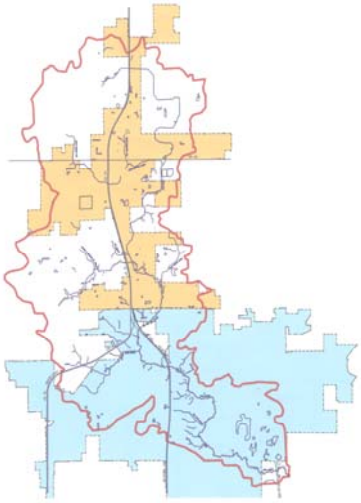
Hamilton County

City of Carmel

Town of Westfield

IDEM Section 319 Report

Cool Creek Watershed Management Plan



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PREFACE

Planning efforts for the Cool Creek Watershed Management Plan began in 2001, when Hamilton County, the Town of Westfield, and the City of Carmel agreed to jointly fund a study of the Cool Creek watershed. Clark Dietz, Inc. was retained by Hamilton County (the lead agency) to conduct the necessary engineering analyses and develop the plan with input from watershed stakeholders. Planning efforts began in September 2001 and were completed in November 2003.

Subsequent to the completion of the original Cool Creek Watershed Management Plan, Hamilton County applied to the Indiana Department of Environmental Management (IDEM) for a Section 319 Nonpoint Source Program Grant. The purpose of the grant application was to update the Cool Creek Watershed Management Plan to make it compliant with Section 319 requirements to reduce nonpoint source pollution. The grant was approved by IDEM in 2004 and a Contract for Services was formally approved by the State of Indiana on December 29, 2004. On January 24, 2005, Clark Dietz was retained by Hamilton County to provide the additi9onal enhancements to the Cool Creek Watershed Management Plan.

This document is an update to the original November 2003 Watershed Management Plan, containing the additional Section 319 requirements. A new Chapter 9.0 has been added titled "Section 319 Updates to the Cool Creek Watershed Management Plan." A new Appendix H, containing various exhibits from the Section 319 update project, has also been added.

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND AND PURPOSE

The Cool Creek Watershed drains significant portions of the City of Carmel and the Town of Westfield. The watershed and corporate boundaries for Carmel and Westfield are illustrated in Figure 1-1. The watershed drains approximately 23.7 square miles, with its headwaters near its headwaters near 199th Street. Cool Creek flows south and southeasterly, discharging into the White River south of 116th Street. Tributaries include Hot Lick Creek, Little Cool Creek, Highway Run, Mary Wilson Drain, Osborn & Collins #2 Drain, H. G. Kenyon Drain, and Anna Kendall Drain. US 31 and SR 431 run through the middle portion of the watershed. The Westfield portion of the watershed contains both urbanized areas as well as significant tracts of undeveloped land (primarily agricultural). The Carmel portion of the watershed is fully urbanized. Portions of the watershed lie in unincorporated Hamilton County, but are subject to potential annexation in the future.

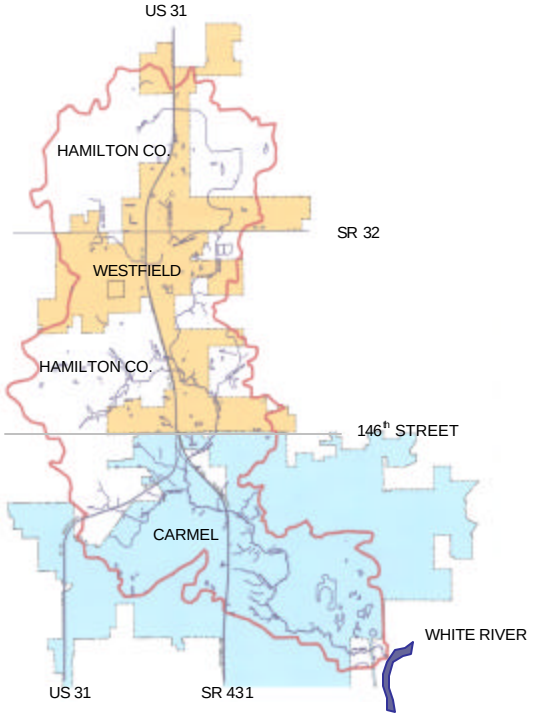


Figure 1-1 – Cool Creek Watershed

Recently, there has been growing interest and concern regarding stormwater design and management practices and their effectiveness in controlling the quantity *and quality* of stormwater runoff. This issue is of special concern given rapid growth in the Westfield area and pending requirements from the United States Environmental Protection Agency (US EPA) and the Indiana Department of Environmental Management (IDEM).

New federal regulations promulgated by the US EPA and administered by IDEM require Hamilton County, Carmel, and Westfield (and other communities throughout the country) to improve the quality of stormwater runoff. Stormwater runoff is a leading source of stream impairment due to pollutants that collect on parking lots, streets, highways, commercial, industrial and residential areas and wash off during rain events. These new regulations will require communities to educate and involve the public on stormwater quality issues, minimize erosion from construction sites, improve the long-term quality of stormwater being discharged from new developments, and develop effective municipal housekeeping operations to minimize stormwater pollution.

Hamilton County (through the County Surveyors Office), Westfield and Carmel entered into an agreement in 2001 to complete a thorough evaluation of stormwater management in the watershed. Clark Dietz, Inc. was retained to develop a Cool Creek Watershed Management Plan that includes recommendations to correct existing stormwater problems and prevent future problems from occurring as the watershed continues to develop.

A "Watershed Management Plan" can mean many things to different stakeholders, so it is important to identify scope of work for this plan. The focus of the study was on stormwater issues on the main channel of Cool Creek and its major tributaries. There are other isolated stormwater problem areas in the watershed (referred to in this report as "neighborhood" problem areas). Though some of these problem areas were identified (as part of staff interviews and public input) and located on problem area maps, detailed analysis and solution development for these areas was beyond the scope of this project.

This project also included an evaluation of water quality issues in the watershed, including a general review of the condition of the riparian corridor, a stream water quality sampling program, an evaluation of streambank erosion problems, a review of water quality violations (NPDES permit related), and an assessment of best management practices (BMPs) in the watershed. Detailed wetland delineations or ratings, biodiversity surveys, or other ecological evaluations were beyond the scope of this project, but may be considered in the future.

1.2 PROJECT SCOPE

Given the above background and purpose, the following is a summary of the scope of work for the project:

Inventory and Problem Identification	Existing information was gathered and evaluated. Sources included previous reports and studies, interviews with staff, meetings with developers, public meetings, and field reconnaissance. This information was used to compile a problem area map and identify areas for additional analysis and solution development.
Problem Analysis	Hydrologic and hydraulic computer models were developed to analyze identified problems and evaluate improvement alternatives. A stormwater quality evaluation was also performed under this task.
Solution Development	Alternative solutions were developed and evaluated. Solutions included bridge and culvert replacements, streambank stabilization projects, regional detention facilities, and land use policy modifications.

Recommendations and Implementation	This work task included recommending capital and maintenance projects, modifications to stormwater management practices, and identifying costs and implementation issues.
Watershed Management Plan Report	This work element involved compiling the above information into this report.

1.3 REPORT ORGANIZATION

This report has been organized to follow the scope of services in the order shown above. The remaining chapters of this report present the following information:

Chapter 2 Inventory	Summarizes maps, plans, reports, ordinances, standards, and other information used in completing the project.
Chapter 3 Problem Identification	Describes how problem areas were identified. Also presents the problems that were selected for detailed analysis and solution development.
Chapter 4 Water Quality Evaluation	Describes the general condition of the riparian corridor along Cool Creek, discusses wetlands in the watershed and along the stream, identifies potential pollutant sources in the watershed, and presents the stream sampling program and results. This chapter also includes a general description of how this watershed plan may be useful to Carmel, Westfield and Hamilton County and complying with upcoming stormwater quality regulations (NPDES Phase II, or Rule 13).
Chapter 5 Hydrologic Analysis	Describes the hydrologic model development and analysis results. Includes an evaluation of the effectiveness of current detention requirements in controlling stormwater on an overall watershed basis.
Chapter 6 Hydraulic Analysis	Describes the hydraulic models that were developed to evaluate solutions to stream related problems. Also includes floodplain mapping of previously unmapped tributaries.
Chapter 7 Solution Development	Presents solutions to the various problems that were identified through the problem identification and hydrologic/hydraulic analyses. Solutions were developed for stream flooding problems, streambank problems, and selected "neighborhood" problems.
Chapter 8 Recommendations, Implementation, and Funding	Summarizes recommendations, implementation issues, and funding options for the various categories of improvement projects.

2.0 INVENTORY

2.1 INTRODUCTION

Multiple sources of information were collected and analyzed to provide baseline data for the project. This chapter briefly summarizes data sources and their relevance to this study. These sources consisted of maps and plans, previous reports and studies, ordinances and standards, and other regulatory information.

2.2 MAPS AND PLANS

2.2.1 GIS Maps

Hamilton County has a comprehensive Geographic Information System (GIS) that was used extensively on the project. Data from the GIS is available to the public at the County's web page http://www.co.hamilton.in.us/gis. Figure 2-1 is an excerpt from the Hamilton County GIS.

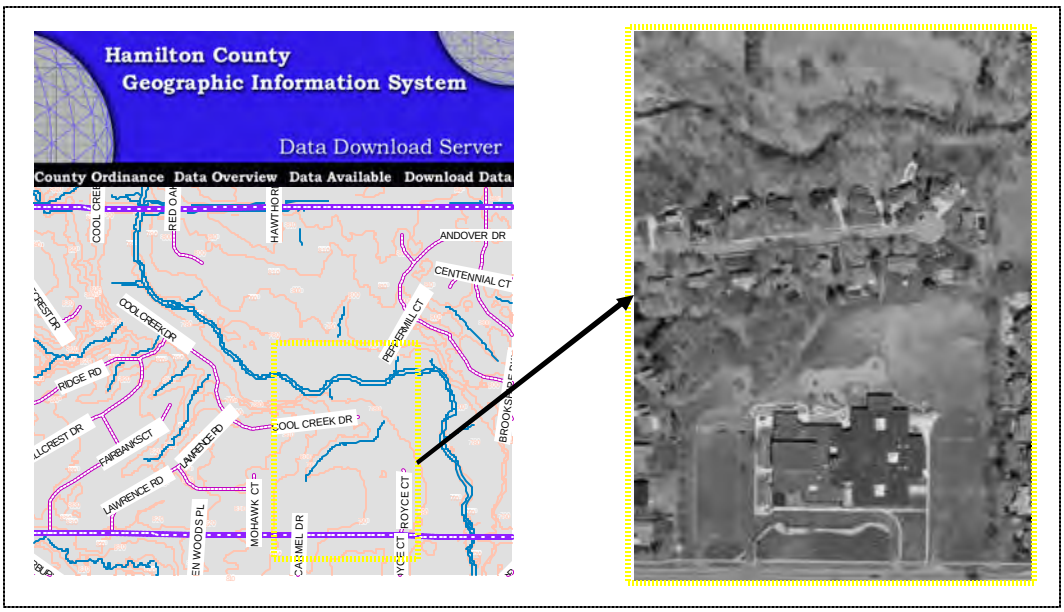


Figure 2-1
Hamilton County GIS Excerpt

The GIS contains several layers of information including the transportation system (highways, primary roads, minor roads, railroads); drainage system (drainage structures, regulated drains, streams, ponds); planimetric features (building outlines, fences, walls); topography (2' and 10' contour intervals); soils types; and political and survey boundaries. High resolution aerial photography is also available in the GIS. The GIS was updated in the fall of 2002 and was incorporated into this study.

The GIS was used to delineate watersheds and subbasins, identify land use for hydrologic modeling, analyze drainage features, identify the extent of the riparian corridor and stream buffers, and provide base mapping for figures and exhibits in this report.

2.2.2 USGS Quadrangle Maps

USGS maps (1" = 2000') were used to complement and verify the GIS topographic maps in performing watershed and subbasin delineation. Four quadrangle maps provide coverage of the entire Cool Creek watershed:

- Carmel, 1988 (5' contour interval)
- Westfield, 1992 (10' contour interval)
- Noblesville, 1992 (10' contour interval)
- Fishers, 1998 (5' contour interval)

2.2.3 National Wetland Inventory Maps

The National Wetland Inventory Maps are provided by the U. S. Department of Interior, Fish and Wildlife Service. The maps, last updated in 1989 and 1990, are provided on copies of the above mentioned USGS maps (see Figure 2-2 for an excerpt of the map along the lower reach of Cool Creek before it discharges into the White River). These maps provide the general location and extent of wetlands. Detailed delineation or assessment of the quality of wetlands in the watershed was beyond the scope of this project; however, they were included on the stream inventory maps (Chapter 3) in order to bring attention to their presence in the watershed. Final verification of the wetland boundaries should be performed by a licensed Wetland Consultant prior to approval of site plans adjacent to these areas.

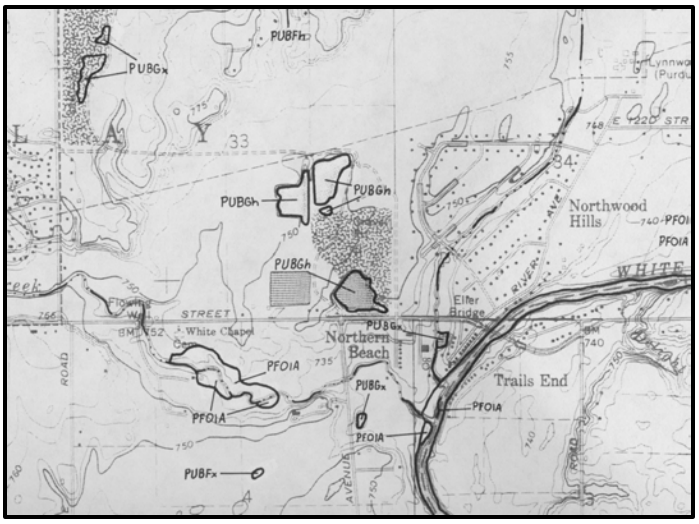


Figure 2-2
National Wetland Inventory Map Excerpt

Wetlands provide valuable functions including filtering pollutants in stormwater, providing habitat for wildlife, recharging groundwater, and providing natural flood storage. Wetlands are protected under the Federal Clean Water Act and require special permits from the U.S. Army Corps of Engineers (Section 404 permit) and IDEM (Section 401 Water Quality Certification).

Wetland regulations in Indiana (and many other states) are currently in a state of fluctuation due to a ruling in January of 2001 by the U.S. Supreme Court. In this ruling, the Court ruled against the U.S. Army Corps of Engineers and its authority to regulate certain isolated wetlands that are not adjacent to waters of the United States. Indiana has historically protected the state's waters, which include wetlands, by applying the Section 401 Water Quality Certification program in conjunction with the Section 404 U.S. Army Corps of Engineers permit program. IDEM is currently regulating isolated wetlands (those that no longer fall under Section 404 jurisdiction) through the use of NPDES permits, until a state wetland permit program is established and effective.

In order to better enforce compliance with wetland regulations and to protect their existence in future growth areas, it is recommended that wetland areas be added to the County GIS. The County will benefit from having this information readily available during the site plan review process. Furthermore, easy access to this information could be considered a Stormwater Best Management Practice (BMP) and could be used to comply with NPDES Phase II regulations.

Wetlands are scattered throughout the Cool Creek watershed though many are along the stream floodplains. The most commonly found wetland is classified as PFO1A, which stands for *Palustrine Forested Broad-Leaved Deciduous, Temporarily Flooded* wetlands. "Palustrine" comes from the Latin word "palus" or marsh. Wetlands within this category include inland marshes and swamps as well as bogs, fens, tundra and floodplains. In the Cool Creek watershed, most of the PFO1A wetlands are the floodplain type. Though all wetlands are valuable, regulatory agencies such as IDEM place a higher value on forested wetlands as compared to a small isolated wetland in a farm field. Forested wetlands provide shade to streams which in turn improves habitat for fish and wildlife.

The second most frequent type of wetland found in the watershed is Palustrine Emergent (shown as a PEMA, PEMB, PEMC, etc.). The letters following the PEM designation further describe the frequency of inundation. Emergent wetlands (sometimes known as marshes) are usually dominated by grass-like plants such as cattails, sedges or bulrush, which are rooted in bottom sediments, but "emerge" above the surface of the water.

Significant wetland areas along the Cool Creek Corridor are illustrated on the Stream Inventory Maps (Section 3.7 of Chapter 3).

2.2.4 Flood Insurance Maps

Flood Insurance Rate Maps (FIRMs) depict the regulatory floodway, the 100-year and 500-year floodplain boundary, base flood elevations, cross-section locations and other related information. During the course of this project, updated FIRM maps were being prepared for the County by others. Draft updated FIRMs were obtained from the County in the fall of 2002. The FIRMs were finalized and became effective February 19, 2003. The floodplain information in this report is based on the February 2003 updated maps. An excerpt from one of the updated FIRMs is shown on Figure 2-3.

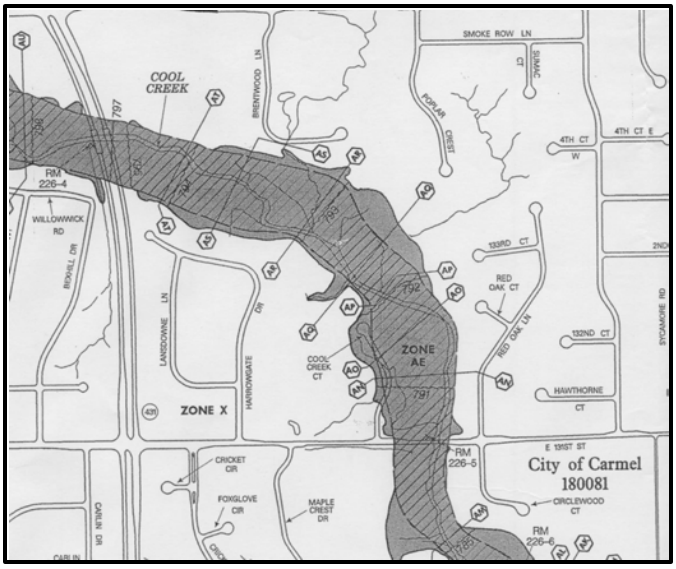


Figure 2-3
Flood Insurance Rate Map Excerpt

The flood insurance maps by themselves do not adequately illustrate the risk of flooding to buildings or other structures as they are based only on approximate topography. To better assess the flood risks and potential damages, the floodplain boundaries were re-delineated using detailed GIS-based topography with planimetric features shown. These maps are discussed Section 3.7 of Chapter 3.0.

The *floodway* is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment in order that the 100-year flood may be conveyed without substantial increases (0.1 feet or less in Indiana) in flood heights. The Indiana Department of Natural Resources (IDNR) regulates construction in the floodway. Local jurisdictions (Carmel, Westfield, and Hamilton County) regulate the portion of the floodplain outside of the floodway, referred to as the floodway *fringe*. The County has regulations prohibiting fill in the portion of the floodplain that they regulate (i.e. the floodway fringe). Carmel and Westfield currently do not have regulations that prohibit fill in the floodway fringe. This issue is discussed in more detail in Chapter 4.

A more detailed discussion of some of the problems identified from the Flood Insurance Rate Maps is included in Chapter 3.

2.2.5 Zoning Maps

Zoning maps were used to assist in identifying existing and future land use (an important variable in hydrologic analysis). Carmel has an official zoning map produced by the City of Carmel GIS for the City's Department of Community Services. The map was last modified in March 2002. Westfield also has an official zoning map (January 1997). Both the Carmel and Westfield maps list several different categories of residential, commercial, business, and other districts.

2.2.6 Aerial Photography Maps

In addition to the aerial photography maps provided with the Hamilton County GIS, paper maps of aerial photographs (spring 1997) from the State Land Office were also obtained and used on the project. While these maps are somewhat out of date in developing areas, and their resolution is not as good as the County's GIS maps, they do provide a more convenient viewable scale. The State Land Office maps are at a scale of 1" = 400' and 15 maps provide complete coverage of the watershed.

2.3 PREVIOUS REPORTS AND STUDIES

Several previous reports and studies were used in this study. The following is a summary of these documents.

2.3.1 IDNR Department Memorandum on Grassy Branch Re-Study, July 12, 2001

Grassy Branch is a tributary to Cool Creek that begins near 186th Street and flows south then east under US 31, through Westfield, and discharges into Cool Creek just south of SR 32. The entire stream is named "Grassy Branch" on USGS Quadrangle Map (Westfield). On the FEMA floodplain maps, the stream is called "Evan Kindall Drain." Locally, the stream is known as the *Anna Kendall* Drain (note difference in drain name and spelling). For this report, the stream will be referred to as the Anna Kendall Drain.

The purpose of this IDNR Department Memo was to summarize changes to the hydraulic model of the Anna Kendall Drain. The memo states that the model was updated between 1998 and September 2000 by a Christopher B. Burke Engineering, LTD (CBBEL). The model was revised to reflect changes in the upstream portion of the stream. A portion of the channel downstream from SR 32 and Oak Ridge Road was reconstructed, and an abandoned railroad crossing was removed. A complete restudy of the drain upstream of US 31 was also completed. The restudy was prompted because of a dredging project that occurred in 1998, upstream of SR 32 that resulted in the channel bottom being lowered approximately 4 feet. IDNR made some changes to the CBBEL models. These changes included minor revisions in flows, starting water surface elevations, and channel roughness coefficients. The final IDNR model was used in analyses performed in this study. The results of the Grassy Branch Re-Study were also incorporated into the February 2003 updated FIRMs.

2.3.2 Hydraulic Report for Village Farms Wilfong, July 10, 1996

This report, prepared by Weihe Engineers, Inc., analyzed the performance of a lake and dam at the Village Farms subdivision. The lake is the upstream-most of a series of two lakes that drain a tributary of the Osborn & Collins #2 Drain in unincorporated Hamilton County, west of Oak Ridge Road and north of 146th Street. This lake, which was designed as a Class 'B' dam structure in 1980, provides runoff control for approximately one square mile. The lake was originally 12.7 acres, but was increased by 3.44 acres, for a total surface area of 16.14 acres. The software used to perform the analysis is not identified in the report though it is clear that SCS methodology was used. The report indicates that the 100-year flow would be reduced from 1000 cfs to 87 cfs. This basin was analyzed independently of the hydrologic model in this study. The results of our hydrologic analysis are quite different than those reported in the Village Farms Wilfong report (see Chapter 5, Section 5.5.2).

2.3.3 Countryside Overall System Drainage Report, August 1, 2001

This report, prepared by Stoeppelwerth and Associates, analyzed the detention basin system provided for the Countryside residential subdivision in Washington Township in unincorporated Hamilton County. The subdivision is located in west of Oak Ridge Road and north of 161st Street and drains into the H. G. Kenyon Drain. The total site consists of 483 acres, though only the eastern portion of the development is in the Cool Creek watershed. The ponds were designed according to current Hamilton County stormwater standards.

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

The Soil Survey of Hamilton County was used, in conjunction with aerial photographs and zoning maps, to determine runoff Curve Numbers (CNs) for the hydrologic analysis. These soils designations are also provided on the County's GIS. Along the Cool Creek soils are mostly classified as Shoals-Genesee (Sh, Ge). The Shoals series of soils consists of deep, somewhat poorly drained, moderately permeable soils on floodplains. The Genesee series are adjacent to Shoals and consist of deep, well drained, moderately permeable soils on floodplains.

The upper portion of the watershed consists of Crosby and Brookston (Cr, Br) soils (about 50/50 distribution). The Crosby series consists of deep, somewhat poorly drained, slowly permeable soils on glacial till plains. The Brookston series consists of deep, very poorly drained, moderately permeable soils on glacial till plains and are generally near Crosby soils. Crosby soils are better drained and are in a higher position than Brookston soils. The lower portion of the watershed, closer to the White River, has more Miami series soils (Mm). The Miami series consists of deep, well drained soils on till plains and have loose sand and gravelly sand in the underlying material.

Soil types are used to help determine runoff CNs through the identification of hydrologic soil groups. Soils are classified into four groups – A, B, C, or D, depending on their minimum infiltration rate. The groups are summarized below (Source: TR-55, Urban Hydrology for Small Watersheds, SCS, June 1986).

Group A	Low runoff potential and high infiltration rates even when thoroughly wetted. Consist of deep, well to excessively drained sands or gravels. Infiltration rate greater than 0.30 in/hr. Low runoff potential.
Group B	Moderate infiltration rates when thoroughly wetted. Consist of moderately deep to deep, moderately well to well drained soils. Infiltration rate of 0.15 to 0.30 in/hr. Low/Medium runoff potential.
Group C	Low infiltration rates when thoroughly wetted. Soils impede downward movement of water. Infiltration rate of 0.05 to 0.15 in/hr. Medium/High runoff potential.
Group D	Soils have high runoff potential and very low infiltration rates. Clay soils with high swelling potential and a permanent high water table. Infiltration rate of 0.00 to 0.05 in/hr. High runoff potential.

In the Cool Creek watershed, the Genesee and Miami soils are Group B, while the Crosby and Shoal soils are Group C. Brookston soils are listed as B/D with B for locations that are drained and D for areas that are undrained. Conversations with Hamilton County Soil and Water Conservation District indicate that these soils often respond like Group D soils due to soil compaction that often accompanies development.

2.3.5 Flood Insurance Studies

Flood Insurance Studies (FIS) for Carmel, Westfield, and Hamilton County were obtained and reviewed. As mentioned previously, these studies were updated during the course of this project; however, resulting flood flows and stages are generally consistent with the previous studies. The FIS reports list peak discharges and corresponding flood profiles for 10-, 50-, 100-, and 500-year recurrence interval storm events.

A summary of 100-year peak discharges for Cool Creek and its tributaries is provided in Table 2-1. Peak flows for Cool Creek range from 6000 cfs at the mouth to 1200 cfs at 186th Street. The hydrologic modeling completed for this project resulted in flows that were generally within 20 percent of those published in the FIS.

Table 2-1
Flood Insurance Study – 100-year Flow Summary

Location	Drainage Area (sq. mi.)	100-year peak flow (cfs)
Cool Creek		
At mouth	23.7	6000
Below Hot Lick Creek	20.5	5400
Below Highway Run	15.8	4300
At 146th Street	13.8	3720
Below Anna Kendall Drain	7.2	2420
Above Anna Kendall Drain	3.9	1550
At East 186th Street	2.8	1200
Hot Lick Creek		
At mouth	0.4	540
Anna Kendall Drain		
At mouth	3.3	2400
Above Bowman Drain	2.3	1050
At US 31	2.0	940

2.4 OTHER INFORMATION FROM REGULATORY AGENCIES

Other information obtained from regulatory agencies included:

- Hydrologic/Hydraulic Models
- IDNR Permits
- IDEM Rule 5 and 6 Permits
- INDOT Information on US 31

2.4.1 Hydrologic/Hydraulic Models

Existing hydrologic/hydraulic models were obtained from IDNR. The models included:

- HEC-1 model of the Cool Creek Watershed
- HEC-2 model of Cool Creek (to 186th Street)
- HEC-2 model of Upper Cool Creek (upstream from 186th Street)
- HEC-2 model of Little Cool Creek
- E-431 (hydraulic) models of Hot Lick Creek and Grassy Branch (Anna Kendall Drain)
- HEC-RAS model of the upper portion of Grassy Branch (Anna Kendall Drain)

The HEC-1 model (software developed by U. S. Army Corps of Engineers) is a hydrologic model that simulates the rainfall runoff process and generates hydrographs for various storm events. The HEC-1 model of the Cool Creek was used by IDNR to assist in developing Coordinating Discharges for the stream. The IDNR model is more generalized than the detailed hydrologic model developed for this project.

The HEC-2 models (software developed by U. S. Army Corps of Engineers) simulate stream hydraulics and predict peak flood stages for various storm events. The IDNR models were converted to HEC-RAS (a newer release of HEC-2 with a graphical user interface) and were used to analyze problems and develop solutions in the Cool Creek watershed. The E-431 models are older hydraulic models that are no longer supported by the model developer (U. S. Geological Survey).

2.4.2 IDNR Permits

IDNR regulates construction activity or land alteration in mapped floodways and also issues any changes to floodway maps (called Letter of Map Amendments or Revisions). Information on floodway permits can be found at IDNR's web site:

http://www.state.in.us/dnr/water/permits/index.html.

Permits issued in the Cool Creek watershed total 102 (82 on Cool Creek; 6 on Little Cool Creek; and 14 on Grassy Branch/Anna Kendall Drain). The approximate distribution by permit type is as follows:

44%	Utility related (storm outfalls, water main crossings, etc.)
24%	Stream crossings (bridge replacements, new bridges/culverts, bridge repair, etc.)
11%	Fill activities (tennis courts, parking lots, etc.)
10%	Miscellaneous grading and excavation
6%	Excavation for ponds
5%	Streambank stabilization

A summary listing of the IDNR permits is provided in Appendix A.

2.4.3 IDEM Rule 5 and Rule 6 Enforcement

IDEM regulates stormwater runoff from construction sites and certain industrial activities. Rule 5 is a general permit that requires erosion and sediment controls for all construction sites that disturb more than five acres. This threshold recently dropped to sites disturbing more than one acre. Rule 6 governs stormwater runoff from certain industrial sites (ones that are more likely to cause stormwater runoff pollution).

The IDEM database was reviewed to determine if there were any enforcement actions regarding Rule 5 and Rule 6 (and other regulations) in the Cool Creek watershed. Information on IDEM enforcement is found at http://www.in.gov/serv/idem/oe. Two "Notice of Violations" were issued in the watershed. One in 1997 for a residential subdivision development that failed to submit a Notice of Intent (NOI) to comply with Rule 5 and one in 2001 for a commercial development that failed to submit an NOI, did not have its erosion and sediment control plan approved prior to construction, and had erosion control measures that were not properly installed and maintained. Both of these cases appear to have been resolved without Agreed Orders or civil penalties. No Rule 6 violations were found.

A water quality violation (unrelated to Rule 5 or Rule 6) occurred in April of 1999 for a private water utility (Hamilton Western Utilities, Inc.) that was found to be discharging water treatment plant backwash into a tributary of Cool Creek. This water treatment plant, located at 1140 Greyhound Pass, is no longer used since the new River Road water plant was put on line. The violation was settled with an Agreed Order and an assessed civil penalty of $4,250.

2.4.4 INDOT Information on US 31

The Indiana Department of Transportation (INDOT) is currently undertaking a study on improvements to US 31 between I-465 and SR 38 (12.5 miles). Information on the project can be found at http://www.us31indiana.com/. The purpose of this project is to reduce congestion for the US 31 corridor; improve the level of safety for motorists; and provide for reliable and efficient movement of commerce and regional travel. This project will essentially upgrade US 31 to Interstate standards by removing all at-grade intersections and uncontrolled access points.

A "US 31 Preliminary Alternatives Analysis and Screen Report" (Parsons Transportation Group, July 2002) narrows upgrade options down to two alternatives shown as Alts F and G in the Figure 2-4. Alt F generally follows the existing US 31 corridor while Alt G swings to the east of Westfield north of 161st Street. A Draft Environmental Impact Statement is expected to be released in 2003 for public comment.

Alts F and G would disturb 4 and 9 acres of wetlands and 38 and 54 acres of floodplains, respectively. Alt F would have 12 stream crossings involving 5170 feet of stream and Alt G would have 11 crossings involving 4715 feet of stream. As this project moves forward, impacts to water quality and quantity should be carefully evaluated and mitigated as needed.

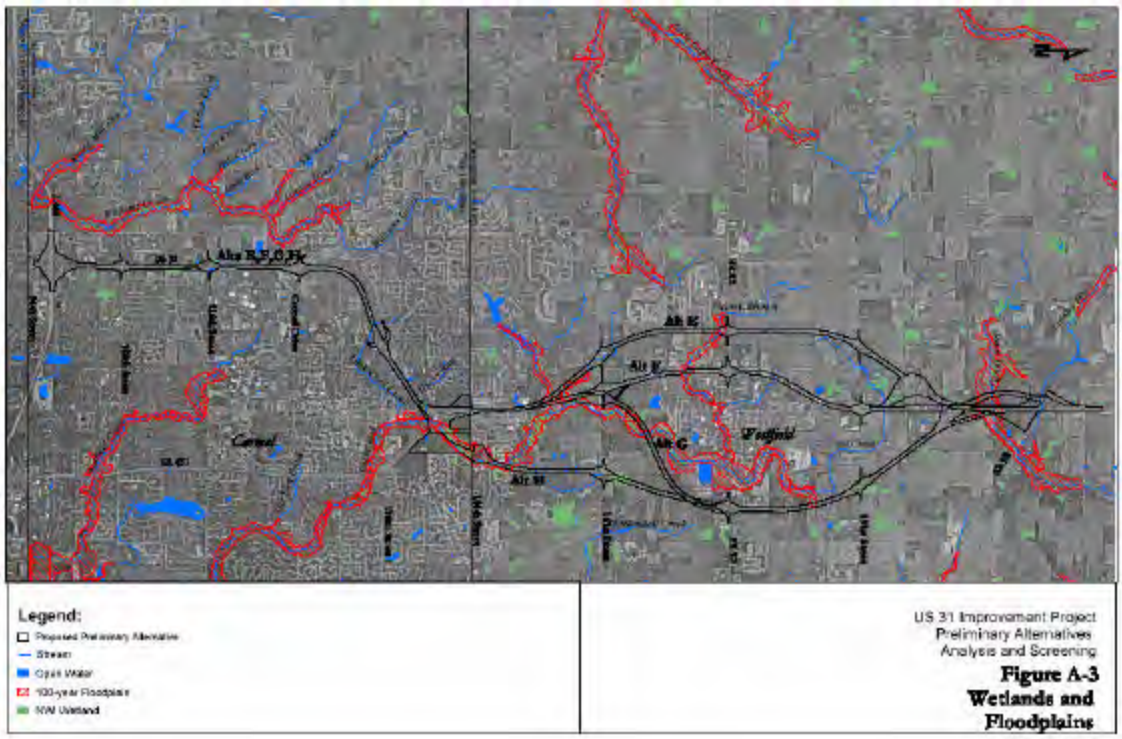


Figure 2-4
Excerpt from US 31 Improvement Report

2.5 ORDINANCES AND STANDARDS

Hamilton County, Westfield, and Carmel ordinances and site design standards were reviewed as they pertain to stormwater management. Carmel and Westfield both follow the Hamilton County standards, which is a key advantage in terms of providing consistent stormwater management controls in the different jurisdictions in the watershed.

Local site design standards require developers to provide detention facilities (ponds) that temporarily restrict increased stormwater runoff resulting from new impervious surfaces (e.g. roadways, sidewalks, rooftops) that are constructed in new developments. Ponds must be designed to limit stormwater discharge for both large and small storms. Developers are currently required to construct detention ponds that collect water from their respective developments and restrict the peak discharge to a magnitude below the pre-development condition. Chapter 5 – Hydrologic Analysis includes an evaluation of the effectiveness of current detention requirements on peak flow control.

Many ponds in new developments have a permanent pool of water that remains after a storm event. These ponds (often referred to as wet ponds) provide some water quality benefit. However, design standards for these types of ponds need to be upgraded to provide better water quality enhancement performance and protect downstream channels.

Hamilton County also has an ordinance that prohibits fill in the floodplain of any drainageway. This is a proactive requirement in that it preserves natural flood storage and also protects water quality. Carmel and Westfield (and many other communities in Hamilton County) allow development within the floodplain, provided that it meets certain standards to prevent flooding.

3.0 PROBLEM IDENTIFICATION

3.1 INTRODUCTION

Stormwater problems were identified from several sources, including staff interviews, developer input, previous reports/studies, and field investigations. This information was compiled and summarized on a Stormwater Problem Map. A selected group of projects were identified for detailed hydrologic/hydraulic analysis (Chapters 5 and 6) and solution development (Chapter 7). The following sections summarize the problem identification process.

3.2 INTERVIEWS

Interviews were completed with staff from Hamilton County, Carmel, and Westfield. The purpose of the interviews was to obtain knowledge of both general and specific problem areas. Specific problem areas were annotated on work maps. More general input is summarized as follows:

- The entire stream is in need of maintenance to address erosion, log jams and beaver dams.
- Most of the streams upstream from 146th Street are regulated drains. The Anna Kendall Drain is the only regulated drain on a maintenance assessment.
- There have been several petitions to re-construct the regulated drain down to 146th Street.
- Several bridges in the watershed have been replaced or plan to be replaced.
- Many reported problems are on private property.
- Anna Kendall Drain is one of the more problematic tributaries in terms of flooding concerns. Portions of the drain have been reconstructed. The culvert at the abandoned railroad on the drain serves as a control structure to store flood waters. This structure should remain.
- Impacts from the planned upgrades to US 31 should be considered and mitigated.
- Carmel and Westfield should consider additional ordinance language to protect floodplains.

Input on potential problem areas or watershed concerns was also obtained from the Hamilton County Soil and Water Conservation District. Input is summarized as follows:

- Concern with Creek being too close to Grassy Branch Road north of State Road 32. There a general safety concerns and limitations on future expansion.
- Land east of US 31 and between 151st street and SR 32 is wooded with rolling hills. Concern that as this land is developed there will be a high potential for sedimentation of Cool Creek and the hydrology of the watershed will change significantly.
- From 126th Street to SR 431 there are homes that back up to steep slopes. This area is generally stable but if the channel were to start eroding, there could be homes and property harmed.
- Significant sediment has been deposited on the south side of the 116th street bridge and needs to be cleaned out for that structure to have full capacity.
- Cool Creek south and north of 116th street is widening and eroding.
- Soils along much of Cool Creek are terrace or floodplain soil. These soils lack the texture, strength, and glacial till that upland soils possess to resist bank erosion.

- Criteria for a riparian corridor should be established for Cool Creek. Programs are available to assist landowners and new developments should be required to establish the buffers.
- Focus should be placed on maintaining the floodplain and not allowing construction even in the fringe. Corridor repair should also be stressed, which is being addressed by new ordinances that Hamilton County has passed.
- There is a need for an established system for construction site inspection. Site visits need to be more frequent.
- Need for a reduced nutrient program (lawns/clippings)

3.3 DEVELOPER INPUT

On October 30, 2002, a meeting was held at the Hamilton County Surveyors Office to obtain input from the development community on stormwater issues affecting the Cool Creek watershed. One of the key drivers of the study was the concern with stormwater impacts resulting from new development, particularly with the upper watershed (Westfield) developing and the lower watershed (Carmel) being already fully developed. Topics covered at the meeting included:

- Overview and purpose of the Cool Creek Watershed Plan
- Existing stormwater problems in the watershed
- Effectiveness of stormwater runoff controls associated with new development
- Regional detention facilities
- Rule 13 requirements and impacts to new development

Key feedback from representatives of the development community included:

- Regional on-line detention has become very difficult to implement because of environmental permitting issues.
- Regional detention for areas less than one square mile can work; however detention basin configurations are often dictated by other engineering issues (need for earthwork fill, limitations on conveyance facility sizes, etc.)
- If regional basins are constructed, credit should be given towards open space requirements.
- If the communities or the County want a particular regional detention basin site, the development community should know this early on so it can be accommodated in the development process.
- Development restrictions in the floodplain should be re-considered in areas of very wide, shallow floodplains.
- Street widths and parking space requirements should be considered when looking at the non-structural aspects of upcoming water quality requirements.

A summary of detailed discussion with the development community representatives is provided in Appendix B.

3.4 PUBLIC INPUT

Public input was obtained through two public meetings held in the spring of 2002, one in Westfield and one in Carmel. A total of approximately 70 people attended the meetings. A copy of the presentation handout and meeting summaries is provided in Appendix C. Each meeting included introductions, a presentation on the scope of the project, and a description of findings to

date. After the presentation and question and answer session, work maps were available for residents to identify specific problem areas. Key input and areas of concern are summarized as follows:

- Several residents expressed concern with filling or development taking place within the floodplain.
- A general desire was expressed to maintain the aesthetic value of the creek, including preservation of riparian areas.
- Concerns about water quality were discussed. Residents showed interest in continued sampling and monitoring of the quality of water in the creek. Comments were expressed that we should strive to improve the water quality, not just maintain it.
- Concern was expressed regarding the amount of native plant growth residing in the riparian areas adjacent to the creek and the invasion of non-native plants. It was suggested that a bio-diversity assessment of the creek/watershed system be considered.
- General concern was expressed regarding blockages in the creek.
- Interest was expressed to have information available on the Internet
- There were some questions regarding the future expansion of US 31 and its impact on the watershed.
- Residents displayed interest in performing channel clean out, erosion control, streambank stabilization, and general creek maintenance.
- Residents showed interest in Rule 5 compliance (erosion control) within the watershed.

3.5 PROBLEMS IDENTIFIED IN PREVIOUS STUDIES AND REPORTS

The primary source used in problem identification was the Flood Insurance Studies for Hamilton County, Westfield, and Carmel. These reports, along with the accompanying floodplain/floodway maps and the hydrologic/hydraulic analyses performed in this study, were used to identify flooding problems such as roadway overtopping or other structures at risk from flooding. A summary of stream related flooding in the three jurisdictions in the watershed is as follows:

Carmel

- Cool Creek – No roadway overtopping problems along the main Cool Creek channel
- Hot Lick Creek – Overtopping at Carmel Drive during 10-year event (creates about 3 feet of backwater)
- Highway Run – Overtopping at Walter Street and Walter Court during 25-year and greater events.
- Highway Run – Overtopping at Thornberry Drive during 25-year and greater events.

Westfield

- Cool Creek – E. 151st Street overtopping during 10-year event
- Cool Creek – Oak Road just overtopped during 100-year event
- Cool Creek – S. Union Street/Westfield Boulevard overtopping or nearly overtopping during 10-year event (at two stream crossing locations)
- Cool Creek – Private Drive overtopped during 10-year event
- Cool Creek – Oak Road just overtopped during 10-year event

- Cool Creek – 171st Street almost overtopped during 10-year event
- Anna Kendall Drain – Four (4) Private Drives overtopped during 10-year event.
- Anna Kendall Drain – Gurley Street and Cherry Street overtopped during 50-year event
- Anna Kendall Drain – Park Street overtopped during 10-year event
- Anna Kendall Drain – Abandoned railroad embankment overtopped during 10-year event
- J. M. Thompson Drain – W. Jersey Street overtopped during 10-year event

Hamilton County Unincorporated Areas

- H. G. Kenyon Drain – Two private gravel drive crossings with small culverts overtop during even small storms
- Mary Wilson Drain – 151st Street overtopped during 10-year event
- Mary Wilson Drain – One private drive overtopped during the 10-year event.

As highlighted above, conveyance problems at stream crossings are more pronounced in Westfield, with several undersized bridges and culverts on both Cool Creek and Anna Kendall Drain. Flooding problems along Cool Creek in Carmel is not a major problem. Erosion is more of a concern along Cool Creek in Carmel.

3.6 FIELD RECONNAISSANCE

A field reconnaissance of Cool Creek and its major tributaries was performed during the spring of 2002. The purpose of the field reconnaissance was to:

- Assess the general condition of the riparian corridor
- Photograph and note areas with erosion problems
- Note areas with log jams or debris build up
- Measure and record location and size of storm sewer outfalls
- Check outfalls for evidence of scour
- Note any illegal dumping of trash
- Photograph and note flood prone areas

The following photographs illustrate the types of problems that were recorded.

Debris Jam and Streambank Erosion

Unknown Leachate

Culvert in Need of Sediment Cleanout

Culvert Pipe Collapse and Erosion

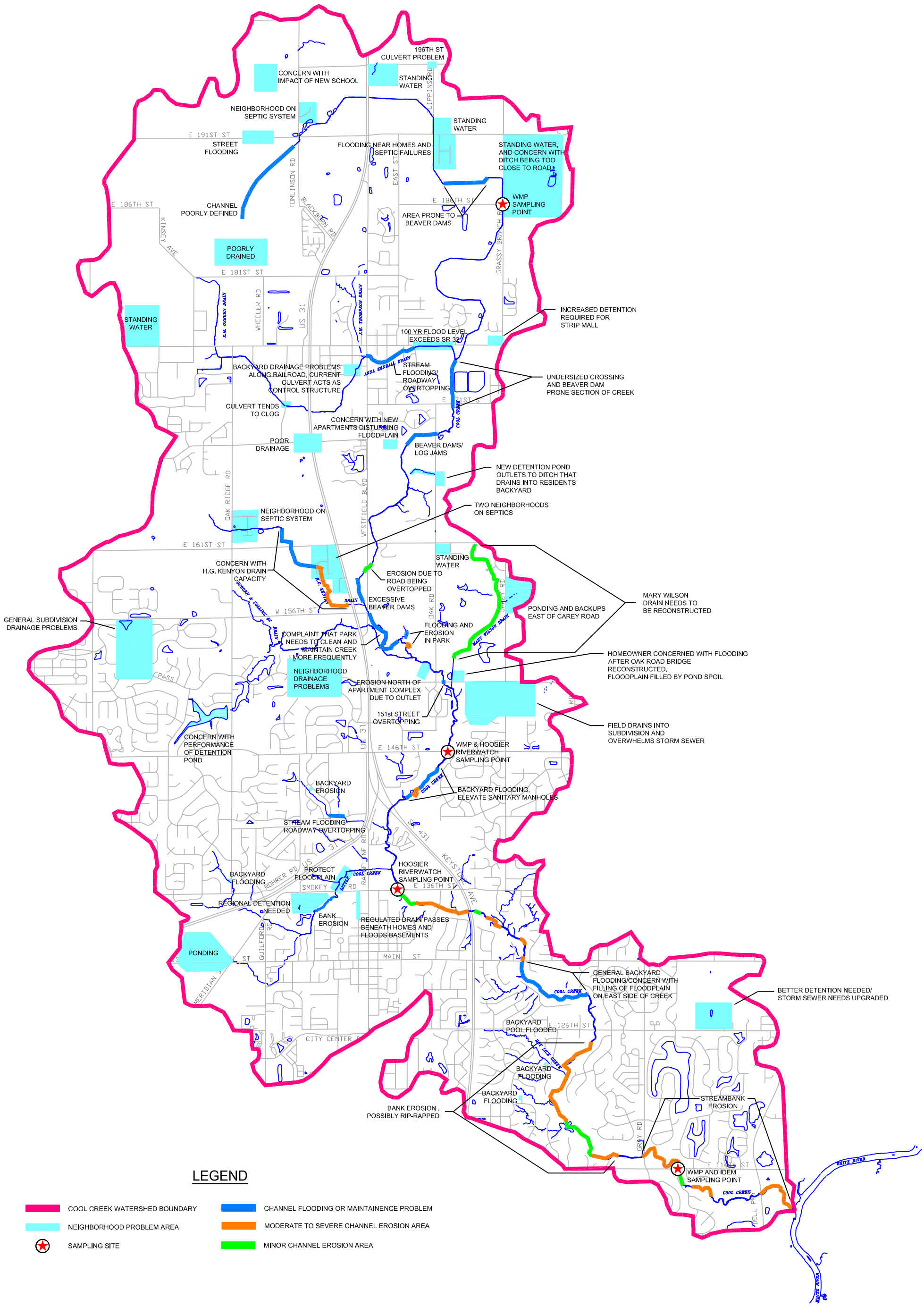
3.7 PROBLEM AREA MAP

Problem area information obtained from the various sources is summarized on the Problem Area Map, provided in Figure 3-1. The map shows the areas of channel erosion, localized flooding problem areas (neighborhood areas), and stream reaches with reported flooding problems, and other problems or concerns reported through the interviews and public meetings.

A second set of more detailed maps was also prepared and transmitted separately from this report. This map set, titled "Cool Creek Stream Inventory Maps", is comprised of 13 sheets (24" x 36") covering the main Cool Creek channel and floodplain. This map set provides a baseline condition inventory from which to compare and assess future watershed conditions. The maps show the following information:

- 100-year base flood elevation reference marks
- 100-year floodplain delineation
- Structures located in the floodplain
- Cross-section locations from the Flood Insurance Study hydraulic models
- Approximate wetland locations from the National Wetland Inventory Maps
- Location and size of stormwater outfalls
- Photographs of channel erosion, debris blockage and other areas of interest

Selected problem areas were targeted for more detailed analysis and solution development. These areas are presented in Chapter 7.



Clark Dietz

COOL CREEK WATERSHED MANAGEMENT PLAN

FIGURE 3-1
PROBLEM AREA MAP

4.0 WATER QUALITY EVALUATION

4.1 INTRODUCTION

A water quality evaluation was performed as part of the Cool Creek Watershed Management Plan. This task included a review of the general condition of the riparian corridor, an evaluation of floodplain development issues in the watershed, and water quality sampling at selected locations in the watershed, and a general overview of pending stormwater quality related regulations.

4.2 RIPARIAN CORRIDOR EVALUATION

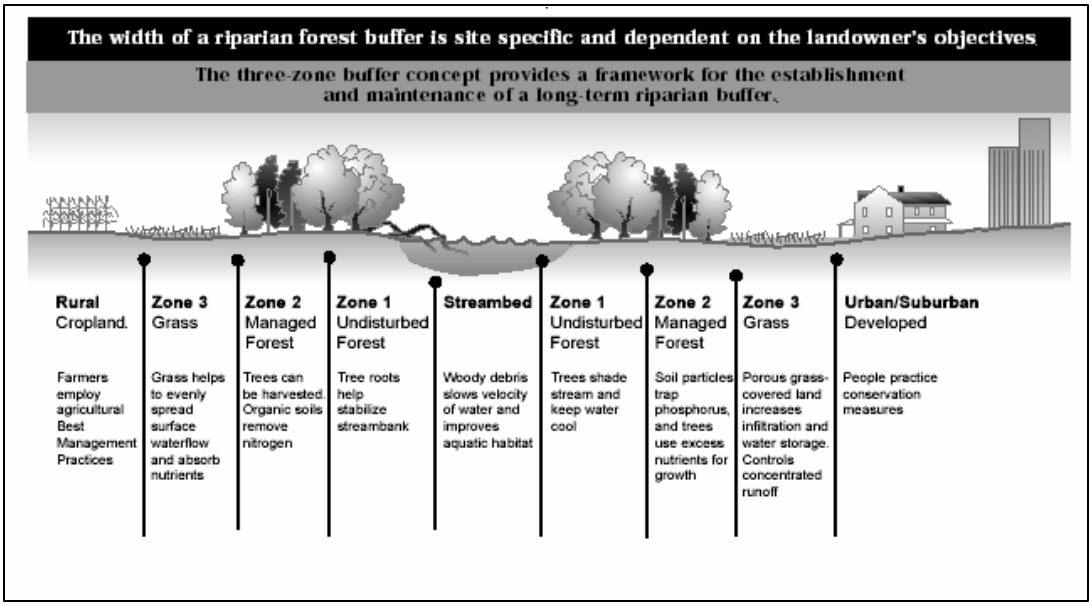
The term riparian refers to anything connected with or immediately adjacent to the banks of a stream or other body of water. A riparian forest buffer encompasses the area from the streambank to the area of trees, shrubs, and herbaceous vegetation located upslope from the body of water. Buffers are established and managed to reduce the impact of adjacent land use. A buffer serves several important functions: it preserves the stream's natural characteristics, protects water quality, and improves habitat for plants and animals on land and in the water.

For a good portion of its main stem, Cool Creek has a healthy riparian forested buffer. From the mouth at the White River upstream to 116th Street, the stream corridor is forested. Between 116th Street and 126th Street, Cool Creek runs through a golf course. There are some forested areas along the creek in this reach, but not to the extent seen in other reaches. Upstream of 126th Street to approximately SR 32 there are healthy riparian buffers, though there are segments with limited forest cover.

Upstream of SR 32, Cool Creek has limited riparian vegetation and is farmed to the edge of the stream. Several segments of Cool Creek have been channelized and straightened. The photographs below illustrate the difference in riparian vegetation for the lower and upper reaches of Cool Creek. As the agricultural tracts in the upper watershed are developed, stream buffers should be considered. Figure 4-1 shows an illustration of the various zones and benefits of a properly planned riparian buffer.

Forested riparian buffer along Cool Creek east of SR 431

No riparian buffer – Cool Creek south of 191st Street



Source: University of Maryland, Cooperative Extension

Figure 4-1
Riparian Forest Buffer Illustration

4.3 FLOODPLAIN DEVELOPMENT

Floodplain development concerns tie directly to preservation of the riparian buffers along Cool Creek (and its tributaries). Filling of floodplains can cause loss of flood storage and riparian habitat. As noted previously, Hamilton County has an ordinance that prohibits filling of land in the floodplains of its regulated drains. It would be appropriate for Carmel and Westfield to adopt similar policies for floodplains under their jurisdiction. This would provide a uniform policy and would help preserve existing riparian buffers. Many communities have adopted buffer ordinances to protect headwater streams where floodplains are often narrow and floodplain protection alone may not adequately protect buffer systems. This management practice would also help comply with IDEM water quality regulations.

4.4 WATER QUALITY SAMPLING

Stream sampling was performed at three locations in the watershed: 186th Street, 146th Street, and 116th Street. The 186th Street sampling point captures mostly agricultural runoff. The 146th Street sampling point includes runoff from most of the Town of Westfield. The 116th Street sampling point includes 98 percent of the watershed.

Two wet weather events (03-25-02 and 8-19-02) and two dry weather events (06-21-02 and 09-09-02) were selected for the water quality sampling. The total rainfall during the two wet weather events was approximately 0.7 inches (3-25-02 event) and 2.9 inches (8-19-02 event).

Samples were collected by Clark Dietz staff and were delivered with appropriate chain of custody to Test America, Inc. for laboratory analysis. Samples were analyzed in accordance with EPA standard methods. Grab samples analyzed for the following parameters:

- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Chromium, Hexavalent
- Cyanide
- Nitrogen (Ammonia, Kjeldahl, Nitrate, Organic, Total)
- Oil & Grease
- Ph
- Phenol
- Phosphorus (Dissolved and Total)
- Solids (Suspended and Dissolved)
- Fecal Coliform
- Fecal Streptococcus
- E. Coli
- Metals

Table 4-1 summarizes the results of the sampling program. Complete reports from the testing laboratory can be found in Appendix D. The highlighted values in Table 4-1 represent sample results that were somewhat elevated as compared to national averages. The following is an evaluation and interpretation of some of the specific parameters that were tested in the Cool Creek watershed. Several references were used in interpretation of the sampling data:

- Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPS, Metropolitan Washington Council of Governments, July 1987.
- Urbanization and Water Quality: A Guide to Protecting the Urban Environment, Terrene Institute, March 1994.
- Polluted Urban Runoff: A Source of Concern, University of Wisconsin-Extension, 1997.
- Watershed Protection Techniques Vol. 3, No. 1, Microbes and Urban Watersheds: Concentrations, Sources, & Pathways, Center for Watershed Protection, April 1999.
- Stormwater Magazine: The Journal for Surface Water Quality Professionals, The ABCs of Water-Quality Assessment in Georgia, March/April 2002.
- National Management Measures to Control Nonpoint Source Pollution from Urban Areas – Draft, U. S. Environmental Protection Agency, July 2002.

4.4.1 Oxygen Demand (BOD and COD)

BOD and COD levels were found at levels below national averages. BOD and COD are measures of the amount of oxygen used by macroinvertebrates and bacteria in processing organic matter in streams. Organic matter comes from both natural and human sources. Natural sources include riparian vegetation like leaves falling in the stream. Human sources might include sewage, pet wastes, nutrients from fertilizers, and litter. High BOD levels result in low dissolved oxygen in streams, which in turn degrades water quality and lowers diversity of aquatic organisms. Typically, BOD levels from 3 to 5 mg/l are considered moderately clean. Levels below 3 mg/l are considered very clean.

TABLE 4-1
STREAM SAMPLING RESULTS
COOL CREEK WATERSHED MANAGEMENT PLAN

Parameter		Typical Wet Weather Values Reported in Literature	116th Street Crossing				146th Steet Crossing				186th Street Crossing			
			Dry Weather		Wet Weather		Dry Weather		Wet Weather		Dry Weather		Wet Weather	
			06/21/02	09/09/02	03/25/02	08/19/02	06/21/02	09/09/02	03/25/02	08/19/02	06/21/02	09/09/02	03/25/02	08/19/02
BOD	mg/L	12[1]	<5	<5	5.1	5.5	<5	<5	5	6.9	<5	<5	5	5.4
COD	mg/L	91[1]	<10	<10	10	59	<10	9.8	10	81	<10	11	10	32
Nitrogen, Kjelhdahl	mg/L	2.35[1]	0.56	0.3	2.3	3.0	0.84	0.54	2.1	3.6	0.73	0.69	1.1	2.1
Nitrogen, Nitrate	mg/L	0.96[1]	0.65	0.47	0.9	0.69	0.85	0.16	1.2	0.81	**1.8**	0.65	**2.2**	1.2
Nitrogen, Ammonia	mg/L	0.26 - 1.1[2]	<0.10	<0.10	0.88	0.14	<0.10	<0.10	**5.1**	0.16	<0.10	<0.10	**4.3**	0.29
Nitrogen, Total	mg/L	3.31[1]	1.2	0.77	3.2	3.7	1.7	0.7	3.3	4.4	2.5	1.3	3.3	3.3
Nitrogen, Organic	mg/L	1.25[3]	0.56	0.3	1.4	2.9	0.84	0.49	<0.10	3.4	0.73	0.66	<0.10	1.8
Phosphorus, Dissolved	mg/L	0.16[1]	<0.05	<0.05	<0.05	0.15	<0.05	<0.05	<0.05	0.21	0.067	0.07	<0.05	0.28
Suspended Solids	mg/L	100[4]	<5	<5	120	**490**	<5	<5	61	**580**	<5	10	11	160
Dissolved Solids	mg/L	N/R	440	530	280	120	390	430	290	210	360	490	390	140
E coli	/100 ml	11,000[5]	170	>1600	900	1600	220	>1600	300	1600	170	>1600	900	>1600
Fecal Streptococcus	/100 ml	35,000[5]	13	3	120	920	12	<1	240	960	5	4	<10	1700
Chromium, Hex	mg/l	0.007[6]	0.01	<0.01	<0.01	0.015	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.012
Phenol	mg/l	0.008 - 0.115[6]	0.012	0.022	<0.01	0.025	<0.01	<0.01	<0.01	0.017	<0.01	<0.01	<0.01	0.018
Copper	mg/l	0.047[1]	<0.02	<0.02	<0.02	0.033	<0.02	<0.02	<0.02	0.025	<0.02	<0.02	<0.02	<0.02
Nickel	mg/l	0.012[6]	<0.01	<0.01	<0.01	0.018	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.176[1]	<0.05	<0.05	<0.05	0.095	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

(1) Nationwide Urban Runoff Program. 2300 monitored storms at 22 sites across the nation. US EPA 1983.
(2) Range is for newer suburban sites and older urban areas, as reported by Metropolitan Washington Council of Governments, 1987.
(3) Newer suburban sites, as reported by Metropolitan Washington Council of Governments, 1987.
(4) U. S. EPA database for general urban runoff.
(5) Center for Watershed Protection database of 34 recent urban stormwater monitoring studies, 1999.
(6) Metro Seattle as reported in Fundamental of Urban Runoff Management: Technical and Institutional Issues, Terrene Institute, 1994.
N/R = Not Reported
Cells shaded yellow with bold border indicate values somewhat elevated as compared to national averages found in the literature

The Cool Creek sampling results ranged from 5 to 6.9 mg/l during wet weather and were less than 5 during dry weather. The National average for BOD is 12 mg/l. Higher BOD levels are often associated with older, highly impervious areas with outdated combined sewers. Neither Carmel nor Westfield has combined sewers which may be why BOD levels are significantly below the national average.

4.4.2 Nutrients (Phosphorus and Nitrogen)

The average concentration of nutrients from all three sites and both storm events are somewhat higher than national averages reported in the literature, which may warrant further evaluation. Nutrients such as phosphorus and nitrogen are essential nutrients needed by all living plants and animals. Excess nutrients cause extensive algal growth which can in turn cause eutrophication, which in turn increases BOD. Phosphorus comes from several sources, including human wastes, animal wastes, industrial wastes, fertilizers, and human disturbance of land. Ammonia nitrogen is often found in areas where duck and geese excretions are high. Human sewage, caused by failing septic systems and illegal sanitary sewer cross-connections, is a source of nitrates. Fertilizers and runoff from animal feedlots and barnyards are also important sources of nitrates (and ammonia).

Water bodies with total phosphorus present at levels above 0.1 mg/l may be at risk for eutrophication. Typically, concentrations of nitrate nitrogen above 10 mg/l, ammonia nitrogen above 2 mg/l, and Kjeldahl nitrogen above 2 mg/l are a concern and may warrant actions to identify and limit inputs into the receiving streams. The Cool Creek sampling data show Kjelhdahl nitrogen was generally above 2 mg/l during wet weather. Nitrate nitrogen was generally below 2 mg/l (well below the 10 mg/l level of concern), and tended to be higher at the 186th Street sampling location. Ammonia nitrogen was high (4.3 and 5.1 mg/l at the 186th Street and 146th Street locations) during the March 25, 2002 sampling event. Early spring lawn fertilizing may be a partial explanation for this result. The August 19, 2002 sampling event showed ammonia nitrogen levels below 0.3 mg/l.

4.4.3 Sediment

The sediment sampling performed in the Cool Creek watershed showed varying results. Typical urban runoff values for total suspended solids (TSS) are around 100 mg/l. For the March 25, 2002 wet weather event, TSS concentrations were 120, 61, and 11 mg/l at 116th Street, 146th Street, and 186th Street. These values confirm higher TSS from urban areas versus cropland areas. For the August 19, 2002 event, TSS concentrations were much higher – 490 mg/l at 116th Street, 580 mg/l at 146th Street and 160 mg/l at 186th Street. It should be noted, this storm event was not a typical rainfall event, with 2.5 to 2.9 inches of rain. A typical storm event in central Indiana is about 0.65 inches.

High concentrations of suspended sediment in streams cause many adverse impacts. Suspended solids change the color of streams from nearly clear to red-brown. High turbidity causes streams to lose their ability to support diverse aquatic organisms. Suspended solids can also directly impact aquatic life in terms of clogging fish gills, reducing growth rates and decreasing resistance to disease. Excessive sediment deposited in the stream bed can prevent egg and larvae development.

The leading sources of sediment in existing urban areas are industrial sites, commercial development and freeways. But by far the highest loads of sediment come from areas under construction. Construction sites have high erosion rates and high delivery rates. Typical erosion

rates for construction sites are 35 to 45 tons per acre disturbed per year compared to 1 to 10 tons per acre per year for cropland. The delivery rate of sediment is also much higher in construction sites as compared to cropland because ditches and sewers are typically constructed in the first phase of a site development project. Typically 50% to 100% of soil eroded from a construction site is delivered to a lake or stream, compared to only 3% to 10% of the soil from cropland delivered to lakes or stream. This fact illustrates the importance of properly planned, installed and maintained erosion and sediment controls on construction sites.

4.4.4 Bacteria (E. Coli and Fecal Streptococcus)

Bacteria results found in the Cool Creek samples are consistent with the national averages. E. Coli levels were above standards for recreational use (235), ranging from 300 to >1600 counts/100 ml during wet weather. One of the dry weather events (9/9/02) was also well above standards with a reported value of >1600 counts/100 ml. The laboratory was unable to perform counts higher than 1600 due to sample size limitations. Literature on national averages reports a mean E. Coli value of approximately 11,000 counts/100 ml.

Bacteria are indicators of the presence of fecal wastes in surface waters. Escherichia coli (E. Coli) is in the coliform family of bacteria. Fecal streptococci (also known as Entercocci) are another bacteria group found in feces. Coliform bacteria are only an indicator of a potential public health risk, and not an actual cause of disease. Coliform bacteria are also used by most states as a standard for drinking water, shellfish consumption or water contact recreation. Indiana uses E. Coli as its standard (235 counts/100 ml for water contact recreational use of a stream).

The Center for Watershed Protection (see reference previously listed) developed a database of 34 more recent monitoring studies for bacteria. For E. Coli, the group mean was reported to be almost 11,000 counts/100 ml. Nearly every individual stormwater runoff sample exceeded bacteria standards. Bacteria sources in urban watersheds include human sources and non-human sources. Human sources include those caused by combined and sanitary sewer overflows, illegal sanitary connections to storm drains, transient dumping of wastewater, and failing septic systems. Most bacteria present in stormwater runoff are generally assumed to be of non-human origin, unless there are inappropriate human sewage discharges present in an urban watershed. Non-human sources include dogs, cats, raccoons, rats, beaver, geese, ducks, pigeons and other animals. Dogs in particular are often found to be a major source of coliform bacteria. Several studies have found dogs to be the primary source of fecal coliforms in urban watersheds. Dogs have also been found to be significant hosts for Giardia, Salmonella, and other pathogens. Geese, ducks, and gulls are also speculated to be a major bacterial source in urban areas, particularly at lakes and stormwater ponds where large resident populations become established. Relatively little data is available to quantify whether geese and ducks are a major source. Livestock can also still be a major source of bacteria, particularly those areas of the urban fringe that have horse pastures or "hobby" farms. These types of land uses exist in the upper reaches of the Cool Creek watershed.

The Center for Watershed Protection publication lists four conclusions as a result of their research on microbes in urban watershed: 1.) It is exceptionally difficult to maintain beneficial uses of water in the face of even low levels of watershed development, given the almost automatic violation of bacterial water quality standards during wet and dry weather. 2.) Bacteria levels in urban stormwater are so high that watershed practices would need to be exceptionally efficient (99% removal rate) to meet standards during wet weather. 3.) A lot of "detective work" would be needed to narrow down the lengthy list of potential bacteria suspects. 4.) There is little

understanding about the actual relationship between bacterial indicators and the risk to public health in urban watersheds.

4.4.5 Trace Metals

Copper, nickel, and zinc were found above detection limits at the 116th Street sampling location for the August 19, 2002 sampling event. Copper was also found at the 146th Street location during this event. The concentrations for copper and zinc were below averages reported in the literature for typical urban runoff. Nickel was found above detection limits at the 116th Street location during the August 19, 2002 sampling event. Chromium was also found above detection limits at the 116th Street location and the 186th Street location for this event. Nickel and chromium were above typical values reported in the literature.

Trace metals can be a concern because of their toxic effects on aquatic life, and their potential to contaminate drinking water supplies. Sources of metals include roofing materials, downspouts, galvanized pipes, metal plating, paints, wood preservatives, catalytic converters, brake linings, and tires. The most common metals found in urban runoff are lead (has been declining since unleaded gas has been implemented), cadmium, copper, and zinc. The primary source of many metals in urban runoff is vehicle traffic. Concentrations of zinc, cadmium, chromium and lead appear to be directly correlated with the volume of traffic.

4.4.6 Organic Compounds

Phenol is an organic compound that is a main chemical component of oil. Sources of phenol include oil spill, runoff carrying oil from streets, and other oil related activities. Phenol was detected in both dry and wet weather sampling events. The concentration was consistent with urban runoff values reported in the literature.

4.4.7 Summary of Sampling Results

The following observations and conclusions can be made from the sampling of Cool Creek:

- The constituents and concentrations of pollutants found in Cool Creek are generally comparable to urban and urbanizing watersheds across the country.
- Nutrients appear to be somewhat higher than national averages. This could be the result of excess fertilizer use coupled with agricultural runoff from the upper watershed. Public education regarding proper lawn care may be an appropriate follow up activity.
- Suspended solids were very high for one of the sampled events, though this was an atypical storm event. Proper erosion and sediment control on construction sites, in addition to streambank restoration, will help to control suspended solids levels.
- Bacteria levels exceed those required for recreational contact. This finding was expected as nearly all urban watersheds have bacteria counts that greatly exceed health standards for swimming. Efforts should be made to track and reduce human sources of bacteria that may result from failing septic systems, illegal sanitary sewer connections, and other sources. Public education on proper disposal of pet waste would also be a best management practice to help reduce bacteria levels.
- Other management practices, such as enhanced stormwater management practices, will further reduce stormwater runoff pollution into Cool Creek and its tributaries.

4.5 PHASE II NPDES STORMWATER REGULATIONS

In the late 1980s and early 1990s, federal regulations were promulgated (through the US Environmental Protection Agency (EPA) requiring municipalities to develop programs to reduce pollutants in stormwater runoff. The initial regulation applied only to communities with a population of 100,000 or larger (called Phase I communities). In 1999, a federal regulation was passed that addresses Phase II communities (those with populations greater than 10,000). Hamilton County, Carmel, and Westfield will all be regulated under this program.

IDEM is responsible for enforcement of the Phase II stormwater program in Indiana. On August 6, 2003, the final regulation became effective as 327 IAC 15-13 and titled "Rule 13 - Storm Water Run-Off Associated with Municipal Separate Storm Sewer System Conveyances." A Notice of Intent (NOI) letter and other associated initial application documents were due to IDEM by November 4, 2003. The Rule 13 regulation is to be implemented through six minimum control measures, summarized in Table 4-2 below.

Table 4-2
Rule 13 Six Minimum Control Measures Summary

Public Education and Outreach	Distributing educational materials and performing outreach to inform citizens about the impacts polluted stormwater runoff discharges can have on water quality.
Public Participation and Involvement	Providing opportunities for citizens to participate in program development and implementation, including effectively publicizing public hearings and/or encouraging citizen involvement.
Illicit Discharge Detection and Elimination	Developing and implementing a plan to detect and eliminate illicit discharges to the storm sewer system. Includes developing a storm sewer system map and informing the community about hazards associated with illicit discharges and improper disposal of waste.
Construction Site Runoff Control	Developing, implementing, and enforcing an erosion and sediment control program for construction activities that disturb one or more acres of land.
Post-Construction Runoff Control	Developing, implementing, and enforcing a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas. Applicable controls could include preventative actions such as protecting sensitive areas or the use of structural BMPs such as wet ponds or constructed wetlands.
Pollution Prevention/Good Housekeeping	Developing and implementing a program with the goal of preventing or reducing pollutant runoff from municipal operations. (e.g., regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch-basin cleaning).

Rule 13 requires the development of a comprehensive written document called a Stormwater Quality Management Plan (SWQMP). The SWQMP is divided into three parts:

Part A: Initial Application (due along with the NOI by November 4, 2003)

- Listing of entities covered by the permit
- Schedule of activities
- Proposed budget allocation and summary of identified funding sources

Part B: Baseline Characterization and Report (due within 180 days from receivership date of NOI)

- An investigation of land use and assessment of any stormwater BMP locations
- Identification of known sensitive water areas
- A review of known existing and available monitoring data of area receiving waters
- Identification of areas causing or likely to cause pollutant problems
- Assessment of BMP effectiveness

Part C: Program Implementation (due within 365 days from receivership date of NOI)

- Initial evaluation of the stormwater program
- Detailed program description for each minimum control measure
- Timetable for program implementation milestones
- Schedule for on-going characterization of receiving waters
- Narrative and mapped description of the boundaries covered by permit
- Estimate of the linear feet of open ditch or pipe
- Summary of the types of BMPs that will be allowed in developing areas
- Narrative or tabular summary of post-installation performance standards for BMPs
- Summary of the current and projected stormwater budget and funding sources
- Summary of measurable goals for each minimum control measure

All three entities in the Cool Creek watershed have submitted Notice of Intent (NOI) letters and Part A of the SWQMP, with Hamilton County and the City of Carmel being co-permittees. *The Cool Creek Watershed Management Plan will be useful in support of Rule 13 application and implementation efforts.*

The water quality sampling program, the riparian corridor evaluation, streambank erosion assessment and other data collected on this project is directly applicable to development of the Part B: Baseline Characterization and Report requirement. Recommendations in Chapter 7 regarding changes to stormwater detention requirements and land use and planning are directly applicable to post-construction runoff control requirements.

5.0 HYDROLOGIC ANALYSIS

5.1 INTRODUCTION

Hydrologic analysis of the Cool Creek watershed was performed to assist in problem identification and develop solutions and recommendations. The hydrologic computer model HEC-HMS (U. S. Army Corps of Engineers, Hydrologic Engineering Center – Hydrologic Modeling System, Version 2.2.1) was used to perform the peak stormwater runoff analysis. HEC-HMS is a physically based storm event simulation model capable of simulating runoff from various land uses and soil types, combining subbasin hydrographs, and routing flow through storage and conveyance facilities. Flows from the HEC-HMS model were used as inputs to the hydraulic analyses of the stream system (Chapter 6).

A second hydrologic model, XP-SWMM, was used to analyze potential off-line regional detention facilities. XP-SWMM is a dynamic (unsteady) flow model that performs both hydrologic and hydraulic analyses and can more accurately account for unsteady flow conditions associated with off-line detention facilities. The following sections describe the model development, evaluation results, and conclusions.

5.2 HEC-HMS MODEL DEVELOPMENT

HEC-HMS model development requires delineation of subbasins within the watershed, determining land use and runoff characteristics, and determining how subbasins are combined and routed downstream. The remainder of the HEC-HMS model input is divided into a series of operations. Each operation computes land surface runoff from a subbasin, combines two or more hydrographs, or performs flood routing through a channel reach or reservoir. Each operation produces a flow hydrograph as its output. Hydrographs can be added together (combined) to represent the confluence of two streams. The model graphical user interface and example of results are shown in Figure 5-1 below.

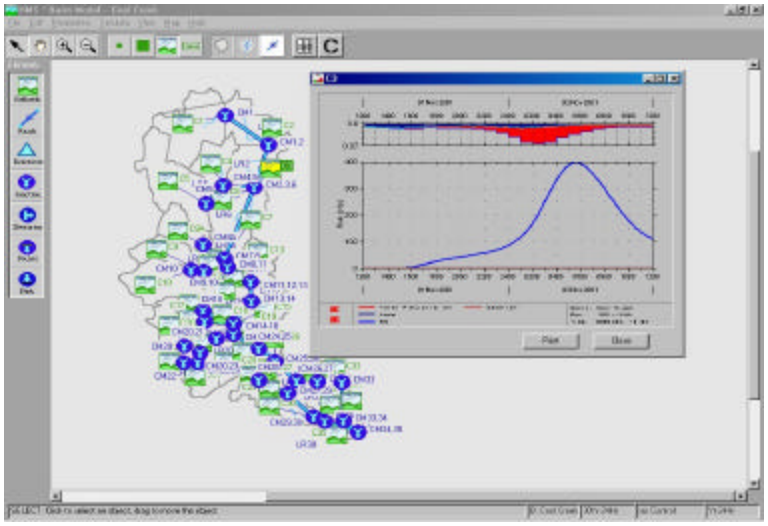


Figure 5-1 – HEC-HMS Model Graphical Interface

The following sections describe the design rainfall data, subbasin parameters, routing of subbasin flows, and model calibration for the watershed. A copy of the HEC-HMS summary output for the 2-, 10, 25-, 50-, and 100-year rainfall events (24-hour duration storm) is provided in Appendix E.

5.2.1 Design Rainfall

The watershed analyses focused on system performance for synthetic (predetermined) rainfall events. A design storm event is defined by precipitation depth, duration, and time distribution. Precipitation depths for various storm durations were obtained from "Bulletin 71 - Rainfall Frequency Atlas of the Midwest" (Midwestern Climate Center and Illinois State Water Survey, 1992). Time distributions (called Huff curves) were used as published in the above referenced Bulletin 71. These "Huff curves" distribute rainfall over the duration of the storm. Different curves (referred to as quartiles) are used for different duration storms. Storms less than 6 hours in duration use the first quartile distribution. Storms with durations of 6 to 12 hours use the second quartile distribution. Storms with durations greater than 12 hours but less than or equal to 24 hours use the third quartile distribution. A fourth quartile distribution is also available for storm durations greater than 24 hours; however, storms longer than 24 hours are not typically used in urban stormwater management analyses. Tables 5-1 and 5-2 list design rainfall depths and distributions.

5.2.2 Subbasin Parameters

The Cool Creek watershed was subdivided into 36 individual subbasins using critical analysis points as subbasin break points. Subbasin delineation was performed using the 2-foot contours in the Hamilton County GIS.

Stormwater runoff from each subbasin was computed using the Soil Conservation Service (SCS) curve number method available in HEC-HMS. Required parameters include subbasin area, curve number, and basin lag time. The time of concentration for each subbasin was estimated using the SCS TR-55 method. Calculations were based on distance, surface characteristics, slope, and velocity of flow from the most remote point in the subbasin to the subbasin outlet. The time of concentration, measured in hours, was converted to the subbasin lag time using the HEC-HMS recommended factor of 0.6.

Subbasin curve numbers were determined using a weighted average of curve numbers assigned to individual sub-areas of homogeneous land use and soil types. Existing conditions land use data was obtained from GIS maps and aerial photos. Future land use data was determined for undeveloped areas from zoning maps. Soil types were obtained from the SCS soil survey discussed in Chapter 2. The individual curve numbers for each land use and soil were selected from tables in SCS Technical Release 55, Urban Hydrology for Small Watersheds, 1986. Subbasin parameters are summarized in Table 5-3. Subbasins locations are shown on Figure 5-2.

5.2.3 Routings

A key feature of the HEC-HMS model is its capability to route stormwater runoff hydrographs through various drainage system components such as detention basins, culverts, and channel reaches. Appropriate flow routings enhance the accuracy of the representation of the watershed response to storm events by incorporating the attenuation of peak flows and time delay of hydrographs which occur as a flood wave travels through the storm system. Both detention pond storage and channel routings were utilized in the Cool Creek watershed HEC-HMS model.

Table 5-1
Design Rainfall Depths

Storm Duration (hours)	Rainfall Depth by Recurrence Interval (inches)					
	2-yr	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
1	1.37	1.71	2.00	2.43	2.80	3.21
3	1.87	2.33	2.72	3.30	3.81	4.28
6	2.19	2.73	3.19	3.87	4.46	5.13
12	2.54	3.17	3.70	4.49	5.18	5.95
24	2.92	3.64	4.25	5.16	5.95	6.84

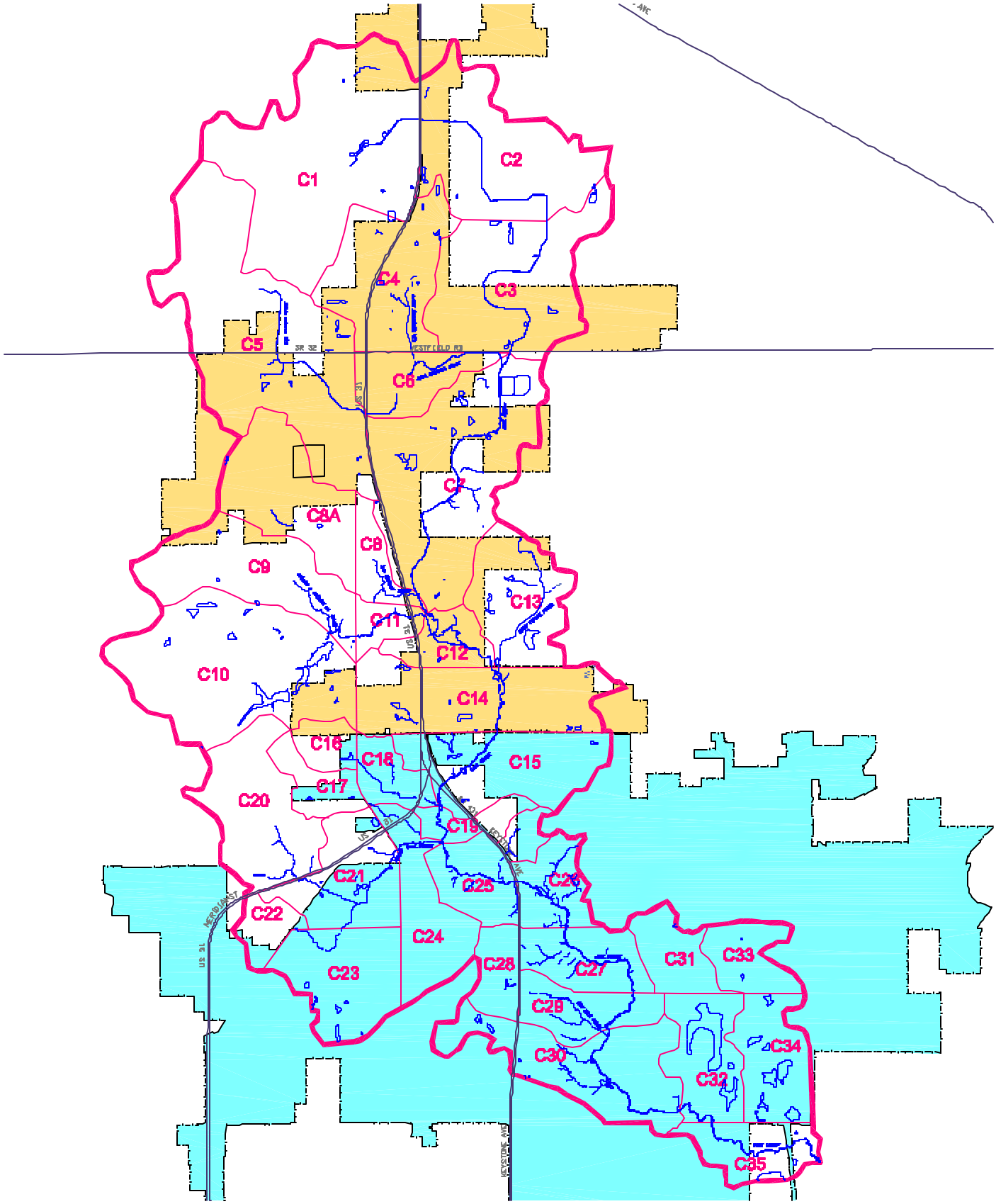
Table 5-2
Design Rainfall Time Distributions

Cumulative Storm Time (%)	Cumulative Storm Rain (%)			
	First Quartile*	Second Quartile	Third Quartile**	Fourth Quartile
5	12	3	2	2
10	25	6	5	4
15	38	10	8	7
20	51	14	12	9
25	62	21	14	11
30	69	30	17	13
35	74	40	20	15
40	78	52	23	18
45	81	63	27	21
50	84	72	33	24
55	86	78	42	27
60	88	93	55	30
65	90	87	69	34
70	92	90	79	40
75	94	92	86	47
80	95	94	91	57
85	96	96	94	74
90	97	97	96	88
95	98	98	98	95
100	100	100	100	100

* First quartile was used in flow computations for smaller tributaries.
** Third quartile was used to compute flows in Cool Creek.

Table 5-3
Subbasin Hydrologic Parameters

Subbasin	Area (sq. mi.)	Time of Concentration (hrs)	Lag Time (hrs)	Curve Number
C1	1.88	3.33	2.00	81
C2	1.18	4.94	2.96	81
C3	1.14	4.04	2.42	80
C4	0.89	2.88	1.73	80
C5	1.95	4.47	2.68	75
C6	0.40	3.07	1.84	77
C7	1.62	4.55	2.73	79
C8	0.18	1.28	0.77	70
C8A	0.67	2.76	1.66	81
C9	0.86	3.12	1.87	81
C10	1.48	2.14	1.28	78
C11	0.17	1.42	0.85	73
C12	0.26	2.39	1.43	66
C13	0.63	2.18	1.31	78
C14	0.87	1.49	0.89	84
C15	0.77	2.58	1.55	73
C16	0.19	1.11	0.67	82
C17	0.24	1.70	1.02	82
C18	0.21	1.36	0.82	79
C19	0.15	1.19	0.71	81
C20	0.78	2.56	1.54	81
C21	0.58	2.08	1.25	82
C22	0.19	0.98	0.59	81
C23	0.65	3.06	1.84	83
C24	0.52	1.90	1.14	74
C25	0.48	2.31	1.39	80
C26	0.35	1.05	0.63	71
C27	0.43	2.72	1.63	75
C28	0.24	1.06	0.64	82
C29	0.36	1.12	0.67	72
C30	0.97	2.00	1.20	75
C31	0.30	1.75	1.05	75
C32	0.53	1.76	1.06	78
C33	0.30	1.09	0.66	73
C34	0.46	2.41	1.45	80
C35	0.50	2.14	1.28	74



Clark Dietz

NOT TO SCALE

Subbasin Boundary

Cool Creek Watershed Boundary

Westfield Corporate Limits

Carmel Corporate Limits

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 5-2
Subbasin Map

5.3 XP-SWMM MODEL DEVELOPMENT

XP-SWMM2000 (Version 8.5), produced by XP Software Inc. is used for free surface open channel and closed conduit flow modeling and for modeling pressure flow networks. The model is based on the EPA Stormwater Management Model (SWMM), which has been in continuous use since approximately 1970. XP-SWMM offers a graphical user interface and detailed model output.

XP-SWMM2000 was used on the Cool Creek watershed project to simulate and evaluate the impact of off-line detention facilities. Off-line facilities were analyzed because on-line basins can create more negative environmental impacts and require a dam safety permit (for drainage areas greater than one square mile). Dam safety issues significantly increase the cost of design, construction, and maintenance of a detention facility. Off-line facilities are more complex to analyze; hence the XP-SWMM2000 model was utilized.

Off-line facilities require a side-channel diversion weir to divert channel flow into the basin when flows in the natural channel begin to rise during a storm event. A restricted outlet is created at the downstream end of the off-line basin to temporarily store flow and reduce downstream flow rates and velocities. XP-SWMM is capable of analyzing the unsteady flow components associated with the interface between the channel, diversion weir, storage facility, and outlet pipe. Figure 5-3 illustrates the XP-SWMM interface for the off-line storage facility modeling.

In this XP-SWMM analysis, an upstream hydrograph is generated using the same hydrologic methodology utilized by the HEC-HMS model. The hydrograph is routed through links that represent the natural stream channel of Cool Creek. A side channel weir is represented along the channel. Flow is diverted into the off-line detention basin storage node. The outflow from the detention basin is restricted, in this case by an orifice controlled structure. Flow is conveyed back to the natural stream channel via a conduit. This hydraulic system is controlled by differentials in water surface elevations between the pond and the channel. Flow will divert into the off-line basin until it is full, in which case flow would bypass the facility and continue downstream via the natural channel. Outflow from the off-line basin will flow back to the natural stream as the hydraulic gradeline in the natural channel subsides.

The location, size, effectiveness, and cost of recommended regional off-line detention storage facilities are summarized in Chapter 7.

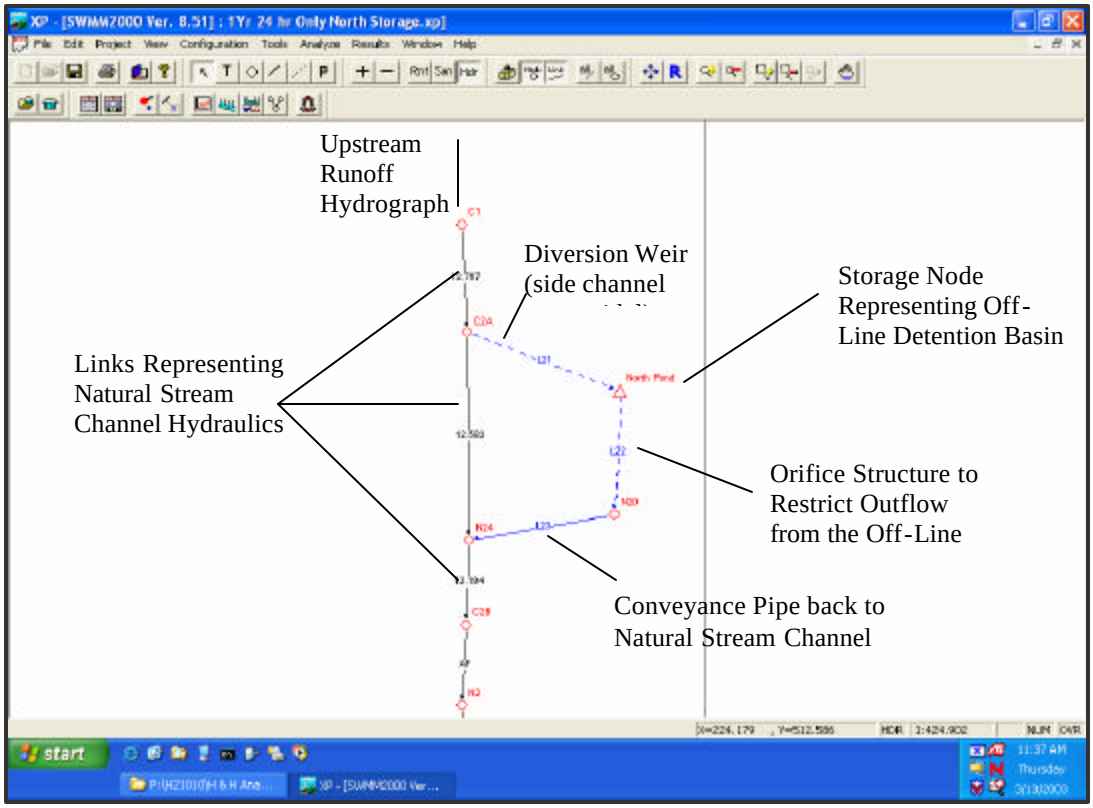


Figure 5-3
XP-SWMM Representation of Off-Line Detention Basin

5.4 MODEL CALIBRATION/VERIFICATION

Hydrologic model calibration/verification was performed by comparison to other analyses or methods and comparing predicted results to general field observations. Detailed comparison of computed hydrographs to gauged stream flow data was not possible because there are no stream gauging stations (and associated rain gauging network) in the Cool Creek watershed. The HEC-HMS model computed flows were compared to those listed in the Flood Insurance Study. The Flood Insurance Study flows were based partly on previous HEC-1 modeling of Cool Creek watershed by IDNR (note: HEC-1 is the predecessor of HEC-HMS). Table 5-4 summarizes the comparison of HEC-HMS model results to previous analyses by IDNR and to the Flood Insurance Studies.

The comparison shows the HEC-HMS model results to be comparable to the IDNR and FIS results, though somewhat lower for the 10-year and higher for the 100-year events. The HEC-HMS model has a more detailed representation of the watershed (36 subbasins) as compared to the IDNR HEC-1 model (10 subbasins). Also, the HEC-HMS model considered an existing regional detention facility on a tributary of the Osborn & Collins # 2 Drain. The IDNR model did not consider this facility as it is privately owned. IDNR will only consider existing storage facilities if they are owned, operated, and maintained by a public entity.

Table 5-4
HEC-HMS Model Results Comparison to IDNR and FIS Results

Location Along Cool Creek	10-Year Storm (cfs)			100-Year Storm (cfs)		
	HEC-HMS	IDNR HEC-1	FIS	HEC-HMS	IDNR HEC-1	FIS
At Mouth at White River	2690	3508	3000	5078	5409	6000
At 116th Street	2601	3394	2700	4892	5223	5400
At Little Cool Creek Confluence	2310	2883	2220	4597	4336	4300
At 146th Street	1842	N/A	2425	3977	N/A	3720
At Osborn & Collins # 2 Confluence	1692	2116	N/A	3732	3244	N/A
At Anna Kendall Confluence/SR 32	1152	1493	1280	2448	2394	2420

The HEC-HMS model also computes flows consistent with observed field conditions for smaller storm events. The HEC-HMS model predicts that Cool Creek would be out of its normal channel banks along its lower reaches in Carmel for the 1-year storm (about 2.5 inches over 24 hours). This modeled condition is consistent with observations to 2-inch and greater storm events that occurred over the course of the project when Cool Creek was observed to be out of its channel banks.

Overall, the HEC-HMS model produces reasonable results consistent with IDNR analyses and with observed field conditions. Additional calibration would require installation of either permanent or temporary stream gauging stations. The County is considering entering into an agreement with the USGS to install and maintain a permanent gauging station on Cool Creek and sharing the cost with Carmel and Westfield. USGS has indicated a new station would cost $5,000 for initial installation and $10,200 annually for maintenance of the station.

5.5 EVALUATION RESULTS

The HEC-HMS flow results were used as inputs to the hydraulic analysis and to develop solutions to flooding problems (Chapters 6 and 7). The model was also used to evaluate the effectiveness of current stormwater detention requirements and existing regional storage facilities in the watershed.

5.5.1 Current Stormwater Detention Requirements

The hydrologic model was used to simulate the cumulative effects of future development in the watershed and evaluate the appropriateness of current stormwater management requirements. Current detention standards require control of 100-year and 10-year storms. For a given site, the 100-year post-development peak rate of runoff must be restricted to the 10-year pre-development peak rate. The 10-year post-development flow must be restricted to the 2-year pre-development peak rate.

The effectiveness of this policy was evaluated by using future land use runoff curve numbers in undeveloped or partially developed subbasins. Storage routing routines were input at the downstream end of these subbasins to represent current detention requirements (control of the 100-year and 10-year post-development flows to 10-year and 2-year pre-development rates, respectively).

The results of this analysis are illustrated in Figure 5-4 which compares existing conditions (blue) and "full build-out" conditions with current detention standards (magenta). The flow vs. time graphs (hydrographs) represent the 100-year and the 1-year storms (24-hour duration) and are located at 146th Street.

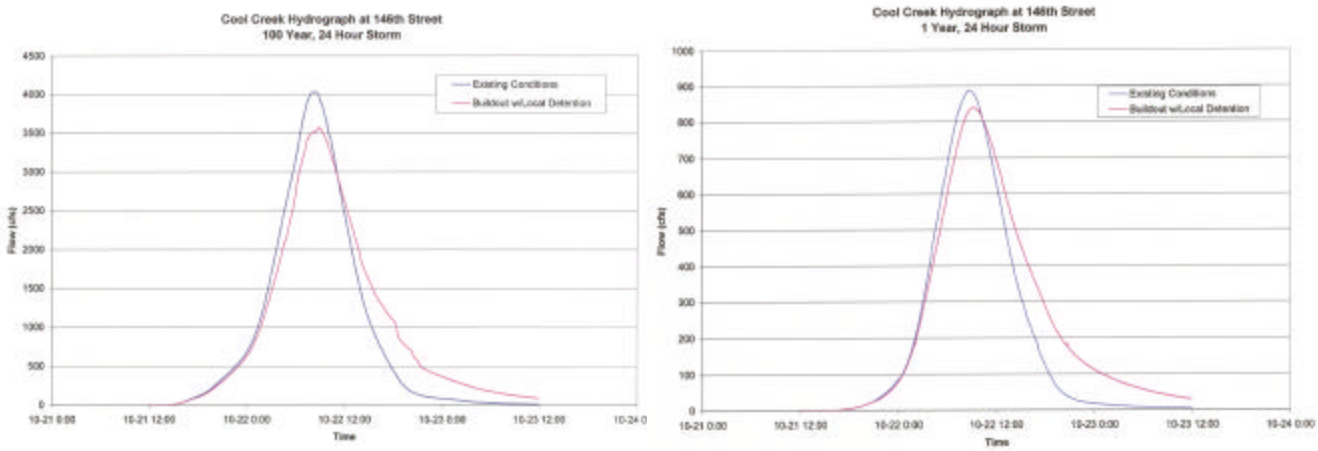


Figure 5-4
Hydrologic Impact of Future Development

The hydrologic analysis shows that current detention standards will be effective in controlling peak flow rates and corresponding flood elevations. However, these hydrographs also illustrate the impact of urbanization on the *volume* and *duration* of stormwater runoff. Under developed conditions, peak flow is reduced but it takes longer for flows to recede.

Urbanization can alter the geometry and stability of stream channels. Larger and more frequent discharges that accompany watershed development cause downstream channels to enlarge, by widening, downcutting, or a combination of both. This is occurring in the lower reaches of Cool Creek. Recommended changes to the current detention standards to help address water quality and channel erosion are included in Section 7.8 of Chapter 7.

5.5.2 Existing Regional Detention Facilities

Two existing regional detention facilities were evaluated as part of the hydrologic analysis. The first is the Village Farms Subdivision lake and dam and the second is storage area created by an undersized culvert at an abandoned railroad embankment on the Anna Kendall Drain.

Village Farms Lake and Dam

The Village Farms Subdivision lake and dam is an engineered on-line stormwater detention facility. The dam was constructed in 1979 – 1980 as a Class 'B' structure. The tributary drainage area is approximately one square mile. The surface area of the lake was increased from 12.7 acres to 16.14 acres in 1996. A hydraulic report was prepared by Weihe Engineers, Inc. in July 1996 to evaluate the hydraulics of the lake enlargement. The hydrologic/hydraulic analysis was completed for large storms only (100-year through the Probably Maximum Precipitation event). The report presents the following results (a 6-hour duration storm was used in the analysis):

Frequency	Inflow (cfs)	Outflow (cfs)	Stage
100-year	1000.7	87.1	877.56
200-year	1394.5	218.0	878.98
300-year	1521.9	300.3	879.18
400-year	1633.3	376.5	879.34
500-year	1712.8	437.3	879.46
½ PMP*	3472.0	2471.5	881.92
PMP*	7112.0	---	Overtop Dam

** PMP: Probable Maximum Precipitation*

The 1996 analysis appears to overestimate the effectiveness of this lake in controlling flood flows in that it accounts for storage that is actually not available. The normal permanent pool elevation for the lake is 873.80 feet. The stage-storage-discharge relationship shown in the 1996 report identifies storage below the normal pool, starting at an elevation of 862 feet and providing approximately 95 acre-feet at the normal pool elevation of 873.80 feet. Unless the lake was completely drained down to elevation 862.0 feet (presumably the bottom of the excavated pond) before a storm event this storage would not be available to attenuate peak inflows. The runoff curve number of 92 used in the 1996 report was much higher than the curve number of 78 computed in this project. A curve number of 92 is appropriate for a highly impervious urbanized commercial/ business district. The zoning map for Westfield – Washington Township shows this area as being zoned single family residential, low density, which is more consistent with a CN of 78. Also the time of concentration in the 1996 analysis was much shorter than in the current HEC-HMS analysis.

Using a curve number of 78, a longer time of concentration, and only accounting for storage above the permanent pool, the HEC-HMS model predicts the following flow reductions for the 2-, 10- and 100-year storm events:

Storm Event (6-hr duration)	Peak Inflow (cfs)	Peak Outflow (cfs)	Percent Reduction	Storage (ac-ft)
2-year	151	55	64%	25
10-year	291	81	72%	49
100-year	610	256	58%	97

The HEC-HMS analysis shows that the Village Farm lake and dam provides significant flood control benefits.

Anna Kendall Drain

A 48-inch culvert under an abandoned railroad embankment creates a significant impoundment area upstream (south) of Park Street on the Anna Kendall Drain. The drainage area at this point is approximately 2 square miles. Although there is significant volume in the impoundment area (approximately 80 acre-ft), an existing breach in the embankment limits the amount of flow that can be stored. Improvements at this location are needed to restore and maintain the flood control benefits of this storage area. The effectiveness of the storage area and specific improvements needed are presented in Section 7.7.3 of Chapter 7.

5.6 SUMMARY AND CONCLUSIONS

A hydrologic analysis of the Cool Creek watershed was completed using the hydrologic computer model HEC-HMS. A second model, XP-SWMM2000, was used to supplement the HEC-HMS model in analyzing proposed off-line regional detention basins. The following conclusions were formed as a result of the hydrologic analysis.

- Existing stormwater detention standards will effectively control peak flows and localized flooding as the watershed continues to develop, especially for larger storm events. However, the volume and duration of flow will increase, especially for the smaller more frequent storm events. This may lead to additional streambank erosion. Modifying detention pond design requirements to provide an extended detention time for the 1-year or "first flush" storm will help reduce erosion and improve water quality.

- Two existing regional detention facilities in the watershed provide significant flood control benefits, though the Anna Kendall storage area is currently ineffective due to a breach in the embankment.

- Additional regional detention facilities in the upper reaches of Cool Creek (discussed in detail in Chapter 7) will provide additional flood control benefits and help reduce downstream channel erosion.

6.0 HYDRAULIC ANALYSIS

6.1 INTRODUCTION

Hydraulic analyses were performed on Cool Creek and its major tributaries to identify existing problem areas, identify floodplain limits for unmapped tributaries, and to develop solutions to stream related flooding areas. The analyses were performed using HEC-RAS (U. S. Army Corps of Engineers, Hydrologic Engineering Center – River Analysis System, version 3.0.1, March 2001).

The following sections provide an overview of HEC-RAS, the analysis using the existing FIS models, summarizes the development and analysis results of the new HEC-RAS models of the unmapped tributary, and the results of the floodplain mapping.

6.2 HEC-RAS OVERVIEW

HEC-RAS is an integrated package of hydraulic analysis programs and a Graphical User Interface (GUI). The system is capable of performing steady flow water surface profile calculations (note: a recent release of HEC-RAS also includes provisions for unsteady flow analysis).

A HEC-RAS "Project" is a set of data files associated with a stream system. The data files for a typical project include plan data, geometric data, and flow data. Plan data defines the geometry and flow data that are to be used, a description and identifier for the model run, and other simulation options. Geometric data consist of stream cross-section data and hydraulic structure data (bridges, culverts, weirs, etc.). Channel and floodplain roughness coefficients (n-values), ineffective flow areas, and levees can also be specified in geometric data. Flow data includes the number of profiles to be calculated and the peak flow data for each stream reach and profile (i.e. 2-year, 10-year, 100-year).

HEC-RAS results can be viewed in both tabular and graphical form. Figure 6-1 illustrates several of the graphical user interface elements.

6.3 HEC-RAS MODEL DEVELOPMENT

6.3.1 Existing FIS Model – Conversion to HEC-RAS

The existing HEC-2 Flood Insurance Study models obtained from IDNR (Section 2.4.1 of Chapter 2) were converted to HEC-RAS models using the *import routine* provided with HEC-RAS. Importing a HEC-2 data set usually requires some modifications to the data, particularly at bridges and culverts, as the bridge routines in HEC-RAS are more detailed than HEC-2. The HEC-RAS model output was very close to the original HEC-2 flood elevations.

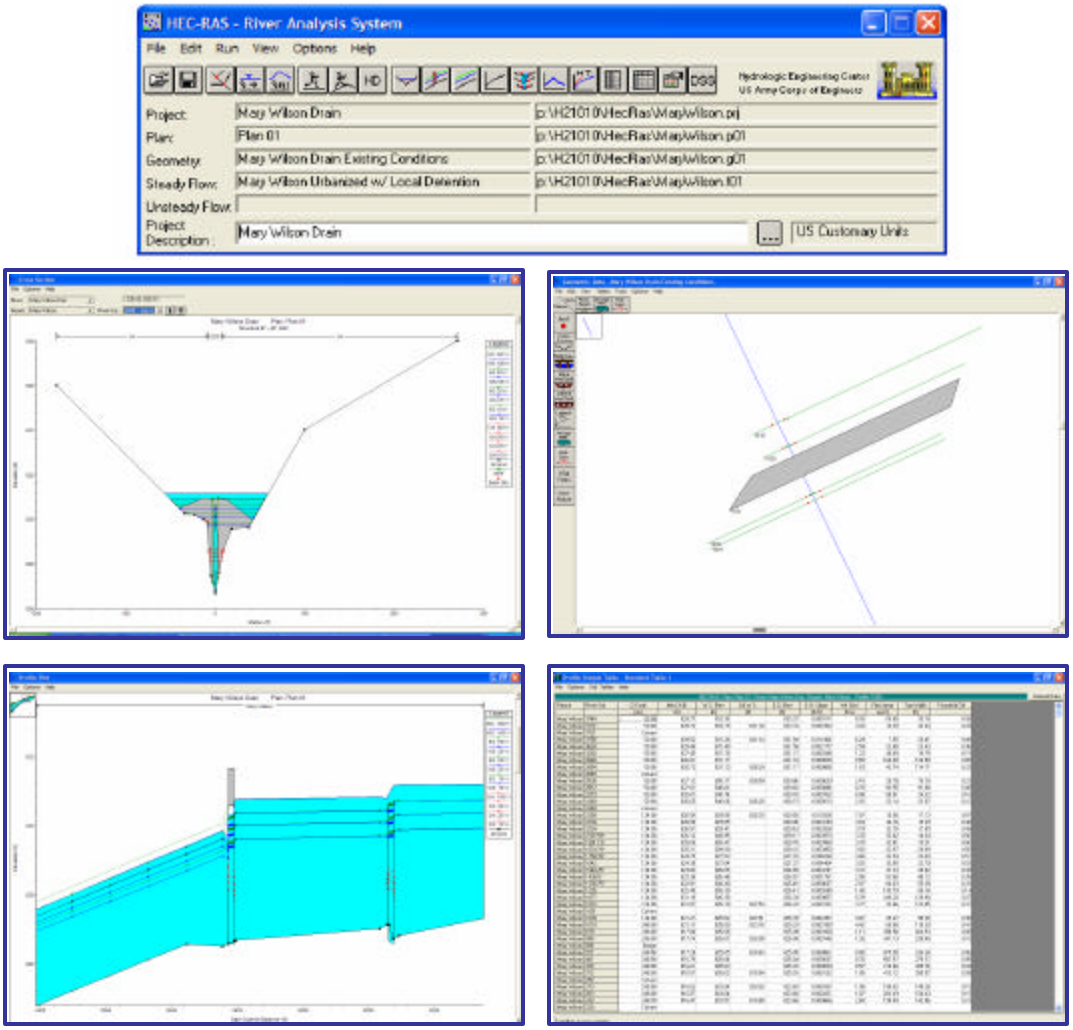


Figure 6-1
HEC-RAS Graphical User Interface

6.3.2 New HEC-RAS Models

New HEC-RAS models were developed for four minor tributaries that have not previously been analyzed:

- Mary Wilson Drain
- H.G. Kenyon Drain
- J.M. Thompson Drain
- Highway Run

Field surveying of the four unmapped tributaries was completed in April 2002. Surveys were based on benchmark information provided by the Hamilton County Surveyor's Office. Table 6-1 summarizes the number of cross-sections and hydraulic structures surveyed on each tributary.

Table 6-1
Hydraulic Survey Summary

Stream	Number of Cross-Sections	Number of Structures
Mary Wilson Drain	18	8
H.G. Kenyon Drain	28	9
J.M. Thompson Drain	12	3
Highway Run	21	10

A Hydraulic Survey Report was prepared and transmitted under separate cover to Hamilton County. The report includes cross-section and structure sketches, photographs of each structure, and field notes. Cross-sections were surveyed and sketched looking downstream. The cross-section sketches list the station offset (from the centerline of the channel) and corresponding elevation for each surveyed point on the cross-section. Structure sketches included station and elevation data along with measurements for culvert size or bridge waterway opening size, pier configuration and size, rail configuration and size, roadway elevation and width, wing wall size and configuration, and other information as applicable.

The above geometry data was input into the HEC-RAS model for each tributary. A copy of the HEC-RAS input and output is provided in Appendix F. Peak flows were computed from the HEC-HMS model (Chapter 5) and input into the HEC-RAS models at locations summarized in Table 6-2. The 3-hour duration storm produced the highest peak flows which were used as inputs to the HEC-RAS models.

Table 6-2
100-Year Flow Summary – New HEC-RAS Models

Stream	Distance Above Mouth (feet)	100-Year Flow (cfs)
Mary Wilson Drain	1010	392
	2350	196
	3740	80
H.G. Kenyon Drain	3307	484
	4654	300
	6864	200
	8172	104
J.M. Thompson	1403	488
	2207	350
	3221	200
Highway Run	1920	510
	2386	425
	2784	350
	4733	186

6.4 RESULTS

6.4.1 New HEC-RAS Model Results

Flood elevations for the four previously unmapped tributaries were computed using HEC-RAS. The resulting 100-year flood profiles for the Mary Wilson Drain, H.G. Kenyon Drain, J.M. Thompson Drain, and Highway Run are shown on Figures 6-2 through 6-5. The corresponding floodplain limits were also delineated on the Stream Inventory Maps (Section 3.7 of Chapter 3).

Mary Wilson Drain

The lower reaches of Mary Wilson Drain are impacted by backwater from Cool Creek. The backwater results in overtopping of 151st Street. There are six private drive culvert crossings upstream of 151st Street. Five of these drives are overtopped during the 100-year storm event. The floodplain is generally narrow and there are no buildings or structures in the floodplain.

H.G. Kenyon Drain

H.G. Kenyon drain has limited roadway overtopping problems. A private drive upstream of US 31 and two private drives downstream of Oak Ridge Road are overtopped during the 100-year storm event. The floodplain is generally narrow, but widens somewhat downstream of Oak Ridge Road where the channel is poorly defined. There may be a building in the floodplain between Oak Ridge Road and Montrose Lane.

J.M. Thompson Drain

The first stream crossing on the J.M. Thompson Drain (Jersey Street) is impacted by backwater from the Anna Kendall Drain. The other two stream crossings on this drain (Main Street and Catherine Drive) can safely pass the 100-year storm event. However, the Main Street culvert creates significant headwater, resulting in a wide upstream floodplain. Six structures along the lower end of J.M. Thompson Drain are flooded by the backwater from Anna Kendall Drain. Numerous structures upstream of Main Street are within the 100-year floodplain.

Highway Run

The US 31 culvert creates significant headwater during the 100-year storm. This headwater impacts the culverts in the vicinity of Walter Street and Walter Court. Five stream crossings of the Highway Run are overtopped during the 100-year event, four in the vicinity of Walter Street and Walter Court, including Thornberry Drive. Rohrer Drive is also overtopped during the 100-year event. There are numerous buildings in the 100-year floodplain, especially downstream of Walter Court.

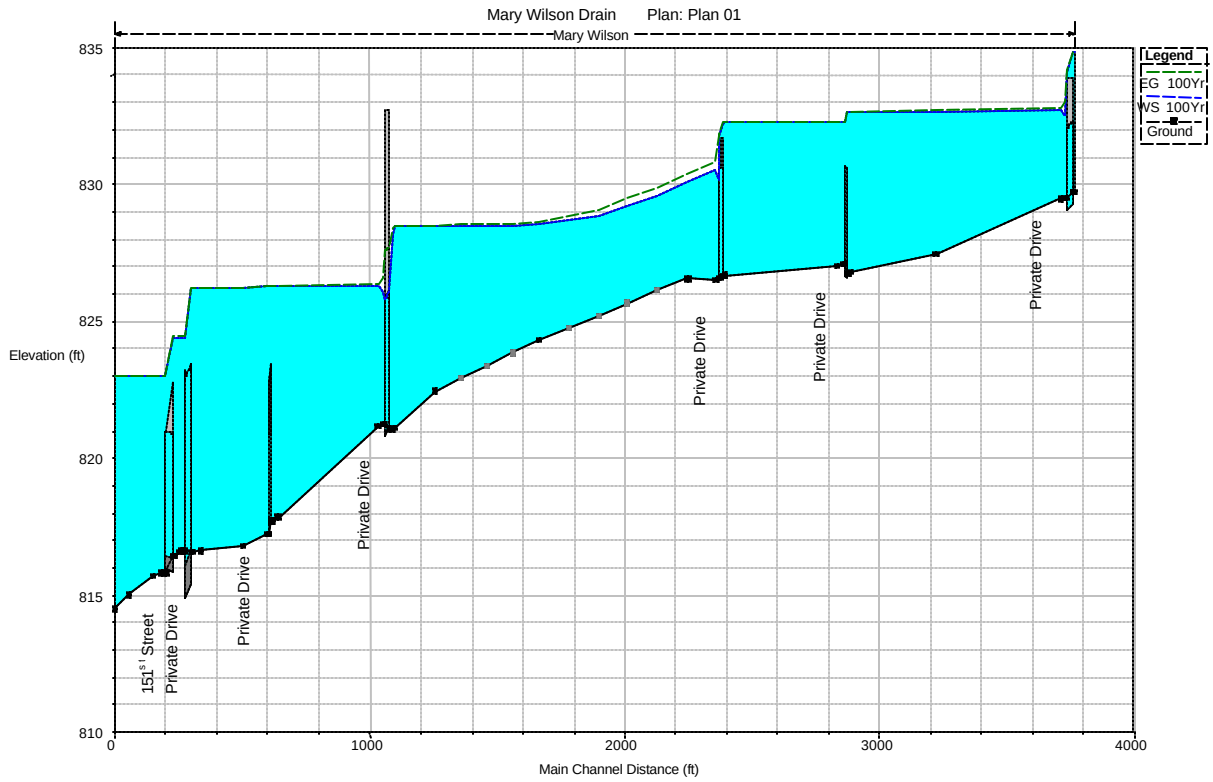


Figure 6-2
Mary Wilson Drain – 100-year Flood Profile

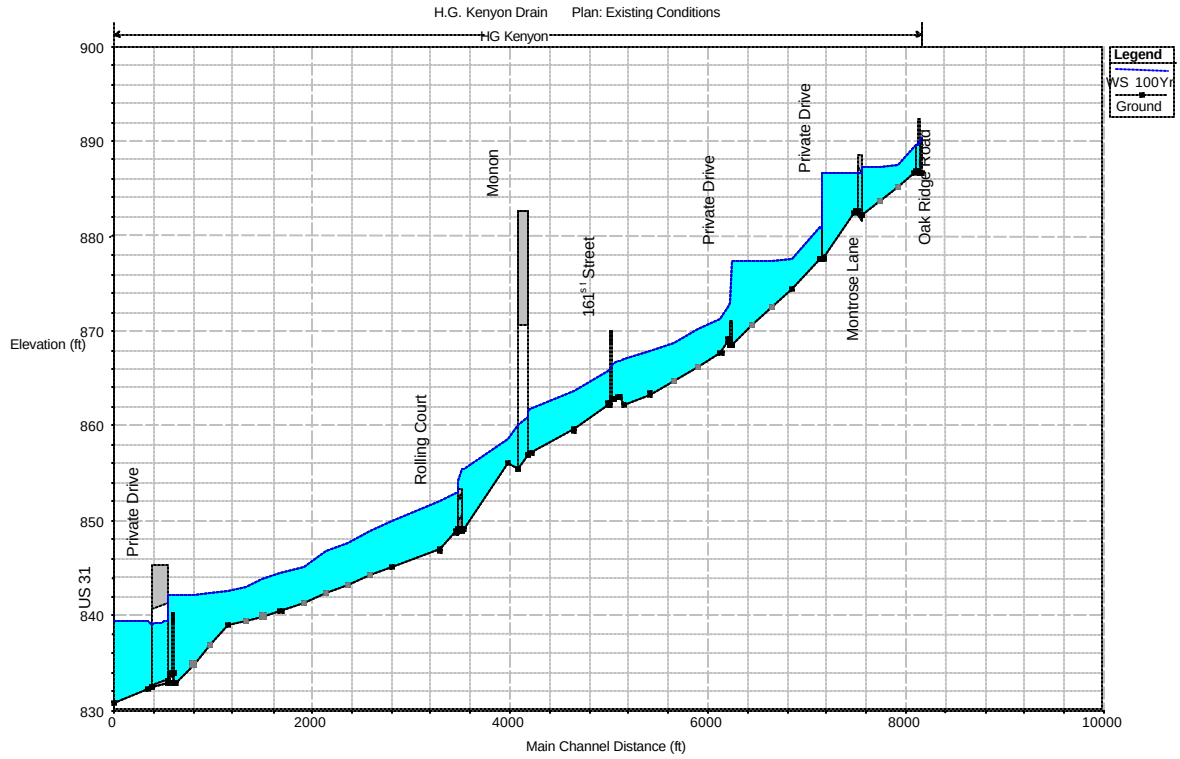


Figure 6-3
H.G. Kenyon Drain – 100-year Flood Profile

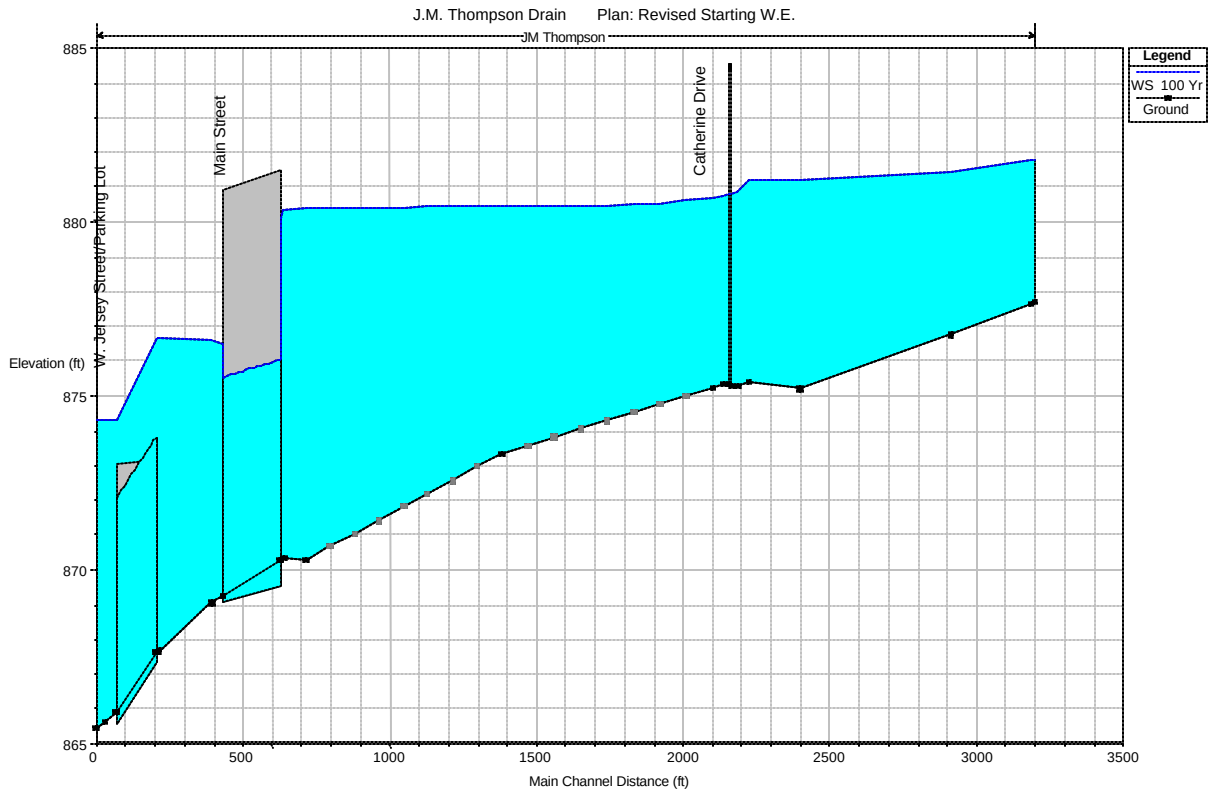


Figure 6-4
J.M. Thompson Drain – 100-year Flood Profile

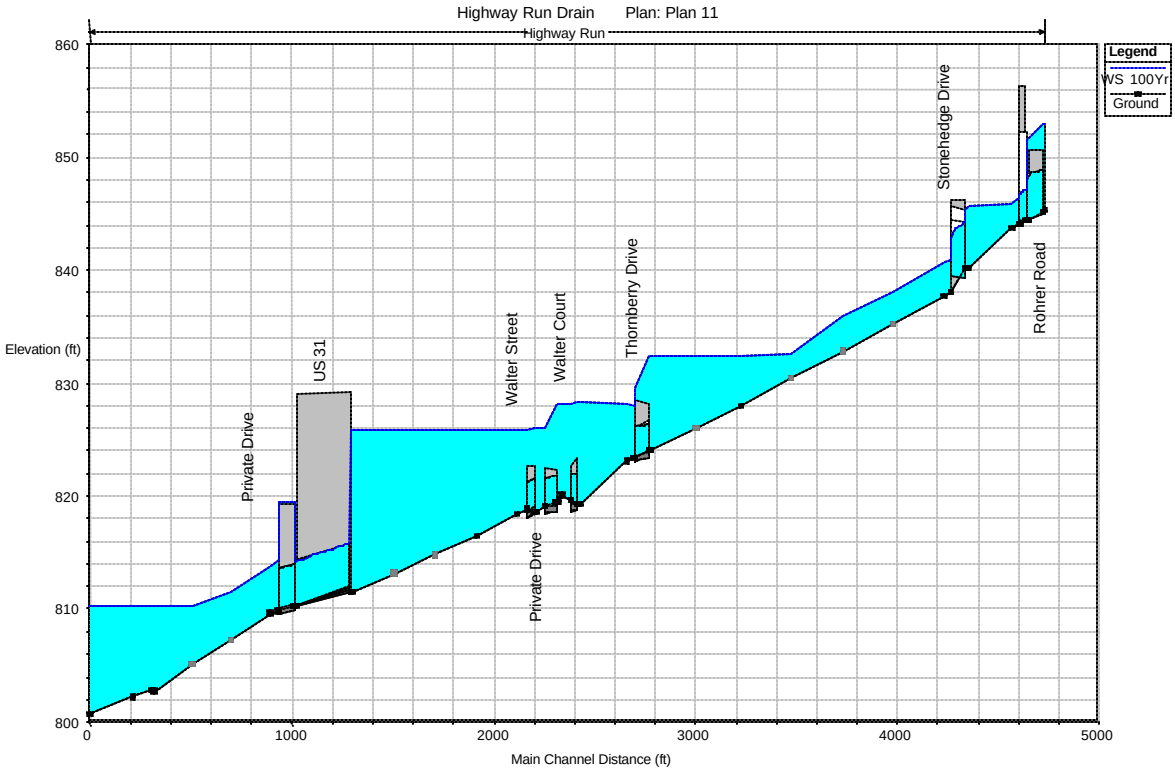


Figure 6-5
Highway Run Drain – 100-year Flood Profile

6.4.2 Existing FIS Model Results

The existing FIS HEC-RAS models (converted from HEC-2) provided model results nearly identical to the flood profiles contained in the Flood Insurance Study reports for Hamilton County, Westfield, and Carmel. The models predict the following roadway overtopping problems areas during the 100-year event.

Cool Creek

- E. 151st Street
- Oak Road
- S. Union Street/Westfield Boulevard
- Private Drive
- Oak Road
- 171st Street

Hot Lick Creek

- Carmel Drive

Anna Kendall Drain

- Four private drives
- Gurley Street
- Cherry Street
- Park Street
- Abandoned railroad embankment

The above results show that conveyance problems are much more pronounced in Westfield. Both Cool Creek and Anna Kendall Drain have several roadway crossings that would be overtopped during significant rainfall events.

A review of the Stream Inventory Maps shows some buildings in the 100-year floodplain of Cool Creek. Most are in the lower portion of the stream, downstream of 116th Street. There are approximately 12 building structures in the floodplain along Cool Creek downstream of Hazel Dell Parkway. This reach of Cool Creek is in the 100-year backwater area of the White River. Four buildings in the vicinity of 116th Street are in the floodplain. Other locations along Cool Creek with isolated buildings or structures in the floodplain are south of 136th Street, north of 151st Street, near 156th Street, and east of Grassy Branch Road. Anna Kendall Drain, along SR 32, has isolated buildings in the floodplain.

6.5 SUMMARY AND CONCLUSIONS

Hydraulic analyses were performed on Cool Creek and its major tributaries utilizing previously developed and new models developed during this project. The models were used to identify roadway overtopping and structures in floodplains. The models were also used to develop solutions to selected problem areas (Chapter 7). The hydraulic analyses lead to the following conclusions:

- The lower reaches of Cool Creek (in the City of Carmel) have limited flooding problems. No roadways are overtopped and limited structures are in the floodplain. Major upstream regional flood control facilities would provide limited benefit. Continued enforcement of the County's detention policy will effectively control 100-year discharges in the future.

- Stream related flooding is more pronounced in Westfield where several roadways along Cool Creek, Anna Kendall Drain, J.M. Thompson Drain and Highway Run are overtopped. Conveyance and/or storage solutions should be considered in these areas.

7.0 SOLUTION DEVELOPMENT

7.1 INTRODUCTION

7.1.1 Introduction to Solution Development

The solutions presented in this section were developed to address multiple needs within the Cool Creek watershed. These needs include:

- Flood control at major roadway crossings
- Neighborhood (local roadway) flood control
- Streambank erosion control
- Regional detention needs
- Land use and planning

Solutions were *not* considered for the following problems:

- Flooding at private crossings
- Flooding at bridges currently being replaced or under consideration for replacement in the near future
- Structures that meet currently-accepted stormwater design guidelines and do not negatively impact the 100-year floodplain

7.1.2 Upper Reaches versus Lower Reaches – Overview of Proposed Solutions

Upper Reaches:

Reduce peak flows during more frequent (i.e. 1-year and 2-year) rainfall events by constructing new and retrofitting existing detention basins. Although these detention facilities may not serve as flood control devices, they will serve as water quality enhancement features, providing the following benefits:

- Reducing sediment, nutrients, and metals in stormwater runoff
- Reducing flow rates resulting from more frequent storm events, thus reducing the erosive forces on downstream open channels
- Providing habitat for aquatic and non-aquatic species
- Reserving open space in the watershed for public access, recreation, and education

Provide adequate conveyance at major roadway crossings. Based on available hydraulic information, there are more severe conveyance problems in the upper reaches of Cool Creek and its immediate tributaries. Replacing inadequate bridges and culverts will help to enhance public safety by reducing the likelihood of roadway overtopping during major storm events and reduce floodplain impacts on property owners.

Lower Reaches:

Many downstream reaches of Cool Creek currently experience severe erosion problems. This is largely due to the following:

- ***Aggregate effects of development in the upstream portions of the Cool Creek watershed.*** Higher peak flows occur more frequently and subject channel streambanks to excessive erosive forces. Numerous detention ponds have been constructed in the watershed. These ponds provide effective peak flow control for larger storm events, but do not adequately restrict flow rates for more frequent (i.e. 1-year and 2-year recurrence interval) storm events. These more frequent rainfall events generally dictate the tendency for channel erosion.

- ***Development at or near existing channels*.** Manmade features, such as residential structures, retaining walls, patios, foot bridges, and decks have been constructed within the floodplain and result in flow restrictions, higher velocities, and promote downstream streambank erosion.

Construction near channel (right side of photo) constricts flood waters and promotes downstream erosion. Landscape debris (left side of photo) prevents the efficient flow of water and traps additional debris, creating a dam.

The proposed improvements to the Cool Creek watershed will be an important first step in reducing nuisance flooding, preventing flooding at major roadways, and reducing streambank erosion. Land use planning within the entire Cool Creek watershed should be implemented to minimize the impacts of development on stormwater pollution, erosion potential, and flooding potential. This will help to ensure a positive return on the capital investments recommended in this section (see discussion on recommended land use and planning policies in Section 7.8).

7.2 DESIGN CRITERIA AND CONSTRAINTS

7.2.1 Erosion Prevention

Channel erosion is a key factor in water quality degradation and presents numerous problems for stormwater infrastructure. The absence of vegetation along channel banks, when combined with high flow velocities, results in channel deepening, widening, and incision. This process is accelerated in areas of rapid land development, due to changing flow patterns, increased sediment from construction activities, and inadequate culverts and bridges. The long-term quality of Cool Creek will be improved by reducing steambank erosion. Erosion prevention can consist of the following methods:

- Streambank stabilization of severely eroded areas (Section 7.6)
- Hydrologic modification using regional detention (Section 7.7)
- Monitoring and long-term maintenance of moderately eroded areas
- Modifying the detention policy to better control and detain runoff from the 1-year and 2-year storms (Section 7.8)

Numerous erosion areas exist along the entire reach of the Cool Creek and its tributaries. The cost to repair each identified erosion area would be prohibitive. As such, it was necessary to classify each erosion area as minor, moderate, or severe. This classification allowed the separation of erosion areas posing the greatest threat to public safety and private property from those areas not needing immediate attention.

Severe erosion areas consisted of specific channel segments with evidence of any or all of the following:

- Deep, undercut channel banks
- Absence of vegetation along entire eroded bank
- Steep bank slope (exceeding 1:1 ratio and approaching vertical)
- Close proximity of manmade structures

Seven separate severe erosion sites have been identified in the Cool Creek watershed. Of these sites, five are along the Cool Creek. Two sites are located on tributaries. These sites are discussed in more detail in Section 7.6.

Minor and moderate erosion areas showed initial signs of channel undercutting and loss of vegetation. These areas have been identified on the Cool Creek Inventory Maps and should be monitored in the future for any negative physical changes.

HEC-RAS v. 3.0 was used to estimate peak flow velocities for seven (7) individual sites experiencing *severe erosion* (using HEC-2 data from the most recent Cool Creek Flood Insurance Study, supplemented with GIS contour data). As discussed in Section 7.6, the calculated velocities have been used to develop recommendations for streambank improvements for each identified area. Peak flow velocities resulting from the *10-year* recurrence interval storm were used to evaluate each erosion area and to determine appropriate erosion prevention measures.

7.2.2 Flood Control

Numerous flood-prone areas have been identified through past resident complaints, FEMA floodplain maps, and independent hydraulic analysis. Many of the flood-prone areas are caused by private driveway crossings and are located in remote, undeveloped portions of the watershed. Proposed flood control solutions have been prepared only for major public roadways and other public rights-of-way with significant known flooding problems.

Neighborhood Flooding. Typical municipal standards were employed for solution development in identified neighborhood flooding areas. Culverts, storm sewer pipes, and open channels were designed to convey the runoff generated from a 10-year recurrence interval rainfall event. In developing the proposed solutions for neighborhood flooding areas, it was assumed that access to private property could be secured through permanent and/or temporary construction easements.

The proposed solutions were developed using HEC-RAS and HY8 (HY8 is a culvert analysis program). GIS data were used to determine approximate site characteristics and identify potential construction limitations.

Roadway (Bridge) Overtopping. INDOT design standards were employed for bridges identified as flood-prone. The hydraulic capacities of 151st Street and 171st Street bridges (each at Cool Creek) and Cherry Street, Gurley Street, and Park Street (each at Anna Kendall Drain) were analyzed for both the 25-year and 100-year recurrence interval rainfall events. INDOT standards specify that a bridge with an Average Daily Traffic (ADT) count between 1,000 and 3,000 shall convey stormwater runoff generated from a 25-year recurrence interval rainfall event without roadway flooding. *The above crossings should fall within the referenced ADT range.* For a 100-year event, the upstream hydraulic grade line shall be less than or equal to 0.10 feet above that under existing conditions. The proposed modifications for the above crossings, with the exception of Gurley Street (ADT < 1,000), were based on these criteria.

HEC-RAS v. 3.0 was used to develop a hydraulic model for the existing and proposed bridge geometries. Existing bridge geometries and cross-sectional data for Cool Creek were based on the pending 2003 update of the Flood Insurance Study (HEC-2 model). Cross-sectional and roadway crossing geometries for the Anna Kendall Drain were based on approximations developed using the GIS contour and roadway elevation data.

Excessive Hydraulic Restrictions at Roadway Crossings. The US 31 crossing (Highway Run), the SR 32 (Main Street) crossing (J.M. Thompson Drain), and several culverts in the vicinity of Walter Street/Walter Court (Highway Run) create significant headwater, resulting in wide floodplains upstream of each location, affecting numerous residential structures. HEC-RAS was used to determine necessary culvert replacements that would lower the 100-year water surface elevations upstream of selected culverts along the Highway Run and J.M. Thompson Drain. Although these culverts do no overtop during the 100-year event, they result in significant upstream flooding. As such, their replacement is recommended.

7.3 COST ESTIMATING APPROACH

This section describes the basis for determining estimated costs for the proposed solutions. At the end of this section is a summary of the estimated costs for each proposed improvement. These cost estimates are based on typical construction bids for similar work and information available from governmental sources.

7.3.1 Streambank Restoration

Streambank restoration costs vary widely, largely due to the numerous materials and construction techniques currently available. The United States Environmental Protection Agency (USEPA) and the Natural Resource Conservation Service (NRCS) provide useful information on typical costs for streambank restoration work. Unit prices were based on guidance from these sources and available bid history on similar pay items. Estimated restoration costs were adjusted to account for specific site characteristics, such as channel depth, estimated flow velocities and site accessibility/mobilization.

7.3.2 Storm Sewers and Appurtenances

Storm sewer estimates were based on bid tabulations for similar construction work. Adjustments were made for specific site characteristics and site accessibility.

7.3.3 Pavement Re-grading and Bridge/Culvert Removal and Replacement

Pavement re-grading and bridge removal/replacement costs were based on bid tabulations for similar construction work. Cost estimates for bridge/culvert replacement include additional costs for soil testing, structural analysis, excavation, pavement restoration, riprap, boring/jacking (if necessary) and general site restoration.

7.3.4 Detention Facilities

Detention pond construction cost estimates were based on published ranges available from the USEPA and other sources.

The estimated cost to retrofit the detention basin upstream of the Conrail Railroad (Anna Kendall Drain) was modified to reflect additional costs required to satisfy the Indiana DNR *General Guidelines for New Dams and Improvements to Existing Dams in Indiana.*

The detention pond cost estimates do *not* include land acquisition costs, unless specifically noted.

7.3.5 Construction Contingency

A construction contingency of twenty (20) percent was added to each construction estimate to account for unforeseeable site specific items that cannot be identified at the conceptual design level.

7.3.6 Non-Construction Costs

Each proposed improvement will require field survey, detailed site condition analysis, design report preparation, regulatory permitting, plan and specification preparation, and construction

administration. Legal and administrative costs are also typically included on proposed improvement projects. For each proposed solution, it was estimated that an additional twenty (20) percent would be required for these non-construction costs. Land acquisition costs were assumed to be $15,000 per acre, unless the land was generally not conducive to development, in which case it was assumed to be $5,000 per acre.

Table 7-1 contains a summary of cost estimates for the proposed improvements in the Cool Creek watershed. Detailed costs estimates can be found in Appendix G. Additional discussion on the proposed improvements follows in Sections 7.4 through 7.7 of this chapter.

Table 7-1
Proposed Improvements Cost Summary

Project Description	***Total Project Cost***
151st Street Roadway Modification	$10,000
171st Street Roadway Modification/Bridge Replacement	$700,000
Gurley Street Bridge Replacement	$280,000
Cherry Street Bridge Replacement	$340,000
Carmel Drive (Hot Lick Creek)	$90,000
Swimming Pool Inundation (Hot Lick Creek)	$10,000
Private Drive Culvert Replacement @ US 31 (Highway Run)	$100,000
US 31 Culvert Replacement (Highway Run)	$700,000
Walter St., Private Drive, Walter Ct. Culvert Replacements (Highway Run)	$200,000
Thornberry Drive Culvert Replacement (Highway Run)	$80,000
SR 32 (Main Street) Culvert Replacement (J.M. Thompson Drain)	$310,000
Streambank Erosion D/S of Stonehedge Drive (Highway Run)	$5,000
Streambank Erosion D/S of Rolling Court (H.G. Kenyon)	$15,000
Streambank Erosion U/S of Confluence with White River	$300,000
Streambank Erosion D/S of Gray Road	$75,000
Streambank Erosion Near Hot Lick Creek Confluence	$125,000
Streambank Erosion U/S of 131st Street	$20,000
Streambank Erosion U/S of Keystone Avenue	$30,000
171st Street Regional Stormwater Detention Pond	$2,600,000
Grassy Branch Road Regional Stormwater Detention Pond	$1,800,000
Anna Kendall In-Line Detention Pond Retrofit	$700,000
TOTAL	**$8,490,000**

7.4 STREAM FLOODING/ROADWAY OVERTOPPING SOLUTIONS

The HEC-RAS backwater analysis confirmed that several roadway crossings within the Cool Creek watershed are either: 1) not adequate to meet current INDOT hydraulic requirements; or 2) creating significant headwater during the 100-year storm, resulting in the flooding of residential structures. These crossings are:

- 151st Street (Cool Creek)
- 171st Street (Cool Creek)
- Cherry Street (Anna Kendall)
- Gurley Street (Anna Kendall)
- W. Jersey (J.M. Thompson)
- SR 32 (Main Street) (J.M. Thompson)
- US 31 and Adjacent Private Crossing (Highway Run)
- Walter Street, Walter Court, and Adjacent Private Crossing (Highway Run)
- Thornberry Drive (Highway Run)

The proposed solutions for each crossing are discussed in detail as follows:

7.4.1 E. 151st Street (Cool Creek)

Under existing conditions, 151st Street would be flooded during significant storm events. As the roadway elevation is low relative to the channel elevation, overtopping occurs during storm events less than the 25-year recurrence interval magnitude. As such, the crossing does not meet current INDOT hydraulic standards.

151st Street Bridge (Cool Creek)

The proposed solution consists of approximately 160 LF of roadway elevation modification. Increasing the roadway to a minimum elevation of 823.50 will provide flooding protection up to the 25-year recurrence interval rainfall event, per INDOT requirements. Figure 7-1 illustrates the proposed extents of the roadway modification **(note: figures are grouped together at the end of this chapter)**. The total estimated project cost for this solution is $10,000.

7.4.2 171st Street (Cool Creek)

Under existing conditions, 171st Street would be flooded during significant storm events. Similar to 151st Street, the roadway elevation is low relative to the channel elevation. However, the bridge opening is small at 171st street, adding to the hydraulic restriction. Overtopping occurs during storm events less than the 25-year recurrence interval magnitude. As such, the crossing does not meet current INDOT hydraulic standards.

171st Street Bridge (Cool Creek)

The proposed solution consists of approximately 320 LF of roadway elevation modification and the removal and replacement of the existing bridge. Bridge replacement is necessary to prevent excessive headwaters resulting from a 100-year storm. Replacing the bridge and raising the roadway elevation will provide flooding protection up to the 25-year recurrence interval rainfall event, per INDOT requirements. Figure 7-2 illustrates the proposed improvements.
The total estimated project cost for this solution is $700,000.

7.4.3 Gurley Street (Anna Kendall Drain)

Gurley Street is a minor dead-end public roadway with an average roadway width of 11 feet. The existing bridge consists of wooden abutments, 45-degree wooden wingwalls, steel deck supports and a wooden deck. The bridge is in fair to poor structural condition. Under existing conditions, the Gurley Street crossing would be overtopped during the 50-year and 100-year storm events. The overtopping occurs approximately 75 feet north of the bridge at a vertical sag in the roadway. Our independent calculations indicate that this bridge would also be overtopped during the 25-year storm event. However, as this roadway is minor it likely has an ADT well below 1,000. As such, INDOT standards would specify a 10-year storm be used as the criteria for maximum flow before roadway overtopping.

Given the structural condition of the existing bridge, it is recommended that it be replaced. The proposed solution consists of a new single-span concrete bridge. The new bridge will replace the failing wooden structure and provide additional hydraulic capacity. The proposed bridge, as depicted in Figure 7-3, would provide adequate conveyance for the 10-year storm without roadway overtopping. The total estimated project cost for this solution is $280,000.

Gurley Street (Anna Kendall)

7.4.4 Cherry Street (Anna Kendall Drain)

Cherry Street is a 2-lane local roadway with a rectangular concrete bridge opening. The bridge opening area at Cherry Street is smaller than nearby bridges, including Gurley, Union, and Park Streets. Under existing conditions, the Cherry Street crossing would be overtopped during the 50-year and 100-year storm events. This crossing creates a significant hydraulic restriction in the Anna Kendall Drain, raising the 100-year water surface elevation by approximately three (3) feet. Replacing this bridge would provide significant improvements to the upstream floodplain and would help to lower the 100-year floodplain elevation in the downstream reach of the J.M. Thompson Drain.

Cherry Street (Anna Kendall Drain)

The proposed solution consists of a new single-span concrete bridge. The new bridge will replace the current small opening area and will provide adequate hydraulic capacity at the crossing. The proposed bridge, as depicted in Figure 7-4, would provide adequate conveyance for the 25-year storm without roadway overtopping. Furthermore, the hydraulic grade line would be lowered significantly through this reach of drain, helping to alleviate flooding problems upstream of Cherry Street. The total estimated project cost for this solution is $340,000.

7.4.5 W. Jersey Street and SR 32 (Main Street) (J.M. Thompson Drain)

This crossing is impacted by the backwater effects caused by the Anna Kendall Drain, immediately downstream of W. Jersey Street. The proposed improvements to the Cherry Street will help to lower the 100-year floodplain approximately 0.6 feet near the mouth of the J.M. Thompson Drain. However, this is a low-lying area and would nonetheless be subject to flooding during a 100-year recurrence interval rainfall event.

W. Jersey Street Culvert (J.M. Thompson Drain)

Upstream of Main St. (J.M. Thompson Drain)

Replacing the culvert at W. Jersey Street would not have a significant hydraulic impact, given the high tailwater created by the Anna Kendall Drain. As such, it is recommended that no improvements be made at this location.

The Main Street (SR 32) crossing, immediately upstream (north) of W. Jersey Street, creates a significant hydraulic restriction during the 100-year storm, causing flooding in upstream residential areas. In order to reduce flooding potential upstream of SR 32, it will be necessary to replace the existing CMP arch culvert at Main Street with a 12’ x 8’ box culvert, as illustrated in Figure 7-5. The total estimated construction cost to replace this culvert is $310,000.

7.4.6 US 31 and Adjacent Private Drive (Highway Run)

The US 31 crossing, in the lower reaches of the Highway Run, creates a severe hydraulic restriction. Furthermore, the private drive immediately downstream of US 31 creates an additional hydraulic restriction. The resulting headwaters impact the Walter Street/Walter Court neighborhood, causing widespread flooding during a 100-year storm. As such, it will be necessary to replace both culverts in order to lower the 100-year floodplain to a reasonable level.

US 31 Culvert (Highway Run)

The proposed culvert replacements, as depicted in Figure 7-6, will consist of replacing the twin 5' x 4' box culverts (private crossing) with a 10' x 6' box culvert and adding a 60" RCP culvert next to the existing box culverts under US 31. It was assumed that boring and jacking would be necessary at US 31, given the depth of the culvert and traffic volumes. The culvert replacements will help to relieve flooding potential upstream and will reduce flow velocities downstream of US 31. The total estimated construction cost to replace both culverts is $800,000.

7.4.7 Walter Street, Private Drive, and Walter Court (Highway Run)

Three adjacent stream crossings, beginning at the Walter Drive (downstream) crossing and ending at the Walter Court (upstream) crossing, are overtopped during the 10-year storm. The existing crossings, each consisting of triple CMP arch culverts, are partially filled with sediment and do not provide adequate flow conveyance. Replacing each crossing with a single 12' x 4' box culvert, in conjunction with minor channel reshaping, would provide adequate conveyance for the 10-year storm without roadway overtopping. The proposed improvements are illustrated in Figure 7-7. The total estimated construction cost to replace both culverts is $200,000.

Private Drive along Walter Street (Highway Run)

Walter Street (Highway Run)

7.4.8 Thornberry Drive (Highway Run)

The Thornberry Drive culvert does not adequately convey the 10-year recurrence interval rainfall event. This is partially due to the hydraulic restriction created by the Walter Street/Court culverts (described above in Section 7.4.7). Replacing the three culverts as described in Section 7.4.7 and replacing the existing Thornberry Drive culverts with a 11' x 3.5' box culvert (see Figure 7-8) will provide adequate conveyance for the 10-year storm. The total estimated construction cost to replace the Thornberry Drive crossing is $80,000.

Thornberry Drive (Highway Run)

7.5 NEIGHBORHOOD PROBLEM SOLUTIONS

7.5.1 Carmel Drive Overtopping (Hot Lick Creek)

The existing twin 48-inch concrete pipes do not provide adequate conveyance for a 10-year recurrence interval rainfall event. Nearby residential structures would be vulnerable to flood waters resulting from roadway overtopping. As such, it will be necessary to replace the existing culverts such that a 10-year storm flow can be adequately conveyed without roadway overtopping.

Carmel Drive (Hot Lick Creek)

The proposed solution consists of 120 lineal feet of a 4-foot rise by 10-foot span reinforced concrete box culvert with 45-degree wingwalls at each end. This improvement will reduce the 10-year peak water surface elevation at Carmel Street by approximately 0.6 feet, approximately 0.4 feet below the roadway elevation. Peak 10-year flow velocities at the downstream end of the Carmel Drive culvert will be reduced from 9.3 feet per second (fps) to just over 5 fps.

It is also recommended to re-grade approximately 120 lineal feet of the open channel upstream of the Carmel Drive culvert so as to provide additional flow capacity and better erosion protection. This is necessary to curb channel erosion that is beginning to occur in this area. Figure 7-9 illustrates the proposed culvert replacement and channel improvement. The total estimated project cost for this solution is $90,000.

7.5.2 Swimming Pool Inundation (Hot Lick Creek)

The Hot Lick Creek meanders within close proximity to an existing swimming pool in the vicinity of 126th Street and Fairbanks Drive. The channel is currently eroding along a wooden fence located near the swimming pool. However, this erosion is *not* related to the flooding susceptibility of the swimming pool located on this parcel.

It is recommended that approximately 105 lineal feet of the channel be relocated, as shown in Figure 7-10, to direct flow away from the existing residential property. Although this will help to prevent erosion along the existing fence, it will *not* affect the hydraulic capacity of the channel and will *not* prevent occasional flooding of the swimming pool area. Any channel relocation should be performed with careful consideration of existing conditions. The existing slope, cross section, and depth of the relocated channel should match those characteristics of the existing channel. The relocated channel should be immediately restored with vegetation and proper erosion control measures. The total estimated project cost for this solution is $10,000.

The floodplain elevation through this reach of channel can only be manipulated by *extensive* channel improvements. Such improvements would be cost-prohibitive and would provide little other substantial benefits. Therefore, only the channel relocation is recommended.

7.6 STREAMBANK EROSION SOLUTIONS

Seven streambank erosion sites were selected for improvements, based on the criteria described in Section 7.2.1. The proposed improvement sites are described as follows:

- Highway Run — Downstream of Stonehedge Drive
- H.G. Kenyon Drain — Downstream of Rolling Court
- Cool Creek — Upstream of confluence with the White River
- Cool Creek — Downstream of Gray Road (at bend)
- Cool Creek — Upstream and downstream of Hot Lick Creek
- Cool Creek — Upstream of 131st Street (Main Street)
- Cool Creek — Upstream of Keystone Avenue

Proposed solutions range from minor regrading and seeding (for areas experiencing moderate flow velocities) to more intensive improvements such as riprap, geotextile fabric, woody plantings, vegetated geogrids, etc. for areas experiencing high flow velocities or containing steep channel sideslopes. Whenever possible, streambank stabilization should employ vegetative

measures, so as to maintain the natural state of the channel corridor and to enhance instream water quality. In some instances of severe erosion, a more structural solution such as gabion baskets or revetment may be a more appropriate solution.

For all of the following improvement recommendations, the descriptions "left bank" and "right bank" reference the channel when looking *downstream.*

The proposed solutions described in this section are preliminary only. Upon choosing specific streambank restoration sites, detailed information will need to be collected and each site will need to be analyzed separately. Detailed information needed for a final design would be as follows:

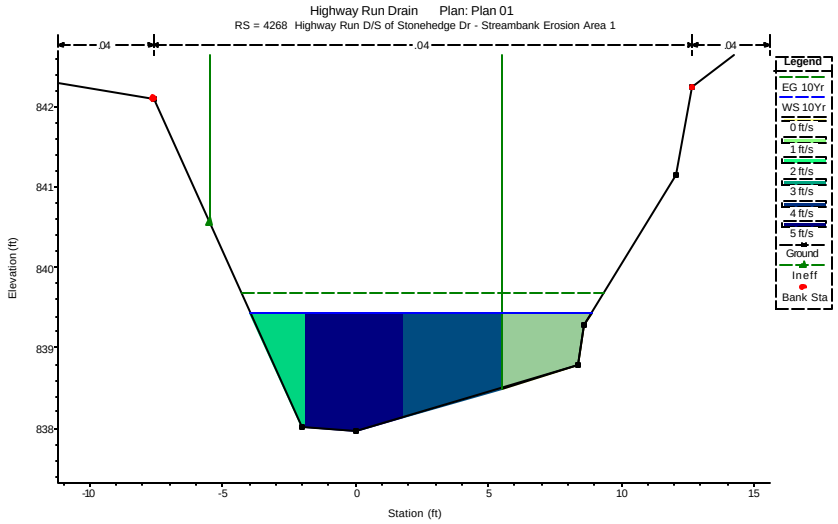
- Channel cross sections at each restoration site, including location of private features, property corners, and nearby utilities.
- Hydraulic analysis for each restoration site, including velocity calculations and shear stress calculations for more frequent (i.e. 1-year, 2-year) recurrence interval rainfall events.
- Soil analysis for each restoration site.
- Determination of land availability (i.e. easements, right-of-way, and land acquisition) for proposed grading.
- Determination of construction access points.
- Public input on proposed improvements (most important when improvements are immediately adjacent to existing homes)

The proposed solutions for each identified erosion area are discussed in detail as follows:

7.6.1 Highway Run: downstream of Stonehedge Drive

Significant streambank erosion is occurring approximately 100 lineal feet downstream of the Stonehedge Drive culvert (see Figure 7-11). Although this erosion area is isolated, it is severe. A utility pole adjacent to the channel is in danger of collapse.

Flow velocities are moderate in this area. The 10-year peak flow velocity, approximately 5 feet per second (fps), will require some vegetation reinforcement but should not require any more intensive improvements. The 10-year flow velocity distribution at this location is illustrated below.



Velocity Distribution: Highway Run downstream of Stonehedge

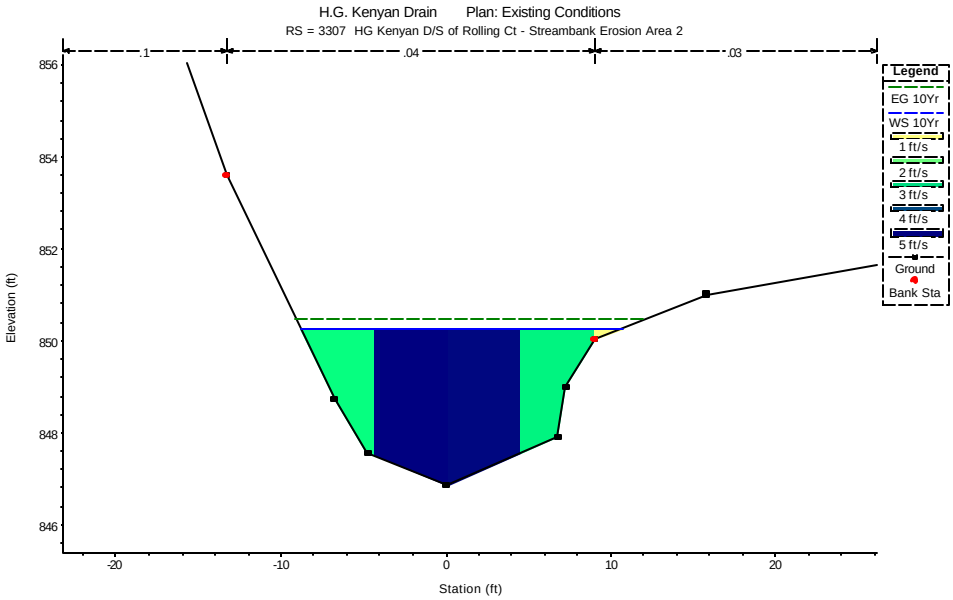
It is recommended that approximately 100 lineal feet of the Highway Run streambank be re-graded to a slope not to exceed 3:1 (horizontal:vertical). This will provide a flatter sideslope and will help to reduce flow velocities. The modified streambank should be reinforced with an erosion matting and grass seed specifically designed for open channels (often referred to as "ditch mix").

Some grading may be required on both sides of the channel in order to accommodate the existing utility pole. Streambank reinforcement should be implemented a minimum of *2 vertical feet* from the channel bottom.

7.6.2 H.G. Kenyon Drain: downstream of Rolling Court

Streambank erosion is occurring downstream of the Rolling Court culvert (see Figure 7-12). This erosion continues around a 90-degree bend in the channel for a total length of approximately 250 lineal feet. Although the majority of the identified erosion is occurring on the right channel bank, there is a steep bank on the left side of the channel that will be vulnerable to considerable erosion if left unchecked.

Flow velocities are moderate in this area. The 10-year peak flow velocity of approximately 5 feet per second (fps), will require some vegetation reinforcement but should not require any intensive improvements. The 10-year flow velocity distribution at this location is illustrated below.



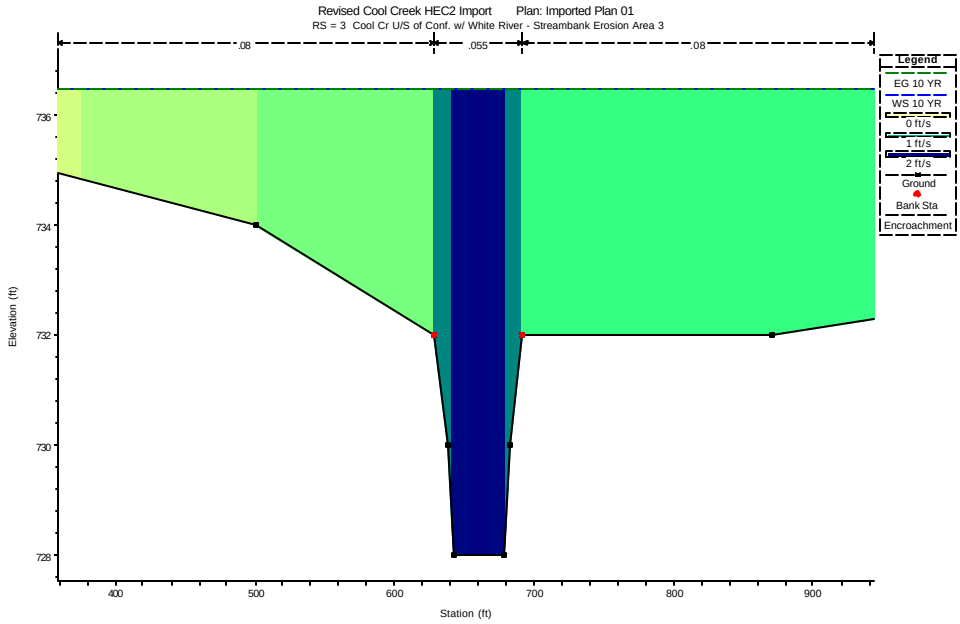
Velocity Distribution: H.G. Kenyon Drain downstream of Rolling Ct.

It is recommended that 250 lineal feet of the Highway Run streambank (right side only) be graded to a slope not exceeding 3:1 (horizontal:vertical) and reinforced with vegetative protection. This will protect the soils and increase the friction coefficient along the streambank, thus helping to reduce flow velocities. The modified streambank should be reinforced with an erosion matting and grass seed specifically designed for open channels (often referred to as "ditch mix"). The proposed improvements for this area are similar to those described in Section 7.6.1. Streambank reinforcement should be implemented a minimum of *3 vertical feet* from the channel bottom.

7.6.3 Cool Creek: upstream of confluence with the White River

Streambank erosion is occurring in the downstream reaches of the Cool Creek, immediately upstream of its confluence with the White River (see Figure 7-13). This erosion occurs over an approximate length of 1500 lineal feet. The erosion in this area is severe, with incised streambanks (near vertical sideslopes) and undercut channels.

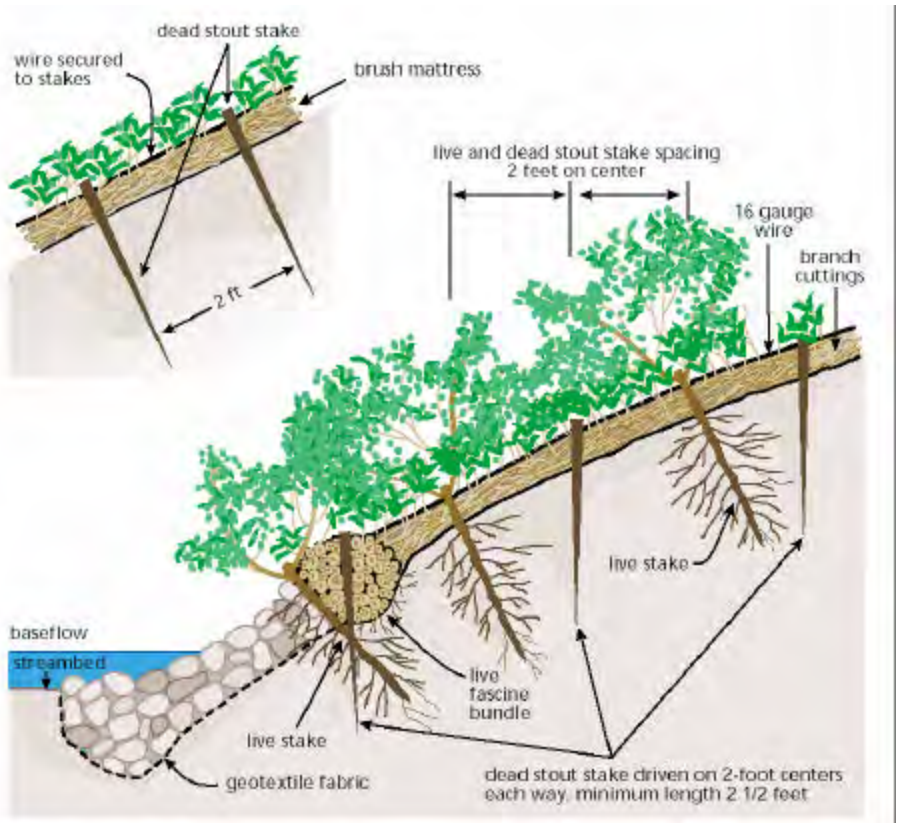
Although the 10-year peak flow velocity is low in this reach, approximately 2 fps, it is likely that more frequent storm events (i.e. 1-year and 2-year recurrence interval) have a significant impact on the channel, as the White River backwater would likely have a smaller impact on the Cool Creek and velocities would be higher. The 10-year flow velocity distribution at this location is illustrated below.



Velocity Distribution: Cool Creek upstream of the White River

Protecting this reach of the Cool Creek is critical, as any erosion in this area would be immediately transported to the White River. Erosion prevention measures at this location should be designed to withstand frequent erosive forces.

It is recommended that 1500 lineal feet of the Cool Creek streambank be re-graded to a slope not exceeding 2:1 (horizontal:vertical) and reinforced using a *brushmattress technique* as illustrated on the following page. This will help to stabilize the streambank from the channel bed to the top of bank with a combination of dense vegetation, geotextile fabric, and riprap. Streambank reinforcement should be implemented a minimum of *4 vertical feet* from the channel bottom. Gabion basket stabilization would also be a viable option at this location.



Brushmattress Technique (Source: USDA-NRCS 1996)

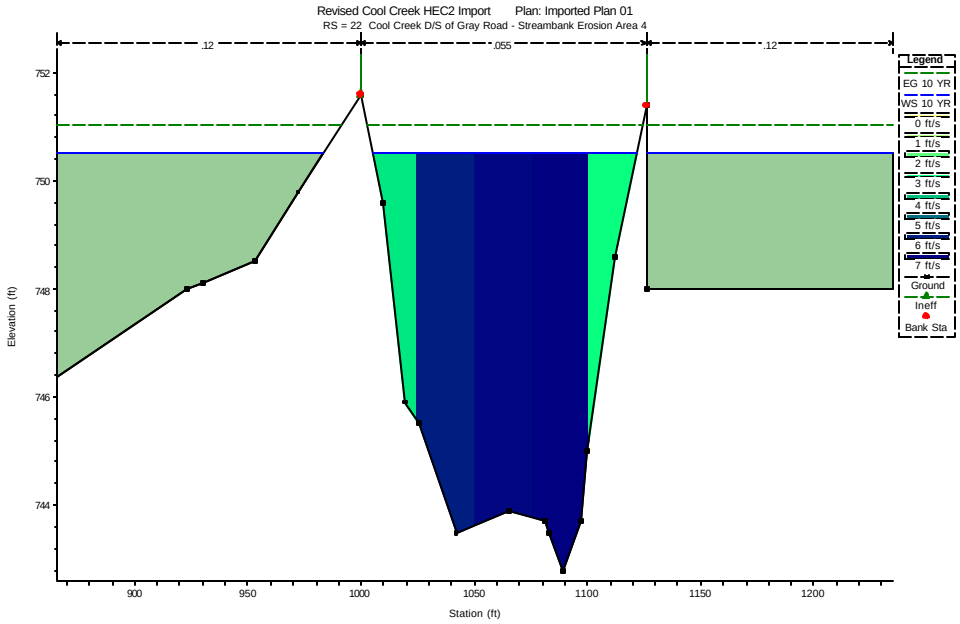
7.6.4 Cool Creek: downstream of Gray Road (at bend)

Streambank erosion is occurring in the Cool Creek downstream of Gray Road (see Figure 7-14). This erosion continues around a sharp bend in the channel for a total length of approximately 200 lineal feet. The streambank along the outside edge of the channel bend is subject to severe erosion. The 10-year peak flow velocities at this location are very high, exceeding 7 fps at the center of the channel. Flow velocities in this range will cause significant erosion in unprotected areas. The 10-year flow velocity distribution at this location is illustrated on the following page.

Protecting this reach of the Cool Creek will require significant protection along the lower portion of the main channel to combat the high flow velocities.

It is recommended that 200 lineal feet of the Cool Creek streambank be reinforced using a *vegetated geogrid* as shown in the illustrations and photographs on the following pages. This will help to stabilize the streambank from the channel bed to the top of bank with a combination of dense vegetation, geotextile fabric, and boulders.

Riprap toe protection should be installed along the toe of streambank to provide additional protection against streambank incision. The riprap toe protection should be provided using brushmattress technique previously discussed. Streambank reinforcement should be implemented a minimum of *6 vertical feet* from the channel bottom.

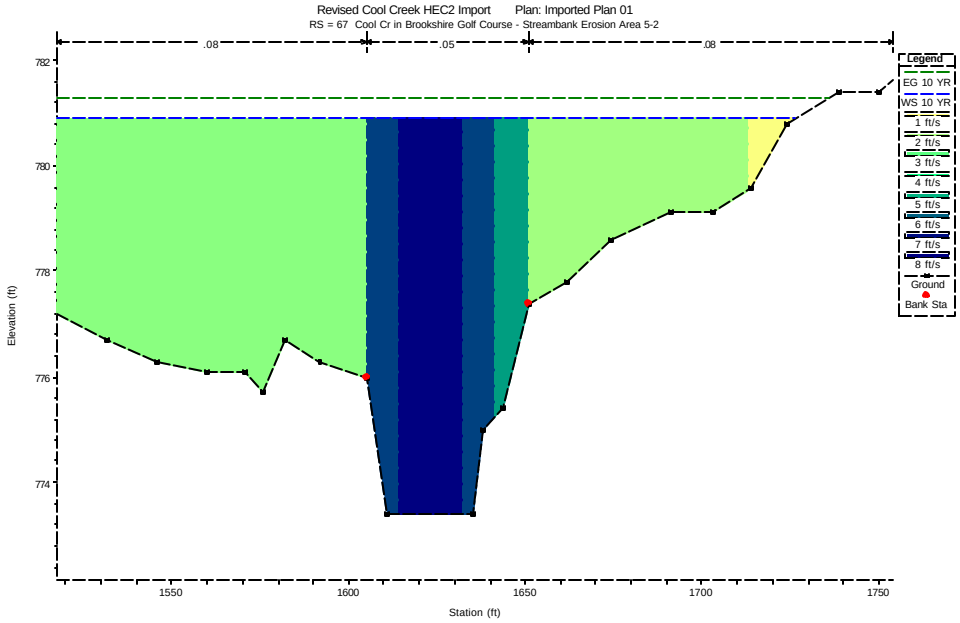


Velocity Distribution: Cool Creek downstream of Gray Road

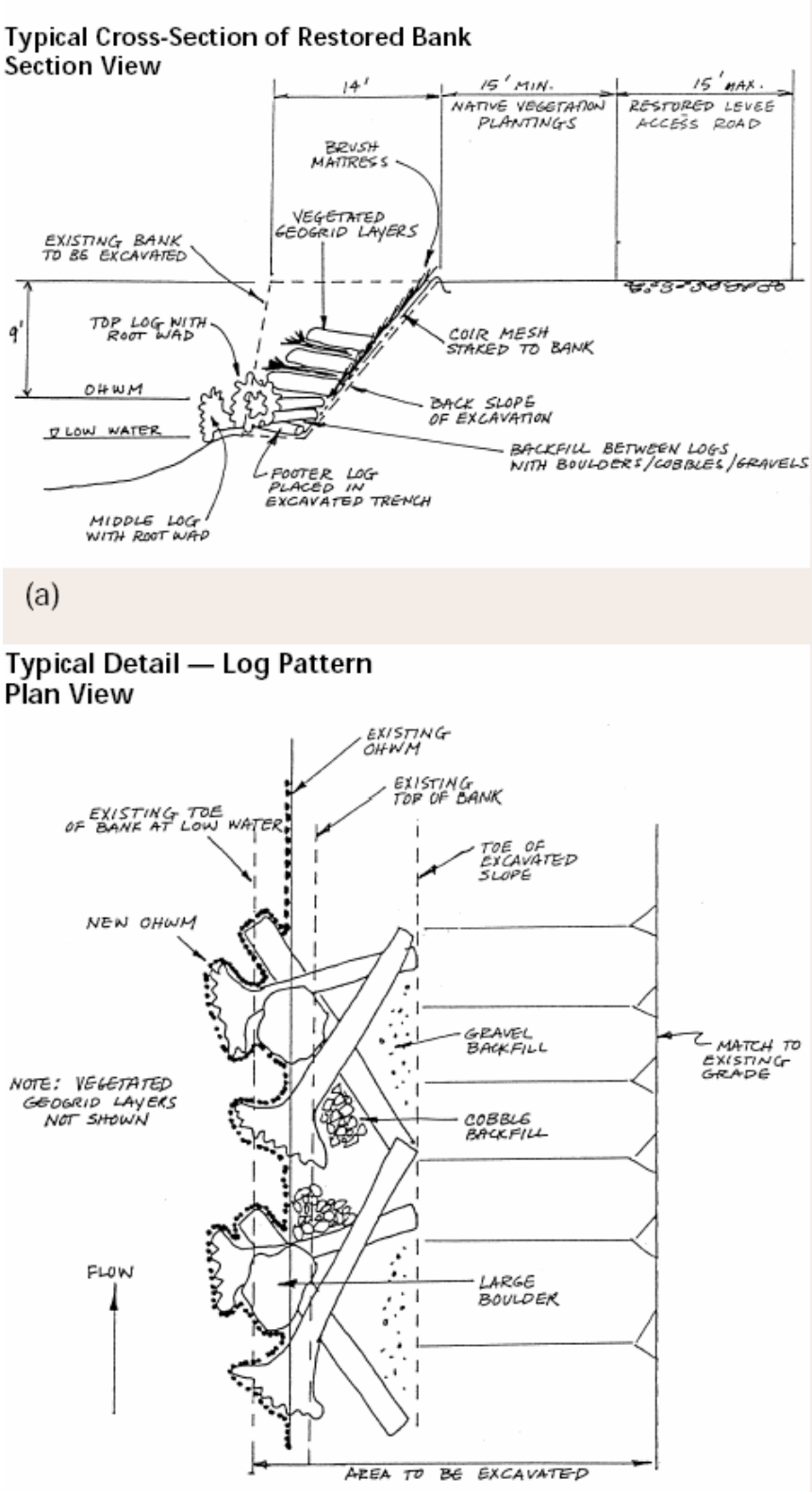
7.6.5 Cool Creek: upstream and downstream of Hot Lick Creek

Streambank erosion is occurring in the Cool Creek in the vicinity of the Hot Lick Creek, through the Brookshire Golf Course (see Figure 7-15). This erosion is severe and will likely continue to worsen unless preventative measures are taken.

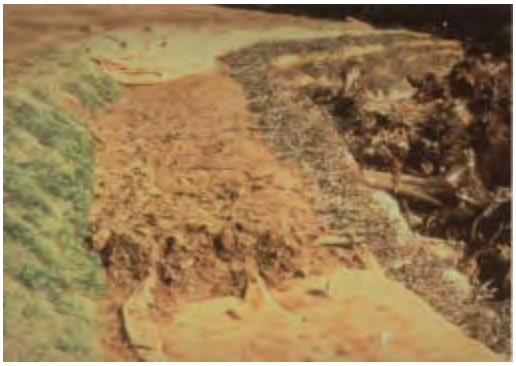
The 10-year peak flow velocities at this location are very high, exceeding 8 fps at the center of the channel. Flow velocities in this range will cause significant erosion in unprotected areas. The 10-year flow velocity distribution at this location is illustrated below.



Velocity Distribution: Cool Creek in vicinity of Hot Lick Creek



Vegetated Geogrid (Source: King County Surface Water Management Division)

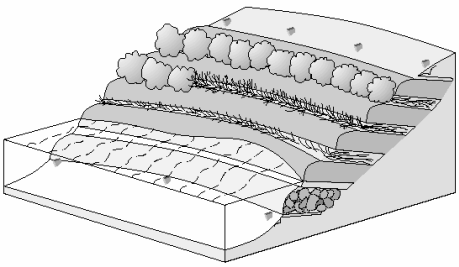


Geogrid Installation

Geogrid Post-Installation

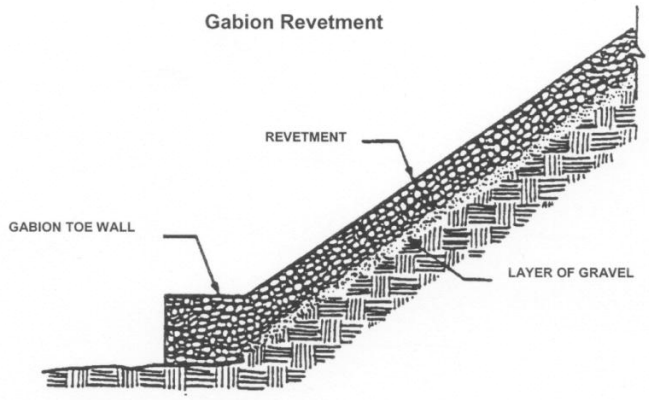
Geogrid after Complete Establishment of Vegetation

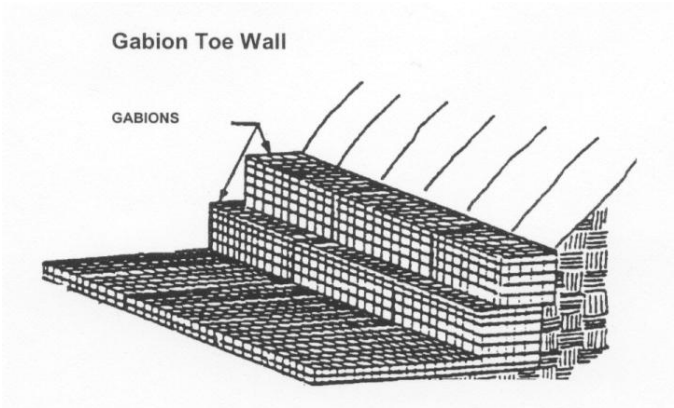
Vegetated Geogrids



Alternating layers of live branch cuttings and compacted soil with natural or synthetic geotextile materials wrapped around each soil lift to rebuild and vegetate eroded streambanks.

Vegetated Geogrids can also consist of branch cuttings and live stakes, as opposed to large diameter tree trunks, as depicted in the photos above. (Source: Federal Interagency Stream Restoration Working Group, 1998)





Source: Chattanooga Public Works Department

Example of Gabion channel bank stabilization on Cool Creek near Underwood Court in City of Carmel

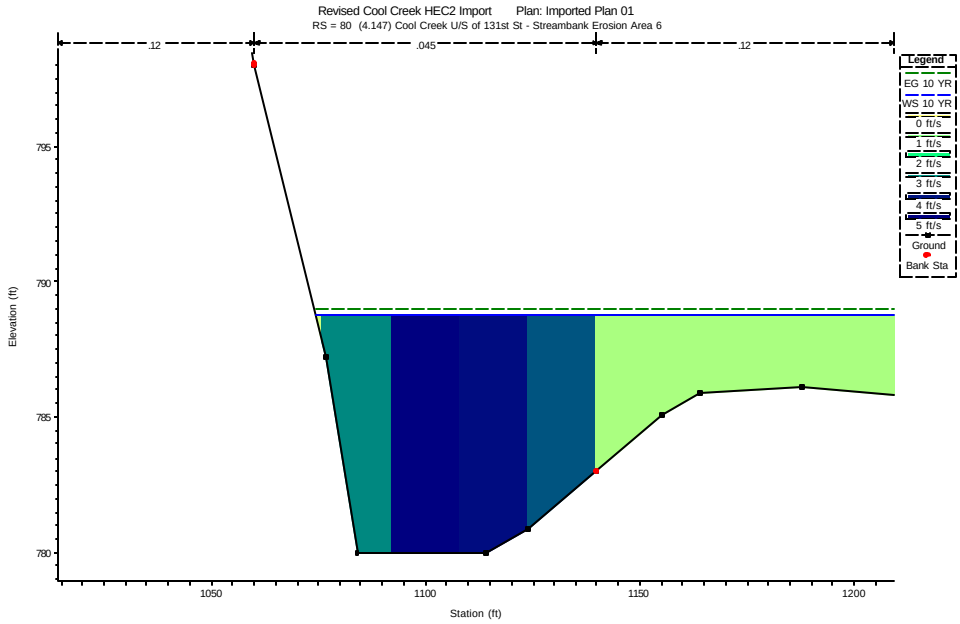
Protecting this reach of the Cool Creek will require significant protection along the lower portion of the main channel to combat the high flow velocities.

It is recommended that a total of 575 lineal feet of the Cool Creek streambank be reinforced using the *brushmattress technique* as described in Section 7.6.3. Streambank reinforcement should be implemented a minimum of *3 vertical feet* from the channel bottom.

7.6.6 Cool Creek: upstream of 131st Street (Main Street)

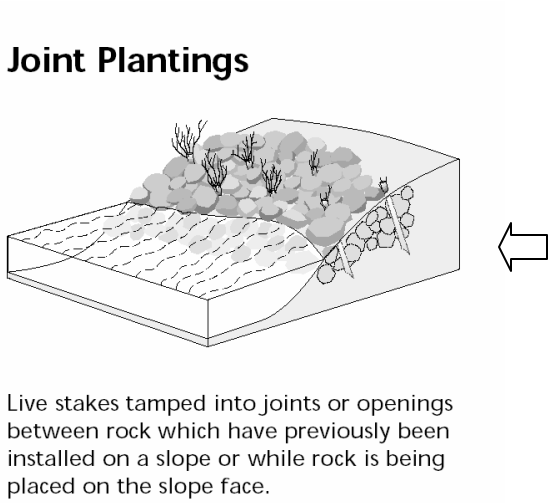
Streambank erosion is occurring in the Cool Creek immediately upstream of 131st Street (see Figure 7-16). This erosion, occurring on 150 lineal feet of the left streambank, is severe and will likely continue to worsen unless preventative measures are taken.

The 10-year peak flow velocities at this location are moderate, exceeding 5 fps at the center of the channel. Flow velocities in this range will cause continued erosion in unprotected areas. The 10-year flow velocity distribution at this location is illustrated below.



Velocity Distribution: Cool Creek upstream of 131st Street

Protecting this reach of the Cool Creek will require some regrading, slope protection, and vegetative reinforcement to protect the channel banks from continued erosion. It is recommended that 150 lineal feet of the Cool Creek streambank be re-graded to a slope not exceeding 3:1 (horizontal:vertical) and reinforced with a combination of riprap (w/geotextile fabric base) and live woody stakes (referred to as the *joint plantings* technique, see illustration on following page). The live stakes will take root along the reinforced streambank and strengthen the channel. Furthermore, the live stakes will grow and shroud the riprap with a natural vegetative cover. Streambank reinforcement should be implemented a minimum of *4 vertical feet* from the channel bottom.

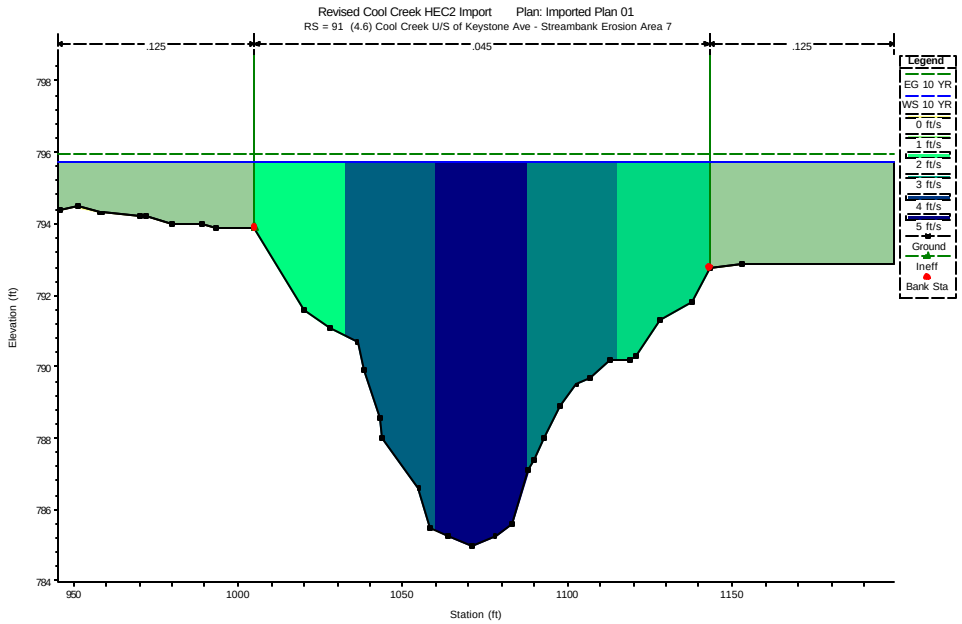


Riprap and Live Stakes (Joint Plantings)
Source: Federal Interagency Stream Restoration Working Group, 1998

7.6.7 Cool Creek: upstream of Keystone Avenue

Streambank erosion is occurring in the Cool Creek immediately upstream of Keystone Avenue (see Figure 7-17). This erosion, occurring on the right channel bank, is severe and will likely continue to worsen unless preventative measures are taken.

The 10-year peak flow velocities at this location are very moderate, exceeding 5 fps at the center of the channel. Flow velocities in this range will cause continued erosion in unprotected areas. The 10-year flow velocity distribution at this location is illustrated below.



Velocity Distribution: Cool Creek upstream of Keystone Avenue

Protecting this reach of the Cool Creek will require some regrading and vegetative reinforcement to protect the channel banks from continued erosion. It is recommended that 100 lineal feet of the Cool Creek streambank be reinforced with a combination of riprap toe protection and a *brushmattress technique* (Section 7.6.3). Streambank reinforcement should be implemented a minimum of *6 vertical feet* from the channel bottom.

7.7 REGIONAL STORMWATER DETENTION

Natural drainage channels are highly sensitive to changes in the magnitude of frequent stormwater runoff (i.e. 1-year and 2-year recurrence interval) events. Urban development, despite the presence of stormwater detention ponds, often increases the magnitude of 1-year and 2-year peak flows. This is a result of a detention pond design focus on the design (i.e. 100-year and 10-year) events. Although detention ponds typically reduce peak flow rates for larger (i.e. 100-year and 10-year) storm events, they often *increase* peak flow rates for more frequent (i.e. 1-year, 2-year) storm events and extend the overall duration of higher flow.

The hydrologic analysis completed for this project showed that major regional detention is not warranted to control the larger storms. Flooding is not a major problem in the lower watershed reaches and the existing detention policy for new development will be effective in controlling peak flows from these larger storms. However, it is recommended that regional detention facilities be constructed in the upper reaches of Cool Creek to help control the magnitude of 1-year and 2-year recurrence interval rainfall events. These facilities should be constructed "off-line" so as to maintain baseflow in the channel, avoid disrupting the existing riparian corridor, and avoid extensive dam safety requirements.

Regional stormwater detention facilities will provide the following benefits to the Cool Creek watershed:

- Reduce peak flow rates for more frequent storms
- Improve water quality by reducing concentrations of sediment, nutrients, and metals
- Increase aquatic habitat by providing wetland and open water areas
- Reduce downstream erosion potential by decreasing the magnitude and duration of the 1-year and 2-year flows, thus further reducing sediment pollution
- Maintain developable land by constructing basins in the existing 100-year floodplain (assuming this land would not be otherwise developable)

Two new regional stormwater detention facilities are recommended. The first is located immediately downstream of 171st Street and the second is located west of Grassy Branch Road. Both detention facilities are located in the upper reaches of the Cool Creek watershed and are within the existing 100-year floodplain.

An existing impoundment created by a culvert under an abandoned railroad embankment is located along the Anna Kendall Drain (immediately upstream of Park Street). This facility is in need of improvements in order to maintain the storage and associated peak flow reductions.

7.7.1 171st Street Off-Line Detention Pond (South Pond)

This detention pond would intercept diverted water immediately south (downstream) of 171st Street. A zero-slope low flow channel would direct the water through in a meandering path towards the pond outlet. Emergent and submergent wetland vegetation should be planted throughout the pond area, creating a means to filter stormwater and remove pollutants prior to discharge back into Cool Creek. The detention pond would discharge into the Cool Creek approximately 1500 channel-feet downstream of 171st Street.

The pond, illustrated in Figure 7-18, would require approximately 160,000 cubic yards of earthwork and would provide approximately 95 acre-feet of stormwater storage. The total estimated project cost for this pond is $2,600,000. Peak flows within Cool Creek could be reduced as follows:

Location	1 Year Storm (cfs)			2 Year Storm (cfs)		
	Existing Flow	Proposed Flow With 171st Street Detention	Percent Reduction	Existing Flow	Proposed Flow With 171st Street Detention	Percent Reduction
171st Street	546	254	53%	699	400	43%
146th Street	883	539	39%	1106	726	34%
131st Street	1107	825	25%	1426	1118	22%
116th Street	1156	944	18%	1497	1267	15%
Confluence	1205	998	17%	1525	1333	13%

The proposed off-line detention basin would provide substantial flow reduction up to the 2-year storm event. Storms exceeding the 2-year magnitude would inundate the detention basin. As the proposed detention ponds are intended to enhance stormwater quality and prevent channel erosion, flow attenuation was not considered for the 10-year through 100-year storm events. Existing detention ponds throughout the watershed provide storage volume for these larger rainfalls.

7.7.2 Grassy Branch Road Off-Line Detention Pond (North Pond)

This detention pond would intercept diverted water from Cool Creek approximately 1,500 feet south of 191st Street and approximately 2,500 feet west of Grassy Branch Road. The general layout and design of this detention pond will be similar to that of the 171st Street Detention Pond. The off-line detention pond would discharge back into the Cool Creek approximately 280 feet west of Grassy Branch Road (approximately 2600 channel-feet downstream of the inlet diversion).

The pond, illustrated in Figure 7-19, would require approximately 100,000 cubic yards of earthwork and will provide approximately 115 acre-feet of stormwater storage. The total estimated project cost for this pond is $1,800,000. Peak flows within Cool Creek could be reduced as follows:

Location	1 Year Storm (cfs)			2 Year Storm (cfs)		
	Existing Flow	Proposed Flow With 186th Street Detention	Percent Reduction	Existing Flow	Proposed Flow With 186th Street Detention	Percent Reduction
171st Street	546	337	65%	699	462	34%
146th Street	883	671	41%	1106	894	19%
131st Street	1107	915	26%	1426	1235	13%
116th Street	1156	989	18%	1497	1347	10%
Confluence	1205	1025	17%	1525	1395	9%

If both the 171st Street and the Grassy Branch Road detention ponds were constructed as recommended in this report, peak flows within Cool Creek would be reduced as follows:

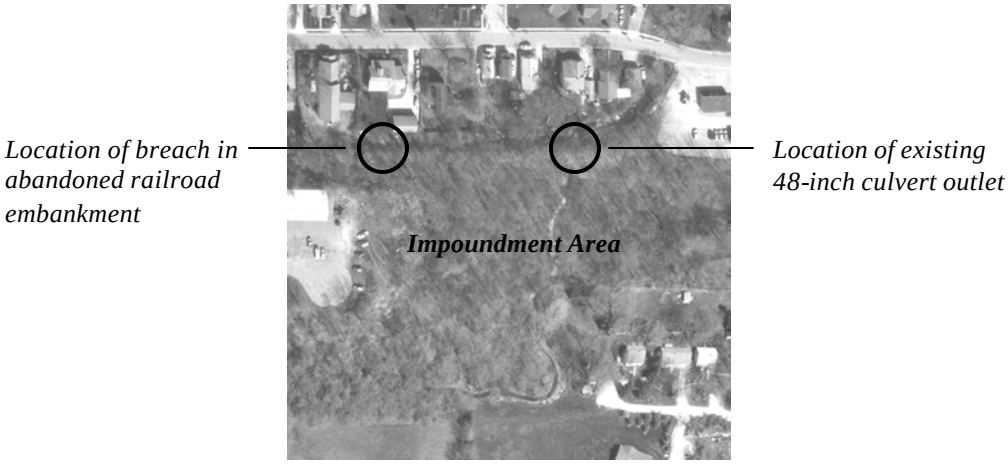
Location	1 Year Storm (cfs)			2 Year Storm (cfs)		
	Existing Flow	Proposed Flow With 171st & 186th Street Detention	Percent Reduction	Existing Flow	Proposed Flow With 171st & 186th Street Detention	Percent Reduction
171st Street	546	192	65%	699	287	59%
146th Street	883	522	41%	1106	696	37%
131st Street	1107	819	26%	1426	1101	23%
116th Street	1156	943	18%	1497	1260	16%
Confluence	1205	998	17%	1525	1327	13%

Constructing the proposed off-line detention basins would require the following activities:

- Obtain permanent easements for the pond area
- Develop planting and landscape plan for detention pond
- Remove soil material to create storage area
- Manage excess soil material
- Construct inflow weir to direct flood waters from channel to pond
- Construct discharge structure to direct water back to channel

7.7.3 In-Line Detention Pond (Anna Kendall Drain)

A 48-inch culvert under an abandoned railroad embankment creates a significant impoundment area upstream (south) of Park Street on the Anna Kendall Drain. Although there is significant volume in the impoundment area (approximately 80 acre-ft), an existing breach in the embankment limits the amount of flow that can be stored. In addition, the existing 48-inch culvert is beginning to fail and the embankment above the outlet culvert is eroding. The photographs below on the following page show the location and condition of the existing features of this impoundment.



Breach in abandoned railroad embankment (note deteriorated CMP, pipe in foreground appears to be a bucket or rubbish container)

Upstream end of existing 48-inch culvert outlet (note pipe section has fallen into creek and embankment is eroding above culvert)

Downstream of 48-inch culvert outlet (note how existing outlet is at a channel bend and is subject to erosion)

Looking at impoundment area from top of abandoned railroad embankment (note area is heavily forested)

The area surrounding the existing impoundment is potentially unsafe given the existing embankment breach and the location/alignment of the 48-inch outlet. Three options are available at this site:

1. Retrofit the existing impoundment structure
2. Remove the impoundment structure
3. Do nothing

Retrofit Existing Impoundment Structure

Retrofitting the existing impoundment area will require the following activities:

- Obtain permanent and construction easements for the pond area
- Investigate existing soil properties along the embankment (i.e. soil borings)
- Modify the primary detention pond outlet to discharge further downstream, past the sharp bend in the existing channel
- Construct an emergency spillway and raise the elevation of the embankment to provide adequate freeboard.
- Repair the existing breach in the embankment and upgrade other portions of the embankment as needed to satisfy IDNR Dam Safety requirements. This may require significant earthwork, up to a complete removal/replacement of the existing embankment.
- Verify that the proposed retrofit does not adversely impact the regulated 100-year floodplain.
- Obtain an IDNR permit for dam improvements.

The final item above would require significant additional expense, due to Indiana Department of Natural Resources (IDNR) requirements for new and retrofitted dams. The IDNR requires that any dam with a drainage area exceeding 1 square mile (Anna Kendall has a drainage area of 2 square miles at the impoundment) meet their design requirements. Meeting the IDNR criteria would require additional engineering/design effort, as well as higher construction costs to install dam safety features.

The proposed pond retrofit would provide approximately 80 acre-feet of stormwater storage. The estimated cost to upgrade the existing impoundment is approximately $700,000.

Retrofitting the detention storage area as described above would have the following effect on peak flows in the Anna Kendall Drain:

Location	2 Year Storm (cfs)			10 Year Storm (cfs)		
	Existing Flow	Proposed Flow With Retrofit	Percent Reduction	Existing Flow	Proposed Flow With Retrofit	Percent Reduction
Downstream of Abandoned Railroad	205	161	21%	380	215	43%

The above peak flow reductions are based on replacement of the existing 48-inch culvert with a similar sized structure. Minor flow reductions (21%) are achieved during the 2-year storm event. It may be possible to have a multi-stage outlet that provides better control flows for the 1- and 2-year storms. During the 10-year event, the impoundment nearly fills and a peak flow reduction of

43% is provided. During a 100-year storm event, the embankment would overtop and peak flow reductions would be negligible. Raising the embankment to contain the 100-year storm volume is not feasible because nearby residential structures would be flooded. IDNR dam safety requirements generally require containment of the 100-year storm. Accordingly, some relaxation in dam safety requirements would be required to make the retrofit a viable option.

Remove Embankment

The second option is to remove a portion of the existing embankment and allow the existing stream to flow unrestricted. This option would resolve the current safety concerns at the site but would also lose the flood control benefits, particularly for the 10-year storm event. The downstream 100-year flood elevations would not be increased because the existing impoundment has negligible 100-year peak flow attenuation. The estimated cost to remove a portion of the existing embankment and return the channel to an unrestricted condition is approximately $100,000.

Do Nothing

The third option, to leave the existing embankment in its current state, is not recommended. Although this involves the lowest initial cost and minimal disruption, it places downstream property owners in a potentially unsafe condition, should the embankment continue to erode and eventually fail.

Evaluation of Options

Removing the existing embankment is the most cost-effective option. However, the flood control benefits provided for the 2- through 10-year storms would be lost. We recommend that the embankment be retrofitted, *provided a compromise can be met regarding IDNR dam safety requirements*. The decision on which option to implement should be made only after the key design issues are discussed with the IDNR and their complete feedback has been received.

7.8 LAND USE AND PLANNING RECOMMENDATIONS

Land use planning and design policies, including design standards, zoning requirements, and site plan review procedures, can be modified to benefit the condition of Cool Creek and its watershed.

7.8.1 Detention Pond Design - Water Quality Volume

Many communities require detention pond designs that incorporate features to help capture pollutants in stormwater runoff. This is generally accomplished by providing a *Water Quality Volume*. The water quality volume is the storage needed to capture and treat runoff from 90% of the average annual rainfall. The *Indianapolis Drainage Design Standards and Specification Manual* (July 2001) contains a requirement for *Water Quality Volume*. This requirement provides for extended detention for the first 1 inch of rainfall. Design standards for reviewing authorities within the Cool Creek watershed should be modified to contain a similar requirement. The *Water Quality Volume* standard will help to control peak flows during more frequent storm events, reduce pollutant loadings to receiving streams, and reduce the potential for downstream channel erosion.

Properly designed and constructed stormwater ponds are generally capable of the following pollutant reductions:

Pollutant	Percent Reduction*
Total Suspended Solids	80%
Total Phosphorus	51%
Ortho-Phosphorus	65%
Total Nitrogen	33%
Nitrate and Nitrite Nitrogen	43%
Copper	57%
Zinc	66%

**Source: National Management Measure Guidance to Control Nonpoint Source Pollution from Urban Areas. U. S. EPA, Draft, July 2002*

Some communities have adopted a *Channel Protection Volume*, which provides additional storage to further reduce the potential for downstream erosion. Maryland has adopted a method that requires holding the runoff volume generated by the 1-year 24-hour duration rainfall (about 2.5 inches in Hamilton County) to be gradually released over a 12- to 24-hour period (Maryland Department of the Environment, Maryland Stormwater Design Manual, Baltimore, Maryland, Volume 1, 2000). The premise of this approach is that runoff will be stored and released so gradually that critical erosive velocities will seldom be exceeded in downstream channels. This approach should be considered given the channel erosion concerns in the watershed.

7.8.2 Stream Buffer Ordinance

Adoption of a Stream Buffer Ordinance would help to prevent development along channel corridors by setting specific limitations on development along natural channels. Often, the protected corridor is 200 to 300 feet wide. A Stream Buffer Ordinance should be adopted to provide the following benefits:

- Natural buffer on each side of channel filters urban runoff prior to discharge into the main channel
- Required setbacks prevent buildings and utilities from being constructed too close to the channel, thereby minimizing property damage due to flooding and erosion
- Promotes green space with multi-use capabilities, such as bike/walk paths, wetland areas, aquatic habitat, etc.
- Mitigates stream warming
- Promotes long-term health of the open channel, minimizing maintenance efforts

The following internet link provides model Stream Buffer Ordinance language that could be adopted, in whole or in part, to protect the Cool Creek and its tributaries.

http://www.stormwatercenter.net/Model%20Ordinances/buffer_model_ordinance.htm

7.8.3 Floodplain Protection

Floodplain development concerns tie directly to preservation of the riparian stream buffers along Cool Creek (and its tributaries). Filling of floodplains can cause loss of flood storage and riparian habitat. As noted previously, Hamilton County has an ordinance that prohibits filling of land in the floodplains of its regulated drains. It may be appropriate for Carmel and Westfield to adopt similar policies for floodplains under their jurisdiction. This would provide a uniform policy and would help preserve existing riparian buffers. Many communities have adopted buffer ordinances to protect headwater streams where floodplains are often narrow and floodplain protection alone may not adequately protect buffer systems.

7.8.4 Other Management Practices

Other recommended management practices concerning development in the Cool Creek watershed (and throughout Hamilton County) include:

- Identifying and protecting critical conservation areas (wetlands, forested areas, floodplains, riparian forest, meadow/prairie areas, etc.)
- Preserving environmentally significant areas (conservation easements, management areas, maintaining native plant species, etc.)
- Promoting urban forestry (decreases runoff, mitigates stream warming)
- Encouraging waterbody and natural drainage protection when siting developments (cluster zoning, other zoning options, urban growth boundaries, etc.)
- Utilizing sound site planning practices
- Utilizing other structural and non-structural Best Management Practices as appropriate, (e.g. porous pavement, sand filters, infiltration practices, water quality swales, manufactured BMPs, vegetated filter strips, bioretention areas, etc.)

The above issues will need to be considered for all urbanized areas of the County as part of stormwater quality regulations promulgated by IDEM (Rule 13).

7.9 SUMMARY OF IMPROVEMENT NEEDS

The following is a summary of the recommended solutions to problem areas in the Cool Creek watershed.

7.9.1 Stream Flooding/Roadway Overtopping Solutions

- E. 151st Street (Cool Creek) – Modify approximately 160 LF of roadway elevation ($10,000)
- E. 171st Street (Cool Creek) – Modify 320 LF of roadway elevation and replace existing bridge ($700,000)
- Gurley Street (Anna Kendall Drain) – Replace existing bridge ($280,000)
- Cherry Street (Anna Kendall Drain) – Replace existing bridge ($340,000)
- SR 32 (Main Street) (J. M. Thompson Drain) – Replace existing culvert ($310,000)
- US 31 and Adjacent Private Drive (Highway Run) – Culvert replacement/addition ($800,000)
- Walter Street, Private Drive, and Walter Court (Highway Run) – Replace three (3) existing culverts and reshape channel ($200,000)
- Thornberry Drive (Highway Run) – Replace existing culvert ($80,000)

7.9.2 Neighborhood Solutions

- Carmel Drive (Hot Lick Creek) – Replace existing twin culverts with new box culvert and install erosion control measures along creek upstream of Carmel Drive ($90,000)
- Hot Lick Creek Channel Improvement – Re-grade existing channel away from nearby residential structure ($10,000)

7.9.3 Streambank Erosion Solutions

- Highway Run, downstream of Stonehedge Drive – Re-grade approximately 100 LF of streambank, reinforce with erosion matting and vegetation ($5,000)
- H. G. Kenyon Drain, downstream of Rolling Court – Re-grade approximately 250 LF of streambank, reinforce with erosion matting and vegetation ($15,000)
- Cool Creek, upstream of confluence with the White River – Re-grade approximately 1500 LF of Cool Creek streambank, reinforce using brushmattress technique ($300,000)
- Cool Creek, downstream of Gray Road – Reinforce 200 LF of streambank using vegetated geogrid and riprap toe protection ($75,000)
- Cool Creek, upstream and downstream of Hot Lick Creek – Reinforce 575 LF of streambank using brushmattress technique ($125,000)
- Cool Creek, upstream of 131st Street – Re-grade approximately 150 LF of Cool Creek streambank and reinforce with combination of riprap and live woody stakes ($20,000)
- Cool Creek, upstream of Keystone Avenue – Re-grade approximately 100 LF of streambank using a combination of riprap toe protection and brushmattress technique ($30,000)

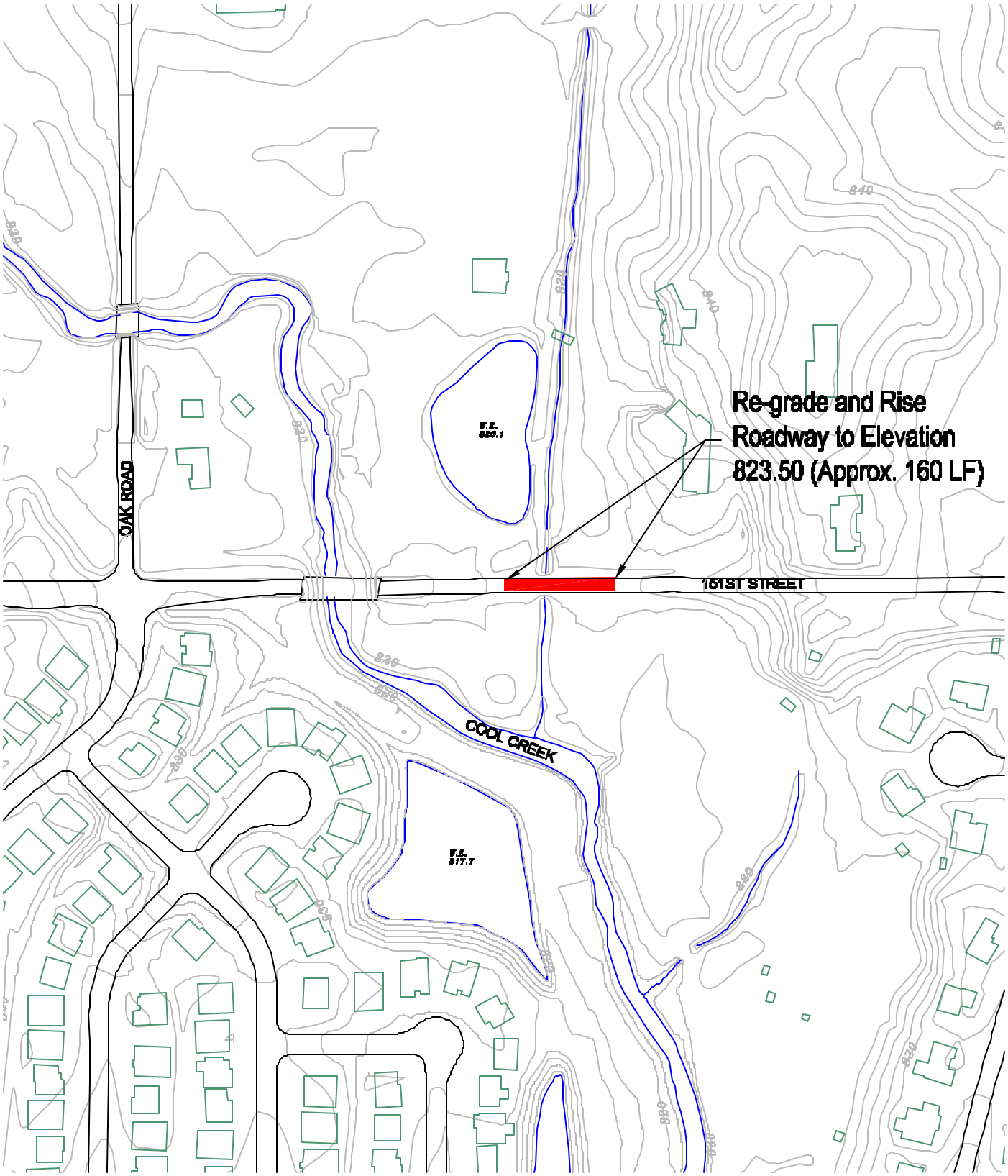
7.9.4 Regional Stormwater Detention Solutions

- 171st Street Off-Line Detention Pond – construct a 95 acre-ft detention basin with a 1800 foot long meandering low flow channel and emergent and submergent wetland vegetation planted throughout the pond area ($2,600,000)
- Grassy Branch Road Off-Line Detention Pond – construct a 115 acre-ft detention basin with a 2600 foot long meandering low flow channel and emergent and submergent wetland vegetation planted throughout the pond area ($1,800,000)
- Anna Kendall In-Line Detention Pond – repair breach in existing embankment, upgrade embankment, and install new control structure and emergency spillway to provide approximately 80 acre-feet of flood storage ($700,000)

7.9.5 Improvements Cost Summary

The costs of the proposed improvements are summarized as follows:

Stream Flooding/Roadway Overtopping Solutions	$2,720,000
Neighborhood Solutions	$100,000
Streambank Erosion Solutions	$570,000
Regional Detention Solutions	$5,100,000
Total of All Proposed Solutions	**$8,490,000**

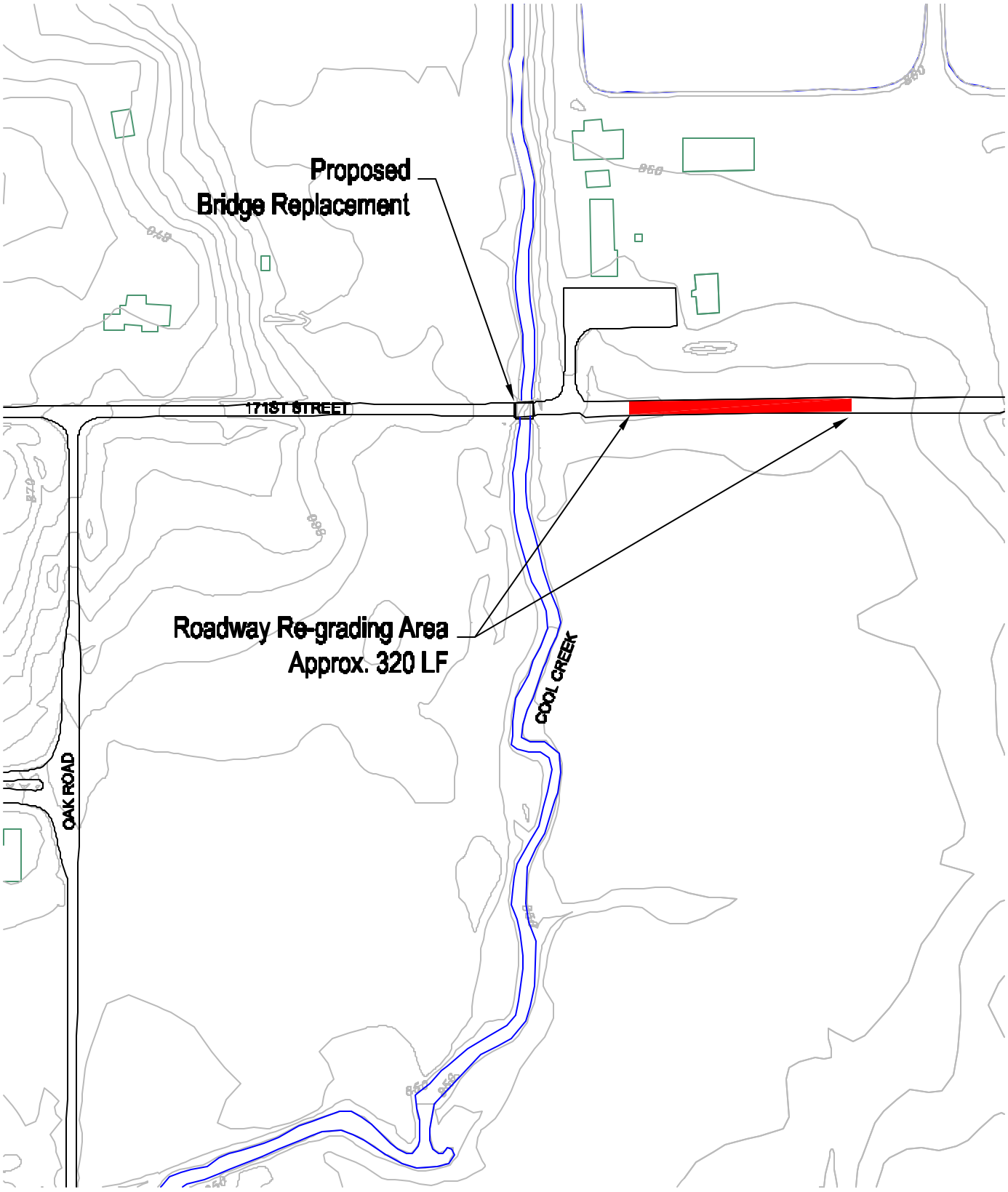


Clark Dietz

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-1
151st Street
Stream Flooding/Roadway Overtopping

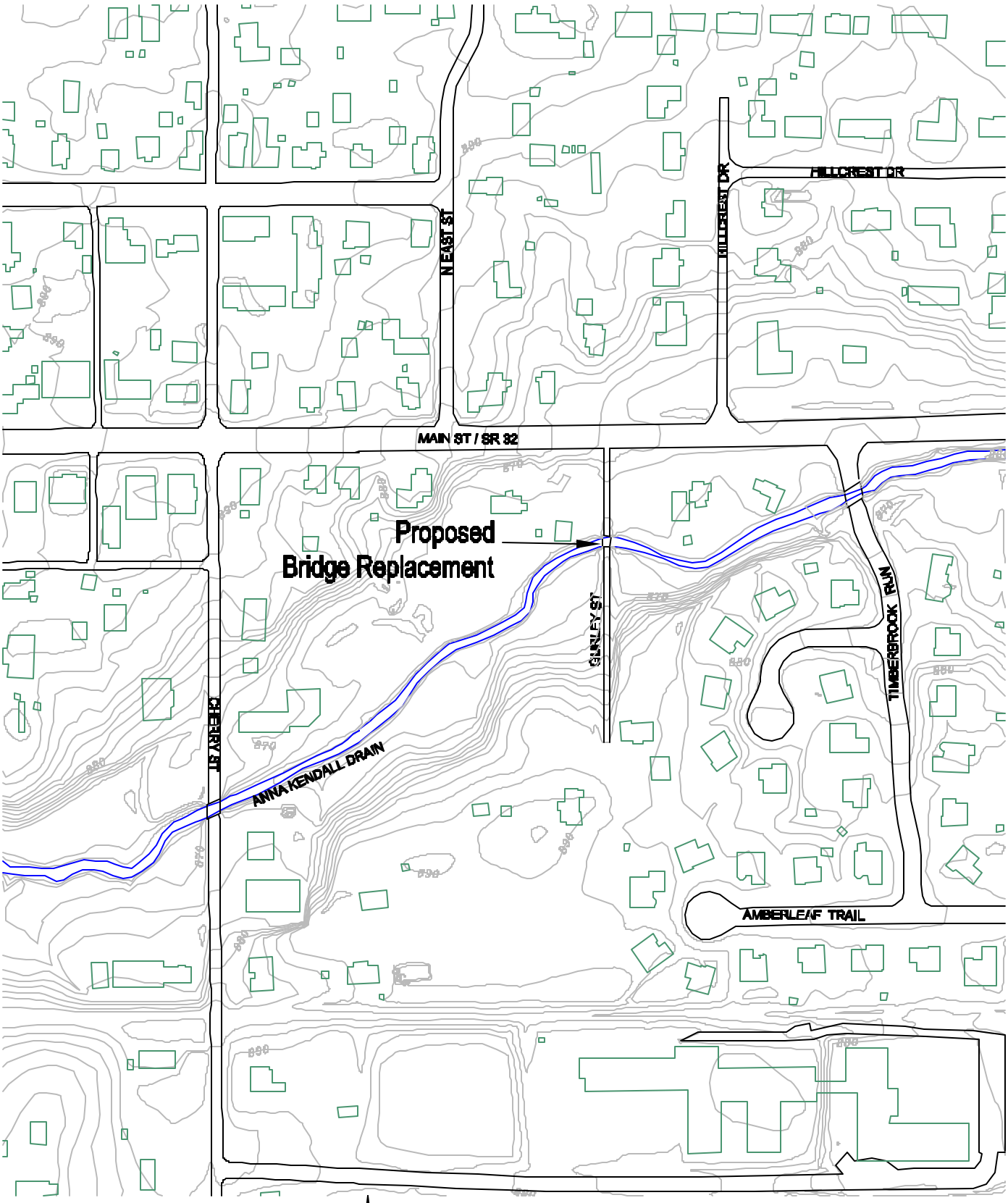


Clark Dietz

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-2
171st Street
Stream Flooding/Roadway Overtopping

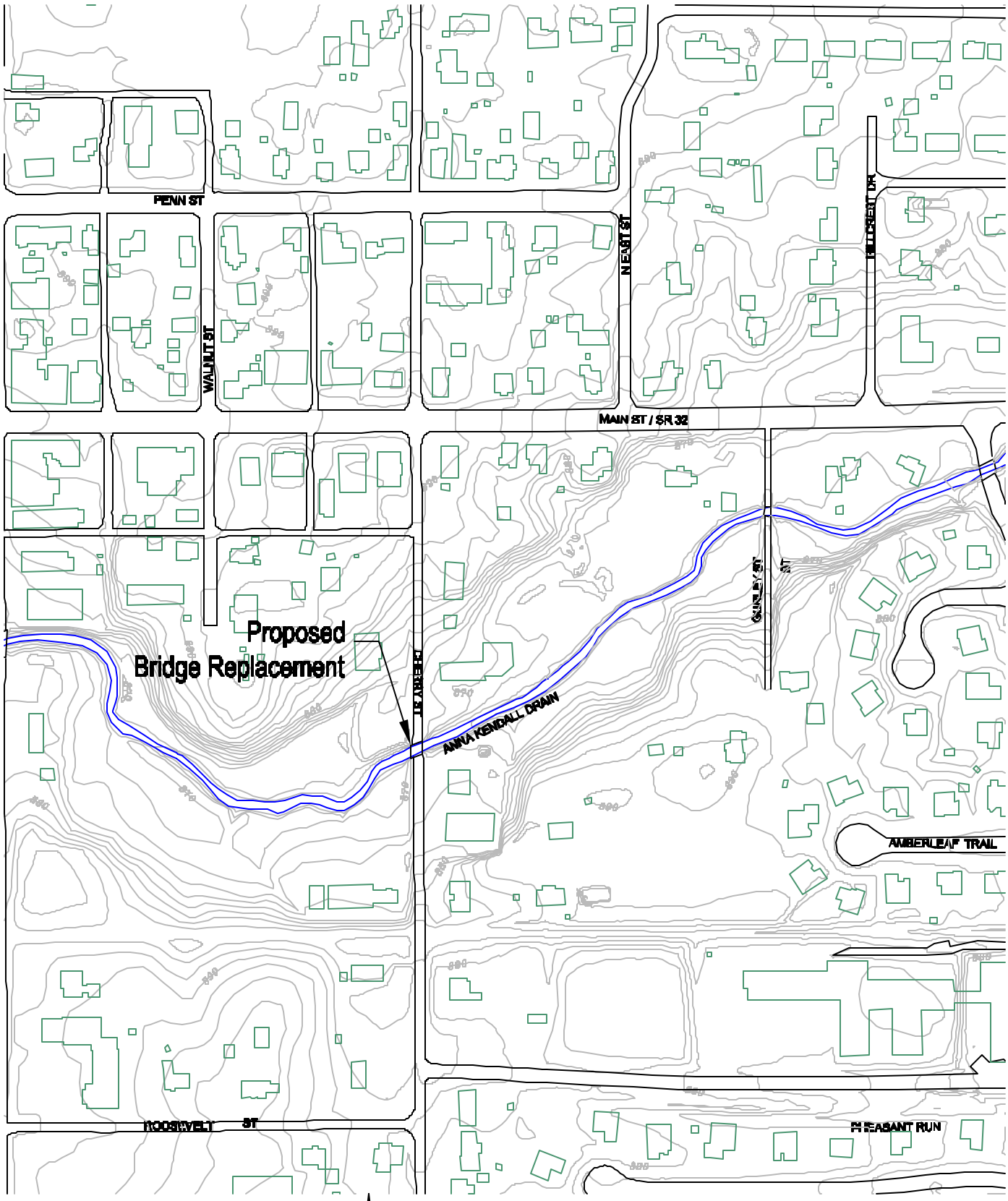


Clark Dietz

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-3
Gurley Street
Proposed Bridge Replacement

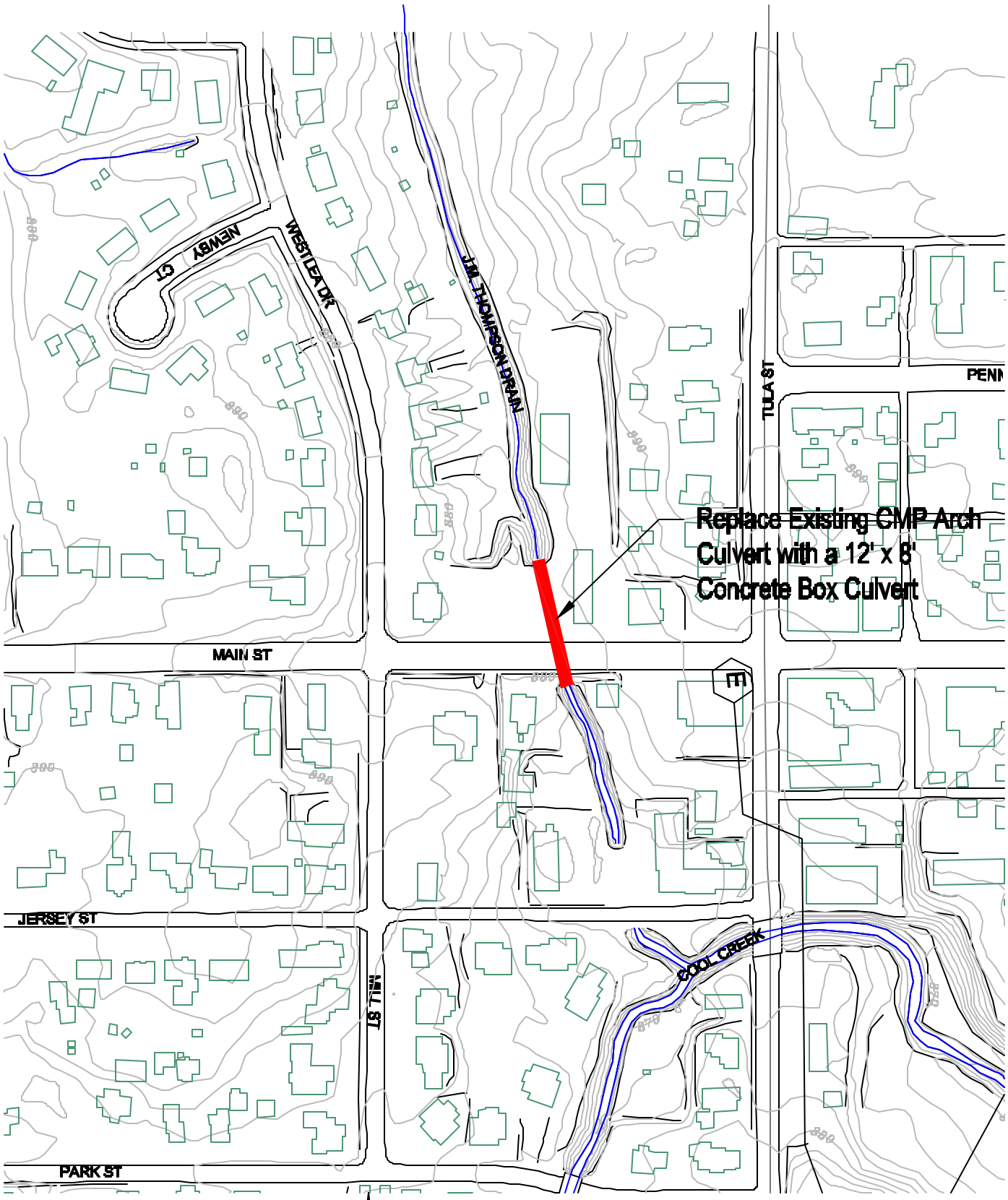


Clark Dietz

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-4
Cherry Street
Proposed Bridge Replacement



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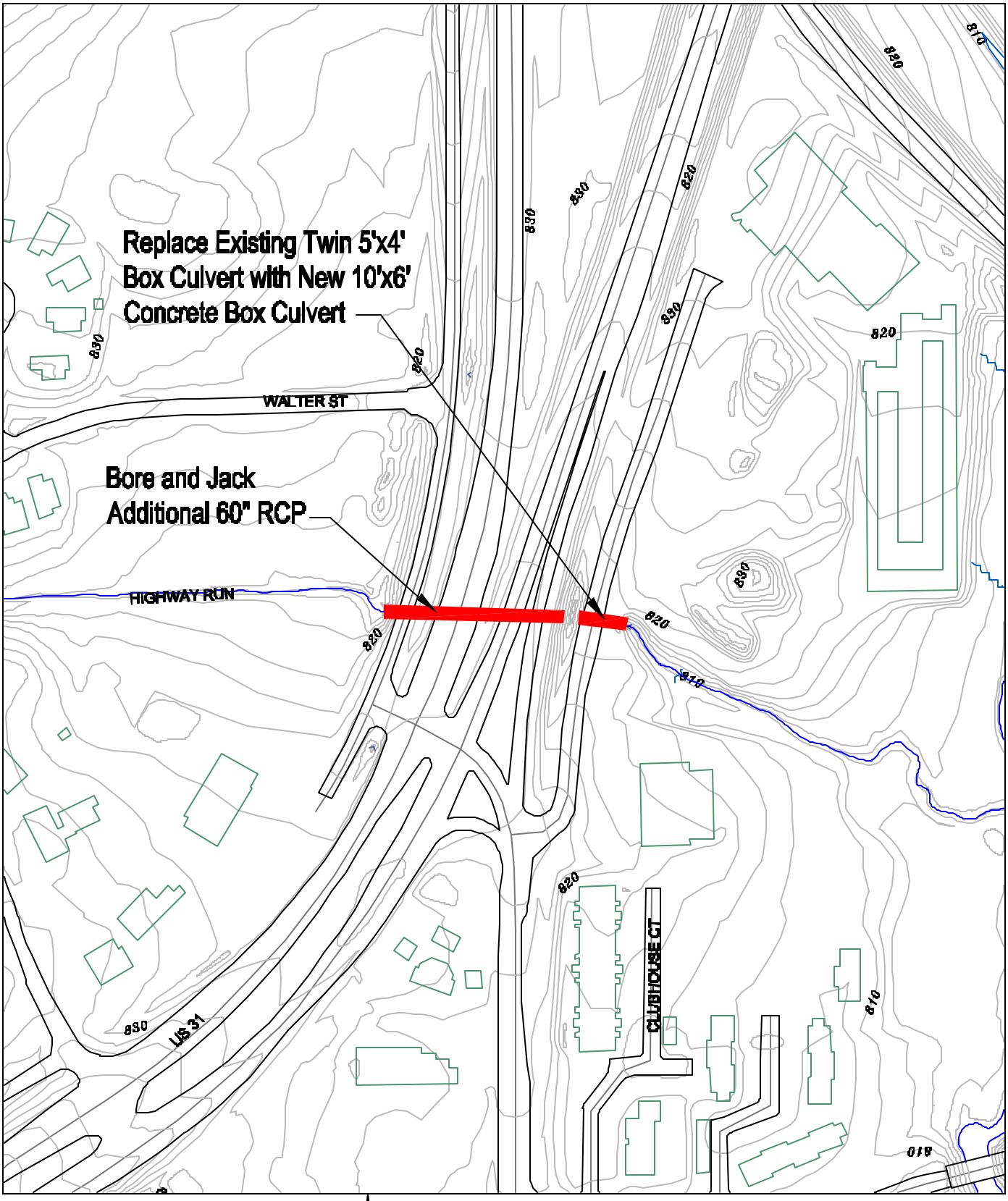
Clark Dietz

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-5
Main Steet (J.M. Thompson Drain)
Culvert Replacement



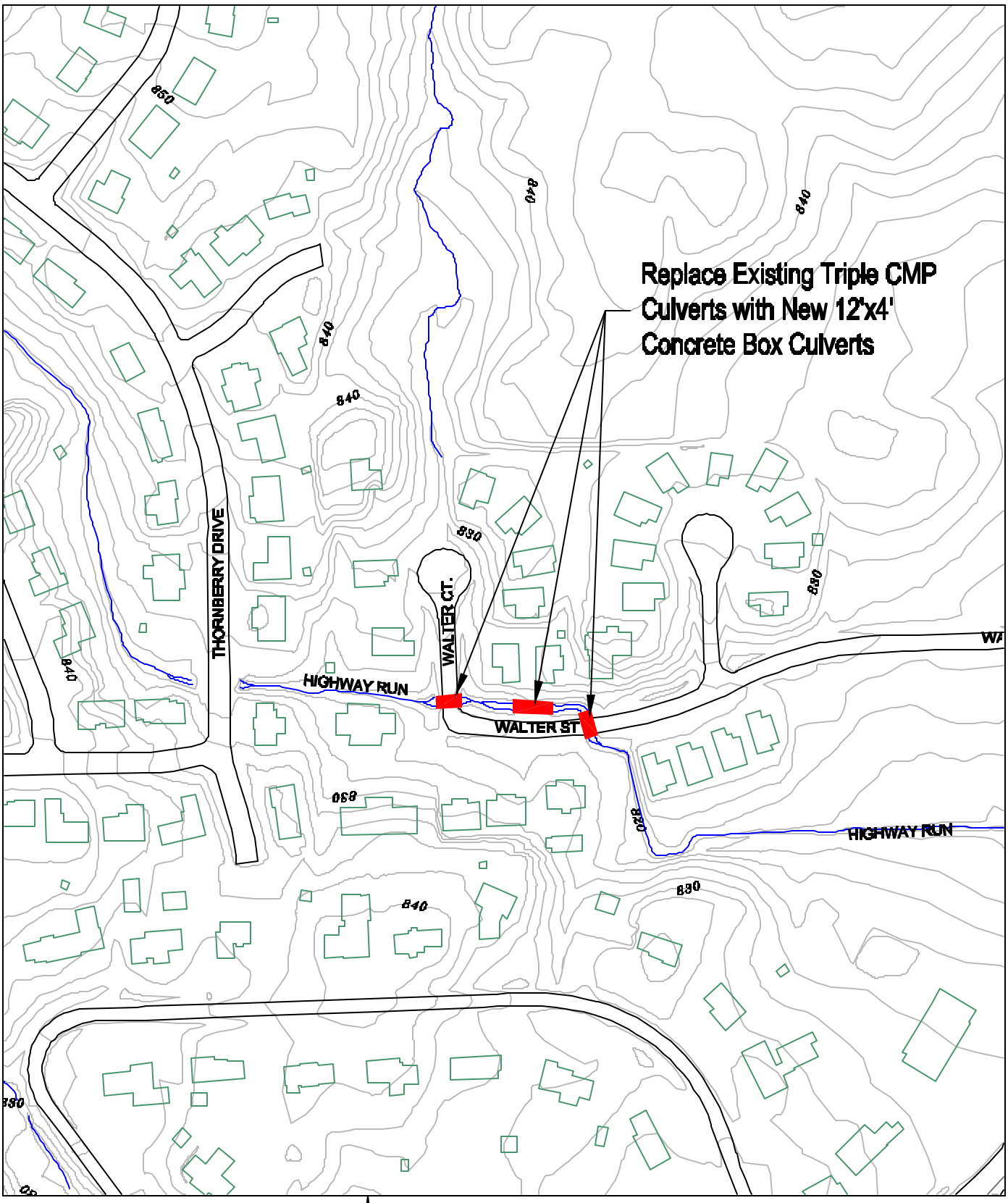
Clark Dietz

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-6

US31 & Private Drive (Highway Run) Culvert Addition & Replacement

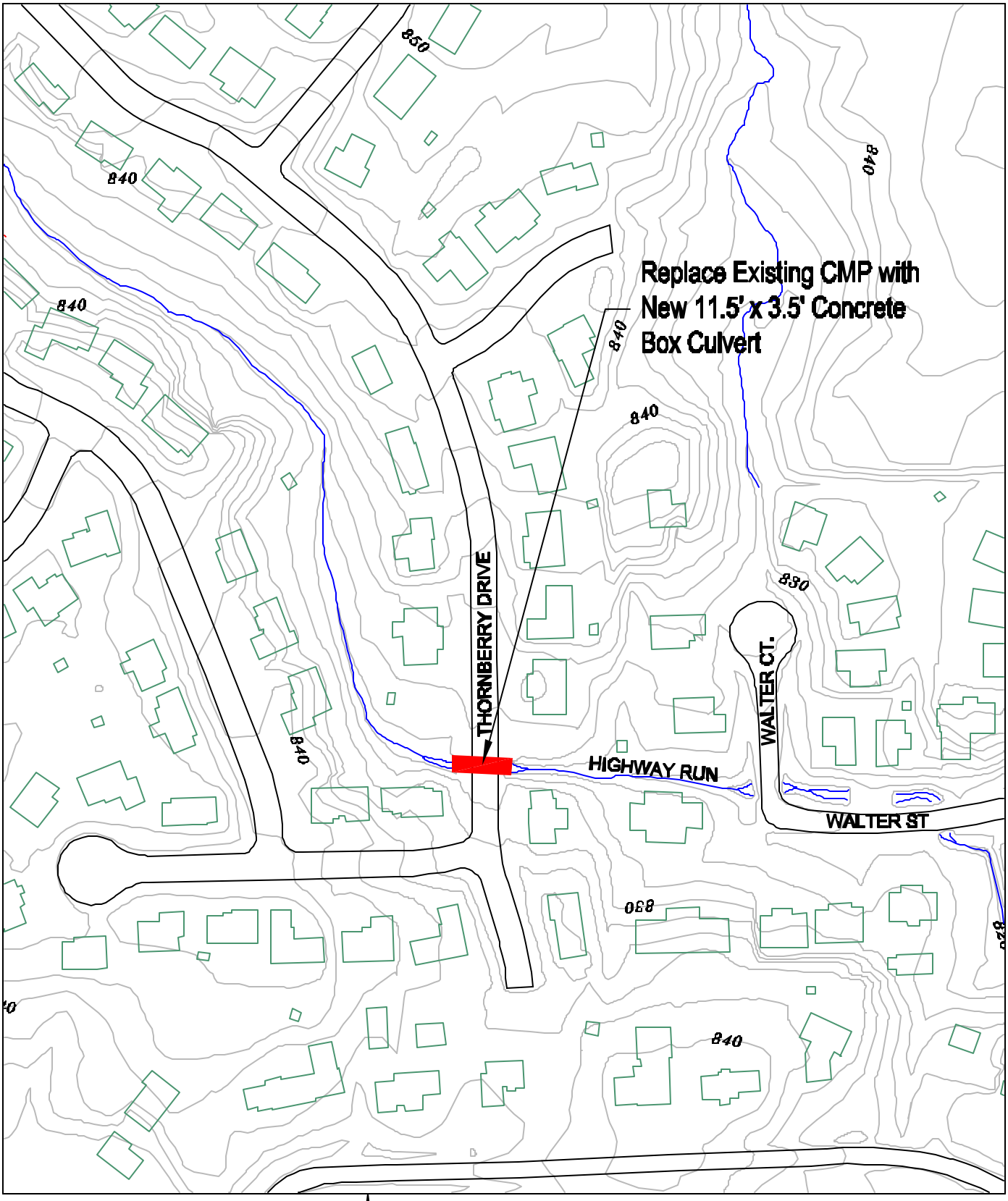


Clark Dietz

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-7
Walter St./Walter Ct. (Highway Run)
Culvert Replacements



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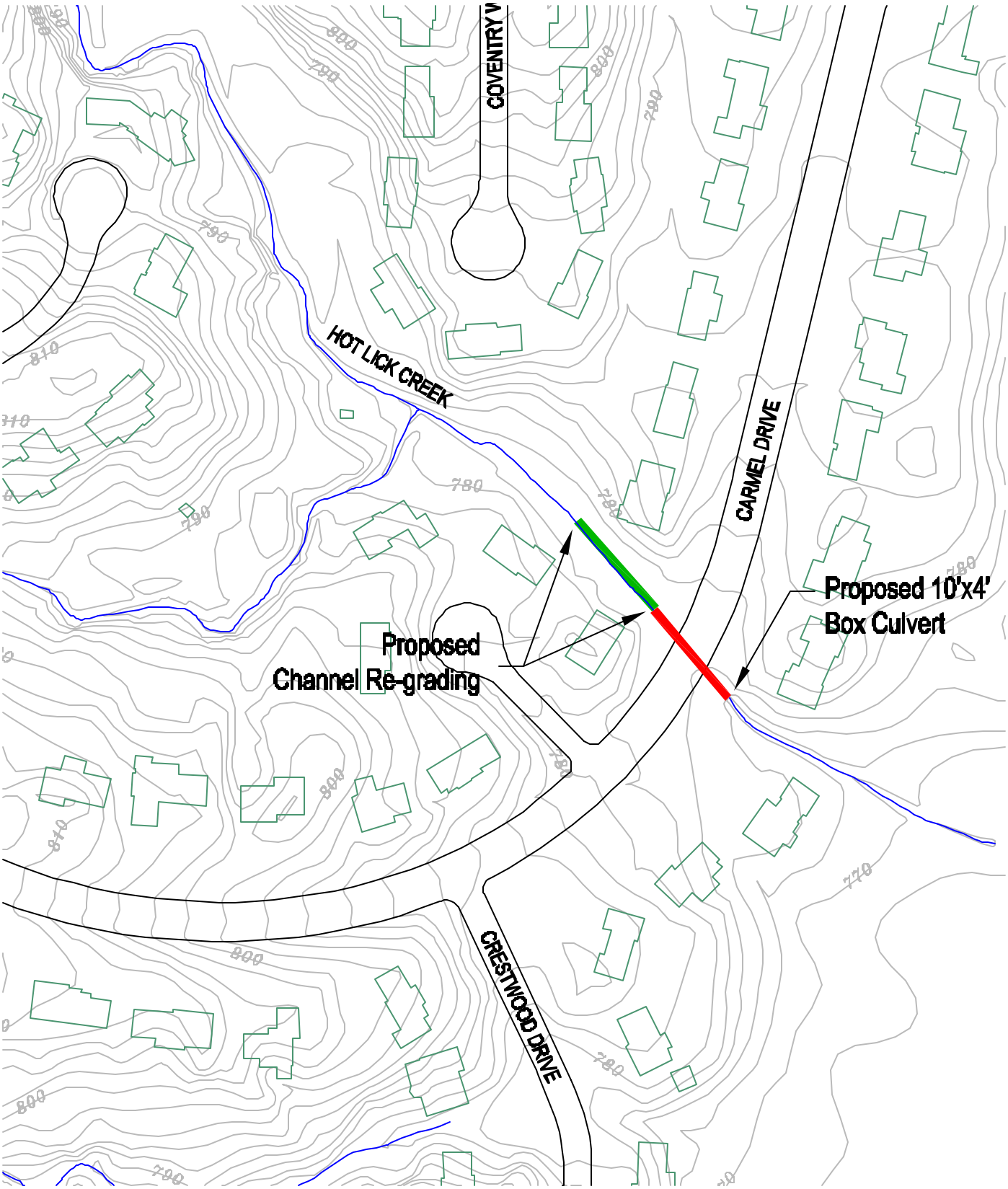
COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-8
Thornberry Drive (Highway Run)
Culvert Replacement



Clark Dietz

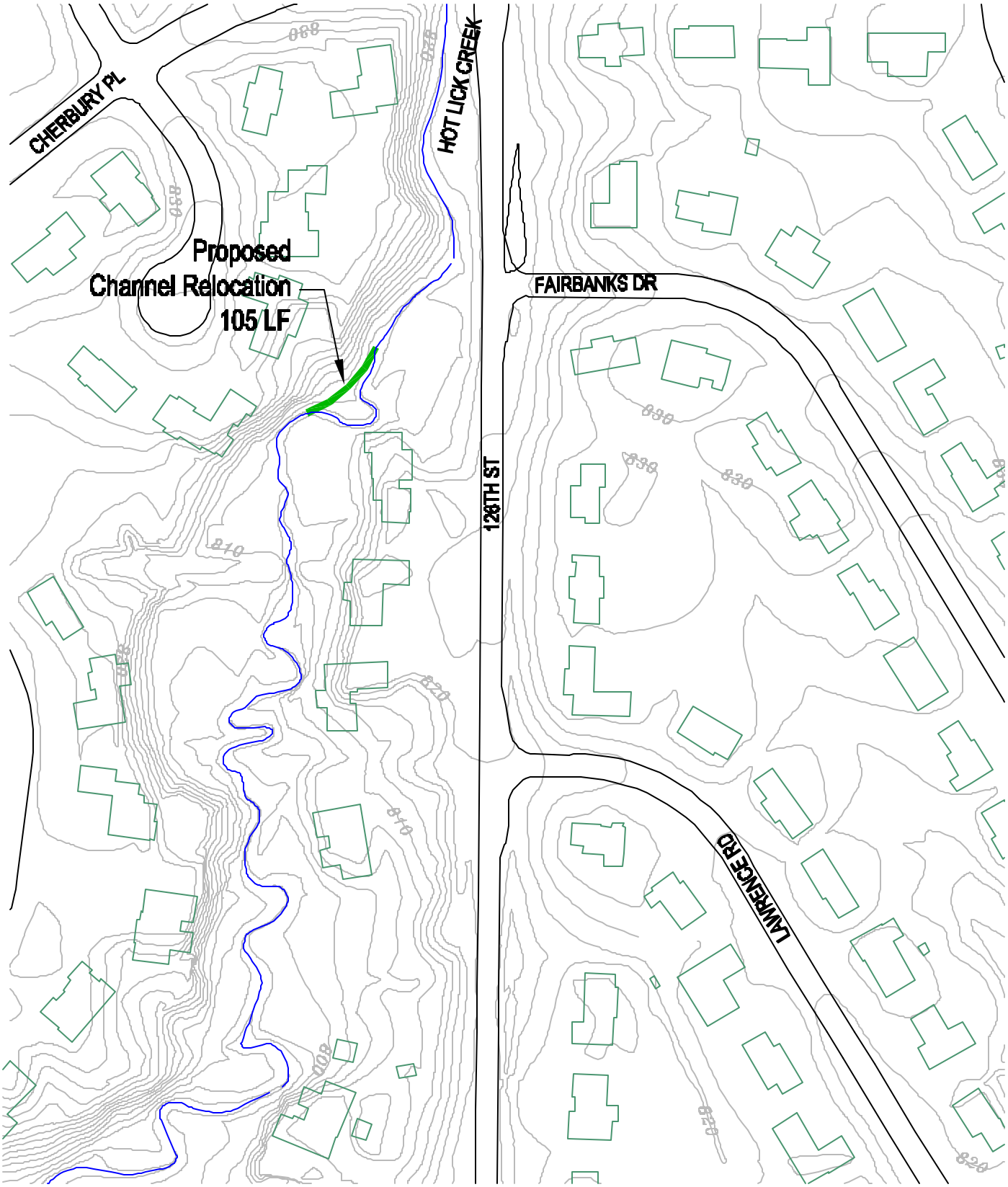
Scale: 1" = 150'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-9

Carmel Drive (Hot Lick Creek)

Neighborhood Problem Area



COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-10

Hot Lick Creek Channel Improvement

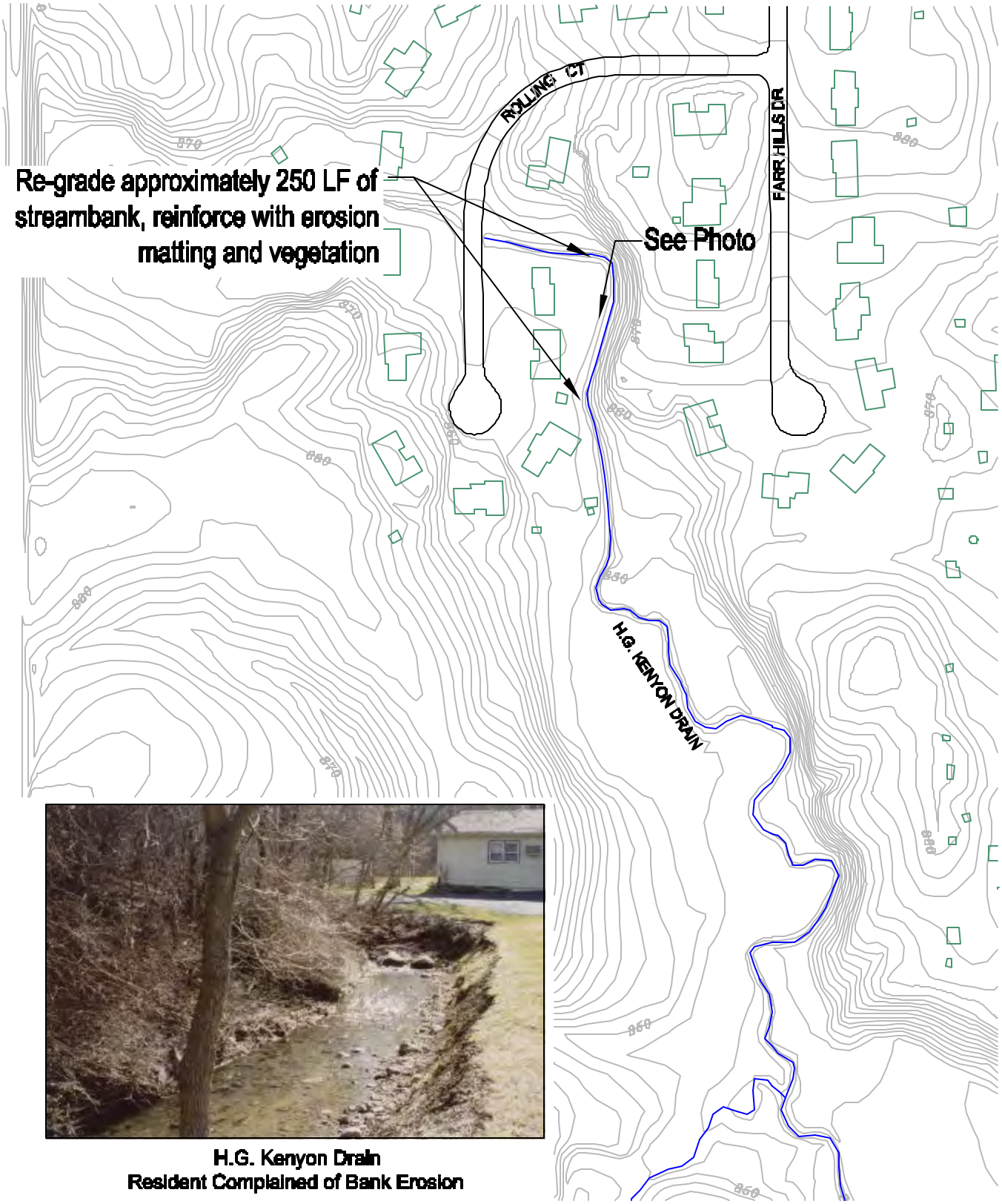
Neighborhood Problem Area

Photo #34 - Highway Run Drain
Trees Undercut by Bank Erosion

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-11
Highway Run
D/S of Stonehedge Drive

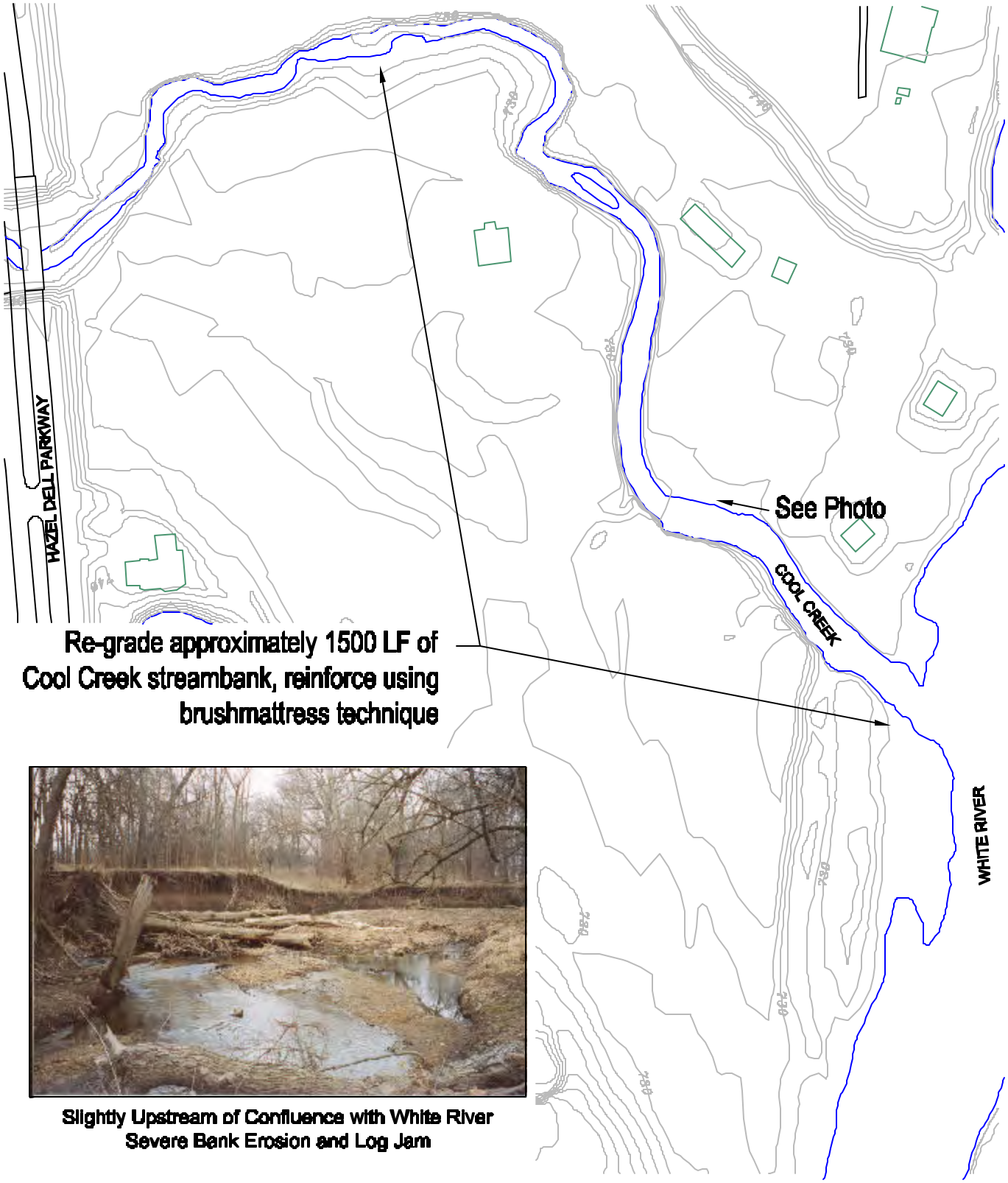


H.G. Kenyon Drain
Resident Complained of Bank Erosion

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-12
H.G. Kenyon Drain
U/S of Rolling Court

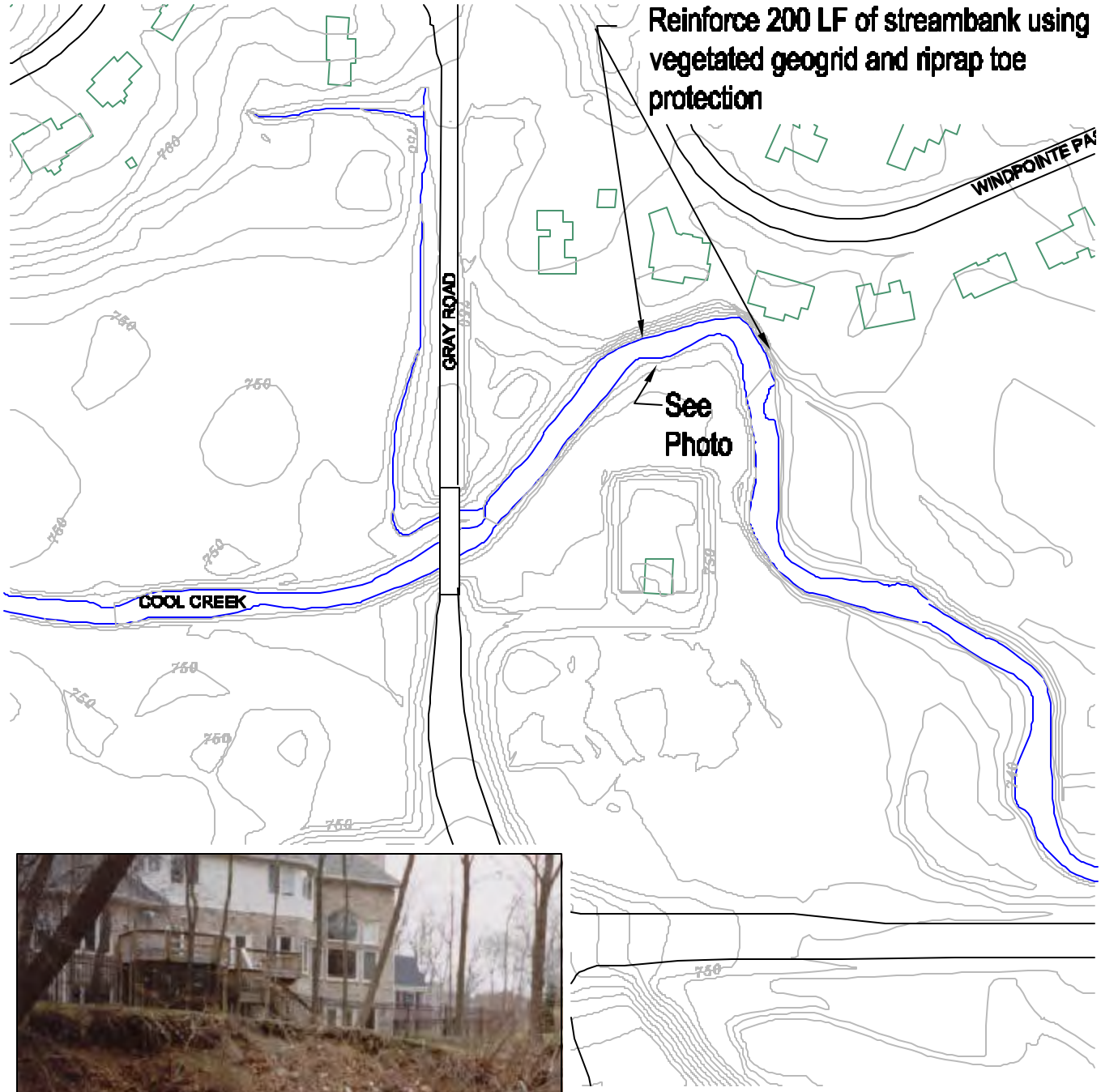


Slightly Upstream of Confluence with White River
Severe Bank Erosion and Log Jam

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-13
Cool Creek
U/S of White River Confluence



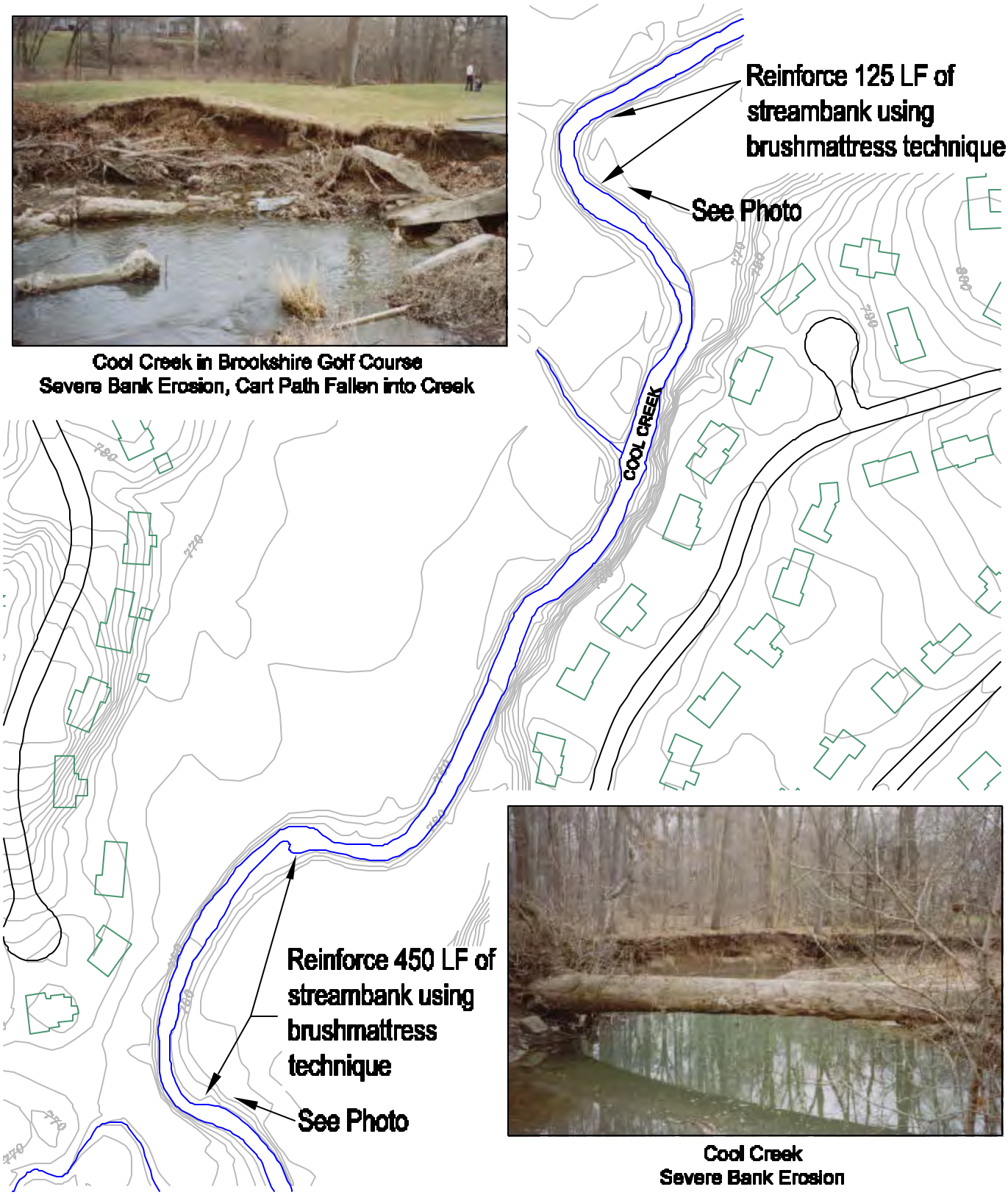
Cool Creek
Severe Bank Erosion and Log Jam

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-14
Cool Creek
D/S of Gray Road

Cool Creek in Brookshire Golf Course
Severe Bank Erosion, Cart Path Fallen into Creek



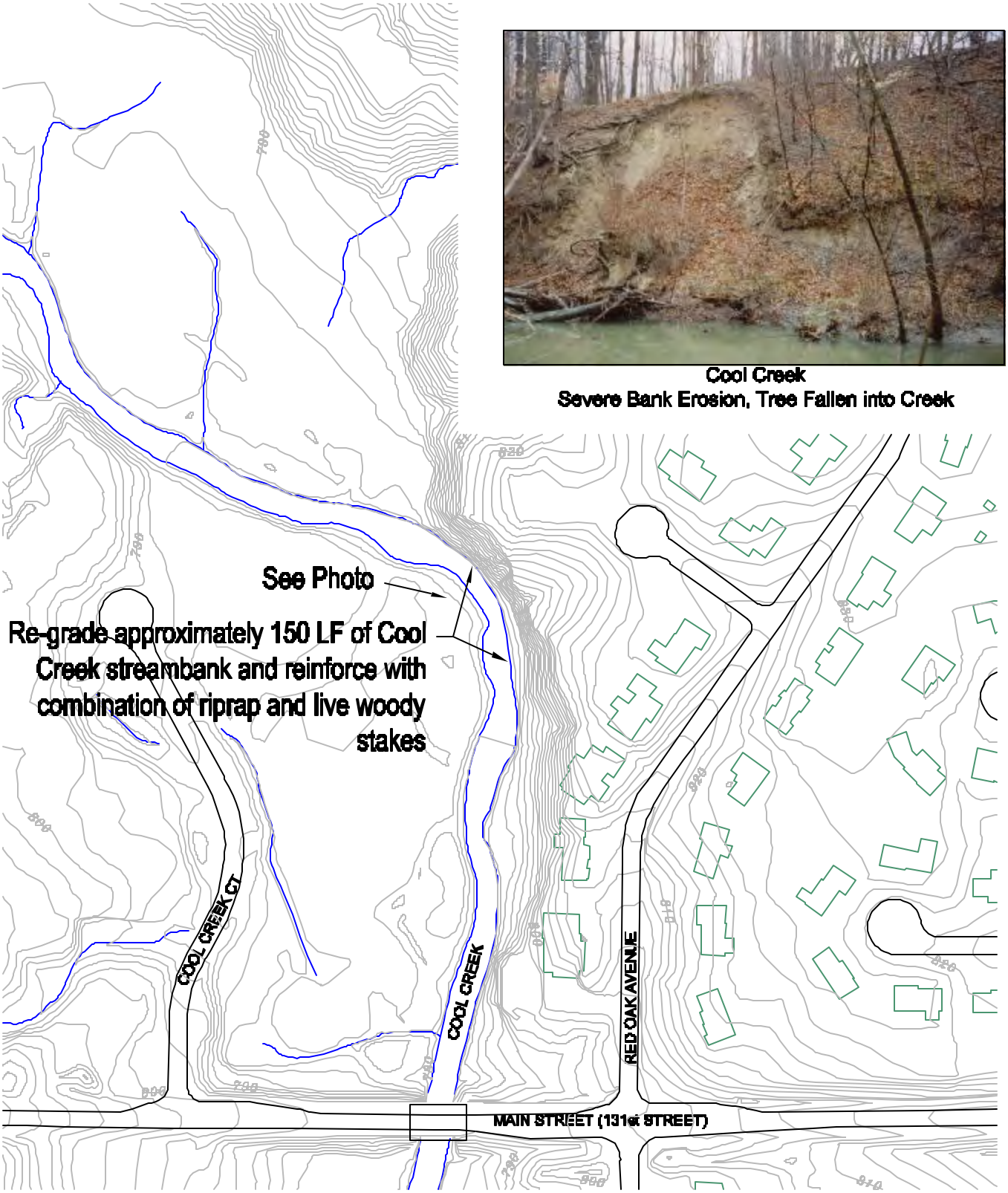
Cool Creek
Severe Bank Erosion

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-15
Cool Creek
U/S & D/S of Hot Lick Creek

Cool Creek
Severe Bank Erosion, Tree Fallen into Creek



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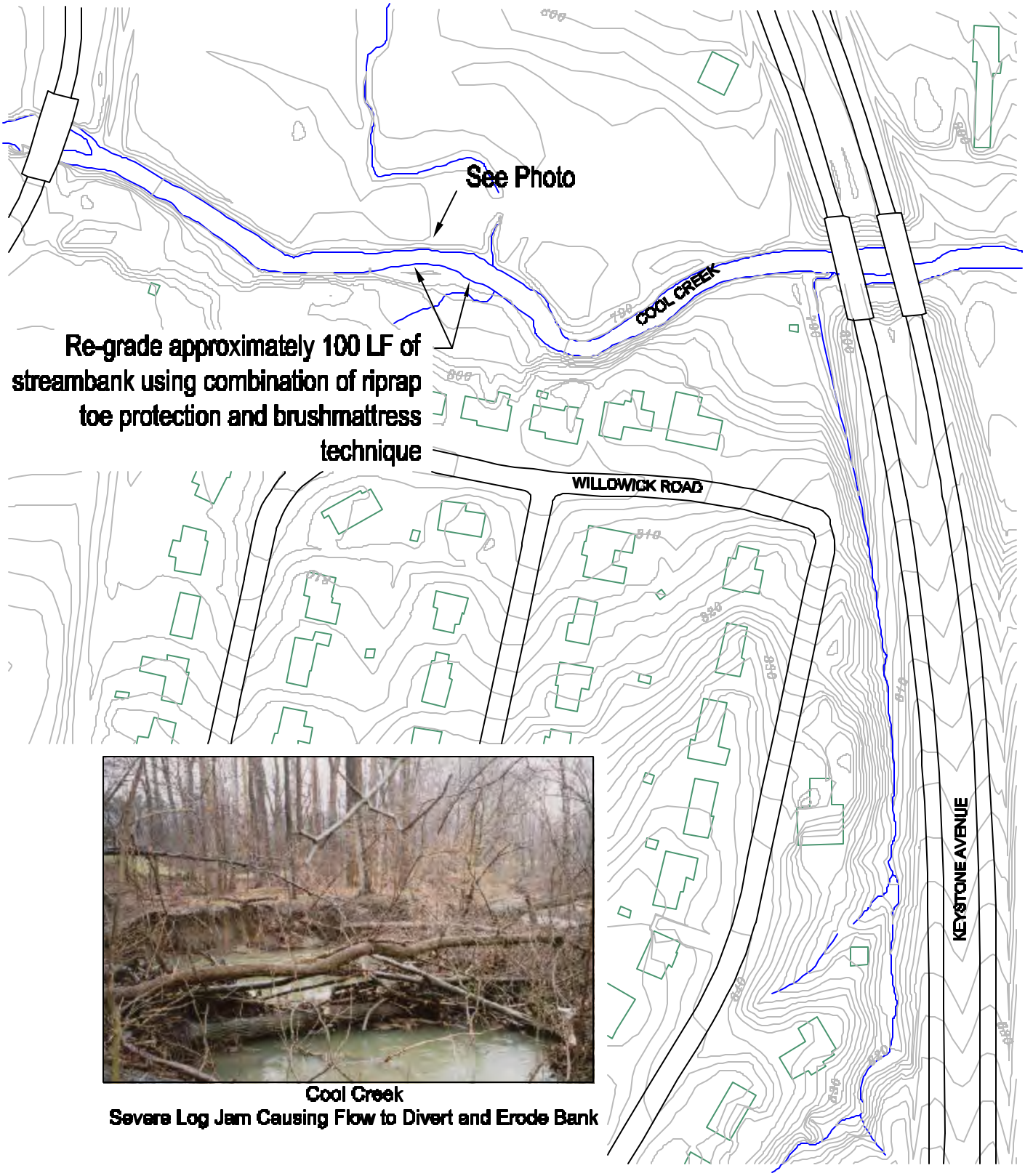
COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-16
Cool Creek
U/S of 131st Street

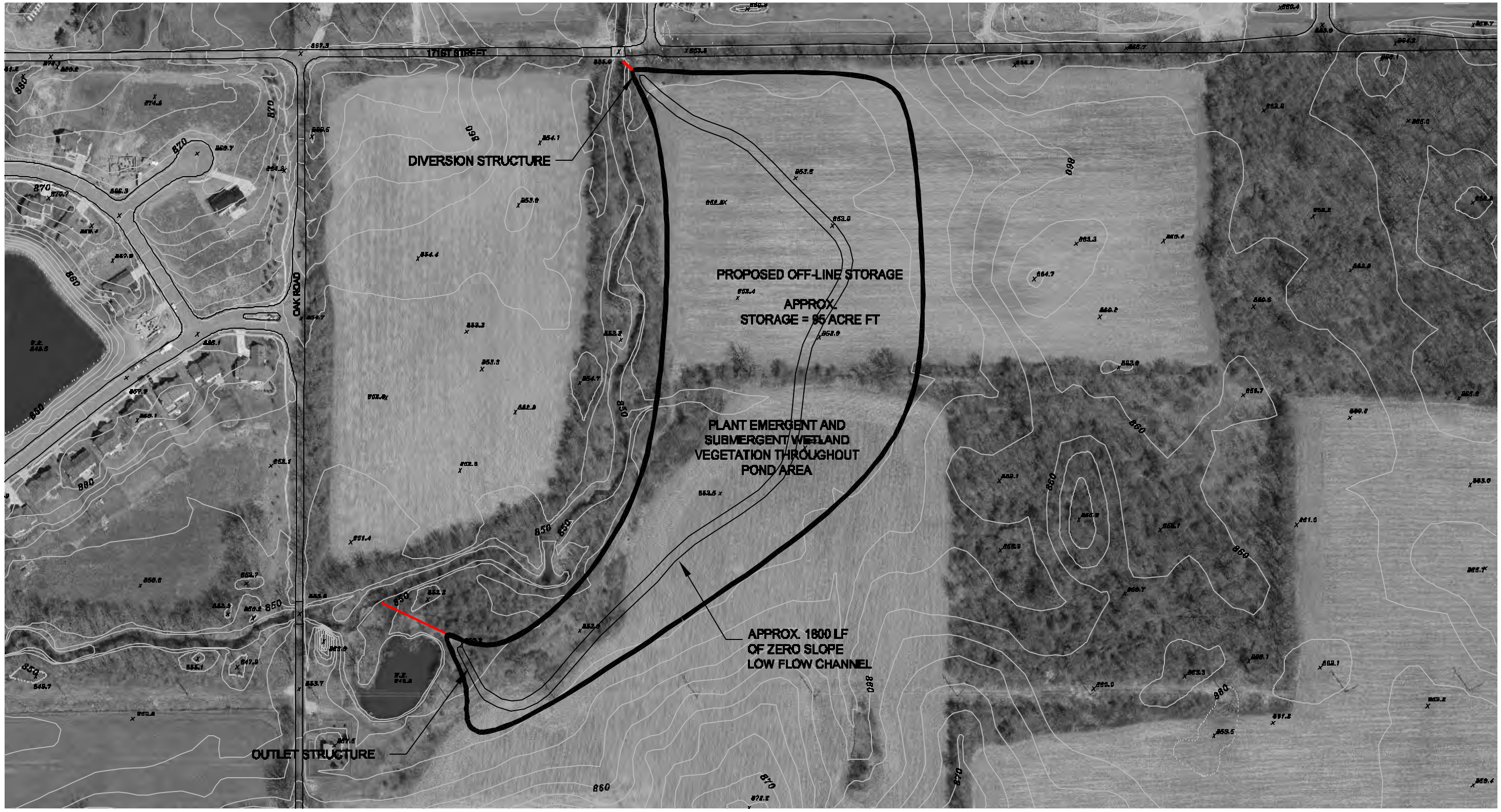


Cool Creek
Severe Log Jam Causing Flow to Divert and Erode Bank

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-17
Cool Creek
U/S of Keystone Avenue

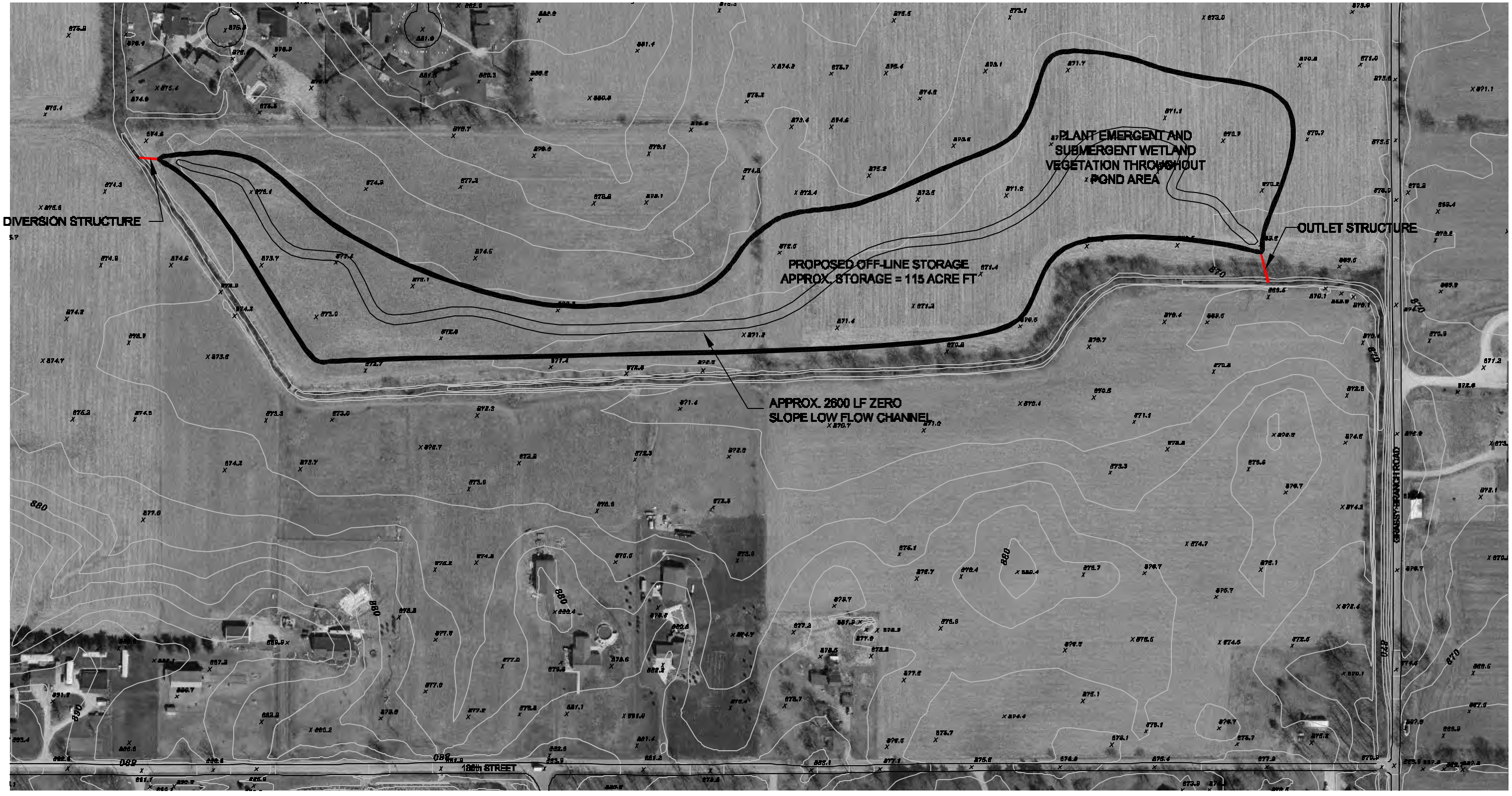


Clark Dietz

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-18
171st Street Off-line Storage
(South Pond)



Clark Dietz

Scale: 1" = 200'

COOL CREEK WATERSHED MANAGEMENT PLAN

Figure 7-19

Grassy Branch Road Off-line Storage
(North Pond)

8.0 RECOMMENDATIONS, IMPLEMENTATION, AND FUNDING

8.1 INTRODUCTION

This chapter summarizes overall recommendations for the Cool Creek watershed and presents implementation and funding issues associated with each category of improvement projects. A detailed discussion of recommended projects is provided in Chapter 7.

8.2 RECOMMENDATIONS

8.2.1 Capital Projects

Bridge/Culvert Improvements - $1,820,000

- E. 151st Street (Cool Creek)
- E. 171st Street (Cool Creek)
- Gurley Street (Anna Kendall Drain)
- Cherry Street (Anna Kendall Drain)
- SR 32/Main Street (J.M. Thompson Drain)
- Thornberry Drive (Highway Run)

Bridge/Culvert Improvements that may not be needed (see Section 8.3.1 for reasons) - $900,000

- US 31 and Adjacent Private Drive (Highway Run)
- Walter Street, Private Drive, Walter Court (Highway Run)

Neighborhood Projects - $100,000

- Carmel Drive (Hot Lick Creek)
- Channel Improvement (Hot Lick Creek)

Streambank Erosion Projects - $570,000

- Highway Run
- H.G. Kenyon Drain
- Cool Creek (5 locations)

Regional Detention Projects - $5,100,000

- 171st Street Off-Line Detention Pond
- Grassy Branch Road Off-Line Detention Pond
- Anna Kendall In-Line Detention Pond

8.2.2 Land Use and Planning Policies

The following changes are recommended to land use and planning policies with regard to stormwater management:

- *Implement consistent floodplain fill regulations in the watershed.* Hamilton County prohibits fill in the floodplain while Carmel and Westfield currently allow fill, provided certain conditions are met. A consistent policy prohibiting fill within the 100-year floodplain would help prevent flooding and water quality problems.
- *Implement a stream buffer ordinance*. Stream buffer preservation/enhancement, coupled with floodplain regulations, will help prevent flooding problems and improve water quality.
- *Establish additional riparian vegetation along the upper reaches of Cool Creek.* Existing creeks have limited streamside vegetation. Additional vegetation would promote wildlife habitat and filter stormwater runoff.
- *Update stormwater ordinances and design standards to more proactively address water quality.* Best Management Practices, both structural and non-structural, should be implemented to prevent or reduce urban runoff problems associated with existing and future development.
- *Modify detention policies to incorporate channel and water quality protection.* Additional storage and more restrictive release rates for smaller storms will help capture stormwater runoff pollutants and reduce streambank erosion to receiving waters.
- *Identify and protect critical conservation areas* such as wetlands, forested areas, floodplains, and riparian areas.
- *Utilize sound site planning practices* by encouraging natural drainage protection and urban forestry when siting developments.
- *Utilize other structural and non-structural management practices* such as porous pavement, sand filters, infiltration practices, water quality swales, manufactured devices, vegetated filter strips, and bioretention areas.

The estimated cost to update ordinances and standards to incorporate the above recommendations is $200,000.

8.3 IMPLEMENTATION AND FUNDING

The follow is a brief summary of key implementation and funding issues associated with recommended improvements.

8.3.1 Bridge/Culvert Improvements *(see Chapter 7 Section 7.4 for project details)*

The optimal time to construct bridge/culvert improvement projects is in conjunction with planned roadway improvement projects so that traffic disruptions are minimized and projects are coordinated with overall infrastructure plans. The bridge/culvert improvements projects are generally located within public right-of-way with minimal land or easement acquisition needs. The Hamilton County Highway Department is responsible for all roads, bridges, and small structures (less than 20 foot span) within Hamilton County that are not state highways and that are not within the corporate limits of a city or town. They are also responsible for bridges which have a span of 20 or more feet on all roads in Hamilton County which are not state highways. Smaller structures within Carmel and Westfield are the responsibility of each community.

Implementation of the 151st Street and 171st Street bridge improvements should be coordinated with the Hamilton County Highway Department, as these structures fall under their jurisdiction. The Gurley Street and Cherry Street bridge replacement projects involve structures less than 20 feet and would fall under the jurisdiction of Westfield Utilities/Public Works Department. The SR 32/Main Street culvert replacement on the J.M. Thompson Drain would need to be coordinated with INDOT. Most of the bridge/culvert replacement projects will require a "Construction in a Floodway" permit from IDNR.

Improvements to culverts on Highway Run (US 31, Walter Street, Private Drive, and Walter Court) *may not be needed.* Plans were recently announced for a major retail development (Clay Terrace) along the west side of US 31 from 146th Street to south of Highway Run. Plans on the developer's web site (www.clayterrace.com) show that this development will encompass Highway Run and the Walter Street/Walter Court neighborhood. The costs for these culvert improvements remain in the Cool Creek Watershed Plan in the event that development plans change at this location. The other culvert replacement project on Highway Run (Thornberry Drive) is upstream from the proposed Clay Terrace development. Replacement of this culvert would fall under the City of Carmel's jurisdiction.

In terms of prioritizing the bridge/culvert replacement projects, the Gurley Street, Cherry Street, and SR 32/Main Street projects would have a higher priority as these structures restrict flows and place residential structures at risk to flooding. The US 31 and Walter Street area culvert improvements would also have a high priority for the same reason; however, the development plans in the area lower the priority of this project. Thornberry Drive would be a higher priority as this restrictive culvert also places residential structures at risk of flooding. The 151st Street and 171st Street bridge improvements are lower priority. While the roadway overtopping at these locations impedes traffic, it does not result in upstream flooding of residential or commercial structures. Alternate transportation routes exist should a flood occur that causes overtopping of these roads.

The recommended bridge/culvert improvement projects would likely be funded from capital budgets for streets and/or local drainage from the appropriate jurisdiction as these structures are a critical component of the transportation and drainage system. It may also be feasible to utilize the regulated drain funding mechanism above 146th Street, where Cool Creek, Anna Kendall Drain, and J.M. Thompson Drain are regulated drains.

8.3.2 Neighborhood Projects *(see Chapter 7 Section 7.5 for project details)*

The two projects categorized as neighborhood projects, are both located along Hot Lick Creek in the City of Carmel. The culvert replacement project at Carmel Drive would have a higher implementation priority than the upstream channel improvement. The restrictive culvert at Carmel Drive creates a backwater condition that places upstream structures at risk of flooding. The roadway (Carmel Drive) is also overtopped. The channel improvement project is primarily intended to direct the channel away from a fence along a residential property. There is a pool that is periodically flooded; however it is very low relative to the channel and extensive channel improvements would be needed to correct this problem.

The culvert replacement would be constructed in existing public right-of-way. The channel improvement portion of this neighborhood project is located on private property. Coordination with three property owners would be required and temporary construction easements would be needed. Funding for the culvert replacement would likely come from City of Carmel drainage

funds. The channel improvement could also involve a cost share from the affected property owner.

8.3.3 Streambank Erosion Projects *(see Chapter 7 Section 7.6 for project details)*

Except for the H.G. Kenyon Drain, the streambank erosion projects are located within the City of Carmel (H.G. Kenyon Drain is in Unincorporated Hamilton County). The main implementation and funding impediment for the streambank erosion projects is that they are located on private property. South of 146th Street, Cool Creek is not a regulated drain and there are no maintenance easements. Hence, undertaking any of these streambank erosion projects will involve easement acquisition (either construction and/or permanent).

The City of Carmel has been reluctant to spend public funds on private property unless a particular streambank erosion area was causing damage or threatening a public utility or facility. If the property owner elects to repair streambank erosion on their own, technical assistance is available from the Hamilton County Soil and Water Conservation District (www.co.hamilton.in.us/gov/soil/services.asp). Technical assistance is *strongly encouraged* prior to any streambank restoration effort to ensure the project will be effective and will not create additional problems upstream or downstream. Most streambank projects would also involve a "Construction in a Floodway" permit from IDNR.

The estimated cost of the streambank erosion projects identified in this study ranges from $5000 to $300,000. It is probably not feasible for a property owner to undertake any of the larger projects. Funding would have to come from local drainage funds or possibly from grants and loans. Information on Federal funding is available at http://cfpub.epa.gov/fedfund/.

8.3.4 Regional Detention Projects *(see Chapter 7 Section 7.7 for project details)*

Implementation of the three recommended regional detention projects (two new basins and one retrofit) will be more difficult because of land acquisition and the high capital costs (relative to the other recommended projects). These ponds would provide significant flow reductions for the more frequent storm events, reduce downstream erosion, and improve water quality. All three government entities in the watershed (Hamilton County, Westfield, and Carmel) would benefit from their construction, indicating a joint funding approach may be appropriate. There may also be opportunities for partial grant funding because of the water quality component.
The 171st Street and Grassy Branch Road regional "off-line" detention basins are more costly to construct because of land acquisition and earthwork requirements. It may be more feasible to construct these ponds in conjunction with future development in the vicinity of the pond locations. Developers often require large volumes of fill for site grading. Having a nearby spoil area for excavated soil would significantly decrease pond construction costs.

The Anna Kendall Drain regional pond is less costly because the existing storage impoundment is created by an existing embankment. Significant upgrades to the embankment, including installation of an improved outlet structure and a new emergency spillway, will be required to meet dam safety regulations associated with "on-line" ponds. It is recommended the County use its regulated drain maintenance assessment to help generate funds for this project.

8.3.5 Ordinance and Standards Updates *(see Chapter 7 Section 7.8 for project details)*

The recommendations outlined in the land use and planning policies section of this chapter will require updates and/or new ordinances and design standards. These updates will likely be lead by Hamilton County since Carmel and Westfield already rely on County stormwater standards. The County is also leading efforts to coordinate upcoming IDEM Rule 13 requirements to address stormwater quality and impacts to receiving streams. The land use and planning recommendations in this study are directly applicable to Rule 13 implementation.

The estimated cost to update ordinances and standards is $200,000. This would include conducting stakeholder group meetings, internal staff meetings, design manual development/updating, and presentations/outreach to the development community.

8.3.6 General Discussion of Funding Options for Local Communities

Primary Sources

Adequate local funding sources for stormwater projects will be required to implement many of the recommendations in this study as well as other stormwater needs. Primary funding sources include tax supported funds, assessments, and user fees. Many Indiana communities use general funds, supported by property taxes, to fund stormwater improvement projects. General obligation, revenue, or special assessment bonds are often issued to finance large capital improvement programs. Repayment is normally through the general fund, special assessment district income and utility revenues. Demand for general funds is very high, as these funds are used for many programs, including police and fire protection. Stormwater often becomes a very low priority. Assessments, such as Barrett Law and Regulated Drains, can be used as a primary funding source for stormwater projects. Hamilton County effectively utilizes regulated drains and regulated subdivisions to construct and maintain drainage infrastructure. The maintenance assessment on the Anna Kendall Drain is an example of an effective method to fund improvements to the drain.

Faced with rising costs for regulatory compliance and a general reluctance to raise taxes, many communities have investigated or implemented user fees to fund drainage, flood control, stormwater runoff quality and other stormwater management activities. User fees are generally based on the volume of stormwater that runs off a property. The most common tool used to determine runoff is the relative amount of impervious area on a given property. Many communities find stormwater fees to be more equitable and stable than property taxes or other types of funding mechanisms. Indiana Counties (including Hamilton County) are also lobbying the State legislature and Governor's office to pass and sign into law enabling legislation that will allow Indiana Counties to establish stormwater user fees.

Secondary Sources

Secondary sources of funding can be used to supplement primary sources. They can be used for specific development or redevelopment projects, to fund ongoing processes like plan review and inspection, and to fund capital projects in existing developing areas.

Some of the more common secondary sources are:

- System Development Charges
- Special Assessments and Improvement Districts
- Plan Review and Inspection Fees
- In Lieu of Construction Fees
- Impact Fees
- Sales Taxes
- Grants and Loans

8.4 SUMMARY

Approximately $8.7 million in improvements are recommended for the Cool Creek watershed, including $8.5 million for capital projects and $200,000 to update stormwater ordinances and standards. Implementation of these recommendations will enhance public safety, improve water quality, assist in regulatory compliance, and provide a significant step towards achieving long-term environmental health for the Cool Creek watershed.

9.0 SECTION 319 UPDATES TO THE COOL CREEK WATERSHED MANAGEMENT PLAN

9.1 PROJECT INTRODUCTION

9.1.1 Preface and History of the Cool Creek Watershed Management Plan

Planning efforts for the Cool Creek watershed began in 2001, when Hamilton County, the Town of Westfield, and the City of Carmel agreed to jointly fund a study of the Cool Creek watershed. The project need grew out of concern about rapid development in the upper watershed of Cool Creek (Westfield and Hamilton County) and the potential for increases in downstream flooding and water quality degradation. Clark Dietz, Inc. was retained by Hamilton County (the lead agency) to conduct the necessary engineering analyses and develop the plan with input from watershed stakeholders. Planning efforts began in September 2001 and were completed in November 2003.

Subsequent to the completion 2003 plan, Cool Creek was placed on IDEM's 303(d) list for *E.Coli* impairment. To help address the impairment from *E.Coli*, as well as other pollutants of concern (nutrients, suspended solids, metals, etc.) Hamilton County applied to the Indiana Department of Environmental Management (IDEM) for a Section 319 Nonpoint Source Program Grant. The purpose of the grant application was to update the Cool Creek Watershed Management Plan to make it compliant with Section 319 requirements to reduce nonpoint source pollution. Although, the original 2003 plan did address stormwater quality issues, concerns, and recommendations, not all of the requirements of a Section 319 project were included. Having a fully compliant Section 319 Watershed Management Plan will further address nonpoint source pollution reductions and allow the County to apply for additional Section 319 grant funds to implement recommended improvement projects. The goal of implementing the water quality improvement projects is to remove Cool Creek from the 303(d) list of impaired waterbodies.

The section 319 grant was approved by IDEM in 2004 and a Contract for Services was formally approved by the State of Indiana on December 29, 2004. On January 24, 2005, Clark Dietz was retained by Hamilton County to provide the additional enhancements to the Cool Creek Watershed Management Plan.

The purpose of this chapter of the Cool Creek Watershed Management Plan is to address the Section 319 grant requirements that were not fully included in the 2003 plan.

9.1.2 Mission Statement

The original mission of the Cool Creek Watershed Management grew out of interest and concern regarding stormwater management practices and their effectiveness in controlling the quantity and quality of stormwater runoff. This issue was of special concern given the rapid growth in the Westfield area (upper half of the Cool Creek watershed). Over the course of the Cool Creek planning efforts, the mission of the Cool Creek Watershed Management Plan has evolved to:

> *Preserve and improve the overall health of the Cool Creek watershed by addressing existing stormwater quantity and quality concerns and by proactively guiding future stormwater management practices and decisions.*

9.1.3 Building Partnerships

A key element of the Cool Creek planning process was involving stakeholders and developing partnerships. The main partnership was through joint planning efforts by representatives of Hamilton County, the Town of Westfield, and City of Carmel. Stakeholders in these entities included the Surveyor's Office, the County Drainage Board, Engineering Departments, Planning Departments, Parks Departments, Soil and Water Conservation District, and others. Developers in the watershed were also consulted to obtain feedback and identify concerns. The general public was also involved through public meetings and outreach activities (newspaper articles, posting information on websites, etc.).

Meetings were held during the development of the 2003 plan as well as during the Section 319 planning process in 2005. Information on partnerships and stakeholder involvement during the original 2003 planning process can be found in the following locations in this report:

- Section 3.2 – Staff Interviews
- Section 3.3 – Developer Meetings and Input
- Section 3.4 – Public Meetings and Input
- Appendix B – Developer Meeting Summary
- Appendix C – Public Meeting Presentation Materials and Meeting Summaries

During the course of the current Section 319 update project, additional outreach and information activities were completed. The structure of these activities included public meetings, stakeholder committee meetings, interviews, and newspaper articles. The meetings were coordinated and advertised by the Hamilton County Surveyor's Office. Since most of the recommendations in the Cool Creek Watershed Management Plan were with regard to stormwater management public policy and public improvements, the primary decision makers were government representatives from Hamilton County, Westfield, and Carmel, which are the three public jurisdictions in the watershed. Clark Dietz's role was to prepare meeting presentations and materials, facilitate meetings, and summarize input obtained at the meetings.

Concerns and input on plan elements were obtained through conservations with the public or other stakeholders at the meetings. A variety of stakeholders were invited to participate in Stakeholder Committee meetings:

- Hamilton County, Westfield, and Carmel Staff (Surveyor's Office, SWCD, Engineering Department, Parks Department, Planning Department, Public Works)
- IDEM Staff
- IUPUI – Center for Earth and the Environment Staff
- Indianapolis Water (Veolia Water)
- Representatives from other Engineering and Ecological Consulting Firms
- Newspaper Reporters
- Business Community Representative
- Watershed Groups (Upper White River Watershed Alliance Technical Committee)

The following sections of Appendix H contain presentation materials, sign-up sheets, and summaries of input obtained at the various interviews and meetings:

- Appendix H.1 – Public Meeting Exhibits
- Appendix H.2 – Stakeholder Meeting Exhibits
- Appendix H.3 – Interview Exhibits
- Appendix H.4 – Newspaper Articles

9.2 WATERSHED DESCRIPTION

9.2.1 Watershed Features

The Cool Creek watershed is a sub-watershed of the Upper White watershed. The Hydrologic Unit Codes (HUC) and drainage areas are as follows:

- Upper White
  - 8-digit HUC – 05120201
  - Drainage Area – 2719.6 mi^2

- Cool Creek-Grassy Branch/Little Cool Creek *(commonly known as Cool Creek)*
  - 14-digit HUC – 05120201090030
  - Drainage Area – 23.6 mi^2

Figure 9-1 shows the Cool Creek watershed within the larger Upper White River Basin.

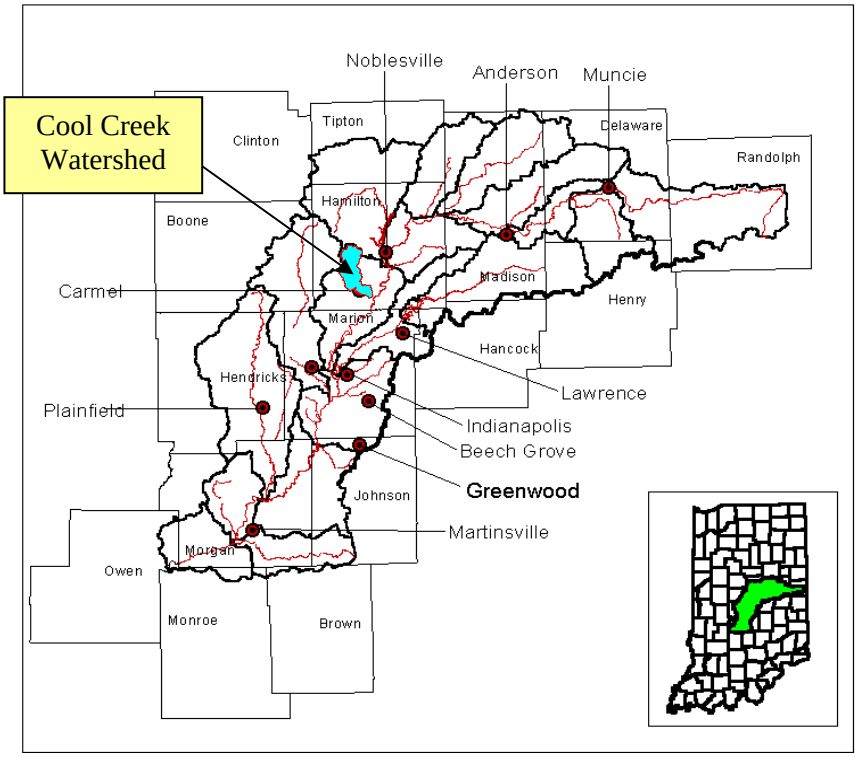


Figure 9-1
Cool Creek Watershed Location within Upper White River Basin
(Base map source – Upper White River Watershed Alliance)

Figure 1-1 in Chapter 1.0 of this report shows a map of the Cool Creek watershed with the approximate corporate boundaries of Westfield and Carmel shown. Figure 9-2 shows an aerial photograph (2003) with the Cool Creek watershed boundary and major streams.

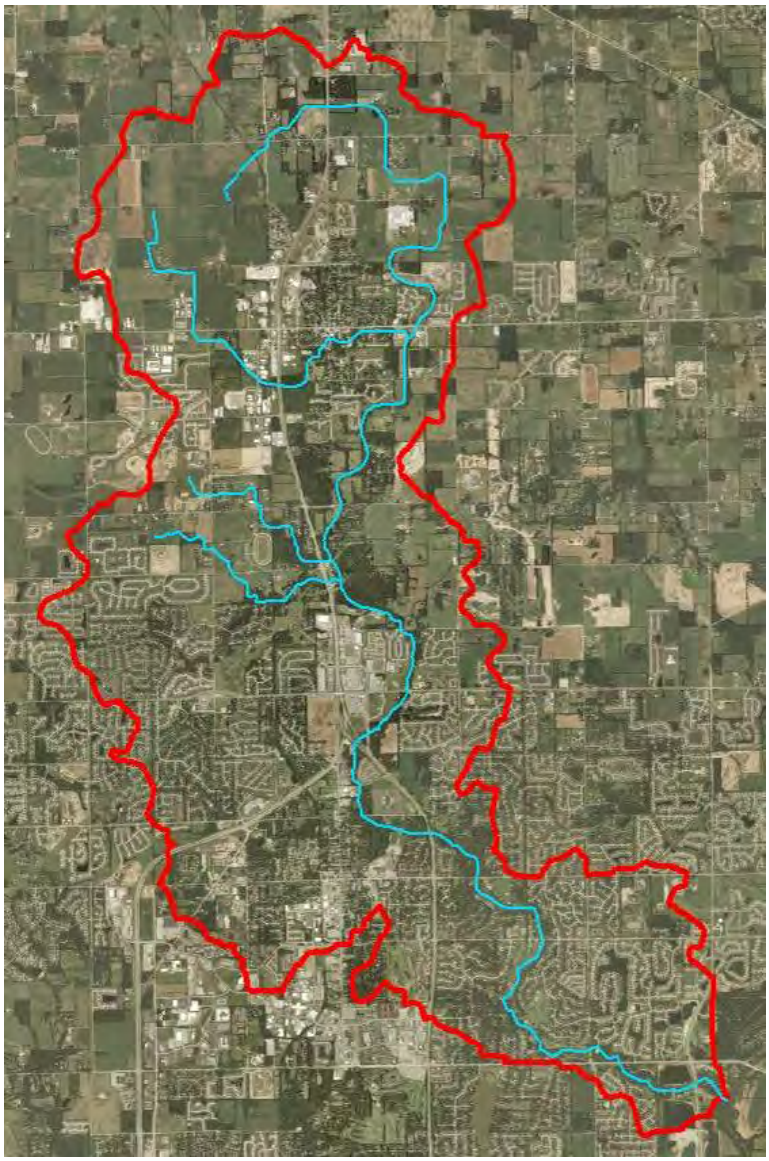


Figure 9-2
Cool Creek Watershed Aerial Photograph

Cool Creek flows south and southeasterly, discharging into the White River south of 116th Street. Tributaries include Hot Lick Creek, Little Cool Creek, Highway Run, Mary Wilson Drain, Osborn & Collins #2 Drain, H. G. Kenyon Drain, and Anna Kendall Drain (see Figure 3-1 in Chapter 3 for location of tributaries). US 31 and SR 431 are major roadways that run through the middle portion of the watershed.

The Westfield portion of the watershed contains both urbanized areas as well as significant tracts of undeveloped land (primarily agricultural). The Carmel portion of the watershed is fully

urbanized. Portions of the watershed lie in unincorporated Hamilton County, but are subject to potential annexation in the future.

9.2.2 Physical Setting

The continental ice sheets covered Hamilton County some 20,000 years ago and earlier and had a profound effect on the terrain of the area. The preglacial bedrock topography which underlies the county was almost completely masked by the deposition of glacial clays, silt, sand, gravel and boulders. The existence of former valleys, which are today filled with as much as 350 feet of glacial materials, cannot be determined by visual examinations of or the present land surface. Much of the sand and gravel occurring within the valleys was deposited by the huge quantities of meltwater which issued from the receding glaciers.

(Source: www.state.in.us/dnr/water/publications/publicat/atlas608.htm)

The Hamilton County climate is temperate, with average monthly temperatures ranging from 24.9ºF in January to 74.3ºF. The climate varies with strongly marked seasons. Winters are often cold (sometimes very cold). The transition from cold to hot weather can produce an active spring with thunderstorms and tornadoes. Oppressive humidity and high temperatures arrive in summer. Autumn generally has lower humidity than the other seasons and mostly sunny skies.

Average precipitation (inches) is as follows:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1.93	1.93	2.88	3.47	3.86	3.91	4.36	3.70	2.79	2.54	3.07	2.67	37.11

(Source: Indiana State Climate Office)

9.2.3 Natural History

Hamilton County, named for Alexander Hamilton, the first Secretary of the Treasury, was organized in 1823. It was largely agricultural and sparsely populated until well after World War II when suburban development began pushing into the area from Indianapolis. Since this time, most of the lower watershed has been converted from agricultural to primarily residential land. The upper watershed still has large tracts of agricultural land.

In the lower watershed, there are larger forested areas along Cool Creek and some of its tributaries. Native species in the forested areas include the following:

Trees

Black Cherry	Sugar Maple	American Basswood
Tulip	American Beech	Black Willow
Hackberry	Cottonwood	American Sycamore
White Ash	Ohio Buckeye	Red Oak
White Oak	Slippery Elm	Pignut Hickory

Shrubs and Small Trees

Flowering Dogwood	Elderberry	Wahoo
Spicebush	Pawpaw	Eastern Redbud

Red-osier Dogwood	Serviceberry	Hawthorne
Witch Hazel		

Forbs and Grasses

Swamp Milkweed	White Snakeroot	Wild Ginger
Pokeweed	Bottle-brush Grass	Blue-false Indigo
Pale Jewelweed	Tall Bellflower	Dutchman's Breeches
Bloodroot		

Vines

Poison Ivy	Virginia Creeper	Trumpet Creeper
Dutchman's Pipe	American Bittersweet	Wild Grape species
Clematis species		

(Source: Hamilton County Parks and Recreation Department)

9.2.4 Endangered Species

Information on threatened or endangered species was obtained from US 31 Preliminary Alternatives Analysis and Screening Report prepared for the Indiana Department of Transportation by the Parsons Transportation Group (July 2002). US 31 runs through the center of the Cool Creek watershed. The following is an excerpt from this report regarding threatened or endangered species:

> *"Information about threatened and endangered species within the project area was provided by the United States Fish and Wildlife Services (USFWS) and IDNR (Appendix C). The USFWS stated that the project area is within the range of the federally endangered Indiana bat and 11 US 31 Preliminary Alternatives Analysis and Screening Report federally threatened bald eagle. There are no current records of Indiana bats near the project corridor, however, the streams in the affected area have not been surveyed for the species. The USFWS indicated that there is suitable summer habitat for Indiana bats in forested areas along Cool Creek and possibly in the other riparian forest areas within the project area. Locally, there are multiple records of this species in adjacent Marion County, including a location within ten miles of the project area. It was also reported that there are no bald eagle nests or significant habitat areas near the project corridor. According to the IDNR NHP database (January 31, 2002), the Red Shouldered hawk, a state species of special concern, and the American badger, a state endangered species, have been reported to occur in the project vicinity, though these reports are 13 to 45 years old. No critical habitat for any threatened or endangered species, including the Indiana bat, has been identified within the project area."*

Table 9-1 also contains a listing of State and Federal endangered, threatened, or rare species in Hamilton County.

In addition to Table 9-1, the endangered, threatened, or rare birds listed below have been observed in Cool Creek Park. Cool Creek Park is a popular attraction for bird watching enthusiasts. The Red Shouldered Hawk (listed in Table 9-1 as a species of special concern) and the Black and White Warbler have been observed nesting in the park. Other birds listed as

endangered or special concern by the IDNR Division of Fish and Wildlife that have been sighted in the park include:

Yellow-crowned Night Heron	Osprey
Bald Eagle	Sharp-shinned Hawk
Peregrine Falcon	Sandhill Crane
Golden-winged Warbler	Cerulean Warbler
Black-and-White Warbler	Worm-eating Warbler
Hooded Warbler	Broad-Winged Hawk

(Source: Hamilton County Parks and Recreation Department)

9.2.5 Soils

Section 2.3.4 of this report describes the predominant soil types and their characteristics in the Cool Creek watershed**.**

9.2.6 Topography

Topography in the Cool Creek watershed was reviewed as part of the hydrologic analysis. The watershed was subdivided into 35 subbasins (see Figure 5-2). To estimate hydrologic times of concentration, subbasin slopes were computed. The slopes ranged from 0.1 percent to 1.7 percent. The upper watershed generally has flatter slopes (average of 0.5 percent) while the lower watershed exhibits steeper slopes (average of 0.8 percent).

The lower watershed (south of 146th Street) generally has reaches of steep slopes (20 to 40 percent) along the floodplain fringe of Cool Creek. In areas where the channel of Cool Creek is located adjacent to the steep banks, streambank erosion is often found. These reaches can be seen on the Stream Inventory Maps contained on the CD found in Appendix H.5.

9.2.7 Hydrology

The major and minor stream systems of Cool Creek are shown on various figures in this report (Figure 3-1, Figure 5-2, and the Stream Inventory Maps on the CD in Appendix H.5). The overall stream system drains in a south, southeast direction, until its confluence with the White River. Some stream channelization and straightening has occurred in the far upper reaches of Cool Creek (referred to as Grassy Branch) as well as along the Anna Kendall Drain.

There are no dams or reservoirs in the watershed, other than a series of on-line lakes that provide stormwater detention for the Countryside development, which is located in subbasin C10 (see Figure 5-2). These lakes are located in the headwaters of the Osborn & Collins Drain.

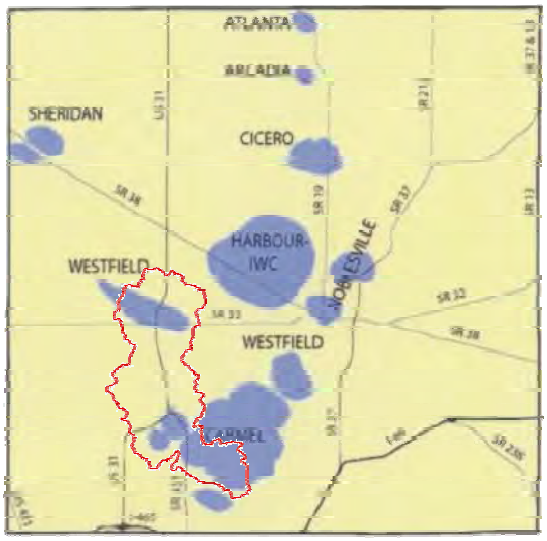
Table 9-1
State and Federal Endangered, Threatened or Rare Species in Hamilton County.

Common Name	State Rank	Federal Rank
Vascular Plants		
Lake Cress	SE	**
Spoon-Leaved Sundew	SR	**
Prairie White-Fringed Orchid	SE	LT
Mollusca: Bivalvia (Mussels)		
Black Sandshell	**	**
Round Hickorynut	SSC	**
Clubshell	SE	LE
Rabbitsfoot	SE	**
Lilliput	**	**
Rayed Bean	SSC	**
Little Spectaclecase	SSC	**
Fish		
Eastern Sand Darter	SSC	**
Amphibians		
Mudpuppy	SSC	**
Reptiles		
Spotted Turtle	SE	**
Eastern Massasauga	SE	**
Birds		
Upland Sandpiper	SE	**
Red-Shouldered Hawk	SSC	**
Least Bittern	SE	**
Black-Crowned Night-Heron	SE	**
Bewick's Wren	SE	**
Mammals		
Bobcat	SE	**
American Badger	SE	**
High Quality Natural Community		
Wet-Mesic Floodplain Forest	SG	**
Mesic Upland Forest	SG	**

Key:
State: SE=endangered, ST=threatened, SR=rare, SSC=special concern, SG=significant, **=not listed
Federal: LT=threatened, LE=Endangered, **= = not listed

(Source: http://www.in.gov/dnr/naturepr/species/)

There are no water supply reservoirs in the watershed. However, there are significant wellfield areas, as shown on Figure 9-3. A smaller wellfield is located in the upper portion of the watershed in Westfield. A larger wellfield is located in the lower watershed in Carmel. Signage is located in the watershed to raise awareness. Carmel, Westfield, and Hamilton County all provide outreach materials (website, brochures) on drinking water protection.



Example Signage for Wellfield Protection

Figure 9-3
Wellfield Protection Areas

(Source: Hamilton County Survey's Office Brochure on "Protecting Your Drinking Water")

Other hydrology features in the watershed include wetlands. Figure 9-4 shows wetlands (light blue areas) from the National Wetland Inventory Maps on an aerial photograph of the watershed. The types of wetlands are more fully described in Section 2.2.3 of this report.

Figure 9-4
Wetland Areas

9.2.8 Land Use

Hamilton County, near the geographic center of Indiana, has a population of about 175,000 (2000 Census) and a land area of 400 square miles. As shown in Figure 9-5, population has steadily increased since about 1970, with a significant increase between 1990 and 2000.

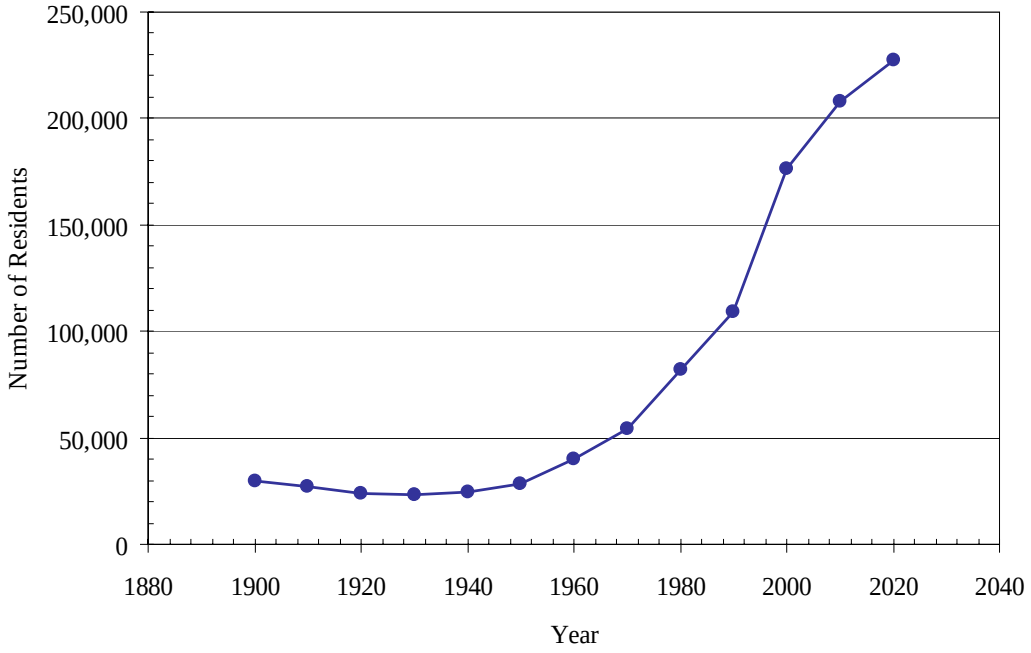


Figure 9-5
Population Trends for Hamilton County

With rapid increases in population, the corresponding land use has changed in the watershed. As part of the hydrologic analysis portion of this project, land use was computed for each of the watershed subbasins (Figure 5-2). Figure 9-6 illustrates the land use distribution for the total watershed, upper watershed, and lower watershed. For the overall watershed, land use consists of 47% agricultural, 39% residential, 7% wooded, 5% commercial, 2% Open Space, and less than one percent industrial. In the upper watershed, agricultural is the predominant land use (70%) while the lower watershed has residential as the predominant land use (70%). Agricultural land in the upper watershed is expected to be urbanized as population in Westfield and Hamilton County continues to grow. Appendix H.6 contains land use maps from the City of Carmel and Town of Westfield.

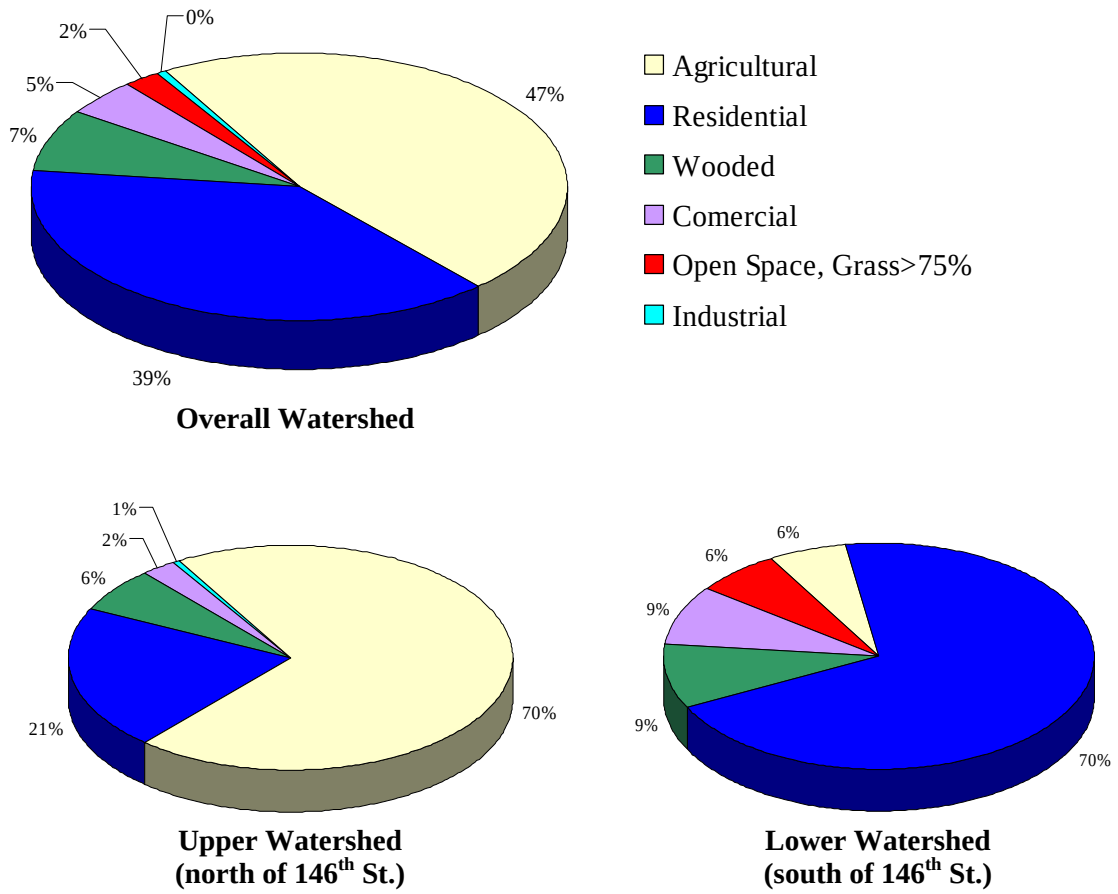


Figure 9-6
Land Use Distribution in the Cool Creek Watershed

The only significant public lands in the watershed are park areas. Cool Creek Park, located north of 151st Street and east of Westfield Boulevard, was opened by the Hamilton County Parks Department in 1990. The park is approximately 90 acres in size and is 80 percent forested and 20 percent open space, with Cool Creek meandering through the park. The park has a large trail network and is a popular attraction for bird watching enthusiasts. A nature center is also located at the park and provides educational exhibits on wildlife habitat.

Flowing Well Park located in the lower watershed (north of 116th Street and east of Gray Road) contains natural areas and open space, a one-and-half-mile walking trail, manmade wetlands, interpretive signs, two observation decks and an open shelter. Cool Creek also meanders through Flowing Well Park. The 18-acre park is a popular attraction for its flowing artesian well. According to historical accounts, the well was discovered by accident when a crew drilling for natural gas in the early 1900s missed the gas but hit a natural pocket of water that spewed under great pressure into the air. People from across Hamilton County gathered to see the geyser. In the 1920s, the well flowed at 60 gallons per minute, and it still runs about 15 gpm, according to the Carmel Parks Department, which maintains the Flowing Well and its small, heavily wooded park.

9.3 WATER QUALITY EVALUATION AND BENCHMARKS

9.3.1 Designated Uses and Stream Impairment

Under the provisions of the Clean Water Act, the Indiana Water Pollution Control Board has designated state waters, except waters within the Great Lakes system (327 IAC 2-2.5), for the following uses (327 IAC 2-1-3): Full-body contact recreation (April-October); capable of supporting a well-balanced, warm water aquatic community and where temperatures permit, capable of supporting put-and-take trout fishing.

Every two years, under Section 303(d) of the Federal Clean Water Act, states are required to identify waterbodies that do not meet water quality standards for designated uses. Impaired waterbodies may be impacted by both point and nonpoint sources of pollution. From the 303(d) list, states must establish priority rankings to develop Total Maximum Daily Loads (TDML). The most recent (2004) IDEM 303(d) list has Cool Creek included, with the parameter of concern being *E. Coli.*

The Indiana Integrated Water Quality Monitoring and Assessment Report (IDEM, 2004) lists Cool Creek as fully supporting for aquatic life support and non supporting for primary contact. The impairment is due to pathogens (classification is moderately impaired).

9.3.2 Water Quality Sampling

Stream sampling was performed during the development of the original Cool Creek Watershed Management Plan (sampling completed in 2002). Section 4.4 of this report provides a detailed description of this sampling program and results as well as more general observations, including the results of visual inspections.

Table 9-2 contains the results of existing pollutant loadings that were calculated for pollutants sampled during the 2003 Cool Creek Watershed Management Plan. The load calculations are based on the March 25th, 2002 sample results and HEC-HMS flow rates for the median storm event in an average year. The March 25th, 2002 storm event was 0.70 inches which approximates a median storm event for central Indiana (about 0.65 inches over 13 hours).

Table 9-2
Load Calculations of Existing Pollutants

Parameter	Units	116th St.	146th St.	186th St.
BOD	tons/yr	2,880	1,890	430
COD	tons/yr	5,640	3,790	870
Nitrogen, Kjelhdahl	tons/yr	1,300	800	100
Nitrogen, Nitrate	tons/yr	510	460	190
Nitrogen, Ammonia	tons/yr	500	1,930	370
Nitrogen, Total	tons/yr	1,800	1,250	290
Nitrogen, Organic	tons/yr	790	----	----
Suspended Solids	tons/yr	67,720	23,110	960
Dissolved Solids	tons/yr	158,000	110,000	34,000
E coli	mCFU/yr	4,620,000	1,030,000	710,000
Fecal Streptococcus	mCFU/yr	615,600	826,700	----

Note: Dissolved Phosphorus, Hex Chromium, Phenol, Copper, Nickel, and Zinc load calculations are not shown since the measured levels were below the detection limits.

Loadings were also calculated using the Indiana Water Quality Standard for *E. Coli* (235 CFU/100ml) in order to find the threshold value for Cool Creek at the different sample locations. E. coli levels for each sample location were above the Indiana Water Quality Standard for *E. Coli*. Table 9-3 shows these results:

Table 9-3
Indiana Water Quality Standard for *E. Coli* Load Calculations

Parameter	Units	116th St.	146th St.	186th St.
Indiana Standard	mCFU/yr	1,206,000	809,000	185,000
Sampled (03-25-02)	mCFU/yr	4,620,000	1,030,000	710,000

During the water quality sampling program completed as part of the 2003 plan, slightly elevated levels of two metals (Chromium Hex and Nickel) were found during one of the wet weather events (August 19, 2002 event). The most common source of metals is automobiles (tire wear, brake linings, leaking fluids, engine parts, etc.). The August 19, 2002 storm event was very heavy and intense, with 2.5 to 2.9 inches falling over a few hours. Runoff of particulates from vehicular roads was likely greater than in a typical median event of 0.65 inches of rain. During the other wet weather sampling event (0.7 inches of rain), metals were found to be below the detection limit. Hence it is not possible to conclude that metals are a major concern in the Cool Creek watershed. Promotion of pollution prevention practices such as proper automobile

maintenance, municipal good housekeeping practices, and other stormwater BMPs will help to reduce metals entering Cool Creek during storm events.

As part of this Section 319 project, additional available water quality data from other sources was investigated and summarized. These sources include the IDEM Assessment Branch Data and volunteer monitoring.

Assessment Branch Data

The IDEM Division of Water's Assessment Branch collected water quality samples in 1992, 1996 and 2001. These results were reviewed and compared to water quality sampling data completed for the original Cool Creek study in 2002. The IDEM samples were taken in the 116th Street area.

The 1992 data included a survey of Benthic aquatic macroinvertebrate Index of Biotic Integrity (mIBI). The resulting score was 4, which indicated fully supporting at that time. The mIBI support classifications are as follows:

- Fully Supporting mIBI ≥ 4
- Partially Supporting mIBI < 4 and ≥ 2
- Not Supporting mIBI < 2

Figure 9-7 and 9-8 compare the IDEM data to the data collected during the original Cool Creek study. The results are presented for E. Coli and nitrogen. E. Coli levels have increased significantly when comparing 1996 to 2001 and 2002. The three samples collected in 1996 were all below the standard for primary contact recreation (235 CFU/100ml). The 2001 IDEM and 2002 Cool Creek study results for E. Coli showed all but two samples exceeding the primary contact standard. This result is reflected in Cool Creek being placed on the 2004 303(d) list. For Kjelhdahl Nitrogen two of the four samples collected in 2002 were significantly higher than the IDEM 1996 data. The other two samples were similar to the 1996 IDEM data.

Figure 9-7
***E. Coli* Sample Results (116th St.)**

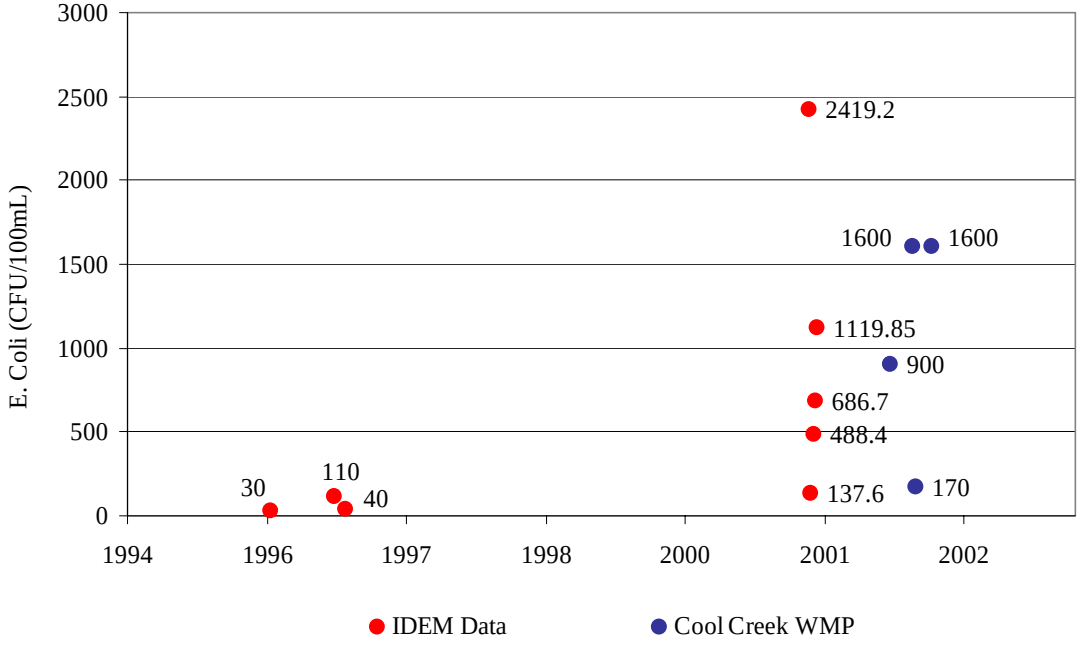
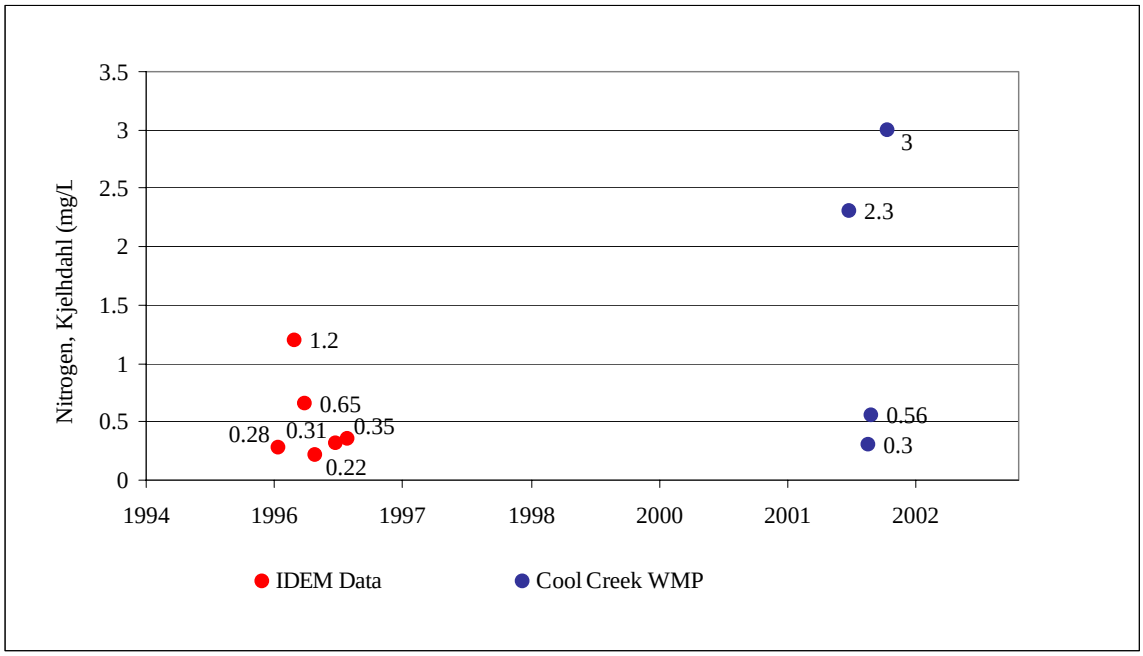


Figure 9-8
Kjelhdahl Nitrogen Sample Results (116th St.)

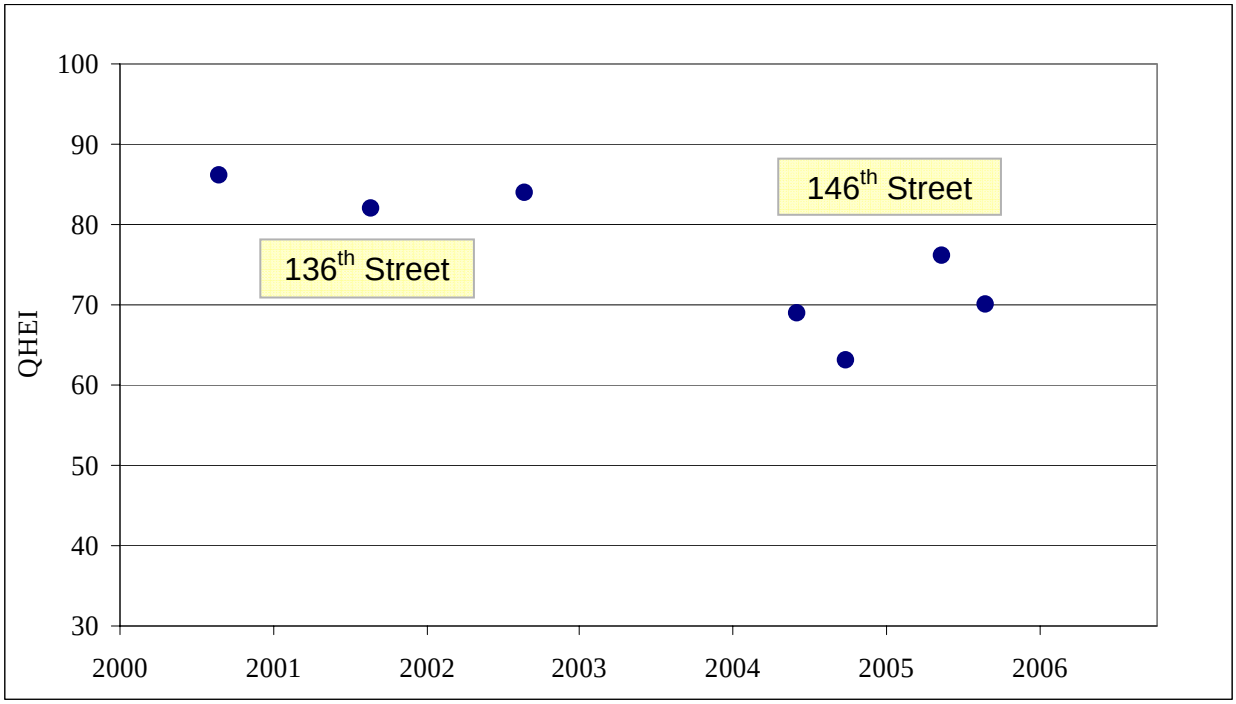


Volunteer Data

Volunteer data for Cool Creek watershed was obtained from the Hoosier Riverwatch Volunteer Stream Monitoring Internet Database. Indiana volunteer stream monitoring groups enter data collected during habitat, chemical, and biological sampling. Only volunteers who have completed a Hoosier Riverwatch training workshop may enter data into the statewide Internet Database. Available data for Cool Creek included the Qualitative Habitat Evaluation Index (QHEI).

The QHEI was developed by the Ohio EPA to provide a qualitative evaluation of the stream habitat by measuring the physical features that affect aquatic communities. This index provides information on a stream's ability to support fish and macroinvertebrate communities. The QHEI is composed of six parameters that are related to stream fish communities: substrate, in stream cover, channel morphology, riparian and bank conditions, pool and riffle quality, and gradient. Each parameter is scored individually and then summed to provide a total score, not to exceed 100. An QHEI of greater than 64 is fully supporting for designated uses, from 64 to 51 is considered partially supporting for designated uses, and less than 51 is not supporting for designated uses. Figure 9-9 illustrates the findings of the volunteer samples taken from 8/30/2000 to 8/29/2005:

Figure 9-9
QHEI Results



The QHEI results showed Cool Creek to be fully supporting for aquatic habitat in 6 of the 7 samples obtained. The samples on the left were taken at 136th Street and the samples shown on the right were taken at 146th Street. The stream characteristics at these two locations differ so the data points at the different location cannot be compared over time to indicate a trend. The scores at 146th Street are a result of a lower substrate scores which could be attributed to sediment from recent construction in the 146th Street area.

Other Sources

Though not directly tied to water quality, other observations and information obtained during the course of the previous and current Section 319 Cool Creek study provide additional insight into the overall health of the Cool Creek watershed. A detailed evaluation of the riparian corridor was completed to identify stream reaches with significant erosion, stormwater outfalls, encroachments, potential pollutant sources, and other noteworthy findings. The results of this effort are shown on the Problem Area Map (Figure 3-1) and on the Stream Inventory Maps contained on the CD in Appendix H.5.

Other observations on water quality included a review of the riparian areas along Cool Creek. South of approximately 171st Street, Cool Creek generally has a healthy riparian zone that provides wildlife and aquatic habitat. This accounts for approximately 9.8 miles of Cool Creek. North of 171st Street, the stream has limited riparian vegetation with agricultural land located very close to the stream (limited stream buffers). This accounts for approximately 2.2 miles of Cool Creek.

Another issue affecting habitat in wooded areas of Cool Creek is the invasion of non-native species. This issue has been identified as part of the Nature Center activities at Cool Creek Park. Staff at Cool Creek Park typically organize 5 to 10 service days for various organizations that assist in the removal of invasive species from the park. The Center for Earth Center for Earth and Environmental Science (CEES) at Indiana University ~ Purdue University, Indianapolis recently sponsored a service day, as outlined on their website as follows:

> *"One of the major threats to the ecology of Cool Creek Park are invasive species; namely Bush Honeysuckle. This shrub is extremely prevalent in the park. Over the last 10 years the plant has found its way into nearly every section of forested area of the park and is drastically effecting the ecological diversity. Several species of native shrubs and small trees including Spicebush, Elderberry, Dogwood, and Wahoo are beginning to decline due to this invasive. Efforts by park staff and volunteers have been underway for about 3 years to manage the issue."*

(Source: www.cees.iupui.edu/Service_Learning/All_Projects/Cool_Creek_Park.htm)

9.3.3 Water Quality Benchmark Summary

To summarize, the review of water quality information collected by IDEM, volunteer monitoring groups, and during the original Cool Creek Study has led to the following benchmark findings:

- Overall, Cool Creek is fully supportive for aquatic life.
- The constituents and concentrations of pollutants found in Cool Creek are generally comparable to urban and urbanizing watersheds across the country.
- Nutrients appear to be somewhat higher than national averages. This could be the result of excess fertilizer use coupled with agricultural runoff from the upper watershed. Public education regarding proper lawn care may be an appropriate follow up activity.
- Suspended solids were very high for one of the sampled events, though this was an atypical storm event. Proper erosion and sediment control on construction sites, in addition to streambank restoration, will help to control suspended solids levels.
- Bacteria levels exceed those required for recreational contact (problem common in many urban watersheds). Efforts should be made to track and reduce human sources of bacteria that may result from failing septic systems, illegal sanitary sewer connections, and other sources. Public education on proper disposal of pet waste would also be a best management practice to help reduce bacteria levels.
- Increased streambank erosion, particularly along Cool Creek south of Keystone Avenue, adversely impacts water quality as eroded channel banks result in downstream sedimentation.
- Limited riparian vegetation and stream buffers north of 171st Street provides limited wildlife habitat and increases transportation of sediment into Cool Creek.

9.4 DEVELOPMENT OF PROBLEM STATEMENTS AND GOALS

9.4.1 Stressors and Sources

The Cool Creek watershed is experiencing rapid development which is resulting in increased urbanization and impervious areas in the watershed. Sampling, investigation, and analysis of the data have shown that the sedimentation, streambank erosion, flooding, and stormwater pollutants have become areas of concern. Previous chapters of this report and previous sections of this chapter have identified numerous stressors and sources throughout the watershed. The following summarizes the stressors and sources that were used to develop problem statements and goals.

- Streambank Erosion
  - Urbanization (increase in impervious areas)
  - Impacts of detention basins (longer bank full flow conditions)
  - Channel encroachments
  - See Figure 3-1 for locations of stream reaches with erosion problems.

- Sedimentation
  - Inadequate erosion control on construction sites
  - Limited stream buffers in upper watershed
  - Supported by high TSS levels during wet weather event with nearby construction site (see Table 4-1)

- Elevated nutrients in wet weather runoff
  - Fertilizers (agricultural, residential, commercial)
  - Supported by high levels of nutrients during wet weather sampling event (see Table 4-1)

- Bacteria (now listed as non-supportive for primary contact on 305(b) report, on 303(d) list for E.Coli)
  - Wildlife, pet waste
  - Leaky septic systems
  - SSOs, spills, general urbanization
  - Supported by sampling results (see Table 4-1 and Figure 9-7)

- Flooding problems
  - Inadequate bridges, culverts
  - Undersized local drainage systems
  - Floodplain development
  - See Chapter 7

- Loss of Ecological Diversity in Riparian Areas (Cool Creek Park)
  - Influx of invasive species (Bush Honeysuckle)
  - Supported by Hamilton County Parks and Recreation Department

9.4.2 Problem Statements

Based on the water quality evaluation benchmarks and the identified watershed stressors and sources for Cool Creek, the following problem statements have been developed.

- Continued urbanization in the upper Cool Creek watershed is increasing streambank erosion, degrading aquatic habitat, and increasing the stormwater pollutants in runoff.
- Lack of riparian buffers in the agricultural areas in the upper Cool Creek watershed increase downstream sediment loads and provide limited wildlife habitat.
- Inadequate construction site erosion and sediment controls threaten downstream aquatic habitat.
- High nutrient levels (particularly ammonia) caused by both urban and agricultural runoff threaten aquatic life.
- Increased bacterial levels caused by urbanization and other sources have impaired full contact recreation use of Cool Creek.
- The influx of invasive species such as the Bush Honeysuckle has resulted in reduced ecological diversity in forested areas of Cool Creek.
- Inconsistent floodplain regulations have resulted in loss of floodplain storage and riparian habitat.
- Undersized bridges and culverts result in roadway overtopping and threaten public safety.

9.4.3 Development of Goals

The following goals have been developed to address the problem statements.

- Reduce impact of urbanization by modifying stormwater detention policy to control smaller storms and treat the first flush of runoff.
- Implement consistent floodplain development restrictions by adopting necessary legal authority (ordinances).
- Develop comprehensive erosion and sediment control programs in Hamilton County, Westfield, and Carmel (ordinance, plan review, inspection, and enforcement).
- Provide public education and outreach to residents and business in Cool Creek Watershed to promote good watershed behavior (disposal of pet waste, proper lawn chemical use, illicit discharges, etc.).
- Construct the bridge and culvert conveyance improvement projects to reduce flood hazards and protect of public safety.

- Continue the Hamilton County Parks and Recreation Department's community service program to remove invasive species and protect ecological diversity in forested areas.

- Implement the Oak Manor Regional Stormwater Quality Facility and other similar facilities to reduce downstream channel erosion and reduce non-point source pollutant levels (nutrients, sediment, metals, bacteria).

- Repair/restore severe channel erosion in the lower reaches of Cool Creek to improve aquatic habitat, reduce sedimentation, and protect public and private facilities.

- Improve the riparian habitat in the upper watershed by establishing stream buffers and vegetation as areas are developed around Cool Creek.

- Provide sanitary sewer service to the few neighborhood areas in Westfield still on septic systems.

9.5 CRITICAL AREA IDENTIFICATION

9.5.1 Targeting Critical Areas

Critical areas for the Cool Creek watershed were identified for each of the stressors/sources listed in section 9.4. The potential pollutant load reductions (for those that could be quantified) for these critical areas are presented in section 9.6.

Streambank Erosion

This is significant threat to the Cool Creek watershed. Streambank erosion transports sediment downstream as channel banks erode and fall into the creek. Erosion also threatens public and private property. Urbanization is the likely cause of increased erosion.

The most critical areas of streambank erosion are the orange shaded areas on the Problem Area Map in Figure 3-1 and summarized as follows:

- Cool Creek upstream of the confluence with the White River (1500 feet)
- Cool Creek downstream of Gray Road (200 feet)
- Cool Creek upstream and downstream of Hot Lick Creek (575 feet)
- Cool Creek upstream of 131st Street (150 feet)
- Cool Creek upstream of Keystone Avenue (100 feet)
- Highway Run downstream of Stonehedge Drive (100 feet)
- H.G. Kenyon Drain downstream of Rolling Court (250 feet)

Sedimentation (from construction sites and agricultural areas)

By volume, sediment is the largest contributor of pollutants to the receiving streams in the Cool Creek watershed. Construction sites are temporary and therefore cannot be specifically targeted. Hamilton County, Carmel, and Westfield will all be implementing programs for plan review, inspection, and enforcement of runoff from construction sites as part of their Rule 13 permit with IDEM.

Agricultural areas can also provide high sediment loads, particularly where conservation tillage is not practiced and where stream buffers are limited. Many agricultural lands in Hamilton County utilize conservation tillage (particularly for soy beans, less so for corn). Stream buffers on Cool Creek north of 171st Street are limited (approximately 2.2 miles of stream). This reach of Cool Creek is targeted for implementation of additional stream buffers.

Elevated Nutrients in Wet Weather Runoff

Elevated nutrients from fertilizers can be caused by both agricultural and urban land uses. As such, it is difficult to target specific critical areas. Elevated nutrients were found during the March 25, 2002 sampling event, but not the August 19, 2002 sampling event. This finding points to spring fertilizers (agricultural as well as residential/business lawn fertilizing) as a potential source. For agricultural runoff, grassed or vegetated buffer strips along Cool Creek would help reduce nutrients. This would be applicable for the Cool Creek from its headwaters, downstream to approximately SR 32. Another potential nutrient source includes a golf course that runs along Cool Creek between 116th Street and 126th Street. However, the sampling results at 116th Street did not show elevated nutrients. Golf courses typically are large users of fertilizers, but they are generally very careful in their application since this is a high cost operation item. Lastly, residential areas are potential sources for nutrients from lawn fertilizers. Neighborhood associations would be good targets to distribute information on proper use of lawn chemicals.

Bacteria

Potential sources of bacteria are widespread and difficult to target critical areas (see section 4.4.4 of this report for additional discussion). Specific areas that could be a source of bacteria are neighborhoods on septic systems. There are five neighborhoods in Westfield that are still on septic systems. These areas on shown on the Problem Area Map (Figure 3-1) and listed below:

- Far Hills
- Buena Vista
- Brookview Place
- Bokeelia
- Ridgewood

Other sources of bacteria include pet waste and wildlife waste. Pet walking is allowed in the two parks that Cool Creek runs through (Cool Creek Park and Flowing Well Park). Pet owners are required to have dogs on leashes and pick up pet waste. Education to homeowners in general regarding pet waste would be a good public education topic in the watershed given the bacteria impairment. Wildlife waste is also a source of bacteria. The proliferation of stormwater ponds associated with new development can be an attraction to increasing geese populations. Proper pond design with shoreline vegetation can discourage resident geese from populating these areas.

Flooding Problems

A total of 10 stream/roadway and neighborhood flooding problems have been identified as critical to the affected communities. These include:

- E. 151st Street (Cool Creek)
- E. 171st Street (Cool Creek)
- Gurley Street (Anna Kendall Drain)

- Cherry Street (Anna Kendall Drain)
- SR 32 (J. M. Thompson Drain)
- US 31 and Adjacent Private Drive (Highway Run)
- Walter Street, Private Drive, and Walter Court (Highway Run)
- Thornberry Drive (Highway Run)
- Carmel Drive (Hot Lick Creek)
- Hot Lick Creek Channel Improvement

These critical flooding problem areas are detailed in Sections 7.4 and 7.5 of this report.

Loss of Ecological Diversity in Riparian Areas

Invasive species such as the Brush Honeysuckle have resulted in loss of ecological diversity in forested riparian areas of Cool Creek. To date, this problem has been primarily targeted towards Cool Creek Park, which is publicly owned land.

9.5.2 Prioritizing Critical Areas

Goals were prioritized to target the most critical areas and maximize environmental benefits to the Cool Creek watershed. Goals are numbered to reflect the general priority (see Section 9.6). Goals 1 through 5 would have higher priority than Goals 5 through 10. Sedimentation in the watershed is one of the primary focuses for this plan since reducing sedimentation generally reduces other pollutants attached to the sediment.

The key critical areas that Hamilton County and other stakeholders would like to address are the channel erosion problems that are worsening with upstream urbanization. The County feels there are viable solutions to address this problem that can be implemented in the next three to five years. In particular, a regional off-line stormwater quality facility at Oak Road and 171st Street appears to be feasible. This facility will help reduce future downstream erosion as well as capture and treat other stormwater pollutants such as suspended solids, nutrients and bacteria. Repairing areas already damaged by streambank erosion is also feasible, especially given some of the cost share programs available for property owners through the Hamilton County SWCD.

The critical flooding areas are also a priority for Westfield, as many of the flooding problems in the Cool Creek watershed are located in this community. These problems are a priority to reduce safety concerns, traffic disruptions, and property damage that can be associated with flooding.

Though stream buffers in agricultural lands would be desirable, they are a lower priority because much of the agricultural land will be developed in coming years. There may be opportunities to establish additional riparian vegetation in the upper reaches of Cool Creek as these areas are converted to residential and commercial land uses.

9.6 IMPLEMENTATION MEASURES

This section summarizes implementation measures needed to implement the goals that were identified during the project. Goals are listed higher priority lower priority. Load reduction calculations and action registers are provided where applicable.

Goal #1 – Develop comprehensive erosion and sediment control program in Hamilton County, Westfield, and Carmel (ordinance, plan review, inspection, and enforcement)

As part of the their requirements for their Rule 13 permits, Hamilton County, Westfield, and Carmel have developed comprehensive erosion and sediment control programs to manage runoff from construction sites. These programs include enacting the necessary legal authority and implementing plan review, inspection, and enforcement procedures. Hamilton County recently has enacted a new ordinance regulating storm water runoff associated with construction and post-construction activities as well as an Illicit Discharge and Detection Elimination (IDDE) ordinance. These county ordinances as well as a Report-a-Polluter program can be found at following link:

http://www.co.hamilton.in.us/services.asp?id=3921&entity=2200

Since Goal #1 is already being implemented by Rule 13 requirements for MS4s which encompass the entire Cool Creek Watershed no action register is included for this goal.

Goal Indicators: Number of construction site inspections and enforcements, reduced concentrations of TSS

Goal #2 – Implement the Oak Manor Regional Stormwater Quality Facility and other similar facilities to reduce downstream channel erosion and reduce nonpoint source pollutant levels (nutrients, sediment, metals, bacteria)

Regional Stormwater Quality Facilities

Natural drainage channels are highly sensitive to changes in the magnitude of frequent stormwater runoff (i.e. 1-year and 2-year recurrence interval) events. Urban development, despite the presence of stormwater detention ponds, often increases the magnitude of 1-year and 2-year peak flows. This is a result of a detention pond design focus on the design (i.e. 100-year and 10-year) events. Although detention ponds typically reduce peak flow rates for larger (i.e. 100-year and 10-year) storm events, they often *increase* peak flow rates for more frequent (i.e. 1-year, 2-year) storm events and extend the overall duration of higher flow.

The hydrologic analysis completed for this project showed that major regional detention is not warranted to control the larger storms. Flooding is not a major problem in the lower watershed reaches and the existing detention policy for new development will be effective in controlling peak flows from these larger storms. However, it is recommended that regional detention/water quality treatment facilities be constructed in the upper reaches of Cool Creek to help control the magnitude of 1-year and 2-year recurrence interval rainfall events and filter stormwater pollutants. These facilities should be constructed “off-line” so as to maintain base flow in the

channel, avoid disrupting the existing riparian corridor, and avoid extensive dam safety requirements.

Regional stormwater detention facilities will provide the following benefits to the Cool Creek watershed:

- Reduce peak flow rates for more frequent storms
- Improve water quality by reducing concentrations of sediment, nutrients, metals, and bacteria
- Increase aquatic habitat by providing wetland and open water areas
- Reduce downstream erosion potential by decreasing the magnitude and duration of the 1-year and 2-year flows, thus further reducing sediment pollution

Several potential sites for regional stormwater quality detention facilities were identified during the course of the Cool Creek planning efforts. In the original Cool Creek study two sites were identified. The first site was along the Grassy Branch of Cool Creek north of 186 Street. The second site was south of 171st Street and east of Oak Road. Two additional sites were identified during the Section 319 update project. The first is at the confluence of the Anna Kendall Drain with Cool Creek. The second is along Cool Creek at the southeast corner of 161st Street and Westfield Boulevard. Figure 9-10 shows the general locations of these facilities.

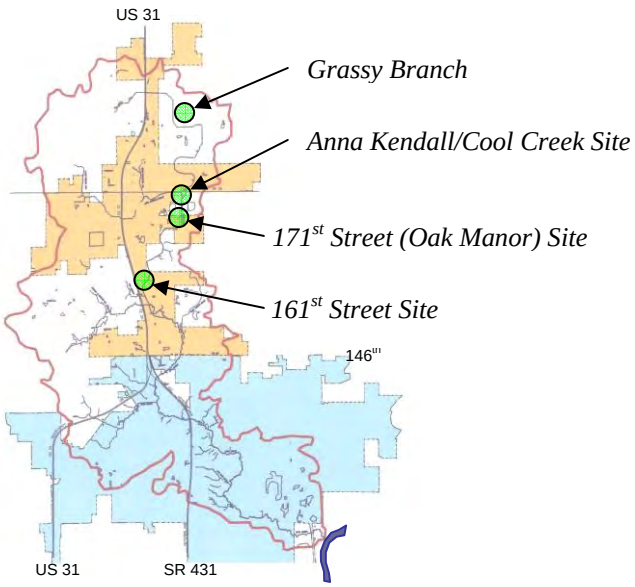


Figure 9-10
Regional Off-Line
Stormwater Quality Facility Locations

Hamilton County has been working on planning and design efforts for the site south of 171st Street. This site was selected because of cooperation with an adjacent development, called Oak Manor. The developer of this site has agreed to donate the land for the facility and possibly coordinate earthwork activities during construction of the facility. The following sections describe the Oak Manor facility in more detail, followed by an overview of the other three sites identified for regional off-line stormwater quality facilities.

Oak Manor Regional Stormwater Quality Facility

The Oak Manor Stormwater Quality Facility (previously referred to as the 171st Street facility in Chapter 7 of this report) involves the construction of a regional stormwater quality facility, off-line and adjacent to Cool Creek south of 171st Street and east of Oak Road. The area where the facility is planned is in the floodplain of Cool Creek, and is currently being farmed. The facility will be situated on the east side of the creek, and will consist of a 3-month storm event inflow channel which will divert flows to a settling pool, approximately one (1) acre in size and then into an additional six (6) acres of a constructed wetland system with a meandering shallow channel. Treated water from this facility will flow back into Cool Creek through a staged outfall pipe system, including a submerged orifice. A similar facility is also envisioned for the west side of Cool Creek, which Hamilton County would like to pursue in the future. Figure 9-11 is a schematic of the Oak Manor Stormwater Quality Facility.

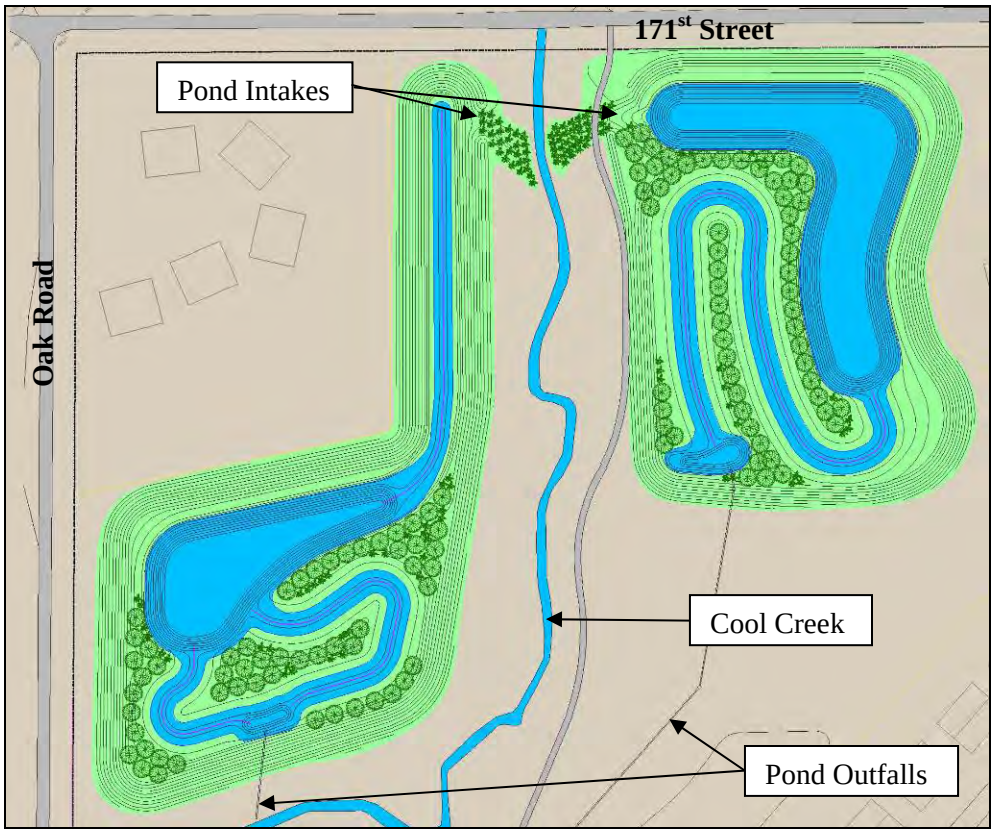


Figure 9-11
Oak Manor Stormwater Quality Facility Schematic

The stormwater quality facilities are designed to collect, detain and treat the "first flush" of urban nonpoint source pollutants. Additionally, downstream peak flows will be reduced by approximately 23% for events up to a 1-year event. Slowing the flow down during these smaller events (up to 1-year) will help reduce downstream bank erosion currently occurring due to urbanization in the watershed.

The Oak Manor pond/wetland system is anticipated to achieve the following pollutant removal percentages *(Source: National Management Measures Guidance to Control Nonpoint Source Pollution from Urban Areas, U.S. EPA, Draft, July 2002)*:

- 80% - Total Suspended Solids
- 56% - Total Phosphorus
- 37% - Ortho-Phosphorus
- 19% - Total Nitrogen
- 40% - Nitrate and Nitrite Nitrogen
- 58% - Copper
- 56% - Zinc

In addition, stormwater wetland systems can help reduce bacteria by a 2 log reduction factor (or 99%) *(Source: Design of Stormwater Wetland Systems, Metropolitan Washington Council of Governments, October, 1992.)*

Existing loadings and load reductions for the Oak Manor Stormwater Quality Facility were computed using the sample taken at 186th Street and flow calculated by HEC-HMS at the Oak Manor location. Flows were based on a median central Indiana storm event (0.65 inches). Load reductions were also based on the above pollutant removal percentages. It was assumed that the Oak Manor Stormwater Quality Facility would treat 75% of the flow during this event.

Pollutant	**Units**	**Existing Loadings**	**Projected Load Reductions**
Total Suspended Solids	tons/yr	2104	1262
Total Nitrogen	tons/yr	631	156
Nitrogen, Nitrate	tons/yr	421	136
E. Coli	mCFU/yr	1,565,050	1,162,050

Additional Off-Line Stormwater Quality Detention Facilities

Though Hamilton County is currently focusing on the Oak Manor Stormwater Quality Facility, three other locations for similar facilities were identified during the course of the original Cool Creek study and during the Section 319 plan update. Figures 9-12, 9-13, and 9-14 show the sites for Grassy Branch, Anna Kendall/Cool Creek, and 161st Street (respectively). The Grassy Branch site was identified in the original Cool Creek study (see Section 7.7.2). The site, at the confluence of the Anna Kendall Drain with Cool Creek, was identified by the Hamilton County Surveyor as a good site to treat runoff from the Anna Kendall Drain. The site at the southeast corner of 161st Street and Westfield Boulevard was suggested by a participant at a public meeting held in the spring of 2005 for the Section 319 update project.

These three additional sites are located off-line in the floodplain of Cool Creek. The sites are currently farmed and would all provide opportunities to enhance water quality and reduce downstream channel erosion by constructing pond/wetland systems in these areas.

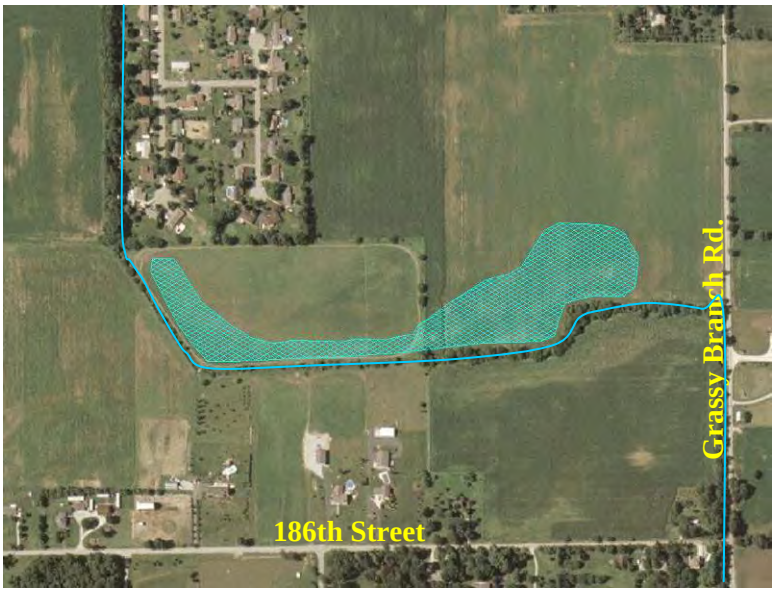


Figure 9-12
Grassy Branch Location
Regional Off-Line Stormwater Quality Facility

Figure 9-13
Anna Kendall/Cool Creek Location
Regional Off-Line Stormwater Quality Facility

Figure 9-14
161st Street and Westfield Boulevard Location
Regional Off-Line Stormwater Quality Facility

161st Street and Westfield Boulevard Stormwater Quality Facility

In November of 2005, the project team learned that a constructed wetland/pond system is planned for the 161st Street and Westfield Boulevard location. This facility is being funded by a private developer who is using the site for mitigation for filling of another isolated wetland in the watershed. The land was already owned by the Town of Westfield Parks Department.

The following is a project summary from Williams Creek Consulting, Inc. who is the consulting firm that designed the project.

> *"Early coordination with a local site developer, Williams Creek Consulting, Inc., Westfield Parks Department, Indiana Department of Environmental Management, and the U.S. Army Corps of Engineers has allowed the implementation of this plan as early as spring of 2006. Through this coordination, the property owned by Westfield Parks will be converted into a 2 acre wetland park for the purpose of natural flood control and water quality improvement with an educational theme for the heavily developed watershed"*
>
> *"The Westfield Parks Department desires to create a wetland area along Cool Creek for the creation of additional community greenspace. The wetland park will additionally provide for an educational public feature demonstrating the important functions and values of wetlands and stream buffers in our environment. Approximately 2 acres will be graded for the wetland area and will include low-flow braided channels. The wetland will be planted with a wet meadow seed mixture and the surrounding upland will be planted with a diverse tall prairie seed mixture. Thirty four native trees and thirty eight native shrubs will be planted within the wetland including species such as oak, sweetgum, maple, river birch, buttonbush, and dogwood. Additionally, the wetland park*

will have a trail and an observation deck constructed to help facilitate the educational experience."

A schematic of the 161st Street and Westfield Boulevard wetland park facility is shown in Figure 9-15.

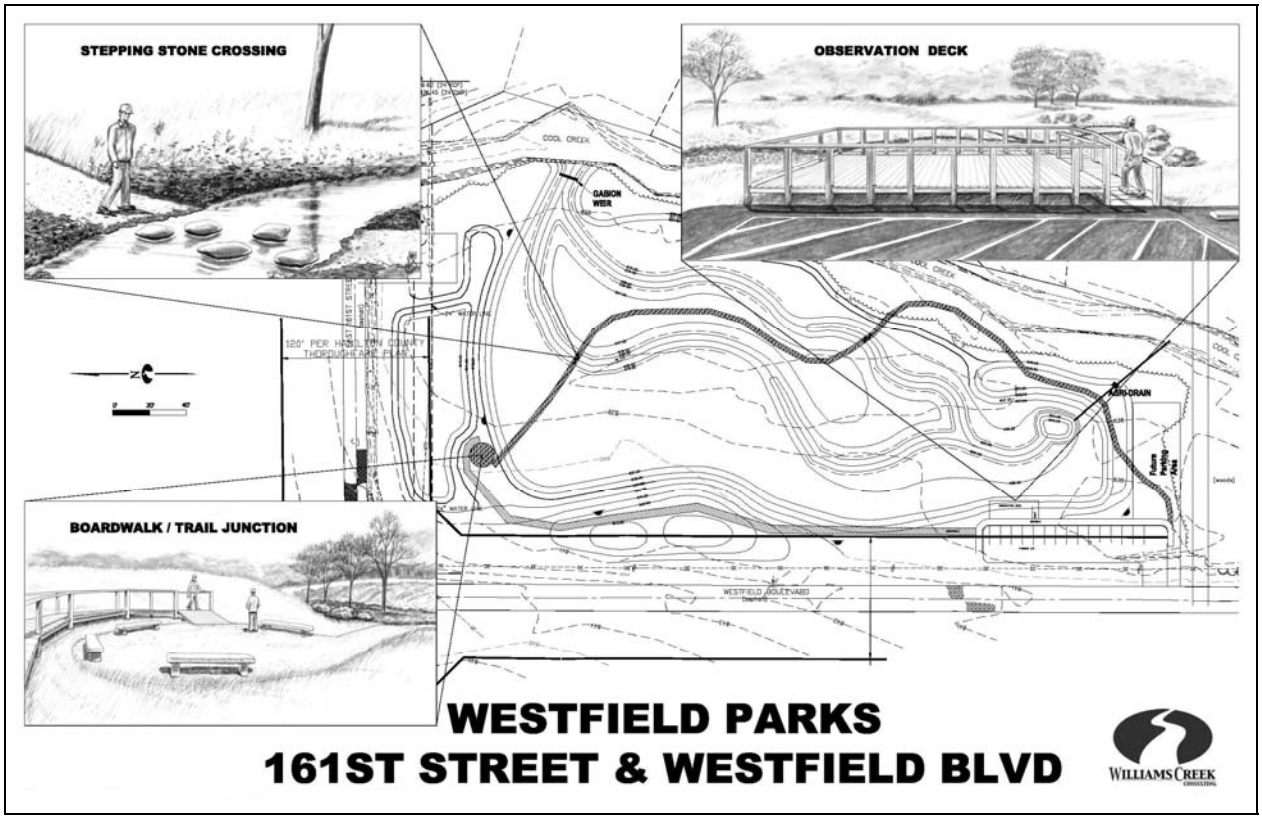


Figure 9-15
161st Street and Westfield Boulevard Location
Site Layout

Goal # 2 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
Oak Manor Regional Stormwater Quality Facility	Complete Construction Plans (East Facility)	Hamilton County	Currently in progress	Hamilton County	Construction Plans
	Bid and Construct	319 Grant, Local Funding	Start in 2006	Hamilton County	Completed Facility
	Complete Construction Plans (West Facility)	Hamilton County	Currently in progress	Hamilton County	Construction Plans
	Bid and Construct	319 Grant, Local Funding	Start in 2007	Hamilton County	Completed Facility

Goal # 2 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
161st Street and Westfield Stormwater Quality Facility	Construct Pond	Developer	Start in 2006	Local Developer	Completed Facility
Anna Kendall/Cool Creek Stormwater Quality Facility	Acquire property	Donation	One year from plan approval	Hamilton County	Property
	Complete Construction Plans	319 Grant, Local Funding	Immediately after grant approval	Hamilton County	Construction Plans
	Bid and Construct	319 Grant, Local Funding	One year after grant approval	Hamilton County	Completed Facility
Grassy Branch Stormwater Quality Facility	Acquire property	Developer	As development occurs near site	Developer or Hamilton County	Property
	Complete Construction Plans	Developer or Hamilton County	As development occurs near site	Developer or Hamilton County	Construction Plans
	Bid and Construct	Developer or 319 Grant	One year after grant approval	Developer or Hamilton County	Completed Facility

Goal Indicators: Number of completed facilities, lower pollutants levels (nutrients, bacteria, TSS, metals, etc.), increased habitat

Goal #3 – Provide public education and outreach to residents and business in Cool Creek watershed to promote good watershed behavior (disposal of pet waste, proper lawn chemical use, illicit discharges, etc.)

Since Goal #3 is already being implemented by Rule 13 requirements for MS4s which encompass the entire Cool Creek Watershed no action register is included for this goal. As part of its Rule 13 program, Hamilton County surveyed residents in the Cool Creek watershed (as well as other parts of the County) to determine current awareness of stormwater quality issues. This survey was completed during the period of July 2004 through October 2004. The surveys were distributed at various local events. When asked "how concerned are you about stormwater pollution," nearly 85 percent responded either somewhat concerned or very concerned. When asked "whether you agree that waterbodies in Hamilton County are polluted," more than 88 percent responded somewhat agree or agree. When asked to rank four key stormwater pollutants in terms of their severity, the respondents ranked toxins (oils and greases) as having the largest impact, followed closely by bacteria, then sediment and nutrients. When asked to select the top three sources of stormwater pollutants from a list of ten potential sources, respondents ranked agricultural runoff as the top source, followed by runoff from industrial/municipal facilities and runoff from parking lots.

Hamilton County residents (including Carmel and Westfield) will be surveyed throughout the Rule 13 permit term to evaluate and monitor the effectiveness of the stormwater education program. Surveys will likely be distributed during local events, at public meetings, via

stormwater websites, and as inserts to local utility bills. Details of each community's Rule 13 program can be found at the following websites.

Hamilton County Stormwater Website:

http://www.co.hamilton.in.us/services.asp?id=3921&entity=2200

Carmel Stormwater Website:

http://www.ci.carmel.in.us/government/deptcommunityrelations3.html

Westfield Stormwater Website:

http://www.westfield.in.gov/egov/apps/directory/list.exe?path=divs&action=47&fDD=8-47

Goal Indicators: Improved public knowledge of water quality issues, reflected through awareness surveys; number of brochures disturbed; number of public outreach events completed

Goal #4 – Repair/restore severe channel erosion in the lower reaches of Cool Creek to improve aquatic habitat, reduce sedimentation, and protect public and private facilities.

Streambank Erosion Solutions (See Section 7.6)

Proposed solutions range from minor regrading and seeding (for areas experiencing moderate flow velocities) to more intensive improvements such as riprap, geotextile fabric, woody plantings, vegetated geogrids, etc. for areas experiencing high flow velocities or containing steep channel sideslopes. Whenever possible, streambank stabilization should employ vegetative measures, so as to maintain the natural state of the channel corridor and to enhance instream water quality. In some instances of severe erosion, a more structural solution such as gabion baskets or revetment may be a more appropriate solution.

The proposed solutions described in this section are preliminary only. Upon choosing specific streambank restoration sites, detailed information will need to be collected and each site will need to be analyzed separately. Detailed information needed for a final design would be as follows:

- Channel cross sections at each restoration site, including location of private features, property corners, and nearby utilities.
- Hydraulic analysis for each restoration site, including velocity calculations and shear stress calculations for more frequent (i.e. 1-year, 2-year) recurrence interval rainfall events.
- Soil analysis for each restoration site.
- Determination of land availability (i.e. easements, right-of-way, and land acquisition) for proposed grading.
- Determination of construction access points.
- Public input on proposed improvements (most important when improvements are immediately adjacent to existing homes)

Critical stream bank erosion areas are listed below. Load calculations for each area have been performed and the areas have been prioritized based on this calculation. A photograph of the erosion area is shown on the right for each area. A figure for each stream bank solution can be

found at the end of Chapter 7 (Figures 7-11 through 7-17). Additional details, including costs, are provided in Section 7.6.

Priority #1 - Cool Creek: upstream of confluence with the White River (See Section 7.6.3)

Severity of Erosion: Very Severe

Lateral Recession Rate: 0.7 ft./yr.

Length: 1500 feet

Height: 4 feet

Load Reduction: **189.0 tons per year**

Priority #2 - Cool Creek: upstream and downstream of Hot Lick Creek (See Section 7.6.5)

Severity of Erosion: Very Severe

Lateral Recession Rate: 0.7 ft./yr.

Length: 575 feet

Height: 4 feet

Load Reduction: **72.5 tons per year**

Priority #3 - Cool Creek: downstream of Gray Road (at bend) (See Section 7.6.4)

Severity of Erosion: Very Severe

Lateral Recession Rate: 0.6 ft./yr.

Length: 200 feet

Height: 8 feet

Load Reduction: **43.2 tons per year**

Priority #4 - Cool Creek: upstream of 131st Street (Main Street) (See Section 7.6.6)

Severity of Erosion: Very Severe

Lateral Recession Rate: 0.6 ft./yr.

Length: 150 feet

Height: 9 feet

Load Reduction: **36.5 tons per year**

Priority #5 - Cool Creek: upstream of Keystone Avenue (See Section 7.6.7)

Severity of Erosion: Very Severe

Lateral Recession Rate: 0.7 ft./yr.

Length: 100 feet

Height: 8 feet

Load Reduction: **25.2 tons per year**

Priority #6 - H.G. Kenyon Drain: downstream of Rolling Court (See Section 7.6.2)

Severity of Erosion: Severe

Lateral Recession Rate: 0.5 ft./yr.

Length: 250 feet

Height: 4 feet

Load Reduction: **22.5 tons per year**

Priority #7 - Highway Run: downstream of Stonehedge Drive (See Section 7.6.1)

Severity of Erosion: Severe

Lateral Recession Rate: 0.4 ft./yr.

Length: 100 feet

Height: 6 feet

Load Reduction: **10.8 tons per year**

Goal # 4 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
Reduce Sedimentation from Channel Erosion	Priority #1 - Cool Creek: upstream of confluence with the White River	319 Grant	Initiate within 1 year	Hamilton County	Complete Project/Reduced TSS
	Priority #2 - Cool Creek: upstream and downstream of Hot Lick Creek	319 Grant	Initiate within 1 year	Hamilton County	Complete Project/Reduced TSS
	Priority #3 - Cool Creek: downstream of Gray Road (at bend)	319 Grant	Initiate within 1 year	Hamilton County	Complete Project/Reduced TSS
	Priority #4 - Cool Creek: upstream of 131st Street (Main Street)	319 Grant	Initiate within 3 to 5 year	Hamilton County	Complete Project/Reduced TSS

Goal # 4 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
	Priority #5 - Cool Creek: upstream of Keystone Avenue	319 Grant	Initiate within 3 to 5 year	Hamilton County	Complete Project/Reduced TSS
	Priority #6 - H.G. Kenyon Drain: downstream of Rolling Court	319 Grant	Initiate within 3 to 5 year	Hamilton County	Complete Project/Reduced TSS
	Priority #7 - Highway Run: downstream of Stonehedge Drive	319 Grant	Initiate within 3 to 5 year	Hamilton County	Complete Project/Reduced TSS

Goal Indicators: Number of projects completed, reduced concentrations of TSS

Goal #5 – Reduce impact of urbanization by modifying stormwater detention policy to control smaller storms and treat the first flush of runoff

Modify Detention Pond Design Standards (See Section 7.8.1)

Many communities require detention pond designs that incorporate features to help capture pollutants in stormwater runoff. This is generally accomplished by providing a *Water Quality Volume*. The water quality volume is the storage needed to capture and treat runoff from 90% of the average annual rainfall (runoff from approximately a 1-inch rain event). Design standards for reviewing authorities within the Cool Creek watershed should be modified to contain a similar requirement. The *Water Quality Volume* standard will help to control peak flows during more frequent storm events, reduce pollutant loadings to receiving streams, and reduce the potential for downstream channel erosion.

Properly designed and constructed stormwater ponds are generally capable of the following pollutant load reductions:

Pollutant	Percent Reduction*
Total Suspended Solids	80%
Total Phosphorus	51%
Ortho-Phosphorus	65%
Total Nitrogen	33%
Nitrate and Nitrite Nitrogen	43%
Copper	57%
Zinc	66%

**Source: National Management Measure Guidance to Control Nonpoint Source Pollution from Urban Areas. U. S. EPA, Draft, July 2002*

Ordinance and Standards Updates (See Section 8.3.5)

The recommendations outlined in the land use and planning policies section of this report will require updates and/or new ordinances and design standards. All three entities in the watershed are currently updating their ordinances and standards to address stormwater quality.

Goal # 5 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
Reduce impact of urbanization	Modify Detention Pond Design Standards	Local Funding	Initiate by year 1	Hamilton County, Carmel, Westfield	Updated Detention Pond Design Standards
	Ordinance and Standards Updates	Local Funding	On Going, complete by year 1	Hamilton County, Carmel, Westfield	Updated Ordinances and Standards

Goal Indicators: Completed Design Standards and Ordinances, lower pollutants levels

Goal #6 – Continue the Hamilton County Parks and Recreation Department's community service program to improve watershed quality, including removing invasive species, stream trash pick up and public education.

Community Service Program

To improve the Cool Creek watershed quality, the Hamilton County Parks and Recreation Department has been organizing community service days for volunteers. These days can be either open to the public or for private groups such as the Boy/Girl Scouts, churches, environmental organizations, and other interested groups. A Service Learning Day was recently (October 16, 2005) sponsored by IUPUI Center for Earth and Environmental Science to get volunteers to assist in removing invasive species. This is a valuable program to improve watershed health and provide public education. The goal included continuing to support and promoting awareness of this program.

Goal # 6 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
Improve Watershed Quality	5-10 Community Service Days a Year	Local Funding	On Going	Hamilton County Parks and Recreation Department	Ecological Diversity and Improved Watershed Quality

Goal Indicators: Number of community service days per year, increased public awareness

Goal #7 – Provide sanitary sewer service to the few neighborhood areas in Westfield still on septic systems

The Town of Westfield has identified five neighborhoods that are served by septic systems, rather than sanitary sewers. Some of these neighborhoods have had failure problems. These neighborhoods are shown on the Problem Area Map in Figure 3-1 of this report. Septic system failures occur when systems are not maintained properly which can increase bacterial levels in receiving streams. Therefore, converting neighborhoods from septic systems to sanitary collection systems has been made a goal of this plan and of the Town. Based on an estimated cost of $15,000 per home, a preliminary estimate of cost to install sanitary sewers in these neighborhoods is as follows:

- Far Hills - $540,000
- Buena Vista - $195,000
- Brookview Place - $615,000
- Bokeelia - $195,000
- Ridgewood - $405,000

Goal # 7 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
Provide Sanitary Service to reduce *E. Coli*	Far Hills Sanitary Sewers	Local Funding	Initiate within 2 years	Westfield	Reduced *E. Coli*
	Buena Vista Sanitary Sewers	Local Funding	Initiate within 2 years	Westfield	Reduced *E. Coli*
	Brookview Place Sanitary Sewers	Local Funding	Initiate within 2 years	Westfield	Reduced *E. Coli*
	Bokeelia Sanitary Sewers	Local Funding	Initiate within 2 years	Westfield	Reduced *E. Coli*
	Ridgewood Sanitary Sewers	Local Funding	Initiate within 2 years	Westfield	Reduced *E. Coli*

Goal Indicators: Number of households converted form septic system to sanitary sewers, lower bacteria levels

Goal #8 – Implement consistent floodplain development restriction by adopting necessary legal authority (ordinances)

Floodplain Protection (See Section 7.8.3)

Floodplain development concerns tie directly to preservation of the riparian stream buffers along Cool Creek (and its tributaries). Filling of floodplains can cause loss of flood storage and riparian habitat. As noted previously, Hamilton County has an ordinance that prohibits filling of land in the floodplains of its regulated drains. It would be very beneficial for Carmel and Westfield to adopt similar policies for floodplains under their jurisdiction. This would provide a uniform policy and would help preserve existing riparian buffers. Carmel and Westfield are currently considering these issues as part of their ordinance updates.

Goal # 8 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
Reduce Flooding and Protect Riparian Areas	Ordinance and Standards Updates	Local Funding	On Going, complete by year 1	Carmel, Westfield	Updated Ordinances and Standards

Goal Indicators: Adoption of consistent floodplain development ordinances

Goal #9 – Construct the bridge and culvert conveyance improvement projects to reduce flood hazards and protect public safety

Stream Flooding/Roadway Overtopping Critical Areas and Solutions (See Section 7.4)

Proposed improvements to solve the critical flooding areas are presented in Section 7.4 of this report. These improvements will be completed as local funds allow.

Goal # 9 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
Reduce Flood Hazards	E. 151st Street (Cool Creek)	Local Funding	During Roadway Improvements	Westfield	Reduced Local Flooding
	Walter Street, Private Drive, and Walter Court (Highway Run)	Local Funding	During Roadway Improvements	Westfield	Reduced Local Flooding
	E. 171st Street (Cool Creek)	Local Funding	During Roadway Improvements	Westfield	Reduced Local Flooding
	Gurley Street (Anna Kendall Drain)	Local Funding	During Roadway Improvements	Westfield	Reduced Local Flooding
	Cherry Street (Anna Kendall Drain)	Local Funding	During Roadway Improvements	Westfield	Reduced Local Flooding
	SR 32 (J. M. Thompson Drain)	Local Funding	During Roadway Improvements	Westfield	Reduced Local Flooding
	US 31 and Adjacent Private Drive (Highway Run)	State Funds	During Roadway Improvements	Carmel	Reduced Local Flooding
	Thornberry Drive (Highway Run)	Local Funding	During Roadway Improvements	Carmel	Reduced Local Flooding
	Carmel Drive (Hot Lick Creek)	Local Funding	During Roadway Improvements	Carmel	Reduced Local Flooding
	Hot Lick Creek Channel Improvement	Local Funding	During Roadway Improvements	Carmel	Reduced Local Flooding

Goal Indicators: Number of completed projects, amount of roadway overtopping occurring during a year

Goal #10 – Improve the riparian habitat in the upper watershed by establishing stream buffers and vegetation as areas are developed adjacent to Cool Creek

Buffer strips should be incorporated into development plans as Hamilton County, and more specifically areas adjacent to Cool Creek and its tributaries, continue to develop. Currently agricultural lands in the northern watershed adjacent to Cool Creek have limited or no buffer strips. Based on current population trends in Hamilton County these lands will be developed relatively soon. Space for buffer strips and green space along Cool Creek provide valuable stormwater runoff protection by filtering pollutants before they enter the stream. These features should be provided as part of the development of the area and incorporated in the plan review process for each community.

Goal # 10 Action Register					
Objective	**Task**	**Funding**	**Schedule**	**Responsible**	**Products**
Improve the Riparian Habitat	Increase Amount of Buffer Strips by Incorporating into Development Plans	Developer, Local Funding	On Going	Hamilton County, Carmel, Westfield	Additional Stream Buffers

Goal Indicators: Length of stream with additional buffers strips added that previously did not have buffers

9.7 EVALUATING, MONITORING, AND ADAPTING THE PLAN

Hamilton County, Carmel, and Westfield will ultimately be responsible for tracking the progress of the plan achievements, making any changes to the plan that the Stakeholder Committee deems necessary, keeping all plan-related records and documents, and distributing copies of the plan to necessary participants. The follow items are recommended to evaluate and monitor the plan achievements:

Stakeholder Meetings

- Quarterly meetings
- Include Hamilton County, Carmel, Westfield representatives
- Include any other parties who have been involved to this point
- Once a year, the Stakeholder committee should invite new participants that have not been involved to this point.
- Review the progress of the plan and implementation measures
- Organize and review water quality monitoring data
- Organize and review visual Inspection
- Organize and review progress of implementation projects in the WMP
- Organize and review plan updates as needed

Water Quality Monitoring Data

- Samples should be taken once per year (ideally two times)
- Samples should be obtained during typical storm events (0.5 inches to 1.0 inches of rain)
- A minimum of 3 sample locations should be considered for each event. If needed more sites could be added to measure the effectiveness of the implementation measures
- Additional samples could be taken in dry weather
- Parameters sampled should included:
    - Sediment
    - Bacteria
    - Nutrients
    - Other Physical Properties (temperature, D.O., pH, etc.)
- Sampling for pesticides should also be considered (at least once) to determine baseline conditions
- Continue to promote volunteer monitoring by Hoosier Riverwatch or other similar programs

Visual Inspection

- Visual inspections responsibilities should be shared by Hamilton County, Westifield, and Carmel.
- Visual inspection logs should be kept for each tributary including the following
    - Date inspected
    - Inspector initials
    - Stream reach location
    - Photo log identified on map of area
    - Specific data on channel problems
- Streams in the watershed should be inspected at least once every three years

- Severe channel problems should be monitored quarterly
- Feet per year estimates of erosion problems should be made and documented in the log

Implementation of Recommended Improvements

- Recommended improvements shall have monthly progress meetings
- Progress reported at quarterly Stakeholder meetings

Update the Plan as Needed

- Plan updates will be made by Hamilton County with input from Carmel and Westfield
- Plan updates will be based on monitoring, visual inspections, and stakeholder and public input
- Plan updates will be discussed at quarterly Stakeholder meetings

The approval of this Section 319 Cool Creek Watershed Management Plan will not be the end of the project but rather the start of continual effort to achieve the mission statement:

> *Preserve and improve the overall health of the Cool Creek Watershed by addressing existing stormwater quantity and quality concerns and by proactively guiding future stormwater management practices and decisions.*

Contact Information

The following persons can be contacted with suggestions to improve the Cool Creek Watershed Management Plan.

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