



## Millers Creek Watershed Improvement Plan



**Prepared by:**  
**Ayres, Lewis, Norris, & May, Inc.**  
**Huron River Watershed Council**  
**Tilton and Associates, Inc.**

**Ann Arbor, MI**  
**April 20, 2004**

## **ACKNOWLEDGEMENTS**

This project was made possible by the foresight and generosity of **Pfizer Global Research and Development, Inc.** The individuals representing Pfizer for this project were Michael Lemon and Steve Kapeller.

### **Consultant Team**

Ayres, Lewis, Norris & May, Inc. (ALNM)  
Huron River Watershed Council (HRWC)  
Tilton and Associates, Inc. (TAI)

### **The Millers Creek Action Team (MCAT)**

MCAT served as the oversight committee during plan development and starting in February 2004 will lead plan implementation. Organizations represented on MCAT include:

Altarum (AI)  
City of Ann Arbor (AAP) Planning Commission  
City of Ann Arbor (AAB) Building Department  
City of Ann Arbor (AAU) Utilities Department (now Systems Planning, Public Services)  
Huron River Watershed Council (HRWC)  
Pfizer Global Research and Development, Inc. (PGRD)  
Pollack Design Associates (PDA)  
State of Michigan Department of Environmental Quality (MDEQ) – Surface Water Division  
University of Michigan (UM)  
Washtenaw County Drain Commissioner (WCDC)

### **MCAT Members**

Robert Black, AI	Steve Kapeller, PGRD
Janis Bobrin, WCDC	Michael Lemon, PGRD
Lisa Brush, HRWC	Joan Martin, HRWC
Malama Chock, UM	Stephen Rapundalo, Watershed resident (Orchard Hills neighborhood)
James D'Amour, AAP	Laura Rubin, HRWC
Theresa Dakin, HRWC	Harry Sheehan, WCDC
Nancy French, AI	Tom Torongo, MDEQ
Chris Graham, formerly of AAPC	Mary-Alice Wiland, AI
Jerry Hancock, AA	Mike Wiley, UM
Craig Hupy, AA	Dennis Wojcik, WCDC
Patrick Judd, PDA	

### **Consultants**

Alicia Askwith, ALNM	Jennifer Reiners, ALNM
Marty Boote, TAI	Jane Tesner, TAI
Heather Dermeyer, ALNM	Don Tilton, TAI
Scott Dierks, ALNM (Principal Author)	Michelle West, ALNM
Chris Mueller, TAI	

For their contributions to this plan, the following individuals are acknowledged. For the rest, please keep reading.

Thomas Edsall – Thurston Pond Group  
Heidi Koester – Thurston Pond Group  
Kevin Gustaffson, Eastern Michigan University Geology Department  
Fred Hoytash, Huron River Valley Laboratories  
Mark Banaszak Holl, UM Chemistry Dept  
Dennis Kahlbaum, UM Weather Station  
Paul Richards, UM  
Randy Trent, Ann Arbor Schools

**Huron River Watershed Volunteers**

Noemi Barabas	Michael Kaericher	Cynthia Radcliffe
Michael Benham	Ric Lawson	Chris Riggs
Rochelle Breitenbach	Brent Lignell	Don Rottiers
Dave Brooks	John Lillie	Bob Smith
Carole Dubritsky	Sue Lillie	John Stahly
Bob Elliott	Mary Lirones	Margaret Steiner
Barb Faust	Richard Manczak	Nancy Stokes
Pam Gerecke	Thad McCollum	Chad Theismann
Ken Gottschlich	John Minderhout	Erin Trame
Scott Green	Tui Minderhout	Carrie Turner
Cyndee Gruden	Beth Moore	Murat Ulasir
Kevin Gustavson	Kirsten Mowry	Norma Jean Wade
Gary Hochgraf	Diane O’Connell	Zoltan
Tom Jenkins	Nancy Perlman	
Meroe Kaericher	Karen Prochnow	

# TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGES</u>
1. EXECUTIVE SUMMARY.....	1-3
1.1 Project Background .....	1
1.2 MCAT Mission and Project Goals .....	1
1.3 Project Overview .....	2
1.4 Existing Conditions .....	2
1.5 Improvement Plan and Analysis .....	2-3
1.6 Quantitative Assessment and Results .....	3
1.7 Implementation, Projected Costs and Funding .....	3
2. BACKGROUND .....	4-19
2.1 Watershed History .....	7-9
2.2 Existing Area Plans .....	10-11
2.2.1 Northeast Area Plan.....	10
2.2.2 PROS Plan .....	10-11
2.3 Significant Watershed Stakeholders and Activities .....	11-15
2.3.1 Pfizer .....	11-13
2.3.2 University of Michigan .....	13
2.3.3 Altarum Institute .....	13-14
2.3.4 Ann Arbor Parks.....	14
2.3.5 Ann Arbor Public Schools .....	14
2.3.6 Geddes Lake Cooperative Homes .....	14
2.3.7 Thurston Pond Nature Center .....	15
2.4 Stream Stability and Rehabilitation .....	15-19
2.4.1 Incised Channel Evolution Model .....	17-19
3. METHODS .....	20-30
3.1 General Summary .....	20
3.2 Existing Data Sources .....	20-21
3.3 Methods .....	21-30
3.3.1 Field Work.....	21-28
3.3.2 Modeling .....	28-29

3.3.3	Public Involvement.....	29-30
3.3.4	Alternatives Analysis.....	30
4.	MODEL EVALUATION.....	31-43
4.1	Model Calibration.....	31-36
4.1.1	Hydrologic Model Calibration .....	31-34
4.1.2	Hydraulic Model Calibration .....	34-36
4.2	SWMM Model Results Summary .....	36-37
4.3	Water Quality Model .....	38-43
4.3.1	Water Quality Model Calibration.....	38-40
4.3.2	Water Quality Model Results Summary.....	41-43
5.	EXISTING CONDITIONS .....	44-60
5.1	General conditions.....	44-60
6.	IMPROVEMENT PLAN AND EVALUATION .....	61-71
6.1	Watershed Management Objectives .....	61-62
6.2	Methodology.....	62-65
6.2.1	Qualitative Feasibility Assessment.....	62-65
6.2.2	Quantitative Goal Assessment.....	65
6.3	Watershed Improvement Tools and Practices.....	65-71
7.	ALTERNATIVE EVALUATION .....	72-83
7.1	Alternative Modeling Scenarios .....	73-78
7.2	Results .....	78-83
8.	IMPROVEMENT PLAN IMPLEMENTATION.....	84-106
8.1	Role of MCAT .....	84
8.2	The Middle Huron Initiative .....	84
8.3	Implementation Activities, Schedule and Costs .....	85-97
8.3.1	Costs and Schedule.....	85-86
8.3.2	Implementation Focus Areas.....	86-95
8.3.3	Existing Huron River Initiatives and TMDL Implementation Activities.....	95-97
8.4	Monitoring and Adaptive Management .....	97-99

8.5	Funding Sources .....	99-106
9.	REFERENCES .....	107-109

### FIGURES

FIG. 1-1:	Damage on Pfizer Campus along Millers Creek	1
FIG. 2-1a:	Location of Huron River Watershed within the State of Michigan	4
FIG. 2-1b:	Location of the Millers Creek Watershed within the Huron River Watershed	4
FIG. 2-2:	Millers Creek Watershed Map	5
FIG. 2-3:	Surficial Geology of the Huron River Watershed	8
FIG. 2-4:	Presettlement Vegetation	8
FIG. 2-5:	1947 Aerial Photograph of the Millers Creek Channel	9
FIG. 2-6:	Jurisdictions and Land Holdings of Major Millers Creek Stakeholders	12
FIG. 2-7:	Upstream of Ruthven Nature Area	14
FIG. 2-8:	Millers Creek Cross-sections	19
FIG. 3-2:	Volunteers measure flow at the study site near Huron High School	21
FIG. 3-3:	Rating Curve for Millers Creek near the Huron High School	21
FIG. 3-1:	Subarea, Sampling Site, and Cross Section Locations	22
FIG. 3-4:	A volunteer installs a transducer at the Meadows study site	23
FIG. 3-5:	Volunteers measure geomorphology at the Hubbard study site	23
FIG. 3-6:	The shape of the channel at the upstream transect at the Glazier study site	24
FIG. 3-7:	Elevated Plant Root Zone	25
FIG. 3-8a:	Examples of Large Concrete Culverts in Millers Creek	26
FIG. 3-8b:	Examples of Large Concrete Culverts in Millers Creek	26
FIG. 3-9:	Example of the Vegetative Cover along a Stretch of Millers Creek where Trees are Lacking	26
FIG. 3-10:	Radar Image of 9-20-02 Rainfall	28
FIG. 4.1:	SWMM Model Schematic (with sub areas shown)	32
FIG. 4-2:	Comparison of Model-Calculated and Measured (by transducer) Peak Flow Rates for the three calibration events at the Plymouth, Glazier and Meadows Sites	33
FIG. 4-3:	Comparison of Model-Calculated and Measured (by transducer) Total Event Volume for the three calibration events at the Plymouth, Glazier and Meadows Sites	34
FIG. 4-4:	Example Flow Calibration Fit, Event 1 (Sept.19-21, 2002) at the Glazier Site	34

FIG. 4-5: Example Water Surface Elevation Calibration Fit Event 1 (Sept.19-21, 2002) at the Glazier Site	35
FIG. 4-6: Model-Estimated Peak Flow Rates for All Existing Conditions Events	37
FIG. 4-7: Model-Estimated Peak Velocities for all Existing Conditions Events	37
FIG. 4-8: Comparison of Model-Calculated and Field Data Total Suspended Solids Concentration at the Hubbard Station for Event 1, Sept.19-21, 2002	40
FIG. 4-9: Comparison of Model-Calculated and Filed Data Total Phosphorus Concentration at the Hubbard Station for Event 1, Sept.19-21, 2002	40
FIG. 4-10: 10 Model-Estimated Total Suspended Solids Loads for the First Flush Event (0.5 inches of rain in six hours)	41
FIG. 4-11: Model-Estimated Total Phosphorus Loads for the First Flush Event (0.5 inches of rain in six hours)	42
FIG. 4-12: Relationships of TSS and TP Total Event Loads to Design Event Rainfall Totals	43
FIG. 5-1: Millers Creek Reaches	45
FIG. 5-2: Elevation Change along Millers Creek	46
FIG. 5-3: Existing Land Cover in the Millers Creek Watershed	48
FIG. 5-4: Storm Sewer in the Millers Creek Watershed	49
FIG. 5-5: Problem Areas throughout the Millers Creek Watershed	50
FIG. 5-7: Fallen end section in Glazier Reach	52
FIG. 5-6: Measured Dry and Wet Weather Total Suspended Solids Concentrations	53
FIG. 5-8: Measured Dry and Wet Weather <i>E. coli</i> Concentrations	56
FIG. 5-9: Measured Dry and Wet Weather Total Phosphorus Concentrations	57
FIG. 5-10: Measured Dry and Wet Weather Orthophosphate Concentrations	57
FIG. 5-11: Riparian Corridor Land Cover and Contiguous Natural Plant Communities	60
FIG. 6-1: Locations of All Identified Improvement Opportunities	64
FIG. 7-1: Assumed Land Use for Built-out Conditions	75
FIG. 7-2: Locations of the Individual Recommended Improvements for Modeling Scenarios 2-5	76
FIG. 7-3: SWMM Schematic of Offline Detention	77
FIG. 7-4: Comparison of Peak Flow Reductions between Existing Conditions and Alternative Four	79
FIG. 7-5: Comparison of Peak Shear Stress Reductions between Existing Conditions and Alternative Five	80
FIG. 7-6: Comparison of Peak Velocity Reductions between Existing Conditions and Alternative Five	81

FIG. 7-7: Calculated Total Suspended Solids Removals for 2-Year Design Recurrence Interval Storm Event	82
FIG 7-8: Calculated Total Phosphorus Removals for 2-Year Design Recurrence Interval Storm Event	83
FIG. 8-1: Improvement Opportunities and Focus Areas	88
FIG. 8-2: Woodland North of the UM Hayward Parking Lot	90
FIG. 8-3: Hubbard 84-inch Culvert Outlet	90
FIG. 8-4: Baffle Box Structure near Huron Parkway	91
FIG. 8-5: Vegetated Geogrid (deformable bank)	92
FIG. 8-6: Sediment Deposition near the Huron High School Sampling Site	93
FIG. 8-7: Example Drywell	95

## TABLES

TABLE 3-1: Criteria and scoring methodology for assessing streambank erosion in the Millers Creek corridor.	25
TABLE 4-1: RUNOFF Water Quality Solids Build-Up Parameter by Land Use	39
TABLE 4-2: Total Annual Millers Creek Exported TSS and TP Loads for an Average Precipitation Year	43
TABLE 5-1: Millers Creek Soils (identified by SCS Texture Class) by Subwatershed	46
TABLE 5-2: Millers Creek Land Cover by Subwatershed	47
TABLE 5-3: Millers Creek Land Use by Subwatershed	51
TABLE 5-4: Flow characteristics during continuous recording (August 2002-April 2003)	52
TABLE 5-5: Rosgen Stream Classification Table for Representative Reaches	54
TABLE 5-6: Existing Velocity and Shear Stress for Bankfull Event	54
TABLE 5-7: The minimum, maximum and average conductivity on Millers Creek	55
TABLE 5-8: Summary of Cover Types Within 200 Foot Wide Stream Corridor	59
TABLE 6-1: Available Technological Controls, Best Management Practices, and Resource Improvement Methods	63
TABLE 6-2: Number of identified improvement opportunities by category	65
TABLE 8-2: Millers Creek Recommended Monitoring Plan and Costs	99
TABLE 8-3: Potential Grant or Loan Sources for Millers Creek Improvements	100-104
TABLE 8-1: Costs and Proposed Implementation Schedule for Recommended Improvement Opportunities	105-106



## APPENDICES

### Appendix A

#### WATER QUALITY

##### A-1 Water Quality Model for All Flood Events<sup>1</sup>

Alternative 2:	TSS & Phosphorous Loads Load Input File Average Detention Times Loads Plots
Alternative 3:	TSS & Phosphorous Loads Average Detention Times
Alternative 4:	TSS & Phosphorous Loads Average Detention Times
Buildout:	TSS & Phosphorous Loads Load Input File Average Detention Times
Calibration 1:	TSS & Phosphorous Loads Depth & Flow Charts Field Water Quality Parameters
Calibration 2:	TSS & Phosphorous Loads Load Input File Field Water Quality Parameters
Calibration 3:	TSS & Phosphorous Loads Load Input File Field Water Quality Parameters

Existing Conditions: TSS and Phosphorous Loads  
Load Input File  
Average Detention Times  
Load Plots

Model Load Summary for all Scenarios  
Brown Park Particle Size Distribution  
Particle Settling Velocities  
West Ann Loads  
Water Quality Model Procedure  
Water Quality Model Calibration

A-2 *E. coli* sample data at Huron location

A-3 Millers Conductivity

A-4 Millers Temperature Report

A-5 Quality Assurance Protection Plan for Water Quality  
Monitoring

A-6 Temperature, DO, pH & Conductivity data 8/15 – 9/28

A-7 Temperature, DO, pH & Conductivity data 10/04 – 11/15

### Appendix B

#### PUBLIC INVOLVEMENT

##### B-1 Graphic Pieces

Business Breakfast Map handout  
Direct Mail 1 - Just Imagine  
Direct Mail 2 - Oct Open House

---

<sup>1</sup> All flood events includes 2 year, 10 year & First Flush Flood Events.

Direct Mail 3 - February public meeting  
Direct Mail 4 - July Open House  
Lunch Tour Poster  
Millers Creek Business Breakfast Invitation  
October 2002 Survey  
Reminder for July Open House  
Reminder for February Open House  
Reminder for October Open House

B-2 Reports

Business commitment from February breakfast  
Business roundtable 3.27 evaluation compilation  
Millers Creek business and breakfast information  
Millers Creek Survey October 2002 responses  
Open house 2.03 evaluation compilation  
Open house 10.02 evaluation compilation

Appendix C

XP\_SWMM

C-1 XP\_SWMM Input & Output Files For All Flood Events &  
SCENARIOS<sup>2</sup>:

Existing Hydrographs Input File  
Flow output results at each conduit  
Existing Cross-Section Output File  
Runoff Output File

C-2 Bed Shear Stress Summary

C-3 Model Calibration

C-4 Infiltration Method/Green Ampt

C-5 Peak Flow Summary for all Scenarios

C-6 Pfizer Wetland Water Level & Rain Data

C-7 Comparison of Flow, Velocity & Depth for all Scenarios

C-8 Runoff & Landuse Data

C-9 Water Level at Thurston Pond

Appendix D

STREAM REACH DESCRIPTIONS

D-1 Photographs

Historic Aerials and vegetation  
Streamwalk photographs  
TAI  
Thurston Pond photographs

D-2 Site Sketches for Baxter, Glazier, Hubbard, Huron Parkway,  
Lakehaven, Meadows, Narrow Gauge Way & Plymouth

D-3 Reach Conditions and Locations

Appendix E

GIS DATA

E-1 Millers Creek Watershed Relief Map (TIN)

E-2 GIS Shapefiles

E-3 GIS Images

E-4 GIS ArcMap Files

Appendix F

PRECIPITATION

F-1 AAPRCP

---

<sup>2</sup>All scenarios includes Alternatives 2, 3 & 4, Calibrations 1, 2, & 3, Buildout & Existing Conditions

F-2 Calibration 1 ppt  
F-3 Calibration 2 ppt  
F-4 Calibration 3 ppt  
F-5 Correlation between University of Michigan and Pfizer Rain  
Gauge Data  
F-6 Washtenaw County Rain Data 1988-1999

Appendix G

FLOWS

G-1 Discharge Rating Curves at Baxter, Glazier, Hubbard, Huron,  
Lake Haven, Meadows, & Plymouth  
G-2 Daily Precipitation during Monitoring Period  
G-3 Biological Impacts of Flow  
G-4 Cable Board Use Instructions  
G-5 Flow Graphs at Baxter, Glazier, Hubbard, Huron,  
Lakehaven, Meadows, & Plymouth  
G-6 Millers Creek Gauge & Model Elevations  
G-7 HRWC Stream Gauge Design  
G-8 Pfizer Wetland Level and Rain Data  
G-9 Quality Assurance Protection Plan for Millers Creek  
G-10 Transducer Data at Glazier, Meadows, & Plymouth  
G-11 Transducer Graphs at Glazier, Meadows, & Plymouth  
G-12 Transducer Instructions

Appendix H

CULVERTS

H-1 Photos of Culverts, Outlets, & Stream Conditions  
H-2 Culvert Identification Sheet  
H-3 Culvert Field Data Sheet

Appendix I

GEOMORPHOLOGY

I-1 Geomorphic Data 06/08/02 – 07/25/02  
I-2 Stream Geomorphic Calculated Data  
I-3 Geomorph Datasheet  
I-4 Geomorph Results Summary and Graphs  
I-5 Geomorphology Pin Maps  
I-6 Hubbard Channel Shape  
I-7 Particle Size Distribution at Baxter, Glazier, Hubbard, Huron,  
Meadows & Plymouth  
I-8 Cross-Sections for Bankfull Conditions at Geddes, Meadows,  
Huron, Lakehaven, Glazier, Hubbard & Plymouth  
I-9 Quality Assurance Protection Plan for Geomorph Study at  
Millers Creek  
I-10 TAI Bank Stability Assessment

Appendix J

BENTHIC MACROINVERTEBRATES

J-1 Checklist for Leader  
J-2 Macroinvertebrate Results  
J-3 Macroinvertebrate Search Data Sheet  
J-4 Quality Assurance Plan for Adopt-A-Stream  
J-5 Techniques for Collectors & Leaders

Appendix K

IN-STREAM HABITAT

K-1 Habitat Data sheet

K-2 In-Stream Habitat Results  
K-3 Procedure for Habitat Inventory

Appendix L           IMPROVEMENT OPPORTUNITIES  
L-1 Improvement Opportunities

Appendix M           COST BACKUP  
M-1 Miller Cost Estimates

Appendix N           EXISTING DATA  
N-1 Millers Creek Report 1993  
N-2 Existing Water, Habitat, & Biological Quality at Glazier

# 1. EXECUTIVE SUMMARY

---



## 1.1 Project Background

This document is a comprehensive watershed improvement plan for Millers Creek, an urban tributary of the Huron River located on the northeast side of the City of Ann Arbor in Washtenaw County, Michigan. This project originated as a unique public and private sector partnership funded by Pfizer Global Research and Development, Inc. (Pfizer), the second largest landowner in the watershed. Plan development oversight was provided by the Millers Creek Action Team (MCAT), a voluntary group of watershed stakeholders including businesses, community representatives, and local and state entities.

This project was prompted by flooding and bank erosion on Pfizer's Ann Arbor campus (See **Figure 1.1**). Pfizer decided to investigate the problems and develop a solution by looking at their campus in the context of the entire Miller Creek watershed. With assistance from the Washtenaw County Drain Commissioner (WCDC) and the Huron River Watershed Council (HRWC), Pfizer initiated MCAT and this project. Concern for the creek coalesced in the middle to early 1990s when an earlier version of MCAT, led by the Environmental Research Institute of Michigan (ERIM), the HRWC and the WCDC began investigating possible watershed-wide improvements.

The creek has little to no existing institutional support. It is not a county drain and is considered a receiving water for the City of Ann Arbor and the University of Michigan North Campus storm water drainage. The creek is also identified as a contributing source in the Ford and Belleville Lakes Total Maximum Daily Load (TMDL) for phosphorus and the Geddes Pond TMDL for *E. coli*.



**Figure 1.1 Damage on Pfizer Campus Along Millers Creek**

On-going planning efforts consulted for this project include the Northeast Area Plan (NAP), the Ann Arbor Parks and Recreation Department Open Space Plan 2000-2005 (PROS Plan), and the *E. coli* implementation plan (2003). The NAP and PROS plans provided recommendations of forecasted land use for a fully built-out Millers Creek watershed.

## 1.2 MCAT Mission and Project Goals

The mission of MCAT is to establish and implement socially, environmentally, and economically sustainable watershed management standards and practices that will improve the quality of the Millers Creek watershed. The goals of this plan are to develop a set of recommendations that will improve stream habitat and watershed hydrology, improve recreational opportunities in and around the creek and help local stakeholders achieve the objectives of the Ford and Belleville Lakes total phosphorus TMDL and the Gallup (Geddes) Pond *E. coli* TMDL. Implementation of these recommendations will also help foster activities that perpetuate urban watershed and stream stewardship, and create a healthier balance between the local community and its ecosystems.

### 1.3 Project Overview

This project began in the spring of 2002. MCAT developed a work scope, selected a consultant team to prepare the Watershed Improvement Plan, and regularly advised and collaborated with the consultant team to create the plan. The consultant team compiled existing source data and undertook a detailed investigation of field conditions including watershed and subwatershed delineations, flow, velocity and, water quality measurements, in-stream and corridor habitat, macroinvertebrate diversity, stream bed and bank stability, and infrastructure conditions. Runoff, flow, velocity, and water quality models were developed and calibrated to field-collected data sets.

MCAT developed a vision statement for the watershed, including goals and objectives to measure progress. Watershed residents and other volunteers helped with stream monitoring and developing management recommendations. Feasibility and performance of each recommended improvement were assessed using qualitative and quantitative measures. This report was compiled to summarize and communicate project results. It includes a prioritized implementation plan, estimated costs and a monitoring plan.

### 1.4 Existing Conditions

Millers Creek is the steepest tributary to the Huron River. Over the mainstem of the creek, the average gradient (change in elevation over creek length) is 52 ft/mi. By comparison, the average gradient of the Huron River is 2.95 ft/mi. Approximately 36% of the 2.4 square mile (1,531 acres) Millers Creek watershed is covered in impervious surfaces – roads, roofs, driveways, and parking lots. Most of the storm sewer was designed to be self-cleaning and does not have catch basin sumps. Many built-out areas in the watershed have little or inadequate storm water detention storage, and watershed soils are predominantly poorly draining clay loams. This combination results in high peak flows arriving at the stream minutes after the onset of rainfall. The steepness and flashiness of the stream wreak havoc on the aquatic community by periodically wiping away the streambed and severely eroding the stream banks. In some locations near Huron Parkway, creek incision and meandering are threatening the bike path. All macroinvertebrate sampling, with the exception of the site near Narrow Gauge Way, has found an impoverished benthic community. This is probably due to frequent episodes of mobilized streambed. High concentrations of *E. coli* (up to 18,000 counts/100 ml), indicative of water contaminated with warm-blooded animal waste, have been found in several locations along the creek. High total suspended solids and high total phosphorus loads are most likely a result of runoff loads and stream bank and bed erosion. Flow and geomorphology data suggest the erosion loads are primarily originating in the middle reaches of the creek. These loads are then deposited in the creek delta that extends from Huron High School to the Huron River or are carried into the Huron River.

### 1.5 Improvement Plan and Analysis

An extensive list of possible improvements was compiled based on field and Geographical Information Systems (GIS) analyses. Improvement feasibility was ranked qualitatively based on technological challenges, engineering design requirements (e.g., level of complexity), property ownership, public acceptance, and potential site constraints. A total of 112 separate improvements were considered. Five alternative scenarios were created to capture key improvement recommendations and to quantify the degree of hydrologic and water quality goal attainment. The alternatives analysis was structured as a series of incremental improvements: from the least costly and most highly feasible projects to the most costly and least feasible. It was assumed that there was no practical limit on the number of improvements that could be implemented to try and reach some predevelopment standard. Research has shown that

streams with a high percentage of impervious surface area (>15%) are not likely to ever be completely restored to predevelopment condition (Booth, et al. 2002). This does not invalidate the need to conserve and enhance the resource, but rather imposes realistic limits for restoration success.

### **1.6 Quantitative Assessment and Results**

Recommended improvement performance was tested using the calibrated suite of models and literature estimates of source control effectiveness. The calibrated models were adjusted to assumed build-out conditions based on the NAP and PROS plans. The build-out scenario included 30.5 acres of new residential development, 18 acres of new commercial land with an additional 80.5 acres set aside for floodplain, recreational area or conservation easements. Since the watershed is almost completely built out, and most soils are poorly drained, hydrologic control relies almost entirely on new and retrofitted best management practices (BMPs). Results also demonstrate that even with a built-out watershed, source control is still more efficient and cost-effective for protecting water quality than end of the pipe BMPs.

### **1.7 Implementation, Projected Costs and Funding**

Implementing the Millers Watershed Improvement Plan will require the concerted efforts of the City of Ann Arbor, Washtenaw County, Ann Arbor Township, and the University of Michigan, all of which are regulated storm water communities under Phase I and II National Pollutant Discharge Elimination System (NPDES) storm water permits. These communities are responsible for ensuring water quality and addressing water use impairments. However, a committed public-private partnership, much like the one that initiated this project, will ultimately be the key to success. All individual landowners, institutions, industries, business owners, and local units of governments have a stake in the Millers Creek improvement process and can contribute to the successful implementation of the plan.

The recommended improvements include structural and non-structural BMPs. The structural BMPs include proprietary BMPs (underground storage/treatment units), detention pond retrofits, roof drain disconnects, sediment traps, detention ponds and regional off-line peak flow reduction facilities. Some of the recommended non-structural BMPs include a phosphorus-free fertilizer ordinance, street sweeping, conservation easements, public education plans and long-term performance monitoring. Except for the purchase of (some) conservation easements, these non-structural BMPs are the most cost-effective solutions for hydrologic and water quality control. Structural BMP priorities include detention pond retrofits, roof drain disconnects, sediment traps, detention facilities and two priority streambank stabilization sites. The next priority is for regional off-line peak flow reduction facilities. Recommended streambed stabilization, daylighting and some bank stabilization measures are assigned the lowest priority.

The next major step for this plan is to obtain City of Ann Arbor, the University of Michigan and the Michigan Department of Environmental Quality (MDEQ) acceptance and endorsement. MDEQ acceptance will make the watershed eligible for Clean Michigan Initiative (CMI) and Clean Water Act-Section 319 funding, two of the most significant sources of outside support. This plan also recommends that watershed stakeholders petition for creation of a Millers Creek Drainage District to provide a long-term framework for financing improvements and maintenance activities. MCAT intends to lead implementation of this plan and offer technical and administrative assistance to watershed stakeholders.