill Creek) it may be necessary to update hydraulic modeling to confirm or revise floodplain limits before committing to pursue voluntary acquisition or retrofitting for those structures. The following is a listing and description of possible categories:

__Category A__

Structures in the floodway with expected flooding depth of 2 feet or more.

Category B
Structures not in the floodway, but with expected flood depth of 3 feet or more.

Category C
Structures in the floodway with expected flooding depth of less than 2 feet.

Category D
Structures not in the floodway but with expected flooding depth of less than 3 feet.

Category E
Structures shown outside the 1% annual chance floodplain but within the 0.2% chance floodplain, unless the Lowest Adjacent Grade (LAG) is at or below the Base Flood Elevation (BFE).

Category F
Structures shown within an approximate study zone (Zone A).

Category G
Structures shown within the 1% annual chance floodplain but with LAG above the BFE.

Category H
Structures currently shown outside 1% annual chance floodplain, but with a LAG at or below the BFE.

Category I
Other structures that may be in proximity to designated flood hazard areas, but with a LAG above the BFE.

Once the expected degree of flood risk is assigned to each structure according to the categories identified above, the following prioritization and mitigation actions may be used as a recommendation for further action.

1. High Priority Mitigation Projects: Pursue voluntary acquisition and remove buildings exposed to the highest flooding risks. Structures in Category A are well suited to being given highest priority in voluntary acquisition plans. Presence in the floodway indicates that these structures are in an area of higher velocity floodwaters with depths significant enough to cause damage. Structures in this category would be at the highest risk of receiving the most

damage and having the most potential for exposing the residents to physical harm. Additionally, repetitive loss structures that fall in this priority class should be given higher priority.

2. Medium Priority Mitigation Projects: Pursue voluntary acquisition and remove buildings exposed to significant flooding risks. Structures in categories B and C are included in the next priority class for voluntary acquisitions due to 1) significant flood hazards created by being in an area with high flooding depth but lower velocity currents (Category B) or 2) by being in an area with high velocity currents but lower flood depth (Category C). Additionally, repetitive loss structures that fall in this priority class should be given higher priority.

3. Low Priority Mitigation Projects: Offer voluntary retrofitting assistance for buildings exposed to relatively low flooding risks. Category D structures are theoretically exposed to shallower flood depths and should be considered for retrofitting, provided flood free access is available to the structure. However, if reasonably safe flood free access is not available, a structure should be considered for voluntary acquisition. Additionally, the remaining repetitive loss structures not already included in priority classes 1, 2 or 5 are included in this class and should also be given higher priority. Also included in this category are structures that, based on the community's knowledge and experience, should be given lower priority for pursuing voluntary acquisition.

4. Structures Needing Further Studies: Determine appropriate mitigation actions (if any) for structures in Category F, G, and H once additional detailed floodplain studies are performed. Based on initial examination of available data within Jeffersonville, structures affected by Lancassange Creek, Lentzier Creek, Lick Creek, and Mill Creek are considered to be in this priority class.

5. Structures Protected or Proposed to be Protected by a Local Structural Flood Control Measure: Of special concern are structures/buildings in Categories A through D that are believed to be protected by the community against 1% annual chance flooding. Although no acquisition or retrofitting measures are typically recommended for these structures, more intensive education and outreach efforts are recommended for these areas to caution residents against a false sense of security that is often associated with structural flood protection projects.

6. No Immediate Action Required: Monitor the occurrence and extent of any flooding impacts for structures for which no action is recommended per community's request. These include structures in Category A through D that, based on the community's knowledge and experience, would not require a mitigation action at this time. As situations change and more experience is gained, the structures in this action class would need to be re-evaluated for possible transfer to other classes.
7. Others: No immediate actions are typically suggested for structures in Category E and I. The appropriate actions in these categories are typically decided upon on a case by case basis.

The prioritization of mitigation projects is meant to provide the City of Jeffersonville with a tool to prioritize their acquisition opportunities and maximize the benefits from the available acquisition funds. As a community makes its selections for acquisition areas, it should be remembered that a structure currently in the Medium or even the Low priority class should be considered for High priority acquisition if it is located in an area where most of the structures will be bought out and it doesn't make sense to leave 1 or 2 structures alone in the area. Focus areas should be targeted for acquisition, instead of haphazardly pursuing individual acquisitions in various neighborhoods, in order to more quickly reduce the number of areas where flood fight activities are needed and reduce the length of time a neighborhood is disrupted.

In selecting acquisition areas, consideration should also be given to coordination with other departments within the City to minimize costs by accomplishing multiple objectives at the same time. Examples would be park projects or road relocation/improvement projects that may require acquisition of structures as well. A mechanism for knowing when a structure in one of the mitigation priority classes is being foreclosed or going out of business would also increase the awareness of timely acquisition opportunities.

Due to limited resources and available data, structures in the SFHA were not categorized as part of this SWMP. However, recommended categories for structures in the SFHA and suggestions for prioritizing mitigation efforts have been provided. The cost for a study that would include development of a database, categorizing the structures, limited field verification, and prioritizing actions to be taken on each is estimated to be about $50,000. Until such a study is conducted in the Jeffersonville area, it is difficult to come up with a reliable estimate for the acquisition and retrofitting costs. However, for early planning purposes, a very crude range of potential costs will be provided for each target study area later in this chapter.

6.2 PROMISING SOLUTIONS THAT UTILIZE CITYWIDE PROGRAMS TO ADDRESS EXISTING PROBLEMS AND FUTURE CONCERNS

Citywide problems and future concerns were identified based on a preliminary review of current policies and programs, issues identified during the screening-level analysis of this SWMP, and meetings with key City staff. These are discussed in detail in Chapter 2 and Chapter 3 of this SWMP.

Eight promising solutions were identified as Citywide programs to address the problems and/or concerns. These include Fluvial Erosion Mapping, Flood Response Plan, Stream Hydraulic Studies, and Green Infrastructure to mitigate existing flooding and drainage issues. Also included are Floodplain Management, Stormwater Ordinance & Technical Standards, Development Codes & Design Standards, and Operations & Maintenance Manuals to prevent worsening of flooding and drainage issues.

PS-3: Citywide Fluvial Erosion Mapping

Fluvial erosion hazard maps are used to illustrate the area that may be susceptible to erosion due to stream meandering. By mapping the meander belt for streams in developing areas, decision makers can adequately size set-backs to reduce the risk of damage to future infrastructure. Meander belt delineation (**Figure 6-3**) can also be used to identify risk to in-place infrastructure. Site specific erosion hazard identification often accompanies meander belt delineations to help address acute erosion problems within a waterway.

Figure 6-3 Example of Meander Belt Delineation

The meander belt, or the corridor defining the area a channel has been or could be expected to migrate, is developed by evaluating the composition, geometry, and history. Typical considerations include soil type, channel slope and sinuosity, evidence of remnant channels and floodplains. Other factors that can impact the size and location of the meander belt of a stream are the flow regime (past, present, and future) as well as the installation of engineered streambank armor or structures. The result of a meander belt determination produces a boundary around a stream that identifies the areas that decision makers can expect to be impacted by the migration of the channel in the future.

Meander belt delineations could benefit the City of Jeffersonville by helping to identify problem areas and to improve the understanding among the public and decision-makers on potential erosion risks and the purpose for setbacks. A brief review of the streams within and around Jeffersonville suggests that the production of citywide meander belt delineations may not be warranted. Several streams within the city limits, most notably Mill Creek, have been modified to an extent that effectively prevents the channel from operating in a natural condition, thus nullifying the result of the analysis. Lancassange Creek, Lentzier Creek, Lick Run, and Silver Creek have been identified as naturally operating streams and good candidates for meander belt delineations based on the sinuosity of the channel, the potential for future development, and the presence of infrastructure and private property nearby. Provided adequate funding exists for additional studies, Battle Creek, Jenny Lind Run, Little Battle Creek, and Pleasant Run would serve as appropriate candidates, largely due to the undeveloped nature of the watershed and the potential for future benefit from adequately sized setbacks.

In addition to mapping the meander belt of a stream, the identification of specific erosion hazards can help to prevent damage to critical facilities and other infrastructure. Infrastructure located within the meander belt can be assessed using several visual indicators. The presence of one or more of the indicators may suggest that the stream poses a hazard to the property:

1. A moderate-to-sharp meander bend upstream or adjacent to the structure/property
2. A hydraulic structure (culvert, bridge, drop-structure, etc) located near the structure/property
3. Presence of a head-cut downstream of the structure/property
4. Obstructions (fallen trees, debris jams, etc) within the channel near the structure/property

A stream's location or geometry may be rapidly changed through erosion due to the factors listed above; however, several other, less obvious stressors may cause the channel to react unfavorably, or exacerbate the impact of other stressors. The following changes within the watershed of a stream should be considered when identifying specific erosion hazards:

1. Large amounts of development planned within the watershed of the stream

2. Modified land-use practices within the watershed which affect the supply of sediment to the stream
3. Modified land-use practices within the watershed which affect the quantity of water supplied to the stream
4. Modified routing of storm water to the stream (diversions, bypasses, altered storm water input locations)

Examples of specific erosion hazards identified during a brief assessment of the streams within Jeffersonville are described in **Table 6-3** and shown in **Figure 6-4**, **Figure 6-5** and **Figure 6-6**. Erosion hazards specific to Lancassange Creek are addressed in the OPCD Target Study Area discussion.

Table 6-3 Erosion Hazards along Streams in Jeffersonville

Channel Name	Hazard Description	Hazard Level
Silver Creek	Meander bend near pond and large development; largely undeveloped watershed	Low
Lentzier Creek	Sharp bend near WWTP & structure under railroad	Moderate / Low
Lick Run	Meander bend at base of Interstate 65	Moderate / High

Figure 6-4 Lick Run FEH - Sharp Meander Bend near I-65 Embankment

Figure 6-5 Lentzier Creek FEH - Stream Adjacent to WWTP with Hydraulic Structure Immediately Downstream

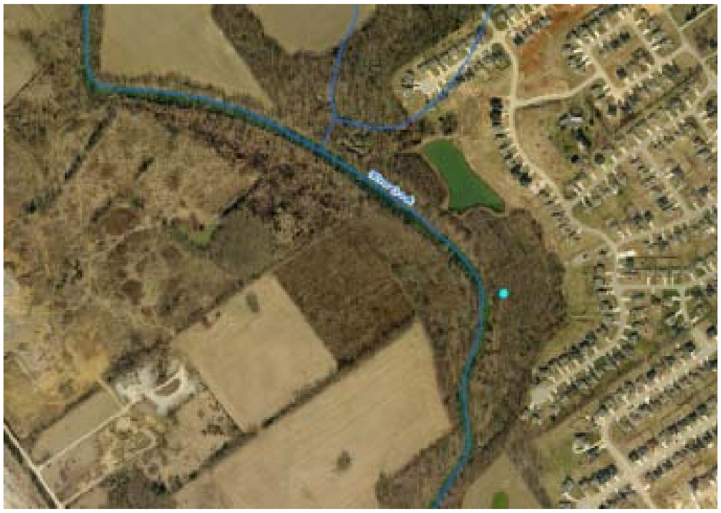

Figure 6-6 Silver Creek FEH – Meander Bend near Large Development in Largely Undeveloped Watershed

Due to limited resources and available data, fluvial erosion mapping was not completed as part of this SWMP. The cost for meander belt delineation and fluvial erosion hazard mapping for the reaches identified above (a total of 44 miles) is estimated to be about $16,000 and is dependent on the quality of data available. High-resolution aerial photography, terrain data, soil data, infrastructure location information, and historical aerial photographs are needed to complete a fluvial erosion hazard assessment.

PS-4: Citywide Flood Response Plan

The purpose of a Flood Response Plan (FRP) is to reduce the risk of human life loss, injury, and damage to property during a flood event. With sufficient warning of a flood, a community and its floodplain (and other low lying areas that frequently flood) occupants can take protective measures such as sandbag to prevent floodwaters from reaching their property, move vehicles and valuables above anticipated flood levels, and evacuate until after the floodwaters recede. Fundamental to the FRP is a Warning and Evacuation Annex with procedures for warning, evacuating, and sheltering the affected public.

A FRP should include the following:

1. Review Flood & Past Flood Fight Efforts – assemble data on past flood events including: the NWS AHPS, USGS stream gage records, and observational data; map the areas that have been impacted and the magnitude of flood-related loss; and meet with key representatives from the City to understand the successes and failures from past flood fight efforts.
2. Prepare Flood Response Plan – detail the following 4 steps that must be followed anytime a flood event has been detected (Figure 6-7). These include:
    a. Flood event detection and severity level determination,
    b. Notification and communication procedures
    c. Expected actions as part of flood response, and
    d. Termination of the flood response effort and follow-up-

Integral to the FRP is inundation mapping that shows the areas expected to flood at various flood elevations. Where inundation mapping associated with various flood events is not available, the current regulatory floodplain boundaries could be used.

1. <u>Warning and Evacuation Annex</u> – establish procedures for warning, evacuating, and sheltering individuals that would be endangered by a flood event. Flood depth mapping and supplemental inundation information should be used to determine the limits of warning and evacuation areas. This step should also identify bridges and roads that may be flooded and not available as evacuation or emergency routes.

2. <u>Training Exercises</u> – one-day training exercise with local decision-makers and flood fight team members. These include:

    a. Table top exercise to go through the FRP step by step and simulate the response to a flood event and
    b. Field exercise that includes decision-makers and flood fight team breaking from their daily routine to activate the FRP and fight a simulated flood event, potentially including simulated sandbagging and partial evacuation.

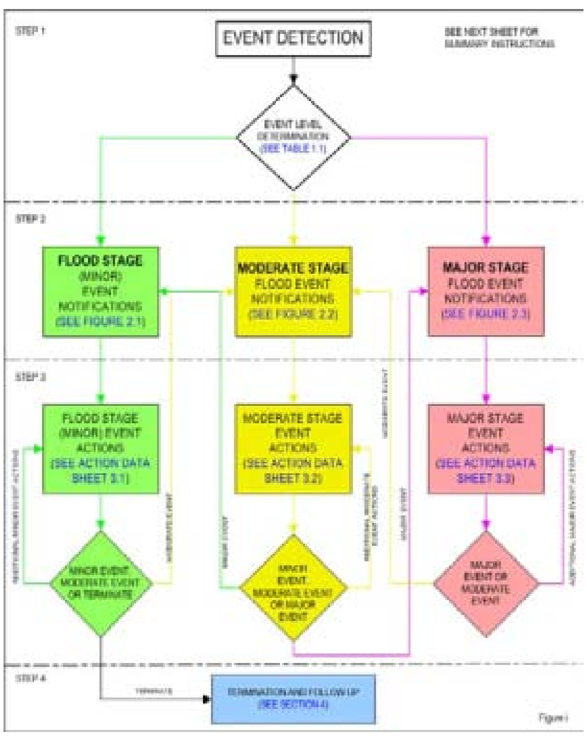

Figure 6-7 Event Detection Flow Chart

An FRP was not developed as part of this SWMP. The cost to prepare a FRP including: review flood and past flood fight efforts, the flood response procedures and actions, a warning and evacuation annex, conduct a table top and field exercise training is estimated at $45,000.

PS-5: Citywide Update of Stream Hydraulic Studies

H&H modeling is used to map the extent of the floodplain boundaries shown on FIRMs produced by the NFIP. These maps designate appropriate levels of flood risks along major streams and are an effective tool for communities to practice sound floodplain management. In the City of Jeffersonville, new FIRMs were completed in 2011 and are expected to be effective in 2012. However, due to the national extent and limitations of the mapping initiative by the NFIP, there are stream reaches in the City of Jeffersonville that do not have a compatible floodplain designation or are based on data that is too general to provide accurate flood limits and/or are outdated (**Figure 6-8**).

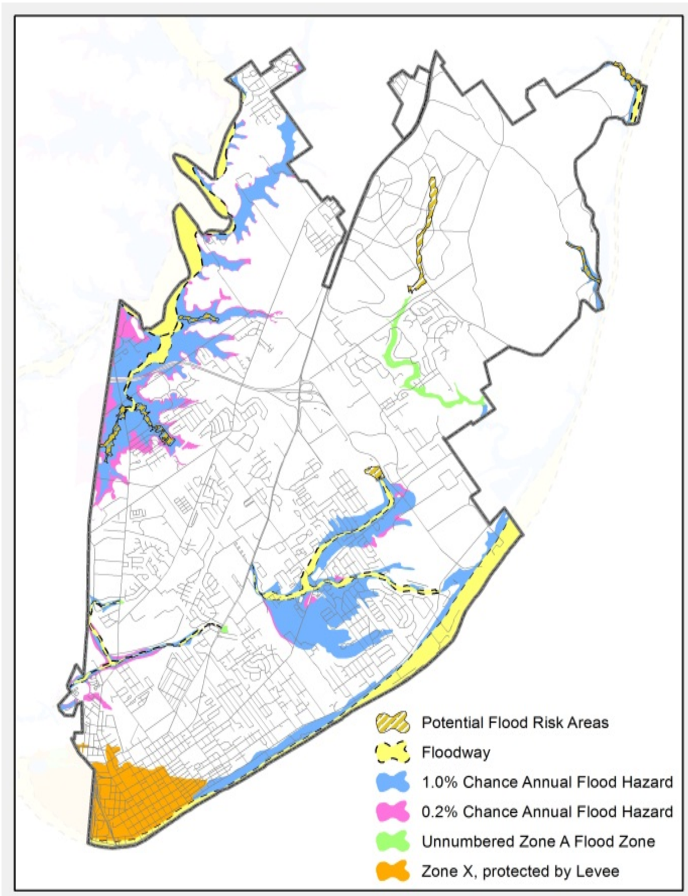

Figure 6-8 Floodplain Delineation Based on Preliminary Analysis of Flood Risk Areas

To assist the City of Jeffersonville in identifying and prioritizing the areas where improved floodplain mapping is needed, information was gathered and GIS layers were created to develop a comprehensive GIS based tool for evaluating options and determining priorities for further floodplain studies. A preliminary analysis of flood risk areas was completed using HEC-RAS (using approximate methods) to complete or extend existing studies up to the 1 square mile drainage area as determined by IDNR. Streams studied by approximate methods as part of this SWMP include: Jenny Lind Run, Battle Creek, Lick Run, Lick Run tributaries, Lentzier Creek (extended), and Lancassange Creek (extended a very short distance).

To evaluate the floodplain delineations as shown on the effective and preliminary FIRM, a comparison was completed between the 2011 preliminary FIRM floodways and BFEs (which for some streams is based on modeling done in the 1970s) and more recent aerial photography and City of Jeffersonville contour data. The comparison was done to determine if:

- Delineated floodplain included ground above the BFE or if ground below the BFE was missed by the floodplain limits.
- The channel was contained within the delineated floodway.

These factors can be good indicators of whether or not the modeling and floodplain delineations provide a good representation of the flood risk. If the comparison of BFE and topography shows areas where the floodplain limits are incorrectly noted, that indicates that at least a redelineation of the floodplain limits would be appropriate. If the channel is not contained within the floodway, it can be an indication that the modeling does not accurately reflect the topography. The flood profiles were also reviewed to identify locations where BFEs would change if bridges had been replaced since survey data that was used in the FIS was obtained. Based on this data, the potential for only minor changes due to bridge replacements was found.

In order to be able to determine the appropriate course of action, stream reaches with questionable or without floodplain data were categorized into the following priorities for stream hydraulic studies:

1. Stream reaches with floodplain designations that are believed to have suspect accuracy and/or need to be updated due to changes in topography, discharges, crossings, stream cross sectional areas, and/or stream alignment as well as cases where the accuracy of the current mapping is suspect as a result of an evaluation that may have identified needed improvements due to deficiencies in the existing modeling or use of outdated or less detailed information in developing the existing floodplain designations. **Table 6-4** provides a summary of these findings. Mill Creek, Lancassange Creek, Woodland Court, and Lentzier Creek are addressed in more detail in their respective Target Study Area discussion.
2. Stream reaches with approximate floodplain designations that are located within a municipality's boundary or its expected growth areas.
    - Lentzier Creek
    - Battle Creek
    - CBBEL reaches studied including Jenny Lind Run, Battle Creek, Lick Run, Lick Run tributaries, Lentzier Creek (extended), and Lancassange Creek (extended a very short distance)
3. Stream reaches with less than 1 square mile of drainage area.
    - River Ridge Development Area

The fee varies based on the suggested method of restudy, level of detailed desired, and length of stream studied. The estimated cost to complete the restudies identified above (excluding those in a specific Target Study Area) is $45,000.

Table 6-4 Stream Reaches with Suspect Floodplain Delineations

Stream	Target Study Area	*Reason for Restudy*					*Suggested Method of Restudy*
		Floodplain elevation discrepancy with BFE	Channel outside Floodway	Old H&H model and/ or data	No detailed study	*Est. Stream Miles*	
Ohio River		X				*12.5*	*Redelineation*
Mill Creek	Mill Creek	X	X	X		*3.4*	*H&H*
Hamburg Pike Tributary		X	X	X		*1.2*	*H&H*
Greenbriar Tributary		X	X	X		*0.6*	*H&H*
Lancassange Creek	OPCD		X	X		*4.2*	*H&H*
Woodland Court Tributary	Woodland Court		X	X		*1.1*	*H&H*
Lentzier Creek	Lentzier Creek		X		X	*4.5*	*Partial H&H*
Pleasant Run					X	*2.0*	*Study*
Battle Creek					X		*Redelineation using LIDAR*
Jenny Lind Run					X		*Redelineation using LIDAR*

PS-6: Citywide Green Infrastructure Policy

Green infrastructure is a stormwater management approach that provides a unique combination of social, economic, and environmental benefits. Depending on the practice, green infrastructure may:

- Create healthier and more livable cities;
- Improve physical health and mental well-being;
- Reduce capital, construction, and life-cycle infrastructure costs;
- Reduce stormwater utility fees,
- Reduce building heating and cooling costs;
- Increase neighboring property values;
- Improve surface water quality;
- Reduce peak flow volumes and velocities;

- Improve air quality, carbon sequestration, and
- Reduce urban heat island effect.

These benefits are accentuated in urban areas where green space is limited and the environmental damage from historical practices is typically more extensive. Green infrastructure practices are most effective resolving nuisance drainage issues from 1-2 inches of runoff and not meant to replace flood control structures needed to larger flood events. Structural solutions include site-specific runoff reduction practices such as bioinfiltration, permeable pavement, and rain water harvesting. These practices could be incorporated into new development or as part of a redevelopment effort. The following provides a brief description, location, storage, and pollutant removal benefit of structural green infrastructure practices.

- Bioinfiltration/Bioretention/Rain Gardens: A recessed landscaped area designed to treat and store stormwater (**Figure 6-9**).
    - Location – publicly-owned right-of-ways, parking lot islands, and medians.
    - Storage – based on a typical design, stormwater storage was assumed to be available in 12 inches of washed stone (40% voids) below the root zone as well as 6 inches on the surface. This does not take into account evapotranspiration or interception of rainfall by the vegetation.

Figure 6-9 Rain Garden

  - Pollutant Removal – based on typical performance data, removal of 55% TP, 64% TN, and 70% TSS may be expected.

- Permeable Pavement: Paving systems (porous concrete, porous asphalt, interlocking pavers) that allow stormwater to pass through the surface to be stored in an underlying stone base and/or infiltrate into the soil (**Figure 6-10**).

  - Location – permeable pavement was considered as a green infrastructure retrofit BMP on publicly-owned interior sidewalks, and parking stalls of parking lots.
  - Storage - based on a typical design, stormwater storage was assumed available in 24 inches of washed stone (40% voids). This depth could vary depending on storage needs.
  - Pollutant Removal – based on typical performance data, removal of 59% TP, 59% TN, and 80% TSS may be expected.

Figure 6-10 Permeable Pavement

- Rainwater Harvesting: A storage device (rain tank or cistern) used to hold rainwater collected from downspouts and roof drains disconnected from the storm sewer system (**Figure 6-11**).

  - Location – at the downspout and roof drains of publicly-owned buildings.
  - Storage - assumes cisterns will be sized to hold 1 inch of rainfall and emptied within 48 hours to allow for storage from the next rain event.
  - Pollutant Removal – based on typical performance data using a filter, removal of 75% TP, 75% TN, and 75% TSS may be expected.

Figure 6-11 Rainwater Harvesting

- Green Roofs/ Blue Roofs: A system by which rainfall is temporarily stored on rooftops. Green roofs have vegetation planted in a lightweight growing medium and blue roofs are designed to simply pool water (**Figure 6-12**).

  - Location - on publicly-owned buildings with large flat roofs that are able to support HVAC systems may be also support a green/blue roof.
  - Storage - based on a typical design of green roofs, it is assumed 1.5 inches of storage is available within the drainage layer below the growing medium of green roofs. This does not take into account evapotranspiration or interception of rainfall by the vegetation. It is assumed that 1.5 inches of storage is available for blue roofs.
  - Pollutant Removal – based on typical performance data, removal of 45% TP, 45% TN, and 70% TSS may be expected.

Figure 6-12 Green Roofs/Blue Roofs

- Tree Boxes: An unpaved area of the sidewalk adjacent to the curb that is used for street trees and covered with a tree grate (**Figure 6-13**).
  - Location – on streets identified as gateways or main arteries as well as streets with existing trees planted in sidewalk tree grates.
  - Storage - based on a typical design, stormwater storage was assumed to be available in 12 inches of washed stone (40% voids) below the root zone as well as 6 inches on the surface. This does not take into account evapotranspiration or interception of rainfall by the trees.

Figure 6-13 Tree Boxes

  - Pollutant Removal – based on typical performance data, removal of 55% TP, 64% TN, and 70% TSS may be expected.

Non-structural solutions may include watershed-based or citywide policies to reduce impervious cover and/or treat a targeted runoff from impervious areas using structural green infrastructure practices. This discussion focuses on establishing a citywide policy (non-structural solution) to reduce impervious cover, nuisance flooding, and water quality problems at the site level using structural green infrastructure practices.

Modeled after the green infrastructure policies in New York City and Philadelphia CSO programs, this SWMP proposes to target runoff from impervious area and treat it using on-site green infrastructure practices throughout the City of Jeffersonville. The goal of the New York City's Green Infrastructure Plan is to control runoff from 10% of impervious surfaces through green infrastructure. Similarly, the City of Philadelphia Green City Clean Waters Plan's goal is the achievement of a "Greened Acre". Each Greened Acre represents an acre that has at least the first inch of runoff managed by green infrastructure. It is estimated that 1 acre receives 1 million gallons of rainfall each year. If this is impervious, this rainfall becomes polluted runoff. A Greened Acre will reduce 80-90% of the polluted runoff from occurring.

The proposed solution is to promote green infrastructure to capture and treat runoff from a targeted percent of impervious from each watershed based on future development. For example, **Table 6-5** shows the area of impervious, 10% of the impervious area to be captured and treated with green infrastructure, and the area of green infrastructure needed based on a rule-of-thumb 5:1 ratio.

Table 6-5 Targeted Percentage of Impervious Areas in which to Promote Green Infrastructure

Watershed	EXISTING LAND USE	FUTURE LAND USE			
	Impervious (ac)	Impervious (ac)	10% Impervious to green infrastructure (ac)	Green Infrastructure @ 5:1 (ac)	Green Infrastructure @ 5:1 (ft^2)
Battle Creek	218	1,218	122	24	1,060,798
Ohio River/Cane Run	1,628	1,628	163	33	1,418,630
Mill Creek	1,873	1,761	176	35	1,533,785
Lancassange Creek	2,579	2,776	278	56	2,418,645
Lentzier Creek	1,365	2,534	253	51	2,207,309
Lick Run	2,289	2,219	222	44	1,933,356
Silver Creek	815	981	98	20	854,757
TOTAL	10,767	13,117	1,312	262	11,427,279

In the Battle Creek and Lentzier Creek watersheds this could be tackled through anticipated development in the River Ridge area. In the remaining watersheds that are built out and don't anticipate a significant change in impervious, green infrastructure retrofit practices could be integrated into the requirements of the LTCP and into special districts (Tax Exempt, Overlay Districts, Historic Districts, TIF Areas, Redevelopment Districts, and Urban Enterprise Zones). The estimated cost to prepare a citywide policy is $5,000.

PS-7: Citywide Floodplain Management Ordinance Update

According to FEMA, floodplain management is a decision-making process that aims to achieve the wise use of the nation's floodplains to reduce flood losses and protection of the natural resources and function of floodplains. The NFIP underwrites flood insurance coverage only in communities that adopt and enforce floodplain management regulations through an ordinance that meets or exceeds NFIP criteria. Currently over 20,100 communities voluntarily adopt and enforce local floodplain management ordinances that provide flood loss reduction building standards for new and existing development.

The City of Jeffersonville's current Floodplain Management Ordinance is from 1994. It is anticipated that this ordinance will be updated in conjunction with the adoption of the new FIRMs in 2013. The following discussion includes items that should be considered as part of the updated Floodplain Management Ordinance.

The IDNR has developed a Model Ordinance for Flood Hazard Areas to assist communities to develop an ordinance that will comply with the minimum participating criteria of the NFIP. The model ordinance includes optional enhancements that should be considered in the City's Floodplain Management Ordinance update. These include:

- Increased Cost of Compliance (ICC) (Article 3. General Provisions, Section J. ICC)
- Stop Work Orders (Article 4. Administration, Section C. Duties and Responsibilities of the Floodplain Administrator)
- Revocation of Permits (Article 4. Administration, Section C. Duties and Responsibilities of the Floodplain Administrator)
- Inspect Sites for Compliance (Article 4. Administration, Section C. Duties and Responsibilities of the Floodplain Administrator)
- Compensatory Floodplain Storage (Article 5. Provisions for Flood Hazard Reduction, Section A. General Standards)
- Reconstruction/repairs to a Repetitive Loss Structure (Article 5. Provisions for Flood Hazard Reduction, Section B. Specific Standards)
- Size of Openings for Elevated Structures (Article 5. Provisions for Flood Hazard Reduction, Section B. Specific Standards)
- Restrictions Prohibiting Conversion of Area below Lowest Floor (Article 5. Provisions for Flood Hazard Reduction, Section B. Specific Standards)

- Skirting for Manufactured Homes (Article 5. Provisions for Flood Hazard Reduction, Section B. Specific Standards)
- Minimize Development in SFHA (Article 5. Provisions for Flood Hazard Reduction, Section B. Standard Subdivision Proposals)
- Safe Access in/out of SFHA (Article 5. Provisions for Flood Hazard Reduction, Section B. Standards Subdivision Proposals)
- Construction below BFE recorded in the Chain of Title (Article 6. Variance Procedures, Section E. Variance Notification)

In addition to the Model Flood Hazard Ordinance, IDNR has also developed “Indiana Local Floodplain Permitting Procedures: a step-by-step guide” and flowchart. Both of these are good tools and should be utilized by the City’s Floodplain Administrator to guide the permitting process.

ASFPM has developed the “Building Public Support for Floodplain Management Guidebook” to increase awareness and support for better floodplain management. This guidebook contains resources for the Floodplain Administrator on consent-building and educating decision-makers and the general public.

Changes were not made to the City’s existing Floodplain Ordinance as part of this SWMP. However, good tools and reference materials are provided to aid in the updating the Ordinance and streamline the permitting process. The estimated cost to update the Floodplain Ordinance using the IDNR Model (including, as appropriate, the optional enhancements) is estimated at $5,000.

PS-8: Citywide Stormwater Ordinance & Technical Standards Update

The Phase II rule of the National Pollution Discharge Elimination System (NPDES) stormwater program permits stormwater discharges from small municipal separated sewer systems (MS4s). As a requirement of the NPDES Phase II program, MS4 entities must prepare a Stormwater Quality Management Plan (SWQMP) that includes 6 minimum control measures (MCMs) to improve the water quality being discharged into receiving waterbodies. These include:

1. Public education and outreach
2. Public involvement and participation
3. Illicit discharge detection and elimination (IDDE)
4. Construction site stormwater runoff control
5. Post-construction stormwater management in development and redevelopment

6. Pollution prevention and good housekeeping for municipal operations

The City of Jeffersonville is a designated MS4 Phase II community and has individual ordinances to meet the requirements of MCM 3, 4, and 5. These include Storm Water Illicit Discharge Control (2004-OR-055), Construction Site Runoff Control (2004-OR-56), and Post-Construction Storm Water Management (2005-OR-65) respectfully, as well as a local ordinance for Drainage (2006-OR-20). In addition to that required by NPDES Phase II program, several provisions can be added to the existing ordinance and standards to allow the use and review of LID/green infrastructure, incorporation of site-specific post-development maximum allowable release rates, and addressing prevention of systemic increase in streambank erosion issues through inclusion of a channel protection volume requirement.

For efficiency and to avoid confusion, it will be advantageous to combine various ordinances and requirements into a single comprehensive Stormwater Ordinance and Technical Standards.

A comprehensive Stormwater Ordinance regulates:

1. Discharges of prohibited non-stormwater flows into the storm drain system.
2. Stormwater drainage improvements related to development of lands located within the corporate boundaries of the City.
3. Drainage control systems installed during new construction and grading of lots and other parcels of land.
4. Erosion and sediment control systems installed during new construction and grading of lots and other parcels of land.
5. The design, construction, and maintenance of stormwater drainage facilities and systems.
6. The design, construction, and maintenance of stormwater quality facilities and systems.

The Ordinance is accompanied by a Technical Standards Manual that contains the necessary technical standards for administering the Stormwater Ordinance. It is not intended to be a regulatory document but rather guidance to assist plan reviewers, developers, and designers. It contains:

- Formulas and methodologies for the review and design of both stormwater quantity and stormwater quality facilities;

- Stormwater conveyance and detention calculations and requirements, including general and site-specific post-development maximum allowable release rate values;
- Information on erosion control requirements and other pollution prevention measures for active construction sites;
- Calculations required to properly size and design stormwater quality features that will treat runoff long-term following construction completion including both Conventional and Low Impact Development (LID) approaches; and
- Appendices with a comprehensive glossary of terms; useful and necessary standard forms; BMPs for erosion control measures during the construction phase; structural and non-structural post-construction BMP Fact Sheets as well as Recommended Plant Lists, Recommended Materials, Soil Infiltration Testing Protocol, BMP Maintenance Checklists, and Maintenance Agreement for post-construction BMPs.

Based on detailed hydrologic analysis performed as part of this Master Plan study, CBBEL has already developed proposed Post-Development Maximum Allowable Release Rate for proposed new developments. Based on experience with other jurisdictions and the current extent of flooding in Jeffersonville, the noted proposed maximum allowable release rates have been based on the control of post-development 100-year peak flow rates at the pre-development 10-year peak flow rates and control of post-development 10-year peak flow rates at the pre-development 2-year peak flow rates. Exhibit 2-1 shows the proposed maximum allowable release rates for various subbasins within Jeffersonville jurisdiction.

A comprehensive Stormwater Ordinance & Technical Standards was not developed as part of this SWMP. CBBEL has recently developed a similar set of Stormwater Management Ordinance and Technical Standards documents that has been customized and adopted by many communities in Indiana. Savings can be realized by utilizing the referenced documents as the basis for the new Ordinance and standards for Jeffersonville. The estimated cost to incorporate existing ordinances and requirements as well as new provisions into a comprehensive Stormwater Ordinance and Technical Standards for the City of Jeffersonville, assuming that the CBBEL template will be used, is $15,000.

PS-9: Citywide Development Codes & Design Standards Update

In 2005, the US EPA, with assistance from the American Planning Association (APA) published "Using Smart Growth Techniques as Stormwater Best Management Practices". This landmark publication discusses the nexus between land development patterns and water quality and quantity – especially as it relates to nonpoint source (NPS) pollution. NPS pollution originates when precipitation (rainfall or snowmelt) moves over and through the ground carrying pollutants and then depositing them into lakes, rivers, and aquifers.

Similar studies by the Center for Watershed Protection have illustrated how imperviousness related to land use and land use change can significantly impact water quality. Impervious areas (rooftops, roads, parking lots, driveways, sidewalks, etc.) decrease infiltration and increase the volume and velocity of stormwater runoff. The Center's studies have shown that a stream's ecology begins to degrade with only 10% imperviousness in the watershed. At 25% imperviousness, water quality problems include increases in bacteria concentrations, additions of toxic materials, increases in sediment loads, alterations of water temperature, and reductions in dissolved oxygen concentrations.

In the City of Jeffersonville, 21 of the 26 subwatersheds have an impervious cover of greater than 25%. If the City develops according to the zoning ordinance, future land use conditions show all subwatersheds with an impervious cover greater than 25% and non-supporting of a healthy stream ecosystem (**Figure 6-14**).

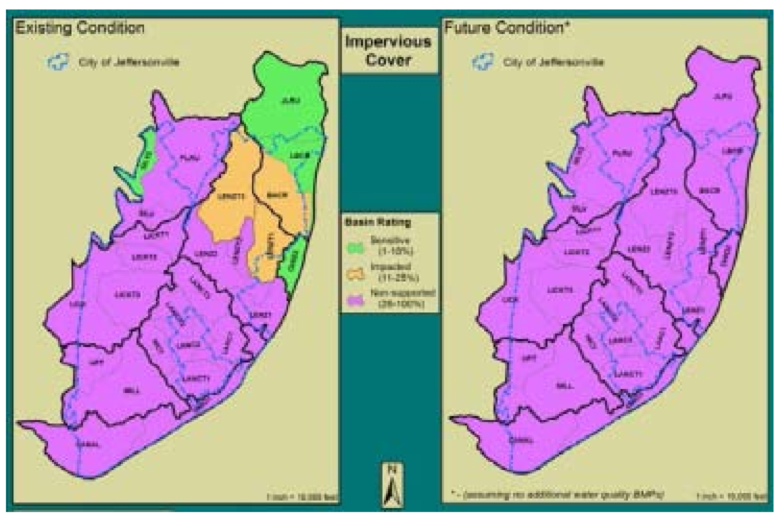

Figure 6-14 Existing and Future Impervious Areas

Low Impact Development (LID) is an effective stormwater management tool that can reduce impervious cover as well as the drainage problems and pollution associated with stormwater runoff. The Center for Low Impact Development defines LID as an innovative stormwater management approach that is modeled after nature. A key concept of LID is to manage rainfall at the source using uniformly distributed decentralized micro-scale controls. This approach mimics a site's predevelopment hydrology through design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. LID consists of:

1. Conservation Design (preserve open space and vegetated buffers along streams)
2. Better Site Design (minimize impact of development, change development codes)
3. Green Infrastructure (mitigate impact of development with onsite practices)

The following are recommended to integrate stormwater management into land use planning.

1. Integrate LID practices at the regional, neighborhood, and site planning scale.
   a. Regional Planning – preserving open space, stream corridors, and critical ecological features; encouraging redevelopment as opposed to new development; and using land more efficiently
   b. Neighborhood Planning – mixed use and transit-oriented development, green streets, parking requirements and strategies, parks and open-space amenities
   c. Site Planning – on-site source control BMPs (porous pavement, bioinfiltration, etc.) to store and treat stormwater

2. Review development codes to identify potential regulatory or planning impediments that affect the use of or successful implementation of LID in new or redevelopment projects. The Center for Watershed Protection has developed a Code & Ordinance Worksheet (COW) that can be use to evaluate existing policies and procedures. Topics include:
   a. Residential Streets, Parking Lots and Other Transportation Infrastructure
   b. Lot Development Principles
   c. Conservation of Natural Areas
   d. Comprehensive Planning, Zoning and Other Regulatory Considerations
   e. Stormwater Planning and Practices

Once the COW is completed, policies and procedures should be prioritized and green infrastructure language incorporated.

1. Promote and create an incentives program for LID in targeted growth areas (
2. **Figure 6-15)** including areas with new development (River Ridge), special development districts (Overlay Districts, TIF

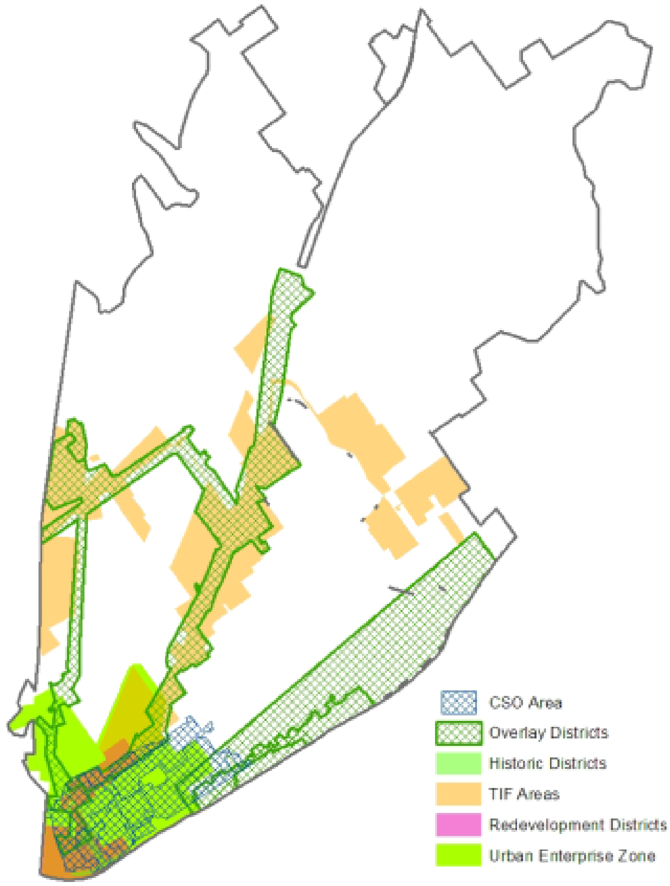

Figure 6-15 Targeted Growth Areas

Areas, Historic Districts, Redevelopment District, and Urban Enterprise Zone) and the CSO Area.

PS-10: Citywide Operations & Maintenance Manuals Update

Proper operation and maintenance is essential to the long-term performance and effectiveness of stormwater management facilities. North Carolina State University did a study and found that 95% of stormwater BMPs failed their initial inspection due to the need for maintenance (erosion, trash, debris). Stormwater BMPs are specialized landscapes features designed to capture and treat stormwater runoff. Individuals responsible for conducting inspections or performing maintenance need to have specialized training.

Obstructions in the receiving streams such as logjams, fallen trees, and garbage can restrict flow in the stream corridor and from stormwater facilities. This can cause increased flooding, property damage, loss of habitat, and increased erosion and sedimentation. The following discusses enhancements to existing operation and maintenance procedures, checklists, and tracking to ensure optimal performance of stormwater facilities and receiving streams.

In the City of Jeffersonville, the Post-Construction Storm Water Management Ordinance addresses operation and maintenance issues for private and public stormwater facilities. In response to green infrastructure practices installed, the City prepared a "Maintenance of Green Infrastructure Facilities and Landscaped Areas" which includes a schedule and description of maintenance practices.

Some additional resources to consider:

- Stormwater BMP Maintenance Inspection Checklist
- Pipeline Assessment Certification Program
- Stream Maintenance and Debris Removal Program
- Maintenance Tracking Database (comprehensive)

Operation and maintenance manuals and procedures were not updated as part of this SWMP. However, tools and resources were identified to enhance existing City policies and procedures. The estimated cost to consolidate and enhance existing stormwater (and stream) maintenance policies and procedures into one resource document is $10,000. The recommendation to update and consolidate the City's stormwater ordinances (PS-8) includes a maintenance component for stormwater BMPs.

6.3 PROMISING SOLUTIONS TO ADDRESS PROBLEMS/CONCERNS IN THE CSO/DOWNTOWN TARGET STUDY AREAS

The CSO/Downtown Target Study Area is heavily urbanized and generates more stormwater runoff than the current infrastructure can handle. As a result, CSO events, flooded buildings, and standing water in the streets are common occurrences. The types of problems reported in the CSO/Downtown area include building flooding or buildings in the SFHA, drainage issues, restrictive structures, and street flooding.

Six promising solutions were evaluated to address the problems/concerns in the CSO/downtown area. These include 4 alternates for Downtown Flood Control (Canal as Planned, Reverse Canal, Storm Sewer Interceptor, and Near-Surface Tunnel & Pump Station), Voluntary Acquisition and/or Floodproofing Program, and Green Infrastructure.

DOWNTOWN FLOOD CONTROL PROJECT ALTERNATIVES

A canal has previously been planned for reducing flooding in the downtown area of the City of Jeffersonville for several years. Recently, the canal was deemed too expensive and conceptual alternatives were to be analyzed as part of this SWMP. Alternatives for reducing flooding during the 100-year (1%-annual-chance) flood event were examined through detailed computer modeling for proposed and currently separated stormwater flow in accordance with the LTCP. No combined sewer flow was added to the model with the assumption that all combined sewer flow will be conveyed to the Mulberry Street Interceptor where it will be stored until the WWTP has available capacity, at which point the 10th Street Pump Station (TSPS) will transfer the combined flow to the WWTP. Several alternatives for conveying separated stormwater flow have been preliminarily discussed and were analyzed for their efficiency and cost-effectiveness.

An XP-SWMM model was originally created by Strand Associates, Inc (Strand) to characterize the response of the combined sewer system as a part of the LTCP. CH2M Hill later modified the model to represent the separated storm sewer system that could be expected to exist, should the downtown area be modified to incorporate the canal. The CH2M Hill version of the model was updated by CBBEL and utilized to evaluate the existing extent of risk and to evaluate the performance of conceptual alternatives for reducing the risk of downtown flooding as part of the stormwater master plan. Drainage basin delineations and other hydrologic characteristics were previously developed as part of the LTCP performed by Strand and were reviewed by CBBEL. A 100-year (1%-annual-chance), 3-hour rainfall event was deemed the critical duration for the downtown area modeling based on the Canal Feasibility Study produced by Strand. The design rainfall depth of 2.87 inches was distributed as a 3-hour event using a Huff 1st Quartile rainfall distribution. No other rainfall frequencies or durations were considered in order to gain a relative comparison to the other alternatives that were analyzed.

Figure 6-16 Assumed Contributing Drainage Area into Each Alternative

In addition to modeling the 1%-annual-chance flooding in the downtown area with a gravity outfall, coincident 1%-annual-chance flooding events on both the downtown area and the Ohio River were also considered. The latter would be an unlikely and infrequent event; however, with the amount of possible infrastructure and life that could be lost in the downtown area during a flooding event, coincident flooding was considered. The City of Jeffersonville could consider lower levels of protection based on their consideration of the level of risk that could be tolerated and design accordingly.

Separated flows from 10th Street, 8th Street, and 7th Street and the surrounding area of the canal are assumed to be separated and discharged into the respective stormwater conveyance alternatives. **Figure 6-16** shows the assumed contributing drainage area into each alternative. The collected stormwater runoff was assumed to be conveyed to respective alternatives through the conceptual storm sewers identified in the Canal Feasibility Study.

PS-11: Canal as Planned Alternative Downtown Flood Control Project

This alternative involves the construction of a two-stage concrete channel (**Figure 6-18**) that would store stormwater flows before discharging into the Ohio River as proposed in previous studies. The

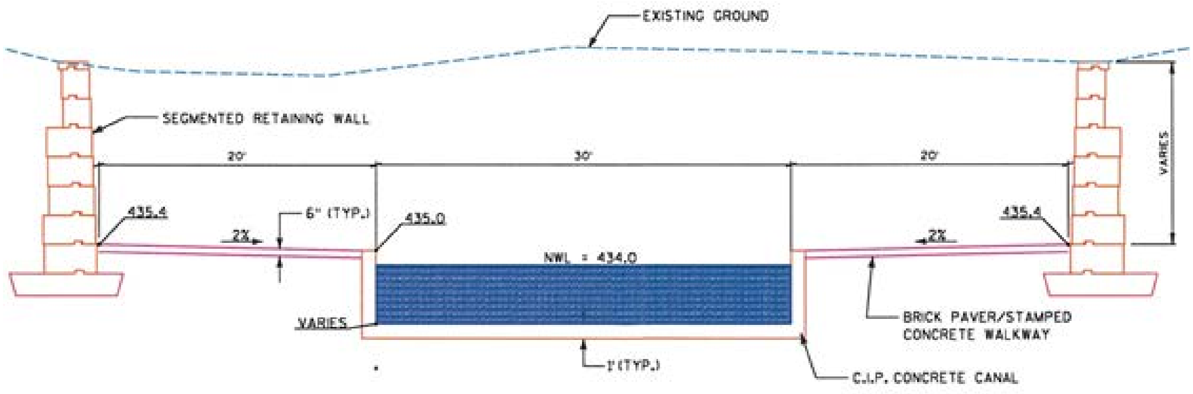

Figure 6-18 Two-Stage Concrete Channel

concrete channel would have a two-stage cross-section, with the lower stage being 40-feet wide and 5.5-feet in depth. The second stage would be 10-feet in width on each side of the lower stage and would extend vertically to the adjacent ground surface. A weir would be situated at the southern end of the 3,550-foot long canal to maintain a pool-depth of 4-feet, establishing a normal water surface elevation of 430.0 feet, NAVD88. The weir would allow the canal water to be utilized not only for storage and stormwater conveyance, but also for recreational purposes. The second stage of the canal would provide ample walking space for pedestrians as well as frontage for businesses along the canal.

Figure 6-17 General Layout of Canal as Planned Alternative

The proposed canal would begin at a 2-acre feeder lake just west of the Indiana Avenue and 8th Street intersection before transitioning to a concrete channel. The 2-acre feeder lake would be able to attenuate flow from the 10th Street prior to flowing into the concrete channel. The channel would then convey stormwater east down 8th Street before heading south along Michigan Avenue before finally turning southeast down Mulberry Street. During normal conditions on the Ohio River, the canal would be capable of moving the stormwater through a gravity outfall; however, when the river level is elevated, a pump station will be required to evacuate the collected runoff through the outfall.

The proposed 10 MGD pump station would be located at the intersection of Mulberry and Market Street and would convey flows to the Ohio River during high river stages through a 700-foot, 120-inch force main outfall pipe. It should be noted that based on XP-SWMM modeling performed by CBBEL, during a 1% annual chance event with no gravity flow to Ohio River assumed, water levels would reach Elevation 435.0 feet, NAVD88, about 1.0 feet below the adjacent street level. This elevation exceeds the first stage of the canal and approaches the adjacent ground level when the Ohio River Stage is high. Therefore if this alternative is chosen, provisions must be considered to limit what improvements will be allowed in the second canal stage. The general layout of Canal as Planned alternative is provided in **Figure 6-17**.

A conceptual opinion of probable costs for each alternative was developed using available information utilizing current industry rates. Combined sewer separation and relocation, utility relocation, and property acquisition costs were taken directly from the "Review of Stormwater Conveyance Project Estimated Costs" report produced by Jacobi, Toombs, and Lantz, Inc. Estimated costs include anticipated construction costs as well as professional services including topographic survey, geotechnical investigation, civil design, and construction observation.

Based on the available data and assumptions noted above, the cost of this alternative is estimated to be about $61,000,000. A summary of technical information and calculations and a breakdown of the estimated cost for this alternative is provided in **Appendix 7**.

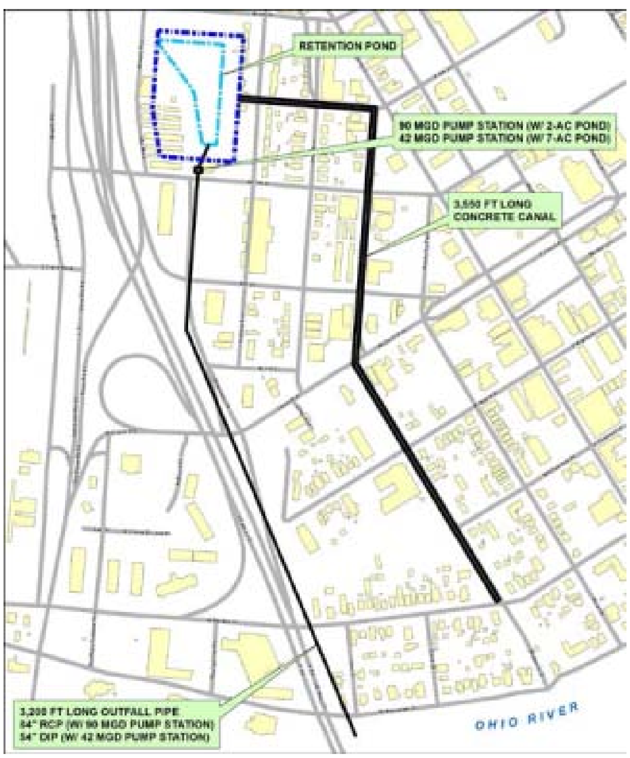

Figure 6-19 General Layout of Reverse Canal Alternative

PS-12: Reverse Canal Alternative Downtown Flood Control Project

This alternative involves the construction of a series of concrete weirs and channels that would store and convey stormwater flows. The current grade of the downtown area is directed away from the Ohio River, toward the low-lying areas near the intersection of Indiana Avenue and 8th Street. This would allow the reverse canal to utilize the existing grade and convey flows to this low area, and in effect, minimize the excavation cost of installing the channels. The width of the canal will be 20 feet, with depth varying from 7-feet to 9-feet. The total length of the canal will be 3,550 feet.

The upstream end of the reverse canal would begin at the intersection of Mulberry and Market Street, heading northwest along Mulberry Street, then north up Michigan Avenue, finally turning westward to the 2-acre detention pond discussed in Alternate 1 (PS-11) near the intersection of Indiana Avenue and 8th Street. A series of weirs would be included along the channel at the intersection of Court Avenue and Mulberry Street as well as Michigan Avenue and 7th Street with crest elevations set 2-feet below the adjacent grade for this analysis. The normal pool of the detention pond would be set at elevation 430.0 feet, NAVD88. During normal stages on the Ohio River, stormwater would be directed south towards the river through an outfall pipe under gravity flow conditions.

A 90 MGD pump station will be required for rainfall events when the Ohio River is at an elevated level. The pump station would be located just north of the intersection of 7th Street and Broadway Avenue and would convey flows via 84-inch force main outfall pipe under Broadway Avenue for 800 feet, then parallel to Interstate 65 for 2,400 feet until reaching the Ohio River. The water surface profile was allowed to increase up to, but not exceed, the adjacent grade to ensure that the drainage system would adequately convey the design flow without flooding. The general layout of the Reverse Canal Alternative is provided in **Figure 6-19**. The alignment of the Reverse Canal was selected to limit disturbance outside of downtown streets; however, the alignment could be modified to more closely resemble the Canal as Planned Alternative. A conceptual profile view of the reverse canal is shown in **Figure 6-20**.

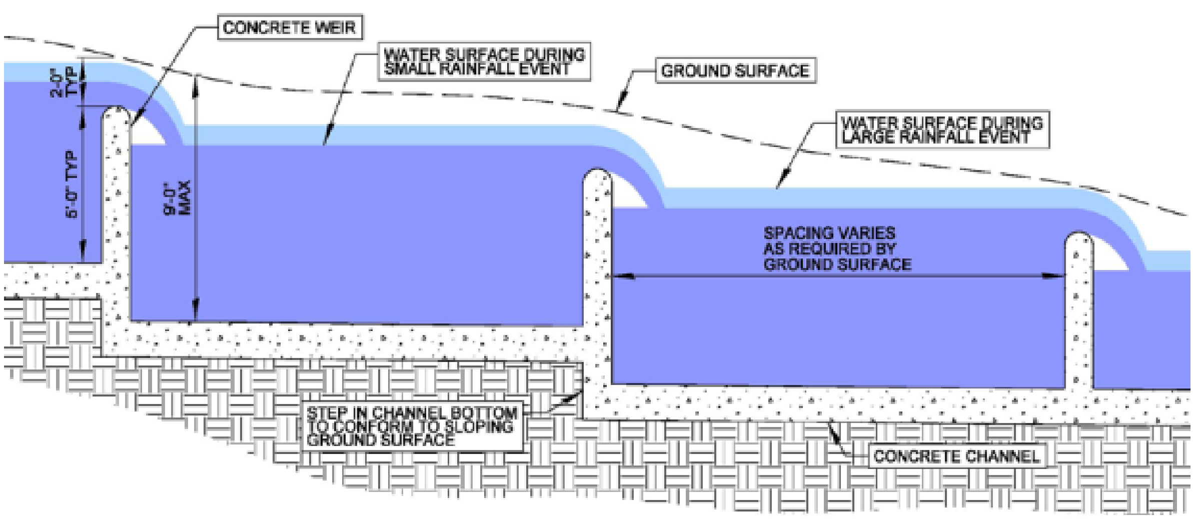

Figure 6-20 Conceptual Profile View of Reverse Canal

To evaluate the sensitivity of the system to available storage space, a second scenario was modeled that included a much larger detention pond, having an area of approximately 7 acres. If the City of Jeffersonville was able to purchase the property bounded by 7th Street, 9th Street, Indiana Avenue, and Interstate 65, the larger detention pond could be incorporated into the system for increased storage. The increased storage volume available to the system could potentially reduce the pump station size and could provide a significant cost-saving opportunity. However, the cost of acquisition and excavation of the larger pond could also potentially offset some of the above savings. So, the net difference in the total costs may not be that significant.

If the 7-acre pond was utilized, the size of the pump station can be reduced to 42 MGD and the force main pipe size can be reduced to 54 inches.

The approximate cost of the reverse canal alternative is estimated to be about $54,000,000 for the 2-acre pond alternate and about $53,500,000 for the 7-acre pond alternate. A summary of technical information and calculations and a breakdown of the estimated costs for this alternative are provided in Appendix 7.

PS-13: Storm Sewer Interceptor Alternative Downtown Flood Control Project

This alternative involves 3,550 feet of a large, 96-inch storm sewer interceptor that would convey and store stormwater flows. As with Alternative 2 (PS-12), the interceptor would convey flow to the north to take advantage of the current grade of the downtown area, limiting the need for excessively deep excavations. The interceptor would begin at the intersection of Market Street and Mulberry Street, then run northwest along Mulberry Street before turning north down Michigan Avenue, finally heading westward down 8th Street before discharging into the 2-acre detention pond. The normal pool of the detention pond would be set at elevation 429.0 feet, NAVD88. The storm sewer will conceptually be buried 2 to 11 feet below grade.

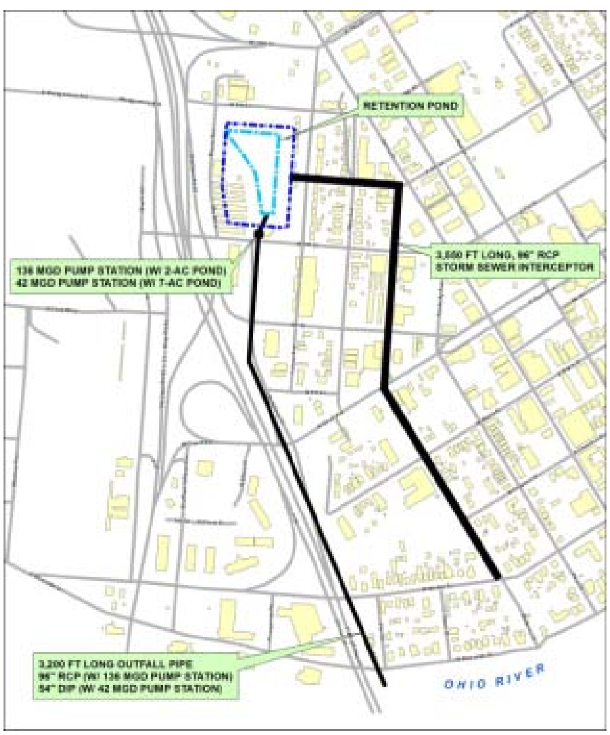

Figure 6-21 General Layout of Storm Sewer Interceptor Alternative

As with Alternative 2 (PS-12), during normal stages on the Ohio River, stormwater would then be directed south out of the detention pond to the river through an outfall pipe under gravity flow conditions. A pump station would be required for rainfall events when the Ohio River is at an elevated level. The 136 MGD pump station would be located just north of the intersection of 7th Street and Broadway Avenue and would convey flows via a 96-inch force main outfall pipe under Broadway Avenue for 800 feet, then parallel to Interstate 65 for 2,400 feet until reaching the Ohio River. The water surface profile was allowed to increase up to, but not exceed, the adjacent grade to ensure that the drainage system would adequately convey the design flow without flooding. The general layout of this Alternative is provided in **Figure 6-21**.

Similar to the previous alternative, a second scenario utilizing a 7-acre pond was also evaluated. If the 7-acre pond was utilized, the size of the pump station can be reduced to 42 MGD and the force main pipe size can be reduced to 54 inches.

The approximate cost of the pond and pump alternative is estimated to be about $43,000,000 for the 2-acre pond alternate and about $42,000,000 for the 7-acre pond alternate. A summary of technical information and calculations and a breakdown of the estimated costs for this alternative is provided in Appendix 7.

PS-14: Near-Surface Tunnel Alternative Downtown Flood Control Project

This alternative involves a 120-inch near-surface tunnel, 3,550 feet long that would convey and store stormwater discharge. Conceptually, the tunnel will be about 6 to 15 feet below grade. Similar to PS-11, the tunnel would convey flow to the south against the current grade of the downtown towards the Ohio River. This would minimize the length of the tunnel and outfall pipe that would be needed. In addition, this alternative would limit the amount of permanent land disturbance. The tunnel would begin just downstream of a 2-acre detention pond near the intersection of Indiana Avenue and 8th Street and head east on 8th Street, then turn south on Michigan Avenue before angling southeast down Mulberry Street toward the Ohio River. As in PS-11, the tunnel would be hydraulically linked to the detention pond at Indiana Avenue and 8th Street to attenuate the stormwater runoff entering the system through the 10th Street storm sewers.

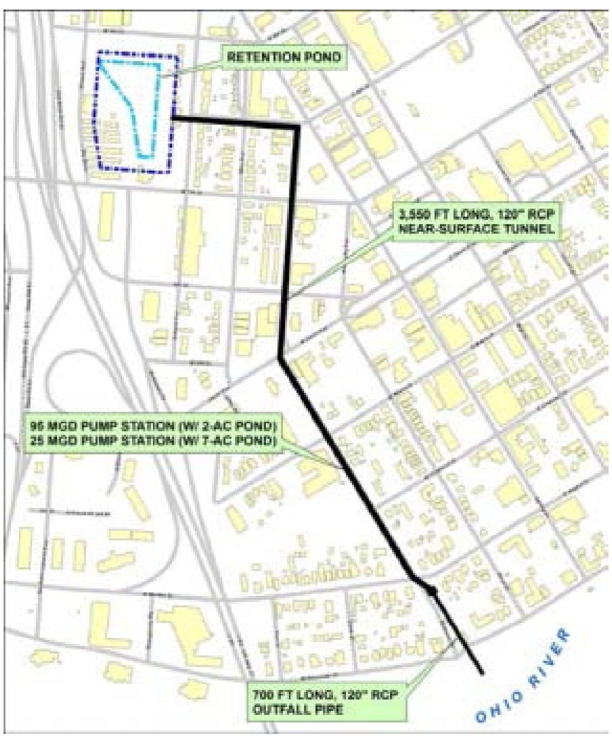

Figure 6-22 General Layout of Near-Surface Tunnel Alternative

For this analysis, the upstream invert elevation of the tunnel was assumed to be approximately 420.0 feet, NAVD88 and the downstream end of the tunnel would also be set at elevation 420.0 feet, NAVD88. This would allow for the tunnel to gravity flow during normal river levels on the Ohio River but would need to be pumped via a pump station during periods of elevated river levels. The pump station would be located at the intersection of Mulberry and Market Street and would convey flows to the Ohio River during high river stages, similar to PS-11, through a 700-foot long 120-inch force main outfall pipe. The water surface profile was allowed to increase up to, but not exceed, the adjacent grade to ensure that the drainage system would adequately convey the design flow without flooding. The general layout of the Near-Surface Tunnel Alternative is shown in **Figure 6-22**.

PS-15: Voluntary Acquisition and/or Floodproofing Program in the CSO/Downtown Area

There are 1,584 structures in Zone X (protected by the levee) in the CSO/Downtown Area Target Study Area. The earlier discussion in PS-2 (Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA) outlines a strategy for grouping and prioritizing these structures based on their expected degree of risk.

Due to limited resources and available data, structures in Zone X were not categorized as part of this SWMP. However, recommended categories for structures in the SFHA and suggestions for prioritizing mitigation efforts have been provided. As noted earlier as part of potential solution PS-2 discussions, due to presence of levees, acquisition or retrofitting is typically not a priority in the protected areas and focused education and evacuation plans such as those discussed earlier as part of potential solution PS-4 (Flood Response Plan) are typically recommended for these areas. However, portions of downtown are also subject to flooding through interior drainage source. Structure acquisition or floodproofing has been and should continue to be considered for structures affected by interior drainage flooding in downtown area as an alternative to the downtown flood control project alternatives discussed previously as part of potential solutions PS-11 through PS-14.

As shown in Figure 2-10, portions of Spring Street, East Court Street, 8th Street, 10th Street, and Market Street can expect to be flooded as well as approximately 75 commercial and 120 residential buildings in this area. Absence any planned major flood control projects, such as those discussed as PS-11 through PS-15, these buildings are recommended to be acquired and/or floodproofed. Based on an assumed City contribution of $20,000 per commercial building and $10,000 per residential building, it is estimated that the matching funds from the City to floodproof these structures is $2,700,000.

PS-16: Green Infrastructure in the CSO/Downtown Area

The earlier discussion in PS-6 (Citywide Green Infrastructure Policy) includes a description, location, storage, and pollutant removal benefit of typical structural green infrastructure BMPs. This information is the basis for the evaluation of how green infrastructure can be used to mitigate nuisance flooding, reduce CSO events, and improve water quality in the CSO/Downtown Area.

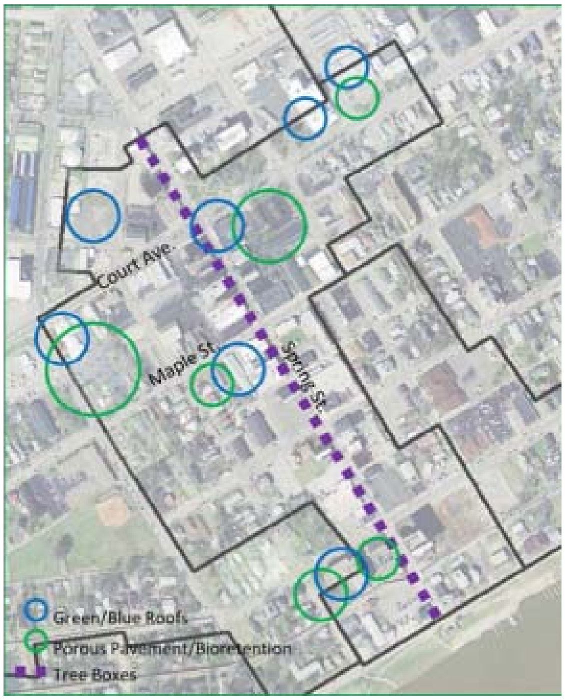

Figure 6-23 Potential Locations for Green Infrastructure Practices in the Spring Street CSO

A GIS-based desktop analysis and field investigation were conducted to identify potential sites for green infrastructure practices in the CSO/Downtown Target Study Area. This area was selected based on the number of drainage complaints, water quality issues, and high impervious cover. This effort was meant to be a screening exercise to identify potential green infrastructure BMP retrofit sites only; detailed site specific analysis will need to be completed as part of the design development phase. The GIS-based desktop analysis included problem areas, tax-exempt properties, building footprints, aerial photography and storm sewer system. The field investigation involved a tour of the problem areas and tax-exempt properties to look for opportunities for green infrastructure. Tax-exempt properties were considered in this analysis as potential green infrastructure sites because they are either owned by the federal, state, or local government or are charitable organizations receiving a tax benefit from the City. Additional sites may be available through public-private partnerships.

The Spring Street CSO (CSO-008) was used as an example of how green infrastructure practices could be retrofitted into an urban setting to address drainage, flooding and water quality concerns. The GIS-desktop analysis identified 437,719 ft^2 or 17% of tax-exempt properties. Within these properties 140,071 ft^2 of parking lots, 156,672 ft^2 of roofs, and 2,448 ft of Spring Street were considered as potential locations for green infrastructure practices (**Figure 6-23**). The following assumptions were made regarding how much of each of these sites could be retrofitted for green infrastructure purposes:

- 25% of parking areas converted to or runoff into bioinfiltration/ bioretention/ rain gardens
- 50% of parking areas converted to permeable pavement
- 20% of roofs converted to green and/or blue roofs
- 30% of roof runoff captured by rainwater harvesting
- 5’x5’ area tree boxes along 1 side of Spring Street at 20’ intervals

Based on these assumptions, 186,449 ft^2 or 7% of the Spring Street CSO subbasin could be retrofitted for green infrastructure practices. Using the storage potential outlined in PS-6, it is estimated that 734,027 gallons of stormwater runoff could be stored and treated using green infrastructure. In the Spring Street CSO subbasin, this volume equates to 12,346 gallons/acre. For comparison, the runoff calculations for the entire Cane Run watershed, the total runoff volume for the 1-year storm is 20,015 gallons/acre and 2-year storm is 29,218 gallons/acre. A significant portion (60% and 42% respectfully) of this runoff could be stored and treated with green infrastructure practices. Based on the number of CSO events (January 2010 through October 2011 as an example), 734,027 gallons of stormwater could be stored in these green infrastructure practices and reduce the CSO events by 78%.

Based on the anticipated pollutant removal for green infrastructure practices noted earlier as part of discussions provided in PS-6, it is expected that these BMPs will remove 11 lbs/yr of total phosphorus (TP), 90 lbs/yr of total nitrogen (TN), and 2,217 lbs/yr of total suspended solids (TSS). Under the NPDES Phase II requirement, the City Stormwater Ordinance requires TSS to be reduced from the first flush as defined by land use characteristics or capture at least 0.5-inch of precipitation. Based on the typical standard of 80% TSS removal, permeable pavement alone or a combination or treatment train of green infrastructure practices could successfully reduce TSS as well as TP and TN loadings into the Ohio River.

Costs were estimated using default data from Water Environment Research Federation's (WERF) BMP and LID Whole Life Cost Models. Whole life costs include capital and associated costs, regular maintenance costs, and corrective maintenance costs over a 50-year period based on a discount rate of 5.5%. The total capital cost for green infrastructure in the Spring Street CSO basin is estimated at $3,900,000. Excluding the green/blue roof, the cost is estimated at $1,400,000 and equates to an average of $4 per gallon of stormwater stored and treated. The 50-year whole life cost is estimated at about $10,000,000. Detailed costs are provided in Appendix 7.

This evaluation illustrated the potential water quality and water quantity benefit of green infrastructure for just 1 of the CSO basins. Further evaluations are needed to estimate the total potential costs for all 8 basins.

6.4 PROMISING SOLUTIONS IN THE OAK PARK CONSERVANCY DISTRICT TARGET STUDY AREA

The Oak Park Conservancy District (OPCD) is in the Lancassange Creek floodplain. Much of the area is either without stormwater infrastructure or the infrastructure that is in place is undersized, needs maintained, or replaced to function properly. The types of problems reported in OPCD include building flooding or buildings in the SFHA, drainage issues, maintenance, restrictive structures, riverine flooding, and street flooding.

Eleven promising solutions were identified in the OPCD to address the problems and/or concerns. These include Flood Depth Mapping, Fluvial Erosion Mapping, Updating Stream Hydraulic Studies, Green Infrastructure, Construction of New Storm Sewers, Bypass Channel, Upstream Offline Detention Basins, Combination Bypass Channel and Offline Detention, Levee and Pump Station, Voluntary Acquisition and/or Floodproofing Program, and Stream Restoration.

PS-17: Flood Depth Mapping in OPCD

Flood depth maps are used to illustrate the area and depth of water in a hypothetical flooding scenario. For the City of Jeffersonville, the benefit of this type of mapping is two-fold: 1) it enhances flood response, road closure, and evacuation efforts and 2) improves the public and City decision-maker understanding of flood depths and associated flood risks.

Flood depth maps are an essential component to FEMA's Risk Mapping, Assessment, and Planning (Risk MAP) program. In 2010, the Risk MAP program was initiated with a vision to deliver quality data that increases public awareness and leads to mitigation actions that reduce risk to life and property. To achieve this vision, FEMA is integrating risk assessment, risk communication, risk planning, and risk mitigation into its traditional flood hazard identification and mapping efforts. Depth grids will be created by a subtraction of the terrain data from the water surface grids. These depth grids will form the basis for refined loss estimates and will be available for a variety of potential flood risk mitigation applications at the local level such as targeting mitigation planning attention to high risk areas, Benefit Cost Analysis (BCA) screening, and project development.

Figure 6-24 Lancassange Creek FEH – Sharp Meander Bend next to private Property

Flood depth mapping could benefit emergency response and improved understanding among the public and decision-makers on potential flood risks. While the City should strive for citywide flood depth mapping, key areas with reported street flooding and building flooding/buildings in the SFHA should be targeted first. This includes the OPCD Target Study Area.

Due to limited resources and available data, flood depth mapping was not completed as part of this SWMP. The cost for flood depth mapping in OPCD Target Study Area is estimated to be $6,000 and may vary based on the quality of data available. A detailed stream study, terrain data, and water surface elevations are needed to complete flood depth mapping. It should be noted that based on the recommendation of this SWMP (PS-19: Updating Stream Hydraulic Studies) Lancassange Creek will need to be restudied prior to completing flood depth mapping.

PS-18: Fluvial Erosion Mapping in OPCD

Based on the GIS-based desktop analysis completed as part of this SWMP, a stretch of Lancassange Creek has a sharp meander and is very close to residential structures and private property (**Figure 6-24**). This area is considered a moderate level candidate for fluvial erosion mapping. The discussion in PS-3 Citywide Fluvial Erosion Mapping provides supporting information on the purpose and benefit of this type of mapping.

Due to limited resources and available data, fluvial erosion mapping was not completed as part of this SWMP. The cost for meander belt delineation and fluvial erosion hazard mapping along 9.5 miles of Lancassange Creek is estimated at $4,000. This fee may vary based on the quality of data available. High-resolution aerial photography, terrain data, soil data, infrastructure location information, and historical aerial photographs are needed to complete a fluvial erosion hazard assessment. The study length proposed includes the entire main stem of Lancassange Creek, as a full-assessment of a channel is prudent to identify system-wide fluvial issues.

PS-19: Updating Stream Study of Lancassange Creek

Based on the review of the preliminary FIRM and most recent topography as part of this SWMP, it was noted that there were instances along Lancassange Creek where the channel is shown outside the floodway and the delineation is based on old H&H modeling and/or data. Supporting information is available in the earlier discussion in PS-5: Citywide Stream Hydraulic Studies.

Figure 6-25 Impact of Floodplain Restudy

In addition to reviewing the floodplain delineations, CBBEL completed a quick analysis of the Lancassange Creek floodplain (**Figure 6-25**). The results showed a smaller floodplain than the one shown on the preliminary FIRM. The smaller floodplain also reduces the number of structures (greater than 400 square feet) in the SFHA, potentially from 964 to 543. This simply illustrates that based on more recent and better data, Lancassange Creek should be restudied. The following lists the steps and data used in CBBEL preliminary analysis:

- Utilize HEC-RAS geometry downloaded from DNR website (FIS study – no modification)
- Use CBBEL hydrology to simulate 100-yr, 24-hr storm event (CBBEL study has slightly higher flow rates than those downloaded with HEC-RAS model; modified flow rates and some input locations)
- Perform a steady-state analysis of the stream using the 10-yr event on the Ohio River as an outlet condition (same as used by FIS model)
- In GIS, digitize selected model XS's proximate to bridges and add water surface profile information to attributes
- Generate water surface TIN for comparison to terrain TIN
- Intersect the WS and terrain TIN's to develop floodplain

As can be seen from CBBEL preliminary evaluation reflected in Figure 6-25, a detailed restudy of Lancassange Creek will result in a more accurate depiction of actual flooding risks and can potentially result in a significantly reduced high flood risk areas. Based on preliminary mapping of the floodplain using current topographic mapping, a restudy of Lancassange Creek could potentially reduce the number of buildings within the SFHA from 964 to 543 buildings based on improved topographical and hydrologic and hydraulic data. The fee to restudy approximately 4 miles of Lancassange Creek is about $26,000.

PS-20: Green Infrastructure in OPCD

The earlier discussion in PS-6: Citywide Green Infrastructure Policy includes a description, location, storage, and pollutant removal benefit of typical structural Green infrastructure BMPs. This information is the basis for the evaluation of how green infrastructure can be used to mitigate nuisance flooding and improve water quality in the OPCD Area.

Figure 6-26 Typical Street in OPCD

As part of this SWMP, CBBEL completed a GIS-based desktop analysis and field investigation to identify potential sites for green infrastructure practices in the OPCD Target Study Area. OPCD was selected based on the number of drainage complaints, water quality issues, and high impervious cover. This effort was meant to be a screening exercise to identify potential green infrastructure BMP retrofit sites only; detailed site specific analysis will need to be completed as part of the design development phase.

The GIS-based desktop analysis included problem areas, building footprints, and aerial photography. The field investigation involved a tour of the problem areas to look for opportunities for green infrastructure. The focus was on publically owned land however additional land could be utilized through private-public partnerships. Public land in the OPCD is limited to the street and street right-of-way. For the purpose of this analysis, only the streets were considered for green infrastructure practices. Many of the streets in OPCD are wide with 2 travel lanes and parking on both sides (**Figure 6-26**).

To determine the area for green infrastructure practices, an average street width of 30 ft was used and the total street area within OPCD was extracted from the GIS street layer for a total street area of 1,484,760 ft^2. The following assumptions were made regarding how much of the street could be retrofitted for green infrastructure purposes:

- 1 parking lane (8') on 50% of the streets
- 50% porous pavement
- 50% bioretention (curb contained)

Figure 6-27 Potential Green Infrastructure in the OPCD

Figure 6-27 illustrates how this would look like on a typical street. Based on these assumptions, 742,380 ft^2 of impervious area could be retrofitted for green infrastructure practices. Using the storage assumptions previously discussed in PS-6, it is estimated that 4,720,052 gallons of stormwater runoff could be stored and treated using green infrastructure.

Based on the anticipated pollutant removal for green infrastructure as discussed in PS-6, it is expected that these BMPs will remove 137 lbs/yr of total phosphorus (TP), 1,097 lbs/yr total nitrogen (TN), and 30,767 lbs/yr total suspended solids (TSS). Under the NPDES Phase II requirement, the City Stormwater Ordinance requires TSS to be reduced from the first flush as defined by land use characteristics or capture at least 0.5-inch of precipitation. Based on the typical standard of 80% TSS removal, permeable pavement alone or a combination or treatment train with bioretention could successfully reduce TSS as well as TP and TN loadings into Lancassange Creek.

Costs were estimated using default data from WERF's BMP and LID Whole Life Cost Models. Whole life costs include capital and associated costs, regular maintenance costs, and corrective maintenance costs over a 50-year period based on a discount rate of 5.5%. The total capital cost for green infrastructure in the OPCD is estimated at about $8,000,000. This equates to an average of $4 per gallon of stormwater stored and treated. The 50-year whole life cost is estimated at about $10,500,000. Detailed costs for the entire OPCD area is provided in Appendix 7.

To illustrate the cost for an individual street, CBBEL used Senate Avenue as an example (illustrated in Figure 6-27). Based on the above assumptions, green infrastructure practices on Senate Avenue are estimated to cost $250,000.

PS-21 Construction of New & Updated Storm Sewers throughout OPCD
Throughout a large percentage of the Oak Park area there is limited drainage infrastructure to convey stormwater away from residential properties and roadways. Drainage is typically conveyed along the roadside in limited capacity side ditches and driveway culverts. This limited infrastructure was constructed as much as 60 years ago and in some cases have been covered up and filled in. There is a need for the construction of new or upgraded storm sewers throughout most of the OPCD to convey stormwater out and away from structures and roadways. In the public comment period of this SWMP, residents along with stormwater staff identified areas that are common low points and flooding areas.

Figure 6-28 Areas with Highest Concentration of Common Low Points and Flooding

Three areas were identified for storm sewer projects in the OPCD Target Study Area. These areas had the highest concentration of problems identified and include the area around McBride Drive, Laurel Avenue, and Capitol Hills Drive. **Figure 6-28** shows the general location of these three areas.

The McBride Drive area system (**Figure 6-29**) includes approximately 7,200 feet of proposed storm sewer, 21 proposed manhole structures, and 30 proposed catch basin structures. This proposed new system will convey stormwater through a proposed 48" storm sewer along Allison Lane to Utica Pike and outlet through a proposed headwall/outlet structure over open ground southeast of Utica Pike and convey

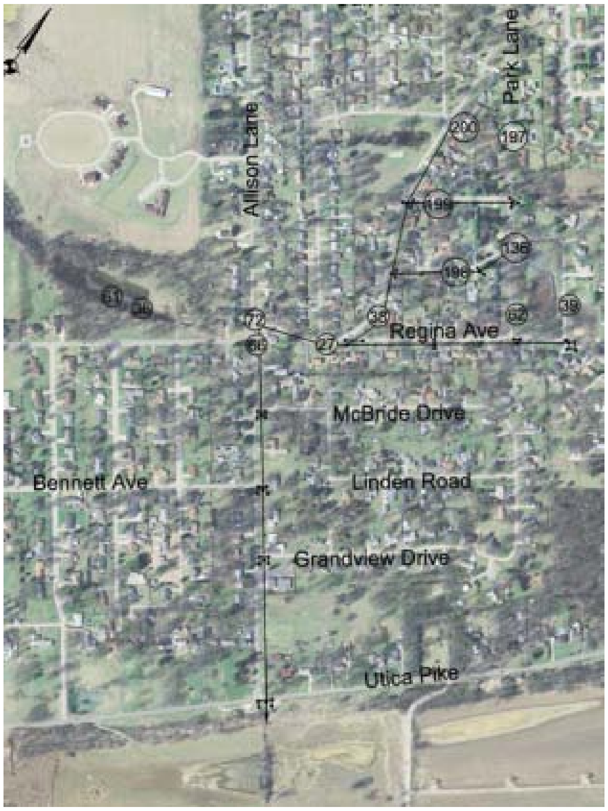

Figure 6-29 McBride Drive Area System

Figure 6-30 Laurel Avenue Area

storm water to the Ohio River. The estimated design and construction cost is approximately $1,400,000. In the Laurel Avenue area (**Figure 6-30**), a similar combination using 6,000 feet of proposed storm sewer, 15 proposed manhole structures, and 45 proposed catch basin structures is considered. This proposed new system will outlet into the proposed system associated with the proposed McBride area and an existing open ditch/drainage system recently improved by the OPCD near Longview Drive that has adequate capacity to accept the newly collected flow. The estimated design and construction cost of this system is approximately $750,000. The Capitol Hills Drive area system (**Figure 6-31**) includes 10,000 feet of proposed storm sewer, 22 proposed manhole structures, and 45 proposed catch basin structures. This proposed new system will outlet into the existing channel of Lancassange Creek. Stormwater runoff in this area currently drains to Lancassange Creek, but will be improved by the proposed collection and conveyance system. Other proposed improvements such as green infrastructure components and a large cutoff channel may help to alleviate capacity concerns of the downstream system. The estimated design and construction cost for this system is approximately $1,600,000.

The estimated total cost of these 3 projects is $3,750,000. Appendix 7 includes details regarding supporting calculations, proposed preliminary dimensions of the structures, and a breakdown of the estimated costs for each of these three proposed systems.

Figure 6-31 Capitol Hills Drive Area System

PS-22: Bypass Channel of Lancassange Creek OPCD Flood Control Project

This potential solution involves the construction of a new bypass channel that would convey floodwater from upstream of OPCD and discharge it downstream of the neighborhood. The objective of this potential solution is to reduce floodwater depth and, in effect reduce flooding of homes in the neighborhood. This bypass channel would be approximately 4,800 feet long and has a location as shown in **Figure 6-32**.

The effective HEC-RAS model from the Indiana Department of Natural Resources (IDNR) was utilized for hydraulic calculations. Flow rates in the model were adjusted to match the peak flow rates that were calculated by CBBEL. The HEC-RAS model was then edited for varying bypass channel sizes to analyze the effectiveness of the option. The goal of the bypass channel was to significantly reduce the Lancassange Creek floodplain size within OPCD. The 2-year (50%-annual-chance) flow rate served as the target discharge downstream of the inlet of the bypass channel (through the main portion of OPCD) during the 100-year (1%-annual-chance) event. Based on the hydrologic calculations, this discharge would be approximately 270 cubic feet per second (cfs) and the remaining discharge, 1,100 cfs, would be conveyed down the bypass channel and, theoretically, significantly reduce the flood elevations in the Lancassange Creek floodplain. The channel was modeled as a two-stage channel with 3:1 (H:V) side slopes, a lower stage with a 3-foot depth, an upper stage with a 3-foot depth, with 10-foot terraces on each side of the lower stage. A schematic of the proposed bypass channel is shown in **Figure 6-33**.

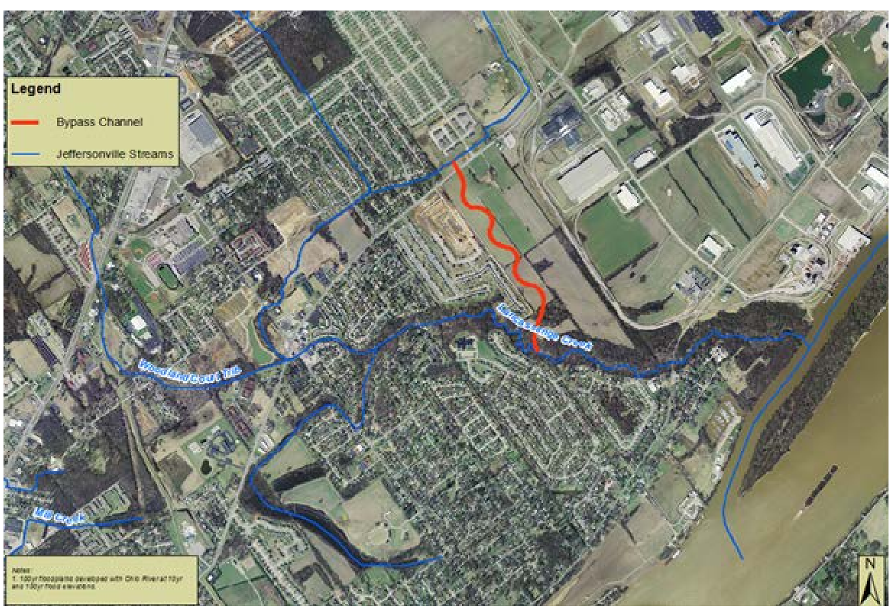

Figure 6-32 Bypass Channel Layout

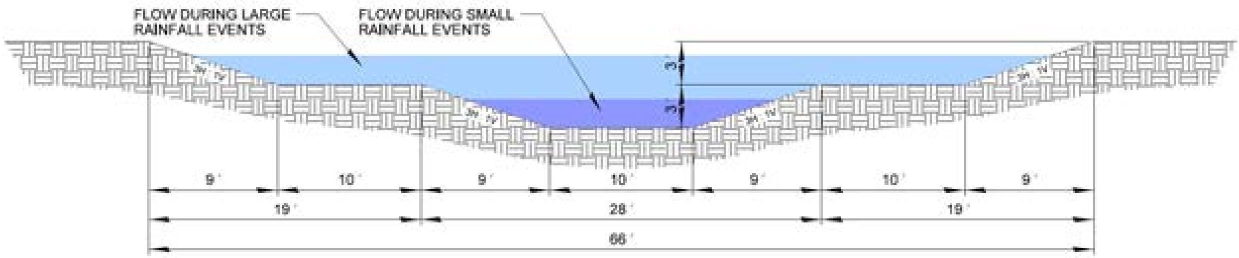

Figure 6-33 Schematic of Proposed Bypass Channel

A bypass channel inlet elevation of 462.0 feet, NGVD29 would allow for approximately 1.5-feet of flow in the main channel before the bypass channel would be used. A Manning's N-value of 0.035 was used, which represents a channel that is mowed occasionally. This channel allowed for 1,077 cfs to be diverted from Oak Park and flow through the bypass channel.

Immediately downstream of the bypass channel inlet, discharges on Lancassange Creek were reduced by an approximate 79-percent, which resulted in decrease in flood depths by approximately 3.3-feet. However, the results show that flood depths near downstream end of the neighborhood remain only slightly affected during the 100-year (1%-annual-chance) event. Several significant tributaries feed into the primary branch of Lancassange Creek downstream of the bypass channel inlet. The effectiveness of the bypass channel is reduced considerably due to the fact that approximately 78-percent of the watershed contributes to the creek downstream of the bypass channel inlet.

As indicated earlier under PS-19, based on preliminary mapping of the floodplain using current topographic mapping, a restudy of Lancassange Creek could reduce the number of buildings within the SFHA from 964 to 543 buildings based on improved topographical and hydrologic and hydraulic data. Additionally, the bypass channel could reduce the number of buildings from 543 based on the improved data to 367 buildings, a net reduction of 176 buildings. **Figure 6-34** shows the impact of the bypass channel project on the floodplain. Note that the base floodplain map in this figure reflects the potential mapping correction described in PS-19.

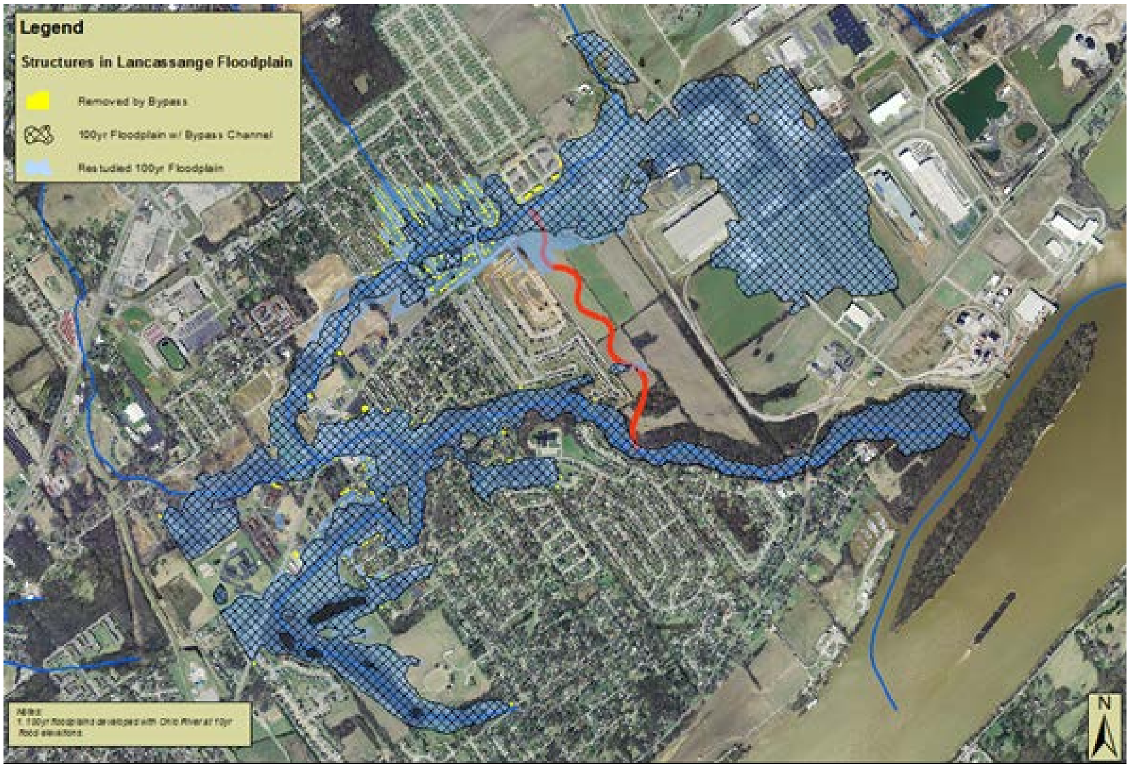

Figure 6-34 Impact of Bypass Channel

A conceptual opinion of probable cost was developed using available information and current industry unit rates. Estimated costs include anticipated construction costs as well as professional services including topographic survey, civil design, and construction observation. The estimated project cost for this potential solution is approximately $2,400,000. A copy of supporting calculations, the HEC-RAS model output, and a breakdown of the estimated cost is included in Appendix 7.

PS-23: Upstream Offline Detention Basins OPCD Flood Control Project

This alternative involves the construction of several upstream offline detention basins that would allow water to be diverted from the channel and temporarily stored. These would act as dry detention ponds. Utilizing these offline storage areas would reduce the peak discharge and would, theoretically, reduce the flooding of buildings in the neighborhood. The preliminary areas targeted for these offline detention basins are undeveloped areas that, at the time of preparing this SWMP, are identified as public/charitable land. These would be the simplest and most likely least controversial locations to add potential storage areas. However, the locations shown are only conceptual and locating a facility in these areas may prove not to be feasible, in which case an alternate area within the immediate watershed will need to be located. Approximately 170-acres of storage area have been proposed for this option; the locations of the offline detention basins are shown in **Figure 6-35**.

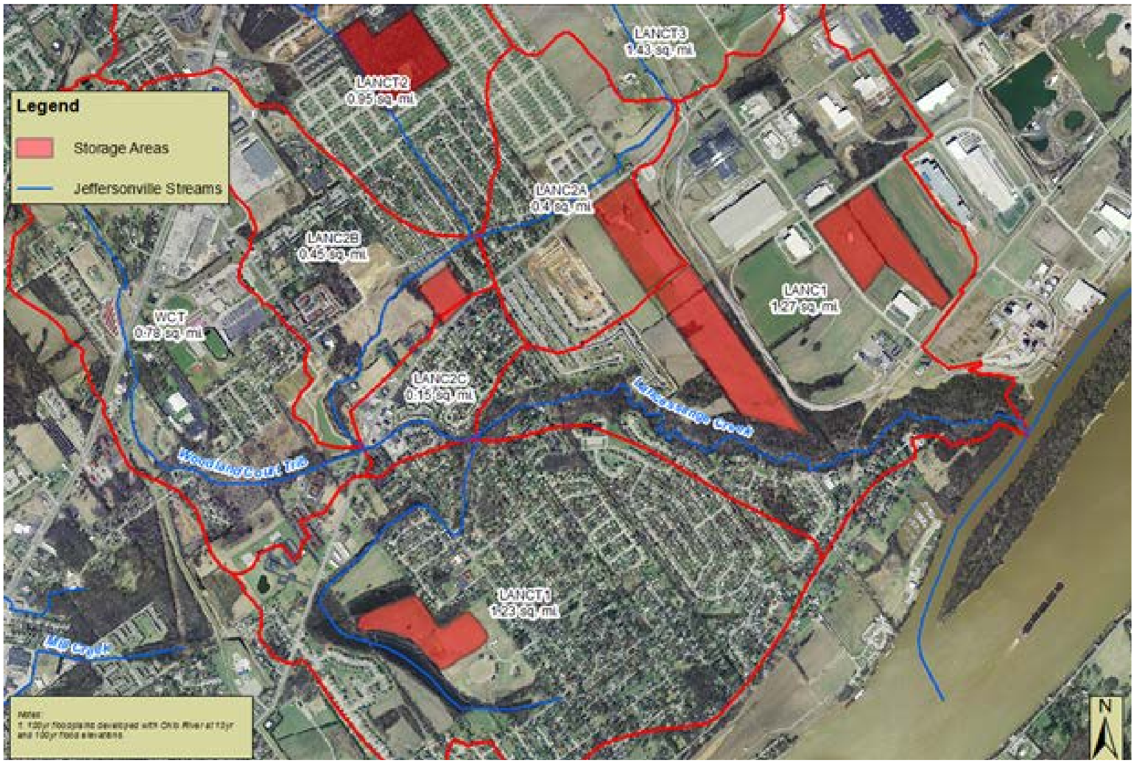

Figure 6-35 Storage Basin Layout

The same HEC-RAS model from the IDNR (with exception of flow rates) was also utilized for hydraulic calculations of this alternative. Using the areas and approximate depths of storage available, a volume of floodwater was calculated to be temporarily diverted from particular subbasins and tributaries of Lancassange Creek. This volume of stored water was assumed to be removed from the system and discharged downstream at a much slower rate, therefore, reducing the peak discharge for these tributaries that contribute to Lancassange Creek. The CBBEL hydrologic analysis of the Lancassange Creek watershed was used to determine the modified peak flows, assuming that the full storage potential of each storage basin was consumed. The reduced peak flow rates served as input for the HEC-RAS model to simulate the effect of offline storage basins. **Table 6-6** shows the contributing subbasins as calculated by CBBEL, as well as the potential storage areas for each of the subbasins.

Table 6-6 Volumes and Flow Rates from Contributing Subbasins

Parameter	CBBEL Drainage Basin							
	LANCT3	LANCT2	LANC2A	WCT	LANC2B	LANCT1	LANC2C	LANC1
Modeled Runoff Volume (ac-ft)	270	158	71	139	80	199	27	238
100yr Peak Flow (cfs)	1282	996	775	830	675	777	309	1495
Modeled Storage Volume (ac-ft)	0	38	26	0	17	57	0	98
Modified Peak Flow (cfs)	1282	407	132	830	290	309	309	279
Equivalent Event (Recurrence Interval)	100yr	10yr	2yr	100yr	10yr	10yr	100yr	2yr

On average, the use of offline storage basins can be expected to reduce the discharges through Oak Park by approximately 22-percent during the 100-year (1%-annual-chance) event.

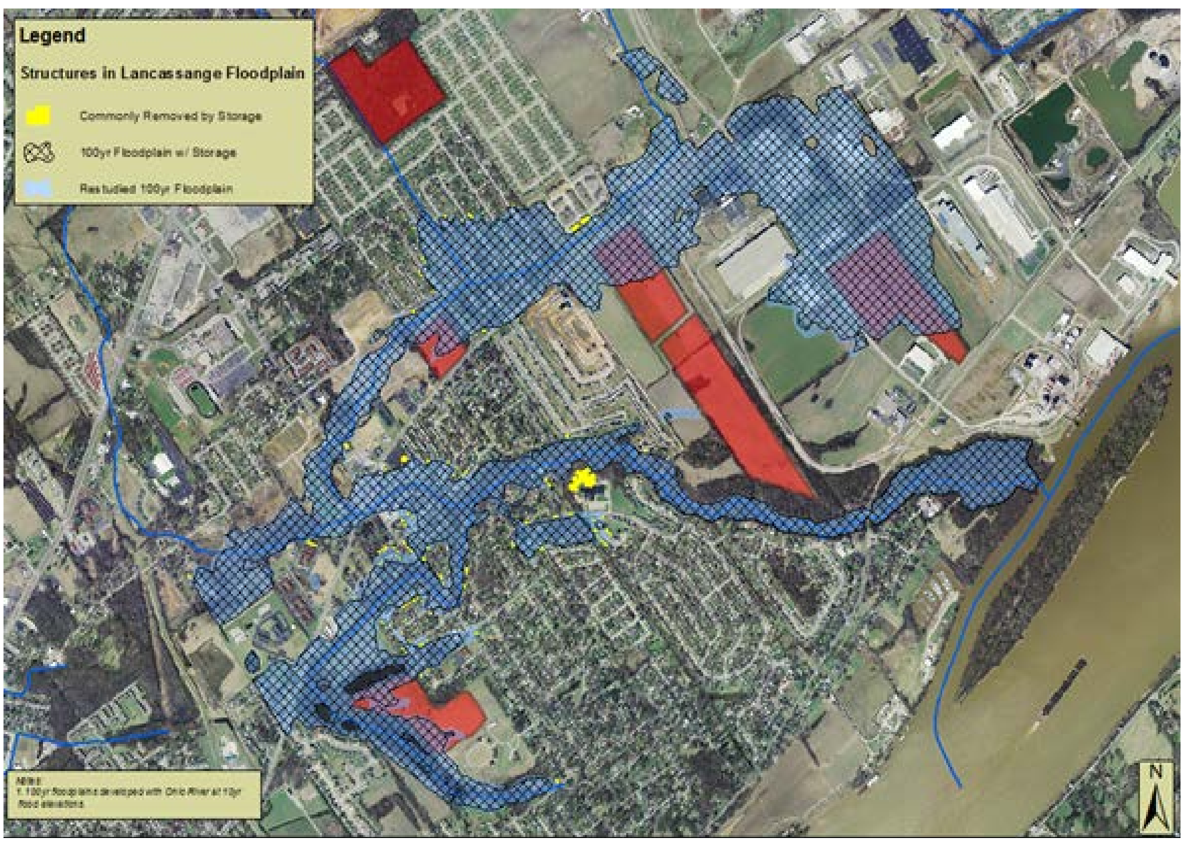

Figure 6-36 Impact of Storage Basins

As indicated earlier under PS-19, based on preliminary mapping of the floodplain using current topographic mapping, a restudy of Lancassange Creek could reduce the number of structures within the SFHA from 964 to 543 based on improved topographical and hydrologic and hydraulic data. Additionally, the upstream offline detention basins project could reduce the number of structures from 543 based on the improved data to 445, a net reduction of 98 structures. **Figure 6-36** shows the impact of the upstream offline detention basins project on the floodplain. Note that the base floodplain map in this figure reflects the potential mapping correction described in PS-19. When compared to the bypass channel project, the upstream offline detention basins are shown to be only marginally effective.

The estimated project cost for this potential solution is approximately $9,500,000. A copy of the supporting calculations, HEC-RAS model output, and a breakdown of the estimated cost is included in Appendix 7.

PS-24: Combination of Bypass Channel and Upstream Offline Detention Basins OPCD Flood Control Project

This alternative would involve a combination of the bypass channel and offline detention basins that were previously discussed. The locations of each are shown in **Figure 6-37**.

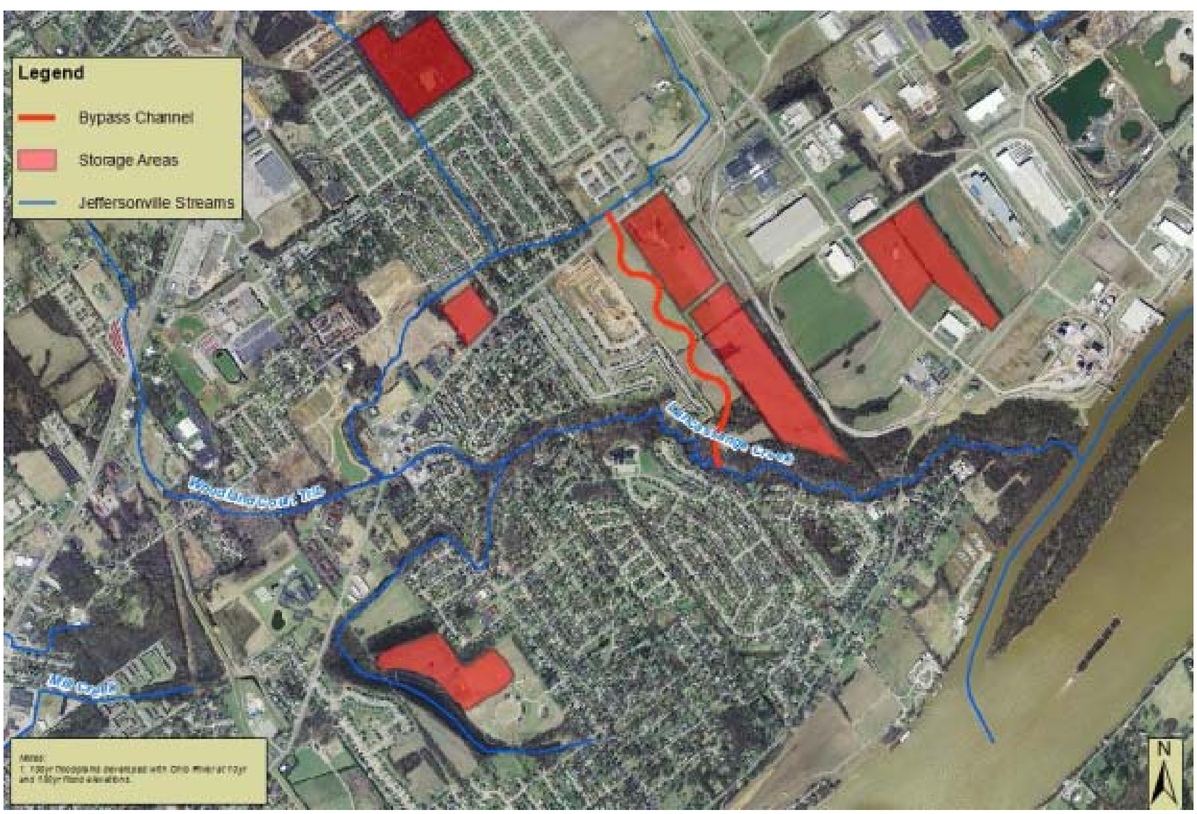

Figure 6-37 Bypass Channel and Storage Basin Layout

Using the combination of the bypass channel and offline detention basin alternatives, the 100-year (1%-annual-chance) event flow rate at the upstream end of Oak Park can be reduced by approximately 75-percent, with an associated 3.4-foot decrease in flood elevation. The peak flow rate near the outlet of the bypass channel would be reduced by 23-percent, producing flood elevations approximately 2.3-feet lower than the current condition. The combination could allow for the number of buildings from within the restudied floodplain to be further reduced.

Figure 6-38 shows the impact of the combination bypass channel and upstream offline detention basins project on the floodplain. Note that the base floodplain map in this figure reflects the potential mapping correction described in PS-19.

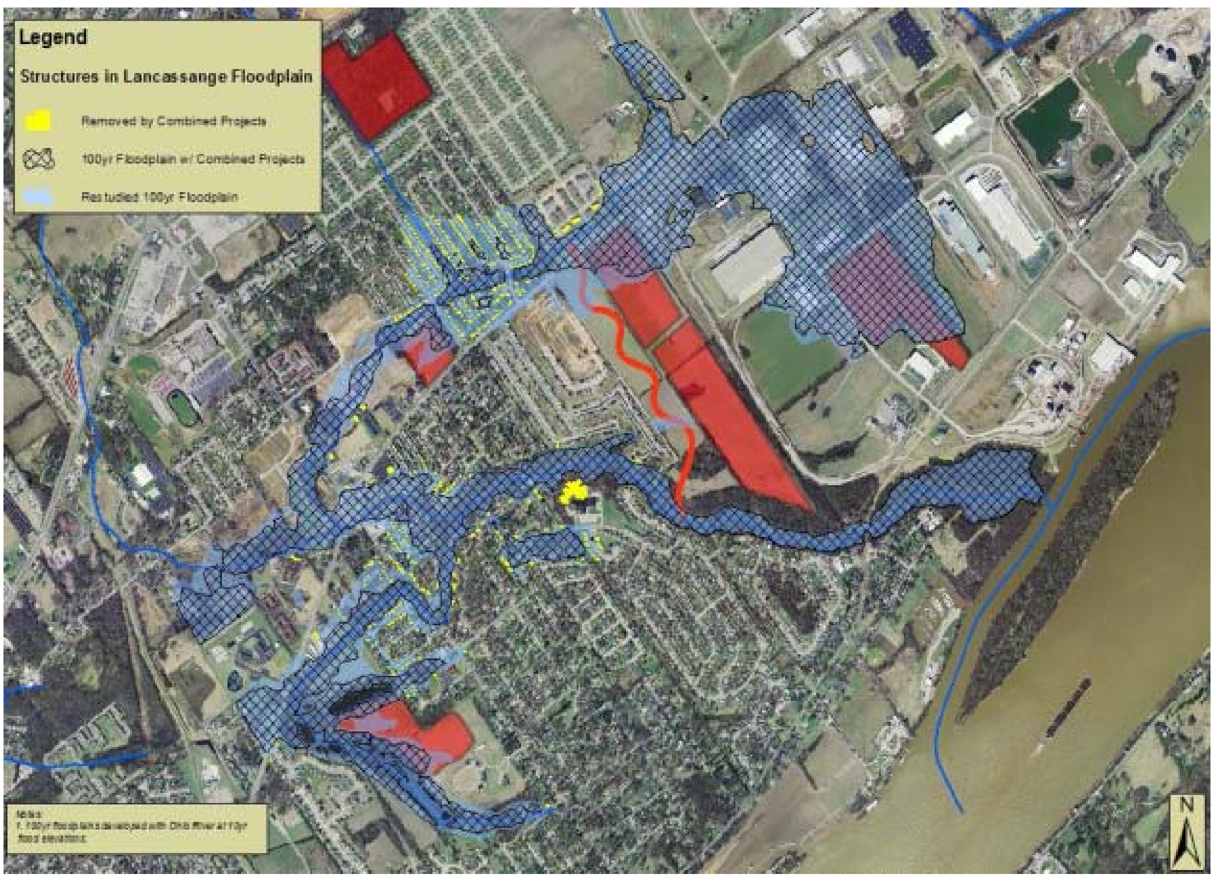

Figure 6-38 Impact of Combined Bypass and Storage Basin Projects

The estimated project cost for this potential solution is approximately $11,900,000. A copy of the supporting calculations, HEC-RAS model output, and a breakdown of the estimated cost is included in Appendix 7.

PS-25: Levee and Pump Station near Lancassange Creek Mouth OPCD Flood Control Project

This alternative would involve a levee and a pump station near the mouth of Lancassange Creek that would, prevent backwater from the Ohio River from flooding the OPCD. This would be done by constructing a levee across the Lancassange Creek waterway as well as placing a pump station at this location in order to pump water from Lancassange Creek downstream towards the Ohio River. This alternative had been discussed in a previous report which stated that significant flooding occurred in the OPCD due to flooding on Ohio River. A conceptual layout of this alternative is shown in **Figure 6-39**.

The size of a pump station needed to pump the entire Lancassange Creek discharge into the Ohio River would be beyond the scale of what is practically employed. A previous study by Jacobi, Toombs, and Lantz suggested that the levee and pump station alternative could be incorporated for approximately $10,000,000; however, based on the size of the pump station, CBBEL believes the cost of implementing this solution would be on the order of $30,000,000.

After analysis of the Lancassange Creek model, it became apparent that the water surface elevations on the Ohio River had little effect on the amount of flooding in Oak Park. **Figure 6-40** shows the amount of

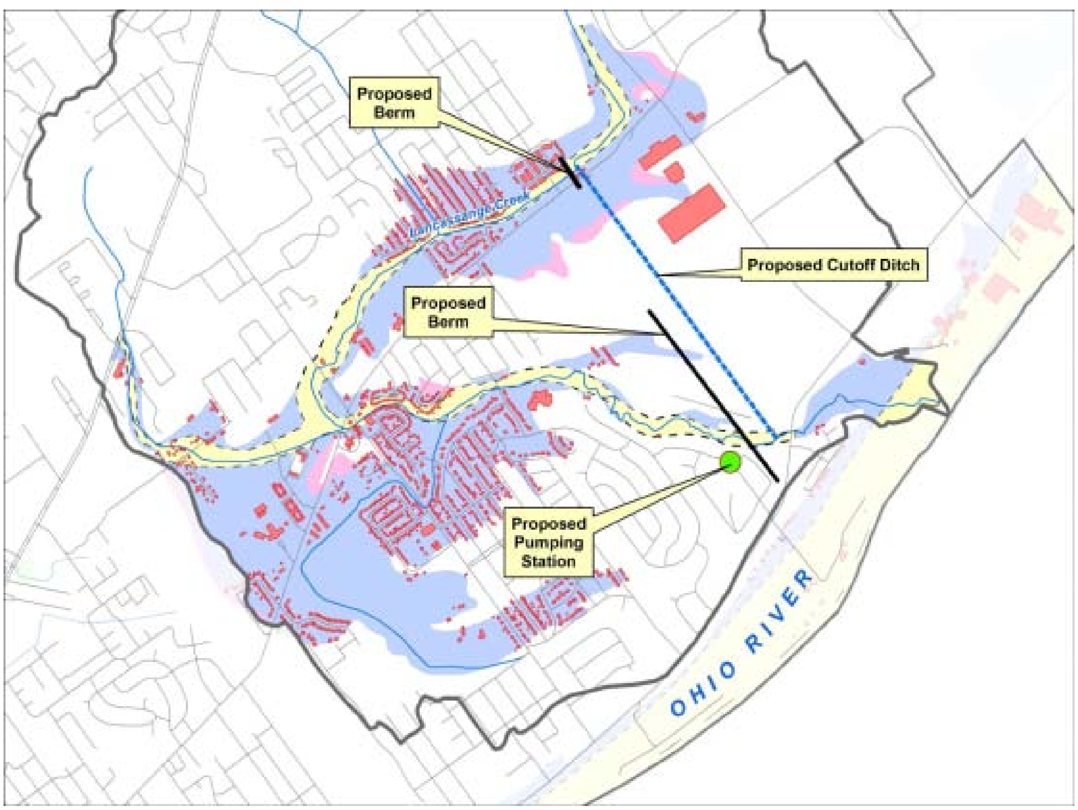

Figure 6-39 Conceptual Layout of Levee and Pump Station Alternative

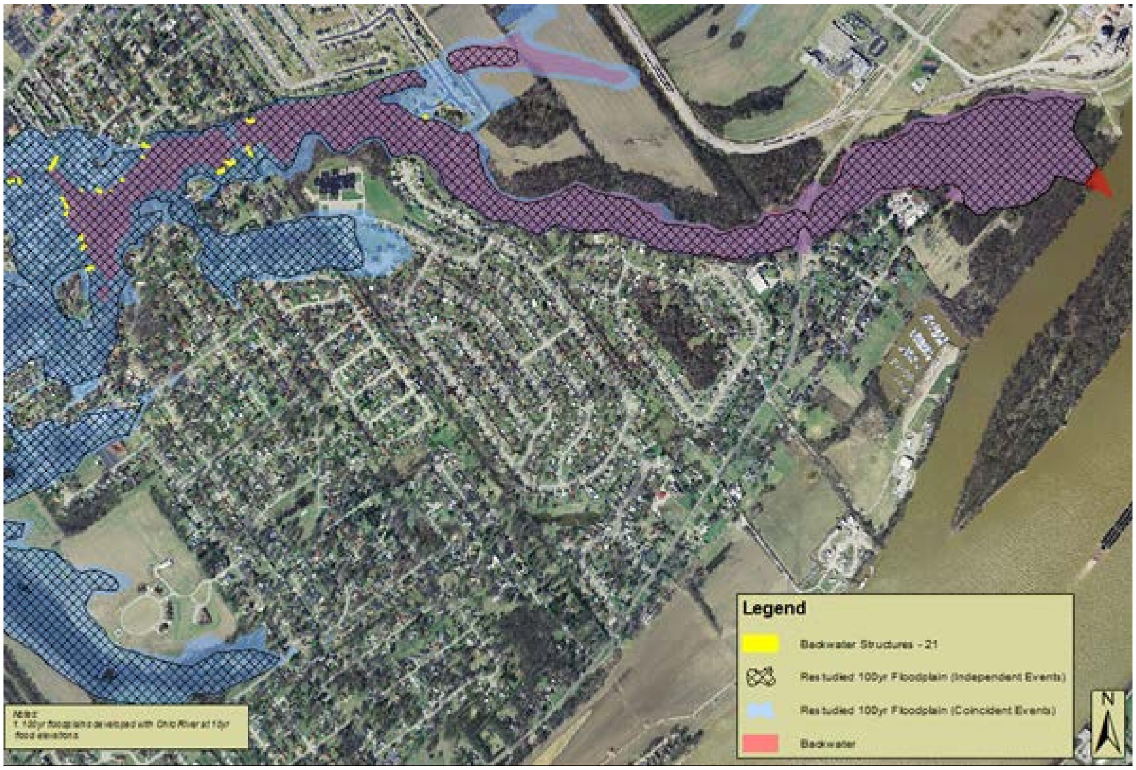

Figure 6-40 Comparison of Flooding of Lancassange Creek and Ohio River

flooding comparing independent flooding of Lancassange Creek and the Ohio River as well as coincident flooding events on both waterways.

As described previously and can be seen by Figure 6-40 there is little difference in coincident flooding events on the Ohio River and Lancassange Creek in comparison to the independent events of both. A total of approximately 21 structures could be protected from flooding from the Ohio River during a 100-year (1%-annual-chance) event by this alternative, with no rainfall on the Lancassange Creek watershed. The pump station on Lancassange Creek would need to be extremely large in order to prevent significant flooding if a flood on the Ohio River were to occur coincidentally with a rainfall event in the Lancassange Creek watershed. Because of the expected significant cost of the pump station and levee as well as the ineffectiveness of the alternative, the levee and pump station option was not considered a feasible structural solution for the OPCD.

PS-26: Voluntary Acquisition and/or Floodproofing Program in OPCD

In the OPCD, there are currently 964 structures (> 400 sf) in the Lancassange Creek SFHA (**Figure 6-41**). The earlier discussion in PS-2 (Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA) outlines a strategy for grouping and prioritizing these structures based on their expected degree of risk.

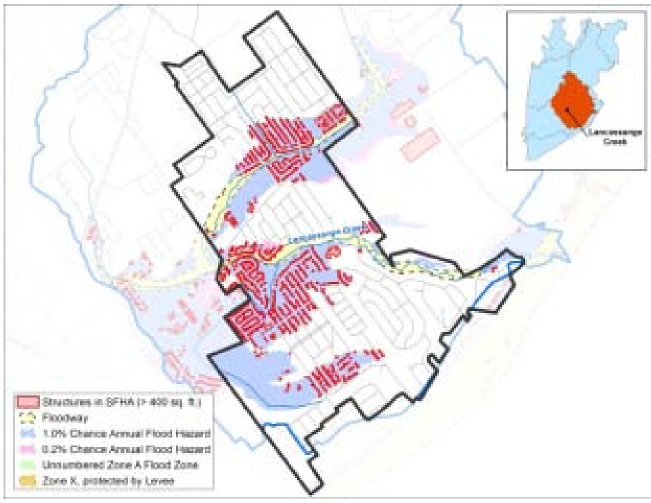

Figure 6-41 Structures in the Lancassange Creek SFHA

Due to limited resources and available data, structures in the SFHA in the OPCD were not categorized as part of this SWMP. However, recommended categories for structures in the SFHA and suggestions for prioritizing mitigation efforts have been provided. As indicated in PS-19, the actual number of structures within SFHA could be substantially reduced if the stream was restudied. The voluntary acquisition and/or floodproofing of remaining structures are an effective means of permanently reducing the flood damages on the affected structures. This can either be considered as an independent alternative to flood control projects discussed under PS-22 through PS-25 or as a supplemental project to a potential flood control project, such as the proposed bypass channel project (PS-22).

As indicated earlier, further evaluations are necessary to determine which structures are appropriate for buyout and which ones are appropriate for floodproofing assistance. However, to provide an idea of the order of magnitude of the costs involved with this alternative (assumed combined with potential solutions PS-19 and PS-22), CBBEL assumed that all structures remaining in the floodway may need to be acquired and the remaining structures outside of the floodway but within the revised SFHA will be floodproofed. Based on these assumptions, all 97 of the residential structures in the floodway will be acquired. Based on an average local real estate value of $110,000 plus 20% for demolition and site restoration this would cost $12,800,000. The 28 commercial and 270 residential structures remaining in the SFHA should be considered for floodproofing cost-share assistance. Using a typical cost-share of $20,000 per commercial building and $10,000 per residential building, it is estimated that the total matching funds from the City to floodproof these structures is $6,500,000. However, until the study in PS-2 is completed, the extent of potential costs will not be known.

PS-27: Stream Restoration of Lancassange Creek in OPCD

Since the 1940's and 1950's when the Oak Park Subdivision and surrounding areas began to develop, Lancassange Creek has undertaken major changes, both in ecological surroundings and water quantity, due to stormwater runoff. As development increased, residential and commercial properties quickly approached the banks of Lancassange Creek, eliminating most riparian areas that would protect water quality and reduce the velocity of stormwater runoff reaching the creek. The banks of Lancassange Creek in some of the residential subdivisions have eroded heavily due to increased stormwater velocity and creek modifications that have altered the natural flow of the stream. A majority of the areas along the Creek were developed before local regulations and ordinances controlled stormwater runoff, and State and Federal regulations controlled the removal of ecologically sensitive areas. The lack of regulations adversely impact water quality.

This stream should be further evaluated to identify problems that have been created due to stream modifications that have adversely impacted the flow of stormwater over time. Similarly, Lancassange Creek would benefit from the creation of a conservation easement and native plantings along the banks of the stream to restore water quality to the overall drainage system. A conservation easement and construction of a vegetative buffer along the creek should be established to allow for natural restoration and growth. A minimum of 50-feet on each side of the creek bank is desirable as vegetative buffer, however the easement will likely not be able to exceed 50-feet in most areas due to existing structures and development. Native plants, including trees, shrubs and tall grasses should be strategically planted along the easement.

The existing flow of Lancassange Creek should be analyzed to identify heavily eroded areas and potential improvements that will help restore the natural stream flow of Lancassange Creek without causing further damage as well as identify areas of the Creek that will require bank restoration to repair stream bank erosion that could lead to property damage. Planting vegetation along the streambank will provide resistance to erosion and reduce the possibility of future stream widening. Planting trees and shrubs inside the buffer will increase bank stabilization by providing a root system that will help keep the bank intact. Similarly, this vegetation will help by filtering sediments and other pollutants out of the stream and provide for overall water quality enhancement. **Figure 6-42** shows the general limits of the proposed stream restoration.

Figure 6-42 General Limits of Proposed Stream Restoration

Costs associated with this alternative will vary based upon the availability of easement areas, value of the property and public/private participation and willingness to be involved in the overall maintenance of the conservation easement. The potential costs for construction of conservation easements and improvements to heavily eroded areas will vary greatly dependent on the engineering analysis of the erosion mapping study; however a generalized cost estimate has been prepared by JTL based on the following assumptions outlined in **Table 6-7**. The project is estimated to cost approximately $2,000,000.

Table 6-7 Potential Costs for Lancassange Stream Restoration Alternative

Item/Description	Quantity	Unit of Quantity	Cost/Unit	Total Cost
Stream Channel Restoration	18000	Feet	$75/LF	$1,350,000
Tree Planting*	1600	Each	$20/Ea.	$32,000
Native Vegetation**	400	Pounds of Seed	$50/lb	$20,000
Easement Preparation & Acq.***	60	Each	$3,000/Ea.	$180,000
Engineering Design & Contingency	1	Lump Sum		$395,500
Total				$1,977,500

**Tree planting assumes a 20 acre area with trees to be planted at a rate of 80 trees/acre.*
***Native vegetation planting assumes 20 acres of native vegetation to be planted at a rate of 20 pounds/acre.*
****Easement preparation and acquisition assumes that there are some existing easements located along the main channel of Lancassange Creek.*

6.5 PROMISING SOLUTIONS IN THE LENTZIER CREEK TARGET STUDY AREA

This Target Study Area is located within the floodplain of Lentzier Creek and as a result experiences flash flooding, standing water in yards, driveways, and streets. Riverine flooding and street flooding were the types of problems identified. Two promising solutions were evaluated to address problems and concerns in the Lentzier Creek Target Study Area. These include: Stream Hydraulic Studies and Stream Restoration.

PS-28: Updating Stream Study of Lentzier Creek

Based on the review of the Preliminary FIRM and most recent topography as part of this SWMP, it was noted that there were instances along Lentzier Creek where the channel is shown outside the floodway. Only an approximate study (Zone A) has been completed and base flood elevations (BFE) have not been determined. Supporting information is available in the earlier discussion in PS-5: Citywide Stream Hydraulic Studies. The estimated fee to complete a partial H&H study on 4.5 miles of Lentzier Creek is $18,000.

PS-29: Stream Restoration of Lentzier Creek

Many subdivisions around Lentzier Creek were constructed before stormwater regulations were in place, allowing for increased runoff rates from the post-developed properties and through storm sewers discharging into the creek. The concentrated stormwater runoff has caused damage to the creek during heavy rainfall events, washing out walls of the creek and damaging natural vegetation along the banks. Similarly, the creation of centralized stormwater discharge points by way of piping or grading has allowed for localized destabilization of the creek walls and bed.

Areas along Lentzier Creek are comprised of residential subdivisions, industrial development (Indiana Army Ammunition Plant), and some undisturbed heavily vegetated areas. There are several residential subdivisions that over the past thirty years have been constructed along the banks of Lentzier Creek due to its natural aesthetics and ability to convey stormwater. Over time, residents have gradually taken over the banks of the stream and manicured their lawns up to the edge of the creek, eliminating most vegetation other than grass. Similarly, some of the residential subdivisions along Lentzier Creek were built before local regulations and ordinances controlled stormwater runoff, and State and Federal regulations controlled the removal of ecologically sensitive areas, which allowed for development to increase stormwater runoff and pollution rates and disturb existing riparian zones, similar to Lentzier Creek.

Lentzier Creek would benefit from the creation of a conservation easement and plantings along the banks of the stream to help restore water quality to the overall ecological system. This riparian buffer may also include the construction of off-line storage or wetland areas to allow for a reduction of flow in Lentzier Creek during flooding events.

To assist with restoration of Lentzier Creek, a vegetative buffer and conservation easement along the creek should be established to allow for natural restoration and growth. The easement, if size permits, would consist of an area approximately 50 to 100 feet from the top of bank on each side of the stream. A series of native plants, including trees, shrubs and tall grasses should be strategically planted along the buffer. Restoring this vegetative buffer should include the use of native plants, whereas they are better for local wildlife and less invasive.

The vegetation along the streambank will provide resistance to erosion and reduce the possibility of future stream widening. Planting trees and shrubs inside the buffer will increase bank stabilization by providing a root system that will help keep the bank intact. Similarly, this vegetation will help by filtering sediments and other pollutants out of the stream from both surface and subsurface flows, providing for overall water quality enhancement.

This project may be impacted by improvements made at the upstream most end of Lentzier Creek. An emergency response plan should identify routes for alternate access, whether through River Ridge or Boulder Creek, in the event of road flooding in this area due to limited residential subdivision access points and flash flooding potential. **Figure 6-43** shows the general limits of the proposed stream restoration.

Figure 6-43 General Limits of Lentzier Creek Proposed Stream Restoration

Costs associated with this alternative will vary based upon the availability of easement areas and value of the property. The best case scenario would be for the donation of easements by individual property owners and the potential for a public/private partnership for maintenance of the conservation easement. A generalized cost estimate has been prepared by JTL based on the following assumptions outlined in **Table 6-8**. The project is estimated to cost $1,000,000.

Table 6-8 Potential Costs Associated with Lentzier Creek Stream Restoration Alternative

Item/Description	Quantity	Unit of Quantity	Cost/Unit	Total Cost
Stream Channel Restoration	9,000	Feet	$75/LF	$675,000
Tree Planting*	800	Each	$20/Ea.	$16,000
Native Vegetation**	200	Pounds of Seed	$50/lb	$10,000
Easement Preparation & Acq.***	35	Each	$3,000/Ea.	$105,000
Engineering Design & Contingency	1	Lump Sum		$201,500
Total				$1,007,500

**Tree planting assumes a 10 acre area with trees to be planted at a rate of 80 trees/acre.*
***Native vegetation planting assumes 10 acres of native vegetation to be planted at a rate of 20 pounds/acre.*
****Easement preparation and acquisition assumes that there are some existing easements located along the main channel of Lentzier Creek.*

6.6 PROMISING SOLUTIONS IN THE WAVERLY TARGET STUDY AREA

The Waverly area is in a low-lying area where the homes, streets, and yards frequently flood (**Figure 6-44**). Water is unable to drain from the area due to undersized and unmaintained culverts under the railroad. Six of 7 problem types were reported in the Waverly Target Study Area. These include: building flooding, drainage issues, maintenance, restrictive structure, riverine flooding, and street flooding. Four promising solutions were evaluated to address problems and concerns.

Figure 6-44 Flooding in Waverly

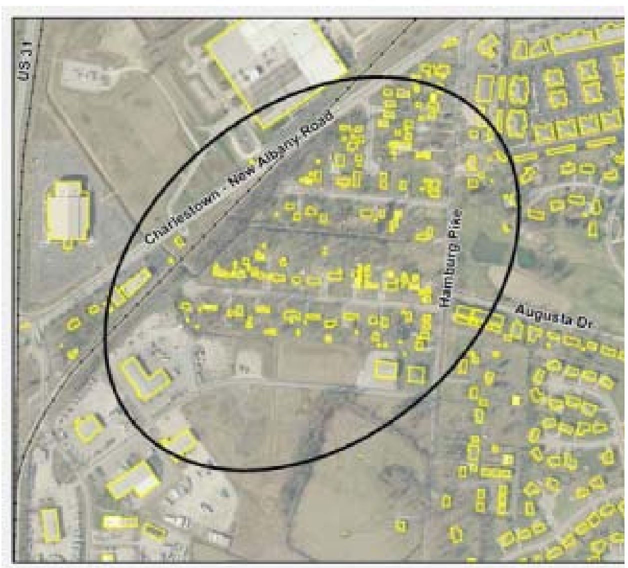

Figure 6-45 Structures in the Waverly Target Study Area

These include: Voluntary Acquisition and/or Floodproofing Program, Increasing the capacity of Upper Lick Run openings under Abandoned Railroad and Charleston New Albany Road, Stream Restoration, and Upstream Stormwater Pond at Golf Course.

PS-30: Voluntary Acquisition and/or Floodproofing Program in Waverly

There are approximately 45 structures in the Waverly Target Study Area that have experienced or been threatened by flooding (**Figure 6-45**). This area is a low-lying area outside of the SFHA. The earlier discussion in PS-2 (Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA) outlines a strategy for grouping and prioritizing these structures based on their expected degree of risk.

Due to limited resources and available data, structures in Waverly Target Study Area were not categorized as part of this SWMP. However, recommended categories for structures in the SFHA and suggestions for prioritizing mitigation efforts have been provided. Based on a preliminary evaluation of the area and assuming that all affected structures can be bought out, the estimated cost of acquisition, demolition, and restoration of each site is $132,000. The total contribution as matching funds from the City is estimated at $1,500,000. Because of the site's low-lying and poor natural drainage, this area could be further restored as a passive recreation wetland amenity for the City.

PS-31: Increasing the Capacity of Upper Lick Run openings under Abandoned Railroad and Charlestown-New Albany Road in Waverly

The drainage system in the area of Waverly Road consists of shallow storm sewers and curb and gutter to collect localized stormwater runoff. The area also conveys stormwater from Hamburg Pike and the adjacent golf course and subdivisions, totaling approximately 645-acres through a large concrete channel that is directly north of the residential properties along Waverly Road. Once stormwater reaches the railroad tracks, it is conveyed under the tracks by four parallel 36-inch pipes, which then drain into a concrete channel for a short distance and then into two parallel 48-inch by 76-inch elliptical pipes to cross under Charlestown-New Albany Road.

Figure 6-46 Inadequately sized culverts under the Railroad lead to flooding during a 10-year storm event.

Frequent flooding has been an issue in this area for an extended period of time. In evaluating the drainage issues, it has been identified that the existing drainage pipes underneath the Railroad tracks and Charlestown-New Albany Road are unable to convey stormwater runoff from a typical 10-year storm event, and are at full capacity at a 2-year storm event **(Figure 6-46**). Similarly, based upon elevation of the existing pipes, both underneath the railroad tracks and Charlestown-New Albany Road, when the current pipes are at capacity, stormwater has already flooded the cul-de-sac and the lower portion of Waverly Road, making properties inaccessible.

Increasing the capacity of stormwater conveyance crossing both the railroad track and Charlestown-New Albany Road may compound downstream flooding issues and potentially move drainage issues further downstream. Due to existing elevations of the roads and residential properties, and constraints with existing infrastructure, it is difficult to increase drainage conveyance in this area without adversely impacting other properties.

Figure 6-47 Existing Concrete Channel

To increase the capacity of conveyance beneath the existing railroad tracks downstream of the Waverly area, it would require the construction of a box culvert approximately 4 feet by 20 feet both at the railroad tracks and Charlestown-New Albany Road, however increasing this capacity by itself does not resolve the flooding concerns. Similarly, for this to be a viable option it will necessitate an upstream stormwater detention facility (or multiple facilities) to provide drainage relief without compounding the issues, as identified in the Possible Solution PS-33, and will still require the acquisition of adjacent properties. Cost estimates for this option could range between $1.5 to 2 million.

Figure 6-48 General Limits of Proposed Stream Restoration of Upper Lick Run

PS-32: Stream Restoration of Upper Lick Run in Waverly

In conjunction with the proposed property buy-out alternative identified elsewhere in this plan, the large concrete ditch that provides drainage conveyance from Hamburg Pike is a viable option for restoration of the channel to a viable natural stream with adjacent riparian zone. The existing concrete channel is approximately 1,200-feet in length by 16-feet in width (**Figure 6-47**). With the removal of the existing concrete channel, a natural meandering stream can be established that will assist with providing a water quality benefit and slowing down the conveyance of stormwater to the downstream system. **Figure 6-48** shows the general limits of the proposed stream restoration.

A generalized cost estimate has been prepared by JTL based on the following assumptions outlined in **Table 6-9**. The project is estimated to cost approximately $550,000, excluding property acquisition associated with the proposed property buyout program.

Table 6-9 Generalized Cost of Stream Restoration of Upper Lick Run Alternative

Item/Description	Quantity	Unit of Quantity	Cost/Unit	Total Cost
Stream Channel Restoration	1,200	Feet	$300/LF	$360,000
Tree Planting*	240	Each	$20/Ea.	$4,800
Native Vegetation**	60	Pounds of Seed	$50/lb	$3,000
Demolition & Removal of Existing Channel	1,200	Feet	$50/LF	$60,000
Engineering Design & Contingency	1	Lump Sum		$107,000
Total				$534,800

**Tree planting assumes a 3 acre area with trees to be planted at a rate of 80 trees/acre.*

PS-33: Upstream Stormwater Pond at Golf Course in Waverly

This promising solution had been suggested by some as a means of reducing the flow reaching the affected homes described in PS-30. However, based on a preliminary evaluations by JTL, in order for the flow to be reduced adequately during a 100-year event, approximately 83 acre-feet of storage will need to be provided at an estimated cost of about $2,100,000 . The golf course owners would like to reduce the existing flooding and drainage issues throughout the golf course and are not amenable to the use of such a large portion of their site as a flood storage space. Therefore, this potential solution does not appear to be feasible for this area. A summary of supporting data and calculations are provided in Appendix 7.

6.7 PROMISING SOLUTIONS IN THE WOODLAND COURT TARGET STUDY AREA

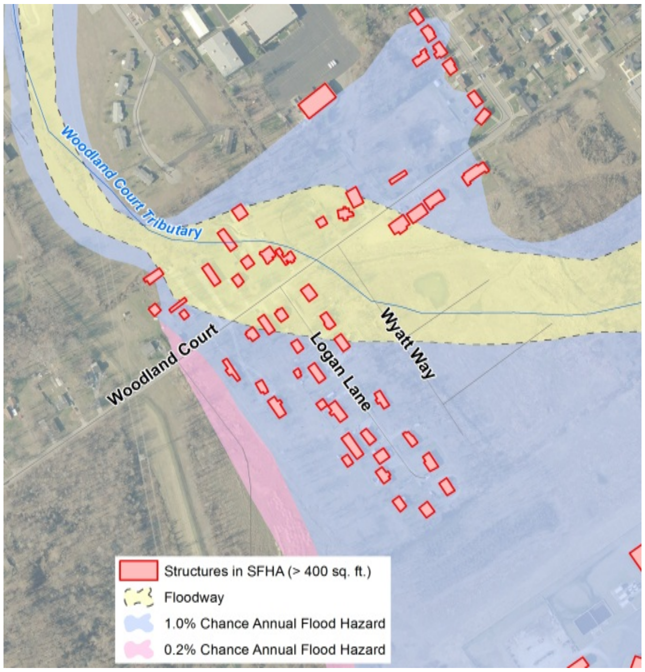

Figure 6-49 Structures in the Woodland Court Target Study Area

This Target Study Area is within the Woodland Court Tributary floodplain and as a result has ponding in the street and standing water in low-lying areas. Riverine flooding and street flooding were the problem areas identified. Six promising solutions were evaluated to address problems and concerns in the Woodland Court Target Study Area. These include Voluntary Acquisition and/or Floodproofing Program, Fluvial Erosion Mapping, Stream Hydraulic Studies, Enlarging Woodland Court Culvert, Stream Restoration, and Constructed Wetland.

PS-34: Voluntary Acquisition and/or Floodproofing Program in Woodland Court

There are approximately 35 structures in the Woodland Court Target Study Area inside the SFHA (**Figure 6-49**). Ten of these structures are in the floodway. The earlier discussion in PS-2 (Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA) outlines a strategy for grouping and prioritizing these structures based on their expected degree of risk.

Due to limited resources and available data, structures in Woodland Court Target Study Area were not categorized as part of this SWMP. However, recommended categories for structures in the SFHA and suggestions for prioritizing mitigation efforts have been provided. To provide an order of magnitude of costs involved with this alternative, CBBEL assumed all 10 of the residential structures in the floodway will be acquired. Based on an average local real estate value of $110,000 plus 20% for demolition and site restoration this would cost $1,300,000. The remaining 25 residential structures should be considered for floodproofing cost-share assistance. It is estimated that the contribution from the City as matching funds for acquisition and floodproofing of these structures would be $580,000.

PS-35: Flood Depth Mapping in Woodland Court

As discussed in PS-18, flood depth mapping could benefit emergency response and improved understanding among the public and decision-makers on potential flood risks. While the City should strive for citywide flood depth mapping, key areas with street flooding and building flooding/buildings in the SFHA should be targeted first. This includes the Woodland Court Target Study Area.

Due to limited resources and available data, flood depth mapping was not completed as part of this SWMP. The cost for flood depth mapping on a half mile stretch of Woodland Court is estimated to be $2,000. This estimate may vary based on the quality of data available. A detailed stream study, terrain data, and water surface elevations are needed to complete flood depth mapping.

PS-36: Updating Stream Study of Woodland Court Tributary

Based on the review of the Preliminary FIRM and most recent topography as part of this SWMP, it was noted that there were instances along Woodland Court where the channel is shown outside the floodway and the delineation is based on old H&H modeling and/or data. Supporting information is available in the earlier discussion in PS-5: Citywide Stream Hydraulic Studies. The estimated fee to restudy Woodland Court Tributary is $10,500.

PS-37: Enlarging the Culvert Under Woodland Court Tributary

Figure 6-50 Location of Proposed Culvert for Woodland Court Tributary Target Study Area

The existing culvert (**Figure 6-50**) on Woodland Court could be replaced with a larger culvert to reduce flooding upstream of Woodland Court. To accomplish this, Woodland Court will likely need to be raised. However, without providing additional storage for flood waters, either upstream or downstream of the culvert, the flooding downstream of Woodland Court could become worse. JTL examined several potential flood storage mitigation sites as part of this study. Based on a preliminary analysis, approximately 53 acre-feet of storage is needed upstream during a 100-year storm event. The estimated cost of this mitigation site alone is about $1,300,000. The cost to enlarge the existing culvert from parallel 43-inch by 68-inch pipes to a 4-foot by 10-foot box culvert and elevating the road to accommodate the new culvert is estimated to be approximately $200,000. Given the magnitude of costs and relatively low returns, this potential solution does not appear to be an effective means of resolving flooding issues in this area. Supporting data and calculations for this analysis are provided in Appendix 7.

PS-38: Stream Restoration of Woodland Court Tributary

The Woodland Court Tributary to Lancassange Creek should be modified and improved in a similar fashion to that recommended for Lancassange Creek since development in and around this area has occurred in similar patterns. This stream should be further evaluated to identify problems that have been created due to stream modifications that have adversely impacted the flow of stormwater over time. The area around the Woodland Court Tributary is unique in nature due to the existing flood levee that separates the upstream most end of the drainage area from an adjacent drainage area. Also, portions of the Woodland Court Tributary are conveyed through or adjacent to an existing wetland.

Figure 6-51 General Limits of Proposed Stream Restoration of Woodland Court Tributary

Conservation easement and construction of a vegetative buffer along the creek should be established to allow for natural restoration and growth. A minimum of 50 feet on each side of the creek bank is desirable as vegetative buffer, however the easement will likely not be able to exceed 50 feet in most areas due to existing structures and development. Native plants, including trees, shrubs and tall grasses should be strategically planted along the easement.

The existing flow of Woodland Court Tributary should be analyzed to identify heavily eroded areas and potential improvements that will help restore the natural stream flow of Lancassange Creek without causing further damage as well as identify areas of the Creek that will require bank restoration to repair stream bank erosion that could lead to property damage. Planting vegetation along the streambank will provide resistance to erosion and reduce the possibility of future stream widening. Planting trees and shrubs inside the buffer will increase bank stabilization by providing a root system that will help keep the bank intact. Similarly, this vegetation will help by filtering sediments and other pollutants out of the stream and provide overall water quality enhancement. **Figure 6-51** shows the general limits of the proposed stream restoration.

Costs associated with this alternative will vary based upon the availability of easement areas, value of the property and public/private participation and willingness to be involved in the overall maintenance of the conservation easement. The potential costs for construction of conservation easements and improvements to heavily eroded areas will vary greatly dependent on the engineering analysis of the erosion mapping study, however a generalized cost estimate has been prepared based on the following assumptions outlined in **Table 6-10**. The project is estimated to cost $550,000.

Table 6-10 Potential Costs of Woodland Court Tributary Stream Restoration

Item/Description	Quantity	Unit of Quantity	Cost/Unit	Total Cost
Stream Channel Restoration	5000	Feet	$75/LF	$375,000
Tree Planting*	480	Each	$20/Ea.	$9,600
Native Vegetation**	120	Pounds of Seed	$50/lb	$6,000
Easement Preparation & Acq.***	15	Each	$3,000/Ea.	$45,000
Engineering Design & Contingency	1	Lump Sum		$108,900
Total				$544,500

**Tree planting assumes a 6 acre area with trees to be planted at a rate of 80 trees/acre.*
***Native vegetation planting assumes 6 acres of native vegetation to be planted at a rate of 20 pounds/acre.*
****Easement preparation and acquisition assumes that there are some existing easements located along the main channel of the Woodland Court Tributary*

PS-39: Constructed Wetland in Woodland Court

The City of Jeffersonville recently purchased an approximate 15-acre site located along the Woodland Court Tributary to Lancassange Creek, on the southeast side of Woodland Court. This area is being dedicated as conservation easement for a wetland restoration area. This site could also be used for flood water storage. The site is located within the 1.0% annual chance flood hazard zone. This minimizes the effect this site may have on flood reduction during heavy events, but it may offer benefits in smaller storm events. **Figure 6-52** shows the general area of the constructed wetland.

Figure 6-52 General Area of Constructed Wetland Restoration Area in Woodland Court

Based on a preliminary evaluation of the site and its need to function as a successful wetland site, the condition and the amenities of the site will need to be enhanced. Per the Conceptual Wetland Restoration Plan prepared for the Jeffersonville Sewer Board identified as the Woodland Court SEP, by Redwing Ecological Services, Inc.:“Restoration plans for the site are focused on improving wildlife habitat, water quality, and flood functions within this portion of Lancassange Creek and Ohio River watersheds in Jeffersonville, Clark County, Indiana. The goal of the project is to establish a diverse wetland complex with a variety of native habitats, including: forested wetland; emergent wetland marsh; forested riparian corridor; and forested floodplain. The completed project will help improve water quality, maintain flood flow attenuation functions of the site, establish native wetland/aquatic and floodplain/riparian forest habitats, and provide outdoor/environmental education and recreational opportunities for the public. Major activities include establishing additional wetland acreage, enhancing existing wetland habitat, and restoring forested riparian stream buffer and forested floodplain." The estimated cost of these potential improvements is about $45,000.

6.8 PROMISING SOLUTIONS IN THE LICK RUN TARGET STUDY AREA

This Target Study Area is in the Lick Run floodplain and experiences building flooding and drainage issues. Undersized culverts may be contributing to the problem as well. Five of the 7 problem types were reported in this Target Study Area including building flooding or buildings in the SFHA, drainage issues, erosion, restrictive structure, and riverine flooding. Three promising solutions were evaluated to address problems and concerns in the Lick Run Target Study Area. These include Voluntary Acquisition and/or Floodproofing Program, Flood Depth Mapping, and Grey Infrastructure.

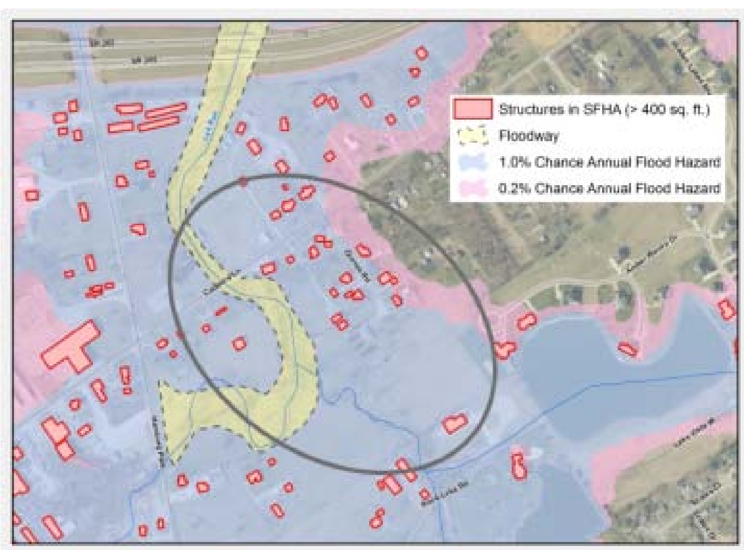

Figure 6-53 Structures in the SFHA of the Lick Run Target Study Area

PS-40: Voluntary Acquisition and/or Floodproofing Program in Lick Run

There are approximately 30 structures in the SFHA in the Lick Run Target Study Area (**Figure 6-53**). The earlier discussion in PS-2 (Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA) outlines a strategy for grouping and prioritizing these structures based on their expected degree of risk.

Due to limited resources and available data, structures in Lick Run Target Study Area were not categorized as part of this SWMP. However, recommended categories for structures in the SFHA and suggestions for prioritizing mitigation efforts have been provided. To provide an order of magnitude of costs involved with this alternative, CBBEL assumed the residential structure in the floodway will be acquired. Based on an average local real estate value of $110,000 plus 20% for demolition and site restoration this would cost $132,000. The remaining 29 residential structures should be considered for floodproofing cost-share assistance. It is estimated that the matching funds provided by the City for acquisition and floodproofing would be $350,000.

PS-41: Flood Depth Mapping of Lick Run

As discussed in PS-18, flood depth mapping could benefit emergency response and improved understanding among the public and decision-makers on potential flood risks. While the City should strive for citywide flood depth mapping, key areas with street flooding and building flooding/buildings in the SFHA should be targeted first. This includes the Lick Run Target Study Area.

Due to limited resources and available data, flood depth mapping was not completed as part of this SWMP. The cost for flood depth mapping for a half mile stretch of Lick Run is estimated at $1,000. This fee will vary based on the quality of data available. A detailed stream study, terrain data, and water surface elevations are needed to complete flood depth mapping.

PS-42: Increasing the Conveyance Capacity of Hamburg Pike and Cooper Lane Crossings of Lick Run Creek

Through public involvement and identification by City representatives, it has been identified that flooding occurs along Hamburg Pike and Coopers Lane near their intersection. This area is located along Lick Run Creek near the convergence of three tributaries. Water surface elevations of this portion of Lick Run are influenced by backwater from Silver Creek, which is located approximately 2 miles downstream. There are two roadway crossings and one private crossing of Lick Run Creek in this area. The crossings are as follows: one culvert crossing along Hamburg Pike directly south of Coopers Lane, one bridge crossing along Coopers Lane directly east of Hamburg Pike, and a private residential bridge directly south of the Coopers Lane bridge crossing. The locations of these crossings are shown in **Figure 6-54** Complaints have identified that flooding occurs at these crossings and obstructs the flow of traffic. This alternative

Figure 6-54 Locations of Flooded Crossings along Lick Run

evaluates the benefit of increasing the conveyance capacity at these crossings.

Based upon the Flood Insurance Study for Clark County, Indiana, prepared by the Federal Emergency Management Agency, the identified crossings are controlled by backwater conditions of Silver Creek. Therefore, increasing the capacities of these two crossings is not expected to lower flood stages affecting the structures subject to flooding. The study identifies that the private covered bridge crossing is the lower of the two adjacent crossings. Backwater from Silver Creek will cause flooding in this location. For the crossings at Coopers Lane and Hamburg Pike to be raised above the 1% annual chance of flooding elevation, they would need to be raised approximately 10 feet, and the private residential bridge crossing would need to be raised approximately 15 feet. It is not physically feasible based on the current geographic location of these structures to make these improvements. An emergency response plan should be prepared to identify this area as a potential flooding area without vehicular access to local emergency management officials during heavy flooding and locate clear routes to all affected parties.

6.9 PROMISING SOLUTIONS IN THE MILL CREEK TARGET STUDY AREA

The Mill Creek Target Study Area has streambank erosion and drainage issues that may be the result of an undersized culvert and low-lying areas. The types of problems reported include drainage issues, erosion, restrictive structure, and riverine flooding. Three promising solutions were evaluated in the Mill Creek Target Study Area to address problems and concerns. These include: Stream Hydraulic Studies, Increasing the Mill Creek Culvert Capacity, and Stream Restoration.

PS-43: Updating Stream Study of Mill Creek

Based on the review of the Preliminary FIRM and most recent topography as part of this SWMP, it was noted that there were instances along Mill Creek where there are conflicts between the floodplain elevation and the BFE, the channel is shown outside the floodway and the delineation is based on old H&H modeling and/or data. Supporting information is available in the earlier discussion in PS-5: Citywide Stream Hydraulic Studies. The estimated fee to restudy 3.4 miles of Mill Creek is approximately $18,000.

PS-44: Increasing the Culvert Capacity of Mill Creek at Woodland Court Crossing

The existing culvert on Woodland Court could be replaced with a larger culvert to reduce flooding upstream of Woodland Court. To accomplish this, Woodland Court will likely need to be raised. However, without providing additional storage for flood waters, either upstream or downstream of the culvert, the flooding downstream of Woodland Court could become worse. JTL examined several potential flood storage mitigation sites as part of this study. Based on a preliminary analysis, approximately 32 acre-feet of storage is needed upstream of the culvert to address a 100-year storm event. The estimated cost of this mitigation site alone is about $800,000. The cost to enlarge the existing culvert from a 3-foot by 8-foot box culvert to a 3-foot by 10-foot box culvert and elevating the road to accommodate the new culvert is estimated to be approximately $200,000. However, increasing the culvert size will only transfer the flooding problem downstream. Given the magnitude of costs and relatively low returns, this potential solution does not appear to be an effective means of resolving flooding issues in this area. Supporting data and calculations for this analysis is provided in Appendix 7.

PS-45: Stream Restoration of Mill Creek

The upstream most end of the Mill Creek stream should be further evaluated to identify problems that have been created due to stream modifications that have adversely impacted the flow of stormwater over time. The area around the upper end of Mill Creek is unique in nature due to the existing flood levee that separates the upstream most end of the drainage area from an adjacent drainage area.

Figure 6-55 General Limits of Proposed Stream Restoration Area for Mill Creek

Conservation easement and construction of a vegetative buffer along the creek should be established to allow for natural restoration and growth. A minimum of 50 feet on each side of the creek bank is desirable as vegetative buffer, however the easement will likely not be able to exceed 50 feet in most areas due to existing structures and development. Native plants, including trees, shrubs and tall grasses should be strategically planted along the easement.

The existing flow of Mill Creek should be analyzed to identify heavily eroded areas and potential improvements that will help restore the natural stream flow of the Creek without causing further damage as well as identify areas of the Creek that will require bank restoration to repair stream bank erosion that could lead to property damage. Planting vegetation along the streambank will provide resistance to erosion and reduce the possibility of future stream widening. Planting trees and shrubs inside the buffer will increase bank stabilization by providing a root system that will help keep the bank intact. Similarly, this vegetation will help by filtering sediments and other pollutants out of the stream from, providing for overall water quality enhancement. **Figure 6-55** shows the general limits of the proposed stream restoration area.

Costs associated with this alternative will vary based upon the availability of easement areas, value of the property and public/private participation and willingness to be involved in the overall maintenance of the conservation easement. The potential costs for construction of conservation easements and improvements to heavily eroded areas will vary greatly dependent on the engineering analysis of the erosion mapping study; however a generalized cost estimate has been prepared by JTL based on the following assumptions outlined in **Table 6-11**. The project is estimated to cost about $300,000.

Table 6-11 Generalized Cost Estimate for Stream Restoration of Mill Creek

Item/Description	Quantity	Unit of Quantity	Cost/Unit	Total Cost
Stream Channel Restoration	2,500	Feet	$75/LF	$187,500
Tree Planting*	240	Each	$20/Ea.	$4,800
Native Vegetation**	60	Pounds of Seed	$50/lb	$3,000
Easement Preparation & Acq.***	8	Each	$3,000/Ea.	$24,000
Engineering Design & Contingency	1	Lump Sum		$54,825
Total				$274,1250

**Tree planting assumes a 3 acre area with trees to be planted at a rate of 80 trees/acre.*
***Native vegetation planting assumes 3 acres of native vegetation to be planted at a rate of 20 pounds/acre.*
****Easement preparation and acquisition assumes that there are some existing easements located along the main channel of the Woodland Court Tributary*

CHAPTER 7 FINAL SCREENING OF PROMISING SOLUTIONS AND SELECTION OF RECOMMENDED MASTER PLAN COMPONENTS

This chapter is a final screening of the promising solutions that were evaluated in detail in Chapter 6. The intent of this screening is to identify and prioritize the promising solutions best suited to become recommended Master Plan components. A triple bottom line assessment is used to compare the economic, social, and environmental benefits of each solution.

7.1 TRIPLE BOTTOM LINE ASSESSMENT

The Triple Bottom Line (TBL) is an expanded baseline for measuring performance, adding social and environmental dimensions to the traditional monetary benchmark. Fundamental to this type of assessment, is that economic, social, and environmental benefits are equally considered.

A TBL was developed for this SWMP as a final screening tool of each promising solution. The Advisory Committee was instrumental to ensure that under each metric (economic, social, and environmental) the assessment criteria, weighting factor, and rating was representative of the values of the City. **Table 7-1, Table 7-2** and **Table 7-3** summarize the Advisory Committee discussion.

A tool such as the TBL should be used for all future City capital improvement projects, regardless of their scale, to assess the economic, social and environmental benefits. A blank copy of the TBL worksheet is in **Appendix 8**.

Table 7-1 TBL Economic Metric

ASSESSMENT CRITERIA	DEFINITION	WEIGHTING FACTOR	RATING
Capital Cost	Planning level costs developed as part of the Detailed Evaluation of Promising Solutions	0.45	0 = > $10M 1 = > $5M < $10M 2 = > $1M < $5M 3 = > $500K < $1M 4 = > $100K < $500K 5 = < $100K

ASSESSMENT CRITERIA	DEFINITION	WEIGHTING FACTOR	RATING
Lifecycle Operation and Maintenance (O&M) Cost	Magnitude of cost for operation and maintenance based on typical lifecycle of each promising solution	0.3	0 = Very High 1 = High 2 = Moderate to High 3 = Moderate 4 = Low to Moderate 5 = Low
Other Funding Opportunities and/or Shared Resources	Percent of project funding that is expected to be provided by the Drainage Board (DB), other City Boards or Departments, or other sources (State/Federal funds, grants, low-interest loans, etc.)	0.25	0 = 100% DB 1 = 75% DB 2 = 50% DB 3 = 75% City 4 = 75% other 5 = 100% other

Table 7-2 TBL Social Metric

ASSESSMENT CRITERIA	DEFINITION	WEIGHTING FACTOR	RATING
Widespread Benefit	Number of properties that the promising solution will benefit	0.40	0 = 0 properties 1 = 1 to 10 2 = 11 to 30 3 = 31 to 100 4 = 101 to 500 5 = 500+
Reduce Flooding and Drainage Problems	Ability of the promising solution to reduce current or anticipated future flooding and drainage problem	0.30	0 = None 1 = Limited 2 = Limited to Moderate 3 = Moderate 4 = Moderate to High 5 = High
Benefit to Public Health and Safety	Ability of the promising solutions to improve public health and safety concerns related to flooding and drainage issues	0.20	0 = None 1 = Limited 2 = Limited to Moderate 3 = Moderate 4 = Moderate to High 5 = High
Promotes Revitalization, Quality of Life (QOL) and Publicly Acceptable	Consistent with City redevelopment goals; improves quality of life; generally accepted by the public	0.10	0 = None 1 = Limited 2 = Limited to Moderate 3 = Moderate 4 = Moderate to High 5 = High

Table 7-3 TBL Environmental Metric

ASSESSMENT CRITERIA	DEFINITION	WEIGHTING FACTOR	RATING
Treat Pollutants of Concern	Effectiveness of promising solution to treat pollutants of concern carried by stormwater runoff	0.40	0 = No Removal 1 = 1% to 20% 2 = 21% to 40% 3 = 41% to 60% 4 = 61% to 80% 5 = > 80%
Improve Stream Habitat	Ability of the promising solution to improve riparian and instream habitat	0.30	0 = No Change 1 = Limited 2 = Limited to Moderate 3 = Moderate 4 = Moderate to High 5 = High
Restore Natural & Beneficial Function of Floodplain	Ability of the promising solution to restore the natural and beneficial function of the floodplain	0.30	0 = No Change 1 = Limited 2 = Limited to Moderate 3 = Moderate 4 = Moderate to High 5 = High

7.2 SELECTION OF RECOMMENDED MASTER PLAN COMPONENTS

Using the criteria, weighting factor and rating of the TBL Assessment described above, each promising solution discussed in Chapter 6 was ranked. **Table 7-4** lists the promising solutions, the TBL score, whether or not the solution is recommended as a Master Plan component, if the solution can be implemented independent of other recommended Master Plan components, and the Target Study Area.

A TBL worksheet was completed by OPCD, JTL, and CBBEL. However, since this is a SWMP for the City of Jeffersonville, the detailed scoring of each promising solution was based on the City staff ranking. Appendix 8 includes the completed worksheets from the City and a summary of overall scores from the City, OPCD, JTL, and CBBEL.

Table 7-4 TBL Score and Selection of Recommended Master Plan Components

ID #	PROMISING SOLUTION	TBL SCORE	Recommended Master Plan Component	Implemented Independent of other Components	TARGET STUDY AREA
PS-1	City's Participation in Community Rating System	11	YES	YES	Buildings in the SFHA
PS-2	Prioritization Plan for Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA	10	YES	NO[6]	
PS-3	Citywide Fluvial Erosion Mapping	9	YES	NO[6]	Citywide
PS-4	Citywide Flood Response Plan	7	YES	NO[6]	
PS-5	Citywide Update of Stream Hydraulic Studies	5	YES	YES	
PS-6	Citywide Green Infrastructure Policy	11	YES	YES	
PS-7	Citywide Floodplain Management Ordinance Update	11	YES	YES	
PS-8	Citywide Stormwater Ordinance & Technical Standards Update	10	YES	YES	
PS-9	Citywide Development Codes & Design Standards Update	9	YES	YES	
PS-10	Citywide Operations & Maintenance Manuals Update	10	YES	YES	
PS-11	Canal as Planned Alternative Downtown Flood Control Project	5	NO[1, 2]	NO[2]	CSO/ Downtown
PS-12	Reverse Canal Alternative Downtown Flood Control Project	5	NO[1, 2]	NO[2]	
PS-13	Storm Sewer Interceptor Alternative Downtown Flood Control Project	5	NO[1, 2]	NO[2]	
PS-14	Near-Surface Tunnel Alternative Downtown Flood Control Project	5	NO[1, 2]	NO[2]	
PS-15	Voluntary Acquisition and/or Floodproofing Program in the CSO/Downtown Area	6	YES[2]	NO[6]	
PS-16	Green Infrastructure in the CSO/Downtown Area	9	YES	YES	

ID #	PROMISING SOLUTION	TBL SCORE	Recommended Master Plan Component	Implemented Independent of other Components	TARGET STUDY AREA
PS-17	Flood Depth Mapping in OPCD	10	YES	NO[6]	OPCD
PS-18	Fluvial Erosion Mapping in OPCD	9	YES	NO[6]	
PS-19	Updating Stream Study of Lancassange Creek	8	YES	YES	
PS-20	Green Infrastructure in OPCD	8	YES	YES	
PS-21	Construction of New or Upgraded Storm Sewers throughout OPCD (McBride Dr., Laurel Ave, & Capitol Hills Dr.)	6	YES	YES	
PS-22	Bypass Channel of Lancassange Creek OPCD Flood Control Project	9	YES[3]	NO[6]	
PS-23	Upstream Offline Detention Basins OPCD Flood Control Project	9	YES[3]	NO[6]	
PS-24	Combination of Bypass Channel and Upstream Offline Detention Basins OPCD Flood Control Project	8	NO[3]	NO[6]	
PS-25	Levee and Pump Station near Lancassange Creek Mouth OPCD Flood Control Project	5	NO[4]	NO[6]	
PS-26	Voluntary Acquisition and/or Floodproofing Program in OPCD	9	YES[5]	NO[6]	
PS-27	Stream Restoration of Lancassange Creek in OPCD	8	YES	YES	
PS-28	Updating Stream Study of Lentzier Creek	7	YES	YES	Lentzier Creek
PS-29	Stream Restoration of Lentzier Creek	7	YES	YES	
PS-30	Voluntary Acquisition and/or Floodproofing Program in Waverly	7	YES	NO[6]	Waverly
PS-31	Increasing the capacity of Upper Lick Run openings under Abandoned Railroad and Charleston New Albany Road in Waverly	2	NO	NA	
PS-32	Stream Restoration of Upper Lick Run in Waverly	5	NO	NA	

ID #	PROMISING SOLUTION	TBL SCORE	Recommended Master Plan Component	Implemented Independent of other Components	TARGET STUDY AREA
PS-33	Upstream Stormwater Pond at Golf Course in Waverly	4	NO	NA	
PS-34	Voluntary Acquisition and/or Floodproofing Program in Woodland Court	6	YES	NO[6]	Woodland Court
PS-35	Flood Depth Mapping in Woodland Court	5	YES	NO[6]	
PS-36	Updating Stream Study of Woodland Court Tributary	5	YES	YES	
PS-37	Enlarging Culvert under Woodland Court Tributary	3	NO	NA	
PS-38	Stream Restoration of Woodland Court	7	YES	YES	
PS-39	Constructed Wetland in Woodland Court	11	YES	YES	
PS-40	Voluntary Acquisition and/or Floodproofing Program in Lick Run	6	YES	NO[6]	Lick Run
PS-41	Flood Depth Mapping of Lick Run	5	YES	NO[6]	
PS-42	Increasing the conveyance capacity of Hamburg Pike and Cooper Lane crossings of Lick Run	5	NO	NA	
PS-43	Updating Stream Study of Mill Creek	5	YES	YES	Mill Creek
PS-44	Increasing the Culvert capacity of Mill Creek at Woodland Court Crossing	4	NO	NA	
PS-45	Stream Restoration of Mill Creek	7	YES	YES	

NOTES:

[1] These promising solutions are considered to be mutually exclusive.

[2] CBBEL used the most updated modeling of the existing downtown stormwater system available to evaluate various downtown flood control alternatives. However, the potential extent of flooding in existing conditions could not be reliably determined from this model. In addition, during the TBL assessment, the City indicated having serious concerns regarding the representativeness and accuracy of the noted modeling given the recent capital improvement projects in the area. A new refined modeling of the downtown stormwater system is necessary before any of these alternatives are considered for implementation. At the time of writing of this report, it was believed that such a refined detailed modeling may have been included as part of a study commissioned by the Jeffersonville-Clarksville Flood Control District (and cost-shared by the Drainage Board) to determine

the appropriate flood control levee interior drainage pump capacity for the Cane Run Watershed. If the noted study does not include a refined analysis of the downtown stormwater system, then it is recommended that such refined analysis is initiated as soon as possible.

[3] The promising solution PS-24 is considered to be mutually exclusive with PS-22 and PS-23. Based on the detailed evaluation by CBBEL, PS-22 (the bypass channel), is the most effective and economical. However, if the bypass channel is found infeasible due to inability to obtain the necessary easements, then PS-23 should be pursued.

[4] The promising solution is technically and economically inferior to other alternatives and is not recommended as a master plan component.

[5] This promising solution is supplementary to other recommended Master Plan components and is expected to address the remaining buildings that will remain at risk after other components are formulated and implemented.

[6] Implementation of this master plan component is dependent on the completion of the PS-2 and associated updated stream hydraulic studies as part of other recommended Master Plan components.

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CHAPTER 8 FUNDING CONSIDERATIONS OF RECOMMENDED MASTER PLAN COMPONENTS

This chapter provides a summary of possible local, state, and federal funding for the implementation of recommended Master Plan components. This listing is not exhaustive as funding availability and priorities may change on a regular basis to meet the changing needs and trends in stormwater and floodplain management. Many of these funding sources identified below are grants and as a result can be very competitive in nature. Therefore, when applying for funds it is important to show a diverse group of partners and funding sources with the ability to utilize one funding source to either leverage additional funds or to complement those funds for the same project.

8.1 LOCAL FUNDING SOURCES

City Stormwater Utility – Jeffersonville residents, excluding the Oak Park Conservancy District, pay a monthly drainage fee of $3.50 to provide funds for drainage maintenance, capital improvements, and implementation of the stormwater management permit. Non-residential properties are billed based on Equivalent Residential Units (ERU) of $3.50 per 2,500 square feet of impervious surface. The drainage fee is included on the sanitary sewer billing statement.

City General Operating Funds – provides the resources necessary to sustain the day-to-day activities and pays for all administrative and operating expenses. This includes updates and revisions to City plans, policies, and procedures.

Oak Park Conservancy District (OPCD) – a special taxing district that is formed to solve problems related to water resource management such as addressing drainage and flooding problems; providing water supply including treatment and distribution, for domestic, industrial, and public use; and providing for the collection, treatment, and disposal of sewage. Since OPCD collects its own fees to address stormwater issues, it does not contribute to the City Stormwater Utility. Projects identified in the OPCD may require special funding arrangements.

Clarksville-Jeffersonville Flood Control District – an independent unit of government, separate from the City of Jeffersonville and the Town of Clarksville that is responsible for maintaining and operating flood control in both communities.

8.2 STATE FUNDING SOURCES

IDEM Section 319 Program – the Federal Clean Water Act Section 319(h) provides funds for various types of projects that work to reduce non-point source water pollution. Funds may be used to conduct assessments, develop and implement Total Maximum Daily Loads (TMDLs) and watershed management plans, provide technical assistance, demonstrate new technology and provide education and outreach. EPA has a special interest in further studying and implementing green infrastructure to manage stormwater runoff. A 40% non-federal in-kind or cash match of the total project if required.

Indiana State Revolving Loan Fund (SRF) – provides low interest loans to Indiana communities for project that improve wastewater and drinking water infrastructure as well as non-point source pollution. IDEM and the State Budget Agency work together to administer this program and to protect public health and the environment.

Indiana Transportation Enhancements (TE) Program – funds for transportation-related activities that are designed to strengthen the cultural, aesthetic, and environmental aspects of the transportation system. Funds are available for the implementation of a variety of non-traditional projects with examples ranging from acquisition of scenic easements, landscaping and scenic beautification, and to the mitigation of water pollution from highway runoff.

Community Development Block Grants (CDBG) – funds provided from the US Department of Housing and Urban Development (HUD) to States for a wide range of unique community development activities including but not limited to property acquisition, public services, planning activities, and development projects. These projects may include flood-related projects such as stream hydraulic studies, floodplain management, infrastructure, and ordinance development. Federal funds are administered through the Indiana Office of Community and Rural Affairs (OCRA) and Indiana Housing and Community Development Authority (HCDA).

FEMA Hazard Mitigation Assistance (HMA) Grants – provide funding for eligible mitigation activities that reduce disaster losses and protect life and property from future disaster damage. Eligible mitigation activities range from emergency response planning to acquisition or retrofitting of floodprone structures. This program includes the Hazard Mitigation Grant Program (MHGP), Pre-Disaster Mitigation (PDM), Flood Mitigation Assistance (FMA), Repetitive Flood Claims (RFC), and Severe Repetitive Loss (SRL) grant programs. Funding is provided to eligible communities through the State Mitigation Office. Available funding and cost-share varies among the different grant programs.

8.3 FEDERAL FUNDING SOURCES

EPA Clean Water State Revolving Loan Fund (CWSRLF) – operate much like environmental infrastructure banks that are capitalized with federal and state contributions. Monies are loaned to communities and loan repayments are recycled back into the program to fund additional water quality protection projects. The revolving nature of these programs provides for an ongoing funding source that will last far into the future. Eligible projects range from wastewater systems and nonpoint source pollution control to estuary management and specific water quality practices. Funding is directed to state-identified high priority projects.

FEMA Cooperating Technical Partner (CTP) – an innovative approach to creating partnerships and leveraging resources between FEMA and participating NFIP communities, regional agencies, State agencies, tribes, and universities that have the interest and capability to become more active participants in the FEMA flood hazard mapping program. Due to the Indiana Department of Natural Resources (IDNR) becoming a state CTP a few years back, this source of funding is now funneled through IDNR who prioritizes and conducts stream hydraulic studies throughout the state.

USACE Section 22 – planning assistance from the US Army Corps of Engineers (USACE) to States for studies and projects related to flood damage reduction, water supply, water conservation, environmental restoration, water quality, hydropower, erosion, navigation, fish and wildlife, cultural resources, and environmental resources. The federal allotment to each State is $500,000 annually and funds projects that are generally $20,000 to $150,000 each, but could be more. The cost-share is 50% federal and 50% non-federal basis.

Land and Water Conservation Fund (LWCF) – provides matching grants to State and local governments for the acquisition and development of public outdoor recreation areas and facilities. Funds have been widely used for land acquisition and open space development which can include wetland development, critical seeding areas and other projects to reduce the impacts of flooding and water quality impairments.

HUD Sustainable Communities Regional Planning (SCRP) Grants – supports metropolitan and multi-jurisdictional planning efforts to integrate housing, land use, economic and workforce development, transportation, and infrastructure investment to meet the challenges of economic competitiveness and revitalization, social equity and access to opportunity, energy use and climate change, and public health and environmental impact.

USGS – provides limited matching funds for operation and maintenance of stream gages for more accurately floodplain mapping and emergency response planning efforts.

National Weather Service (NWS) Automated Flood Warning System (AFWS) Grants – to reduce the loss of life, property damage, and disruption of commerce from floods. AFWS funds may be used to alert local officials of flood threats, environmental monitoring, and water resource management.

Based on current funding allocation and priorities, Table 8-1 illustrates how these possible funding sources could apply to each of the recommended Master Plan components selected for implementation.

Table 8-1 Possible Funding Sources for Recommended Master Plan Components

ID #	MASTER PLAN COMPONENT	LOCAL FUNDING				STATE FUNDING							FEDERAL FUNDING				
		Stormwater Utility	General Operating Funds	OPCD	Flood Control District	IDEM 319	SRF Loan	TE Program	CDBG	HMA Grants	CWSRLF Loan	CTP	USACE Section 22	LWCF	HUD SCRP Grants	USGS Funds	NWS AFWS Grants
STRUCTURAL																	
PS-39	Constructed Wetland in Woodland Court		X										X	X			
PS-16	Green Infrastructure in the CSO/Downtown Area	X				X	X	X	X		X						
PS-20	Green Infrastructure in OPCD	X		X		X	X	X	X		X						
PS-21	Construction of New or Upgraded Storm Sewers throughout OPCD (McBride Dr., Laurel Ave. & Capitol Hills Dr.)	X		X			X		X								
PS-27	Stream Restoration of Lancassange Creek in OPCD	X		X									X	X			
PS-29	Stream Restoration of Lentzier Creek	X											X	X			
PS-38	Stream Restoration of Woodland Court	X											X	X			
PS-45	Stream Restoration of Mill Creek	X											X	X			
PS-15	Voluntary Acquisition and/or Floodproofing Program in the CSO/Downtown Area[1]	X								X			X	X			
PS-22	Bypass Channel of Lancassange Creek OPCD Flood Control Project[2]	X		X	X												
PS-23	Upstream Offline Detention Basins OPCD Flood Control Project	X		X	X												
PS-26	Voluntary Acquisition and/or Floodproofing	X		X						X			X	X			

ID #	MASTER PLAN COMPONENT	LOCAL FUNDING				STATE FUNDING							FEDERAL FUNDING				
		Stormwater Utility	General Operating Funds	OPCD	Flood Control District	IDEM 319	SRF Loan	TE Program	CDBG	HMA Grants	CWSRLF Loan	CTP	USACE Section 22	LWCF	HUD SCRP Grants	USGS Funds	NWS AFWS Grants
	Program in OPCD																
PS-30	Voluntary Acquisition and/or Floodproofing Program in Waverly	X								X			X	X			
PS-34	Voluntary Acquisition and/or Floodproofing Program in Woodland Court	X								X			X	X			
PS-40	Voluntary Acquisition and/or Floodproofing Program in Lick Run	X								X			X	X			
	NON-STRUCTURAL																
PS-8	Citywide Stormwater Ordinance & Technical Standards Update	X		X					X						X		
PS-7	Citywide Floodplain Management Ordinance Update	X	X	X					X						X		
PS-6	Citywide Green Infrastructure Policy	X		X		X			X						X		
PS-10	Citywide Operations & Maintenance Manuals Update	X	X	X											X		
PS-19	Updating Stream Study of Lancassange Creek	X		X								X					
PS-28	Updating Stream Study of Lentzier Creek	X										X					
PS-36	Updating Stream Study of Woodland Court Tributary	X										X					
PS-43	Updating Stream Study of Mill Creek	X										X					
PS-5	Citywide Update of Stream Hydraulic Studies	X										X					
PS-9	Citywide Development	X	X	X					X						X		

ID #	MASTER PLAN COMPONENT	LOCAL FUNDING				STATE FUNDING							FEDERAL FUNDING				
		Stormwater Utility	General Operating Funds	OPCD	Flood Control District	IDEM 319	SRF Loan	TE Program	CDBG	HMA Grants	CWSRLF Loan	CTP	USACE Section 22	LWCF	HUD SCRP Grants	USGS Funds	NWS AFWS Grants
	Codes & Design Standards Update																
PS-1	City's Participation in Community Rating System	X	X	X													
PS-4	Citywide Flood Response Plan	X	X	X												X	X
PS-17	Flood Depth Mapping in OPCD	X										X					
PS-18	Fluvial Erosion Mapping in OPCD	X		X								X					
PS-35	Flood Depth Mapping in Woodland Court	X										X					
PS-41	Flood Depth Mapping of Lick Run	X										X					
PS-3	Citywide Fluvial Erosion Mapping	X										X					
PS-2	Prioritization Plan for Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA	X	X	X						X							

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CHAPTER 9 SUMMARY & CONCLUSIONS

9.1 SUMMARY OF PLANNING PROCESS

The purpose of this SWMP is to present findings and observations, and provide recommended alternatives based on the results of detailed analysis that will:

- Prevent or minimize future damages,
- Solve or reduce existing flood/drainage problems,
- Help preserve the natural and beneficial function of the drainage system, and
- Help preserve and enhance stormwater quality.

To achieve this, the Project Team engaged the public to identify problem areas. In all 205 problem areas were identified and mapped in GIS. These included 32 building flooding, 46 street flooding, 60 drainage issues, 20 restrictive structures, 32 riverine flooding, 10 maintenance issues, and 5 streambank erosion. In addition to this firsthand knowledge of the flooding, drainage, and water quality problems, CBBEL completed a GIS analysis and identified 1,928 buildings in the SFHA, 289 of which are located in the floodway. As part of this SWMP, IU students collected and analyzed chemical, biological, and physical water quality data from 10 sites throughout the City.

The Project Team thoroughly reviewed each of the problem areas, the probably source and potential solution. From this discussion the 205 problem areas were divided into 80 local, 49 neighborhood, and 76 regional scale problems. Based on the consensus of the Project Team and the Advisory Committee, this SWMP focuses only on identifying solutions for the larger, more complicated neighborhood and regional scale problems. Local problems will be addressed directly by the City.

When only the neighborhood and regional problem areas were mapped, 9 distinct Target Study Areas became evident. These were labeled as Buildings in the SFHA, Citywide, CSO/Downtown Area, OPCD, Lentzier Creek, Waverly, Woodland Court, Lick Run, and Mill Creek Target Study Areas. A comprehensive list of structural and non-structural potential solutions was prepared for each Target Study Area. The list of potential solutions was initially screened, under the guidance of the Advisory Committee, using agreed upon economic, social, and environmental performance criteria. This process resulted in a short-list of 45 promising solutions for detailed evaluation.

CBBEL and JTL conducted a detailed evaluation of each of the 45 promising solutions. The discussion was grouped by Target Study Area and includes a brief description of the area and types of problems as well as a discussion, conceptual layout, analysis, and estimated cost. Two promising solutions were evaluated for Buildings in the SFHA, 8 for Citywide, 6 for CSO/Downtown Area, 11 for OPCD, 2 for Lentzier Creek, 4 for Waverly, 6 for Woodland Court, 3 for Lick Run, and 3 for Mill Creek Target Study Areas.

To identify recommended Master Plan components, the list of promising solutions were further screened using a TBL assessment. The Advisory Committee assisted with the development of the criteria and weighting used in the TBL assessment. City representatives used the TBL assessment to rank the 45 promising solutions and identify 33 recommended Master Plan components. The recommended Master Plan components were prioritized and implementation steps listed.

9.2 SUMMARY OF RECOMMENDED MASTER PLAN COMPONENTS

The following tables (**Table 9-1** and **Table 9-2**) prioritize the recommended Master Plan components identified into structural and non-structural solutions. To determine the priority of the recommended Master Plan components, several factors were considered including whether the master plan component could be implemented independent of another component, the TBL score, the ease of implementation, potential timely access to available funding, and judgment of the Project Team.

The Master Plan provides a roadmap for the City of Jeffersonville to address existing and anticipated future flooding, drainage, and water quality problems and concerns in a comprehensive, regional, multi-year approach. Implementation of several recommended Master Plan components may require multiple steps. To aid the City in budgeting for implementing the recommended Master Plan components, the estimated budget for the next necessary step has been identified in Table 9-1 and Table 9-2. These next steps may include a Preliminary Engineering Report, design and construction documents, grant administration, etc. Chapter 10 includes a list of implementation steps for each of these recommended Master Plan components.

Table 9-1 Prioritized Recommended Structural Master Plan Components

PRIORITY	ID #	RECOMMENDED MASTER PLAN COMPONENT	TARGET STUDY AREA	ESTIMATED COST FOR FULL IMPLEMENTATION	ESTIMATED COST FOR NEXT STEP
HIGH PRIORITY					
1	PS-39	Constructed Wetland in Woodland Court	Woodland Court	$45,000	$45,000
2	PS-16	Green Infrastructure in the CSO/Downtown Area (Spring Street CSO Pilot)	CSO/ Downtown	varies (up to $1,400,000)	$75,000[1]
3	PS-20	Green Infrastructure in OPCD (Senate Avenue Pilot)	OPCD	varies (up to $250,000)	$75,000[1]
4	PS-21	Construction of New or Upgraded Storm Sewers throughout OPCD (McBride Dr., Laurel Ave. & Capitol Hills Dr.)	OPCD	varies (up to $3,750,000)	$300,000[2]
5	PS-27	Stream Restoration of Lancassange Creek in OPCD	OPCD	$2,000,000	$160,000[3]
	PS-29	Stream Restoration of Lentzier Creek	Lentzier Creek	$1,000,000	$80,000[3]
	PS-38	Stream Restoration of Woodland Court	Woodland Court	$550,000	$44,000[3]
	PS-45	Stream Restoration of Mill Creek	Mill Creek	$300,000	$22,000[3]
MEDIUM PRIORITY					
6	PS-22	Bypass Channel of Lancassange Creek OPCD Flood Control Project[4]	OPCD	$2,400,000	$50,000[5]
7	PS-23	Upstream Offline Detention Basins OPCD Flood Control Project[4]	OPCD	$9,500,000	$75,000[6]
8	PS-15	Voluntary Acquisition and/or Floodproofing Program in the CSO/Downtown Area[7]	CSO/ Downtown	varies (up to $2,700,000)	$10,000[8]
	PS-26	Voluntary Acquisition and/or Floodproofing Program in OPCD	OPCD	varies (up to $6,500,000)	$50,000[9]

PRIORITY	ID #	RECOMMENDED MASTER PLAN COMPONENT	TARGET STUDY AREA	ESTIMATED COST FOR FULL IMPLEMENTATION	ESTIMATED COST FOR NEXT STEP
	PS-30	Voluntary Acquisition and/or Floodproofing Program in Waverly	Waverly	varies (up to $1,500,000)	$30,000[9]
	PS-34	Voluntary Acquisition and/or Floodproofing Program in Woodland Court	Woodland Court	varies (up to $580,000)	$30,000[9]
	PS-40	Voluntary Acquisition and/or Floodproofing Program in Lick Run	Lick Run	varies (up to $350,000)	$30,000[9]

NOTES:

[1] Estimated cost for a Preliminary Engineering Report (PER) that would also include an initial desktop analysis for the entire proposed study area.

[2] Estimated cost for developing design and construction documents that would also consider being combined with green infrastructure (PS-20)

[3] Estimated cost for developing design and construction documents

[4] Based on the detailed evaluation by CBBEL, PS-22 (the bypass channel), is the most effective and economical structural alternative for the OPCD study area. However, if the bypass channel is found infeasible due to inability to obtain the necessary easements, then the previously discussed Upstream Offline Detention Basins (PS-23) should be pursued instead. If the latter alternative is pursued, the first step will be to evaluate the feasibility and availability of proposed conceptual basin locations.

[5] Estimated cost for developing a Preliminary Engineering Report (PER).

[6] Estimated cost for a feasibility study to determine which sites can be potentially available for basin construction, what size pond can fit in those sites, and performing calculations to determine effectiveness, extent of benefits, potential costs, and priority basin locations.

[7] A new refined modeling of the downtown stormwater system is necessary to confirm the existing extent of residual flooding in downtown area before any voluntary buyout or acquisition or floodproofing effort is considered for implementation. At the time of writing of this report, it was believed that such a refined detailed modeling may have been included as part of a study commissioned by the Jeffersonville-Clarksville Flood Control District (and cost-shared by the Drainage Board) to determine the appropriate flood control levee interior drainage pump capacity for the Cane Run Watershed. If the noted study does not include a refined analysis of the downtown stormwater system, then it is recommended that such refined analysis is initiated as soon as possible. Depending on the findings of this model, it may also be necessary to re-evaluate the necessity and appropriateness of one of the previously discussed (but not currently recommended) downtown flood control projects (PS-11 through PS-14).

[8] Estimated cost for developing a floodproofing cost-share assistance application process

[9] Estimated cost for administrative efforts to put together a buyout grant application

Table 9-2 Prioritized Recommended Non-structural Master Plan Components

PRIORITY	ID #	RECOMMENDED MASTER PLAN COMPONENT	TARGET STUDY AREA	TOTAL ESTIMATED COST	ESTIMATED BUDGET FOR NEXT STEP
HIGH PRIORITY					
1	PS-8	Citywide Stormwater Ordinance & Technical Standards Update	Citywide	$15,000	$15,000
2	PS-7	Citywide Floodplain Management Ordinance Update	Citywide	$5,000	$5,000
3	PS-6	Citywide Green Infrastructure Policy	Citywide	$5,000	$5,000
4	PS-10	Citywide Operations & Maintenance Manuals Update	Citywide	$10,000	$10,000
5	PS-19	Updating Stream Study of Lancassange Creek	OPCD	$26,000	$26,000
	PS-28	Updating Stream Study of Lentzier Creek	Lentzier Creek	$18,000	$18,000
	PS-36	Updating Stream Study of Woodland Court Tributary	Woodland Court	$10,500	$10,500
	PS-43	Updating Stream Study of Mill Creek	Mill Creek	$18,000	$18,000
	PS-5	Citywide Update of Stream Hydraulic Studies	Citywide	$45,000	$45,000
6	PS-9	Citywide Development Codes & Design Standards Update	Citywide	$30,000	$30,000
7	PS-1	City's Participation in Community Rating System	Buildings in the SFHA	$10,000	$10,000
MEDIUM PRIORITY					
8	PS-17	Flood Depth Mapping in OPCD	OPCD	$6,000	$6,000
	PS-35	Flood Depth Mapping in Woodland Court	Woodland Court	$1,000	$1,000
	PS-41	Flood Depth Mapping of Lick Run	Lick Run	$1,000	$1,000
9	PS-4	Citywide Flood Response Plan	Citywide	$45,000	$45,000
10	PS-18	Fluvial Erosion Mapping in OPCD	OPCD	$4,000	$4,000
	PS-3	Citywide Fluvial Erosion Mapping	Citywide	$16,000	$16,000

PRIORITY	ID #	RECOMMENDED MASTER PLAN COMPONENT	TARGET STUDY AREA	TOTAL ESTIMATED COST	ESTIMATED BUDGET FOR NEXT STEP
11	PS-2	Prioritization Plan for Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA	Buildings in the SFHA	$50,000	$50,000

9.3 CONCLUSIONS

This Master Plan provides a roadmap for the City of Jeffersonville to address existing and anticipated future flooding, drainage, and water quality problems and concerns in a comprehensive, regional, multi-year approach. The total estimated cost for recommended structural and non-structural recommended Master Plan components is up to $32,825,000 and $315,500, respectfully. Implementation of the recommended Master Plan components should include a balance of both structural and non-structural solutions. As much as possible, projects should be geographically distributed throughout the City to benefit as many people as possible. Implementation will require many years of funding from various sources.

In addition to the recommended Master Plan components listed in Tables 9-1 and 9-2, this Plan identified 70 local drainage, flooding or water quality problems. These problems are smaller in scale and should be addressed using relatively simple design or maintenance solutions. These do not require the same level of detailed evaluation as the larger neighborhood or regional problems that are addressed in this Stormwater Mater Plan. As solutions to these problems are identified, they should also be subjected to the Triple Bottom Line evaluation procedure identified in this study and prioritized. As of the time of writing of this Master Plan, the following three local-scaled projects have already been identified and recommended to be pursued as early implementation projects:

1. 8th Street & Hopkins Lane Storm Improvements (estimated cost = $430,000)
2. Magnolia Avenue & Roselawn Court Drainage Improvements (estimated cost = $592,680)
3. 8th & Ohio/7th & Indiana Detention Basin (estimated cost = $380,000)

CHAPTER 10 PROPOSED IMPLEMENTATION PLAN

The success of this SWMP will be in its implementation. This Chapter provides a prioritized list of actions to be followed in order to implement the recommended Master Plan components identified in Chapter 7. To facilitate implementation, the recommended Master Plan components have been divided into structural and non-structural projects and organized by either high or medium priority for implementation. Recommended Master Plan components with similar implementation steps, such as stream hydraulic studies, mapping, and restoration have been grouped together.

It should be noted that implementation of each recommended Master Plan component may involve several preparatory or intermediary steps. However, for simplicity, not all preparatory or intermediary steps are included.

10.1 HIGH PRIORITY STRUCTURAL RECOMMENDED MASTER PLAN COMPONENTS

1. **Constructed Wetland in Woodland Court (PS-39)**

   A 15-acre constructed wetland is proposed along the Woodland Court Tributary to Lancassange Creek. This project is expected to improve the natural and beneficial function of the Woodland Court floodplain as well as mitigate flooding in the area caused by smaller storm events.

   - Target Study Area: Woodland Court
   - Estimated Cost for Full Implementation: $45,000
   - Estimated Time to Complete: 12 months
   - Implementation Steps:
     1. Acquire property for wetland mitigation project
     2. Prepare a conceptual wetland restoration plan, design and construction documents
     3. Construct project
     4. Monitor wetland function to reduce flooding and improve water quality

2. **Green Infrastructure in the CSO/Downtown Area (PS-16) Spring Street CSO Pilot**

   Green infrastructure is an effective method to mitigate nuisance flooding, eliminate CSO events, improve water quality, and provide green space in an urban area. The Spring Street CSO area was selected as a pilot area to illustrate the benefit of porous pavement, bioretention, green roofs, and tree boxes.

- Target Study Area: CSO/Downtown
- Estimated Cost for Full Implementation: varies (up to) $1,400,000
- Next Step & Estimated Cost: Preliminary Engineering Report $75,000
- Estimated Time to Complete Next Step: 6 months
- Implementation Steps:
  1. Conduct a detailed field investigation of potential green infrastructure sites identified in the desktop analysis conducted as part of this SWMP
  2. Model specific green infrastructure practices to determine water quality and water quantity benefit.
  3. Complete Preliminary Engineering Report
  4. Complete design, construction and operation and maintenance documents
  5. Construct project and maintain as directed in the operation and maintenance documents
  6. Monitor effectiveness of green infrastructure practices

3. Green Infrastructure in OPCD (PS-20) Senate Avenue Pilot

Green infrastructure practices in OPCD were limited to the streets since they are owned and maintained by the City. Retrofit practices include bioretention and porous pavement in one parking lane of selected streets. Senate Avenue was selected as a pilot to illustrate the benefits of green infrastructure.

- Target Study Area: OPCD
- Estimated Cost for Full Implementation: varies (up to) $250,000
- Next Step & Estimated Cost: Preliminary Engineering Report $75,000
- Estimated Time to Complete Next Step: 6 months
- Implementation Steps:
  1. Implementation should be in conjunction with new or upgraded storm sewers throughout OPCD along McBride Drive, Laurel Avenue and Capitol Hills Drive (PS-21)
  2. Conduct a public meeting with OPCD residents to gain their input and support of the project
  3. Complete a detailed field investigation to select streets for green infrastructure practices
  4. Model specific green infrastructure practices to determine water quality and water quantity benefit.

5. Complete Preliminary Engineering Report
6. Complete design, construction and operation and maintenance documents
7. Construct project and maintain as directed in the operation and maintenance documents
8. Monitor effectiveness of green infrastructure practices

4. Construction of New or Upgraded Storm Sewers throughout OPCD (PS-21) McBride Drive, Laurel Avenue and Capitol Hills Drive

New storm sewers in OPCD are needed to better convey stormwater away from residential properties and roadways along McBride Drive, Laurel Avenue and Capitol Hills Drive.

- Target Study Area: OPCD
- Estimated Cost for Full Implementation: varies (up to) $3,750,000
- Next Step & Estimated Cost: Design and Construction Documents $300,000
- Estimated Time to Complete Next Step: 6 months
- Implementation Steps:
  1. Implementation should be in conjunction with green infrastructure in OPCD (PS-20)
  2. Conduct a walk-thru of the potential areas with OPCD officials
  3. Investigate potential impact to WHPAs from discharge point
  4. Develop design and construction documents
  5. Construct project

5. Stream Restoration (PS-27, PS-29, PS-38, PS-45)

Stream restoration should be completed to improve the conveyance of stormwater runoff and overall water quality of the receiving streams

- Target Study Areas: OPCD, Lentzier Creek, Woodland Court, Mill Creek
- Estimated Cost for Full Implementation:
  - $2,000,000 (Lancassange Creek in OPCD)
  - $1,000,000 (Lentzier Creek)
  - $550,000 (Woodland Court)
  - $300,000 (Mill Creek)
- Next Step & Estimated Cost: Design and Construction Documents
  - $160,000 (Lancassange Creek in OPCD)
  - $80,000 (Lentzier Creek)
  - $44,000 (Woodland Court)

  - $22,000 (Mill Creek)
- Estimated Time to Complete: 18 months for each Target Study Area
- Implementation Steps:
  1. Develop design and construction documents
  2. Construct project
  3. Monitor effectiveness of restoration projects

10.2 MEDIUM PRIORITY STRUCTURAL RECOMMENDED MASTER PLAN COMPONENTS

6. Bypass Channel of Lancassange Creek OPCD Flood Control Project (PS-22)

A bypass channel is proposed to convey floodwater away from the OPCD and reduce flooding in the area.

- Target Study Area: OPCD
- Estimated Cost for Full Implementation: $2,400,000
- Next Step & Estimated Cost: Preliminary Engineering Report $50,000
- Estimated Time to Complete Next Step: 6 months
- Implementation Steps:
  1. To correctly size the bypass channel and accurately measure its benefits an updated stream hydraulic study for Lancassange Creek in OPCD (PS-19) is needed in advance of, or as part of, the Preliminary Engineering Report
  2. Prepare for and meet with representatives from the Indiana Port Authority to discuss the feasibility of obtaining easements or acquiring land needed for construction of the bypass channel
  3. Complete Preliminary Engineering Report
  4. Complete design and construction documents
  5. Construct the project and maintain as directed in the operation and maintenance documents
  6. Construct project and maintain as directed in the operation and maintenance documents

7. Upstream Offline Detention Basins OPCD Flood Control Project (PS-23)

This alternate includes the construction of several upstream offline detention basins that would allow floodwater to be diverted from the channel into ponds and temporarily stored.

- Target Study Area: OPCD
- Estimated Cost for Full Implementation: $9,500,000

- Next Step & Estimated Cost: Feasibility Study $75,000
- Estimated Time to Complete the Next Step: 6 months
- Implementation Steps:
  1. To correctly size the ponds and accurately measure their benefits, an updated stream hydraulic study for Lancassange Creek in OPCD (PS-19) is needed in advance of, or as part of, the Preliminary Engineering Report
  2. Complete a feasibility study to determine which sites can be potentially available for basin construction, what size pond can fit in those sites, and performing calculations to determine effectiveness, extent of benefits, potential costs, and priority basin locations.
  3. Acquire the needed land for the selected priority sites
  4. Complete design and construction documents for the selected sites
  5. Construct the project(s) and maintain as directed in the operation and maintenance documents

8. Voluntary Acquisition and/or Floodproofing Program (PS-15, PS-26, PS-30, PS-34, PS-40)

Description: Removing or modifying structures subject to flooding reduces the risk of future flood-related losses. Participation in this program is strictly voluntary and no homeowners are ever forced to relinquish their property. Seventy-five percent of the cost of acquisition is borne by FEMA.

- Target Study Areas: CSO/Downtown (canal service area only), OPCD, Waverly, Woodland Court, Lick Run
- Estimated Cost for Full Implementation: cost-share portion varies (up to)
  - $2,700,000 (CSO/Downtown – canal service area only)
  - $6,500,000 (OPCD)
  - $1,500,000 (Waverly)
  - $580,000 (Woodland Court)
  - $350,000 (Lick Run)
- Next Steps & Estimated Cost: Develop Cost-share Application Materials and overall Grant Administration
  - $10,000 (CSO/Downtown – canal service area only)
  - $50,000 (OPCD)
  - $43,000 (Waverly)
  - $30,000 (Woodland Court)
  - $30,000 (Lick Run)
- Estimated Time to Complete: multiple year effort which depends on availability of funding and willingness of property owners

- Implementation Steps:
    1. Implementation depends on the completion of the updated stream hydraulic studies for Lancassange Creek in OPCD (PS-19), Lentzier Creek (PS-28), Woodland Court (PS-36), and Citywide (PS-5)
    2. Implementation of the floodproofing projects in the so called "canal service area" (PS-15) depends on the confirmation through refined analysis of the extent of residual interior drainage flooding within downtown areas and further confirming that major structural solutions, such as various storage-pumping station alternatives evaluated as part of this SWMP will not be needed/favored to address the confirmed level of residual interior drainage risks in this area
    3. Implementation also depends on the completion of the Prioritization Plan for Voluntary Acquisition and/or Floodproofing Program (PS-2) which will help prioritize various acquisition/floodproofing sites and to determine what type of mitigation action is the most appropriate for a given building
    4. Create outreach materials and conduct meetings with interested participants
    5. Assemble supporting materials for grant application including elevations, past flood-related losses, acquisition and/or floodproofing costs
    6. Secure mitigation funding from FEMA to acquire and/or floodproof buildings as listed in the Prioritization Plan (PS-2)

10.3 HIGH PRIORITY NON-STRUCTURAL RECOMMENDED MASTER PLAN COMPONENTS

1. **Citywide Stormwater Ordinance & Technical Standards Update (PS-8)**

Combine current individual stormwater-related ordinances into a single comprehensive ordinance to improve efficiency and avoid confusion. Update the ordinance and standards with site-specific post-development maximum allowable release rates, channel protection volume requirement, and the option to use LID/green infrastructure.

- Target Study Area: Citywide
- Estimated Cost for Full Implementation: $15,000
- Estimated Time to Complete: 6 months
- Implementation Steps:
    1. Compare current ordinance with newer, updated model Stormwater Ordinances and Technical Standards recently

developed for many jurisdictions within the State and document differences
2. Evaluate impact and benefit for future development and water quality
3. Update Stormwater Ordinance and Technical Standards
4. Conduct training for staff reviewers, decision-makers and the development community
5. Adopt and enforce new requirements

2. Citywide Floodplain Management Ordinance Update (PS-7)

In conjunction with the adoption of the 2012 preliminary FIRMs (expected to be finalized in 2013), the City should update the Floodplain Management Ordinance. This updated ordinance should be based on the State's Model Ordinance for Flood Hazard Areas and consider incorporating several of the optional enhancements including the requirement for compensatory storage for fill in the floodplain.

- Target Study Area: Citywide
- Estimated Cost for Full Implementation: $5,000
- Estimated Time to Complete: 3 months
- Implementation Steps:
  1. Compare current ordinance with the State's model ordinance and document differences
  2. Evaluate the impact and benefit of the optional enhancements listed in the model ordinance
  3. Update the Floodplain Management Ordinance with optional enhancements as decided
  4. Streamline permitting procedures as outlined in the State's permitting guidance
  5. Conduct training for staff reviewers, decision-makers and the development community
  6. Adopt and enforce new requirements

3. Citywide Green Infrastructure Policy (PS-6)

Adopt a citywide policy to promote the use of green infrastructure to manage stormwater runoff in new and redevelopment projects.

- Target Study Area: Citywide
- Estimated Cost for Full Implementation: $5,000
- Estimated Time to Complete: 3 months
- Implementation Steps:
  1. Evaluate the impact and benefit of a green infrastructure policy

2. Identify incentives for implementation
3. Draft policy for new and redevelopment projects
4. Integrate policy into existing policies and procedures
5. Prepare educational materials for staff reviewers, decision-makers, and the development community
6. Adopt and enforce policy

4. **Citywide Operations & Maintenance Manuals Update (PS-10)**

Consolidate and enhance existing stormwater and stream maintenance policies and procedures into a single resource to ensure proper maintenance, enhance performance, and reduce nuisance flooding.

- Target Study Area: Citywide
- Estimated Cost for Full Implementation: $15,000
- Estimated Time to Complete: 6 months
- Implementation Steps:
  1. Assemble a master list of maintenance practices and schedules
  2. Incorporate maintenance component for stormwater BMPs from the updated Stormwater Ordinance and Technical Standards (PS-8)
  3. Assemble existing or prepare additional operation and maintenance materials
  4. Conduct training for maintenance staff
  5. Track and record maintenance efforts including staff and equipment resources as well as performance

5. **Updating Stream Hydraulic Studies (PS-19, PS-28, PS-36, PS-43, PS-5)**

A review of the 2012 preliminary FIRM and the most recent aerial photography and contour data showed areas where there are elevation discrepancies in the floodplain, locations where the stream channel is shown outside the floodway, streams that do not have a detailed study, or the H&H model or data that was used to develop a detailed study is outdated.

- Target Study Areas: OPCD, Lentzier Creek, Woodland Court, Mill Creek, Citywide
- Estimated Cost for Full Implementation:
  - $26,000 (Lancassange Creek in OPCD)
  - $18,000 (Lentzier Creek)
  - $10,500 (Woodland Court)
  - $18,000 (Mill Creek)

  - $45,000 (Misc Citywide Streams, including Ohio River, Hamburg Pike Tributary, Greenbriar Tributary, Pleasant Run, Battle Creek, and Jenny Lind Run)
- Estimated Time to Complete: 12 months for all Target Study Areas
- Implementation Steps:
  1. Perform hydrologic analyses to determine appropriate peak discharge values for use in the hydraulic model
  2. Obtain and set up the base map with the latest available topographic information
  3. Collect available information regarding stream crossings
  4. Field visit to each stream to measure and record stream crossing information
  5. Develop hydraulic model and determine BFEs and floodway limits
  6. Develop revised flood hazard areas map for each stream, showing the 1% and 0.2% floodplain limits as well as floodway limits
  7. Prepare a detailed documentation report for each stream and submit to IDNR for their use and incorporation into FIS studies

7. Citywide Development Codes & Design Standards Update (PS-9)

Incorporating LID practices into regional, neighborhood, and site planning efforts can improve water quality and flooding issues. To facilitate implementation of these practices, reduce the barriers to green infrastructure in current development codes and design standards and provide incentives to encourage green practices in targeted areas.

- Target Study Area: Citywide
- Estimated Cost for Full Implementation: $30,000
- Estimated Time to Complete: 12 months
- Implementation Steps:
  1. Create a master list of possible LID practices for regional, neighborhood and site planning efforts
  2. Cross-reference with known planning efforts
  3. Complete the Code and Ordinance Worksheet to identify barriers to implementing LID and green infrastructure practices
  4. Identify target growth areas and special districts to incorporate LID and green infrastructure

5. Evaluate the impact and benefit of incorporating LID and green infrastructure practices
6. Draft LID and green infrastructure language to update development codes and design standards
7. Adopt and enforce policy

8. City's Participation in the Community Rating System (PS-1)

The Community Rating System (CRS) is a voluntary incentive program that rewards communities that go above and beyond the minimum NFIP requirements. As a result, flood insurance premiums are discounted to reflect the reduced flood risk.

- Target Study Area: Buildings in the SFHA
- Estimated Cost for Full Implementation: $10,000
- Estimated Time to Complete: 6 months
- Implementation Steps:
  1. Complete the Community Self Assessment
  2. Meet with the regional CRS Specialist to discuss interest, potential class designation, and review application materials
  3. Assemble CRS application and supporting documentation and participate in the Verification Visit
  4. Submit annual recertification paperwork as directed by CRS Specialist to maintain status in program

10.4 MEDIUM PRIORITY NON-STRUCTURAL RECOMMENDED MASTER PLAN COMPONENTS

9. Flood Depth Mapping (PS-17, PS-35, PS-41)

Flood depth maps are used to illustrate the area and depth of water in a hypothetical flooding scenario. This type of mapping enhances flood response, road closure, and evacuation efforts.

- Target Study Areas: OPCD, Woodland Court, Lick Run
- Estimated Cost for Full Implementation:
  - $6,000 (Lancassange Creek in OPCD)
  - $1,000 (Woodland Court)
  - $1,000 (Lick Run)
- Estimated Time to Complete: 6 months for all Target Study Areas
- Implementation Steps:
  1. Implementation depends on the completion of the updated stream hydraulic studies for Lancassange Creek in OPCD (PS-19), Woodland Court (PS-36), and Lick Run (PS-43) and is recommended to be done as part of the same contract

2. Create terrain tin from best available topographic information
3. Create water surface tin from the floodplain map for a specific return interval
4. Intersect the train and water surface tins and create depth map exhibits

10. Citywide Flood Response Plan (PS-4)

Despite all the efforts to mitigate the flood damages to structures, there will still be a need to effectively respond to a flood event so that the loss of life and injury to citizens can be minimized. A Flood Response Plan can improve response efforts and reduce the risk of human life loss, injury, and damage to property. Fundamental to this Plan is a Warning and Evacuation Annex with procedures for warning, evacuating and sheltering the affected public.

- Target Study Area: Citywide
- Estimated Cost for Full Implementation: $45,000
- Estimated Time to Complete: 6 months
- Implementation Steps:
  1. Implementation depends on the completion of flood depth mapping for OPCD (PS-17), Woodland Court (PS-35), Lick Run (PS-41)
  2. Review previous flood events and associated flood fight efforts
  3. Prepare procedures for flood event detection, notification, expected actions and post-flood follow-up
  4. Establish a system for warning and communicating with the affected public
  5. Prepare procedures for evacuation and identify routes to evacuate the affected population from the flooded area
  6. Conduct a one-day training exercise with local decision-makers and flood fight team members
  7. Adopt the implement the Flood Response Plan

11. Fluvial Erosion Mapping (PS-18, PS-3)

Stream channels are not stationary and want to meander over time to balance the energy and forces of flowing water. This meander usually manifests itself in the form of streambank erosion, which threatens existing structures and infrastructure near the banks. Fluvial erosion maps are used to illustrate the area that may be susceptible to erosion due to stream meandering. These maps can be used to guide development away from a potentially hazardous area as well as identify risk to existing infrastructure near waterways.

- Target Study Areas: OPCD, Citywide
- Estimated Cost for Full Implementation:
  - $4,000 (Lancassange Creek in OPCD)
  - $16,000 (Misc. Citywide streams, including Silver Creek, Lentzier Creek, and Lick Run)
- Estimated Time to Complete: 6 months for both Target Study Areas
- Implementation Steps:
  1. Implementation depends on the completion of the updated stream hydraulic studies for Lancassange Creek in OPCD (PS-19) and Citywide (PS-5)
  2. Field visit and evaluate composition, geometry, and history of channel migration and erosion along the stream
  3. Determine channel top width and use appropriate regional curves to determine the meander belt
  4. Delineate meander belt and develop fluvial erosion hazard exhibit

12. Prioritization Plan for Voluntary Property Acquisition (Buyout) and/or Floodproofing Program for Existing Buildings in the SFHA (PS-2)

Voluntary acquisition and/or floodproofing of existing buildings in the SFHA are an effective method to mitigate flood losses. This plan would evaluate and assign a category to each structure in the SFHA based on the flood zone and anticipated depth of flooding.

- Target Study Area: Citywide
- Estimated Cost for Full Implementation: $50,000
- Estimated Time to Complete: 6 months
- Implementation Steps:
  1. Implementation depends on the completion of the updated stream hydraulic studies for Lancassange Creek in OPCD (PS-19), Lentzier Creek (PS-28), Woodland Court (PS-36), and Citywide (PS-5)
  2. Implementation depends on the completion of the flood depth mapping for Lancassange Creek in OPCD (PS-17), Woodland Court (PS-35), and Lick Run (PS-41)
  3. Determine the expected degree of flooding to each building in the SFHA and specifically in the CSO/Downtown, OPCD, Waverly, Woodland Court, Lick Run Target Study Areas

4. Prioritize for mitigation action (high, medium, low, need for additional study, no immediate action, and other)
5. Amend the County Multi-Hazard Mitigation Plan to include this plan to be eligible for FEMA mitigation funding
6. Conduct meetings with building owners to discuss mitigation options and determine level of interest
7. Implement as directed for CSO/Downtown (PS-15), OPCD (PS-26), Waverly (PS-30), Woodland Court (PS-34), Lick Run (PS-40)

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ABBREVIATIONS

APA	American Planning Association
BCA	Benefit Cost Analysis
BFE	Base Flood Elevation
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CBBEL	Christopher B. Burke Engineering, LLC
cfs	Cubic Feet per Second
CFU	Colony-forming Units
COW	Code and Ordinance Worksheet
CRS	Community Rating System
CSO	Combined Sewer Overflow
CWA	Clean Water Act
EPA	(US) Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMAP	Flood Mitigation Assistance Program
FRP	Flood Response Plan
GIS	Geographic Information System
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center River Analysis System
HMGP	Hazard Mitigation Grant Program
ICC	Increased Cost of Compliance
IDDE	Illicit Discharge Detection and Elimination
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
IU SPEA	Indiana University School of Public and Environmental Affairs
JTL	Jacobi, Toombs and Lanz, Ltd
LAG	Lowest Adjacent Grade
LID	Low Impact Development
L-THIA	Long Term Hydrologic Impact Assessment
LTCP	Long Term Control Plan
MCM	Minimum Control Measure
mg or mg/L	Milligram or Milligram per Liter
mIBI	Macroinvertebrate Index of Biotic Integrity
MGD	Million Gallons per Day
MS4	Municipal Separate Storm Sewer System
N/TN	Nitrogen/Total Nitrogen
NAVD	North American Vertical Datum

NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
NPDES	National Pollution Detection and Elimination System
OPCD	Oak Park Conservancy District
ORSANCO	Ohio River Valley Sanitation Commission
PCB	Polychlorinated biphenyl
P/TP	Phosphorus/Total Phosphorus
QHEI	Qualitative Habitat Evaluation Index
RiskMAP	Risk Mapping Assessment and Planning
SFHA	Special Flood Hazard Area
SVAP	Stream Visual Assessment Protocol
SWAC	Stormwater Advisory Committee
SWMP	Stormwater Master Plan
SWCD	Soil and Water Conservation District
SWQMP	Stormwater Quality Management Plan
TBL	Triple Bottom Line
TIF	Tax Incremental Financing
TIN	Triangulated Irregular Network
TSPS	Tenth Street Pump Station
TSS	Total Suspended Solids
USACE	United States Army Corp of Engineers
USGS	United States Geological Survey
WERF	Water Environment Research Foundation
WHPA	Wellhead Protection Area
WWTP	Wastewater Treatment Plant